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IN THE CLIMATE RESPONSE

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EDITORIAL COMMENT: LOCAL ACTORS AND PROCESS IN THE CLIMATE RESPONSEE

By Ayobami Abayomi Popoola

Published 1 February 2026

THE THINK PIECE AND GAP

The underlying argument that motivated the special issue was the role of local people and actors in responding to climate change. The editors argue that responding to the climate crisis calls for a local capacity, voices and approaches to be at the forefront. The local actors' experience in climate risk, the integration of local persons in climate governance responsiveness, and the grassroots and indigenous communities' approaches in responding to climate vulnerability. These positions were forwarded along with the need for a collaborative mechanism to manage and respond to the climate crisis.

In addition to the above, Article 12 of the Paris Agreement recognised the need to enhance climate change education, training, public awareness, public participation, and public access to information. Alluding to this position as forwarded by Finnerty et al. (2024) on the morality and duty of scientists to advocate for scientific information in their publication titled "Between two Worlds: The Scientist's Dilemma in Climate Activism", this special issue posits that research itself can be a form of activism in particular circumstances, blurring the lines between traditional research and activist endeavours, most importantly, the strategic environmental advocacy tool that research serves. Therefore, this issue welcomes research findings and informed climate-driven positions that portray divergent scientific identities toward managing and responding to the climate change discourse.

THE SPECIAL ISSUE: A LOCAL CLIMATE RESPONSE

This special issue contains eight (8) articles with a focus on local communities and specific sectors of the African economy. All the articles are focused on the impact of and how local people and institutions respond to climate change. Across sectors, the impact of climate change remains extensive. There still exists a gap in knowledge on how climate change impacts the aviation industry. Kaniyo (2025) examined the impact of climate change on the aviation industry in Nigeria through the thematic analysis of interviews with stakeholders in the industry. From the interviewee the themes identified were the extreme weather conditions caused by climate change; the business and economy of commercial passenger air transport on scheduled flights (operational cost and travel demand); operational performance of the airports (facilities management); airport capacity (apron capacity, airspace capacity/ Terminal Maneuvering Areas [TMA], and Instrument Landing System); and aviation infrastructure (control tower and air navigation systems). Findings revealed that extreme weather conditions driven by climate change pose significant threats to airport operations, capacity and infrastructure. The threat identified by the author was the exposure of the

international airport in Lagos to flooding due to its proximity to the coastline. Owing to this, the study recommends that the Nigerian Civil Aviation Authority [NCAA], in partnership with the Federal Airport Authority of Nigeria [FAAN], develop and implement a resilience framework that will mandate climate risk assessments for all major airports, and conduct risk assessments of their new and existing aviation infrastructure.

The need for risk assessment is critical in coastline cities such as Lagos. Ayodele-Olajire et al. (2025) study - Climate Change and Megacities: Flooding along the Urbanising Atlantic Coastline of Lagos, Nigeria, through the use of a geospatial tool – satellite imagery simulates flooding and identifies flood-prone areas between 1986 and 2023 in Lagos, Nigeria. Through the Digital Earth Africa (DEA) Sandbox to evaluate the extent, vulnerability, and risk of coastal inundation, the study reveals that some areas previously inundated with water were identified as land in 2023, suggesting that water has either receded from these regions or they have been sand-filled and vis-à-vis. The application of the geospatial technology in this research demonstrates the utility of this toolbox for environmental resource monitoring and urban planning. In the context of the rapidly developing Lagos Megacity. Most importantly, a need for flood management and urban vulnerability mapping. The authors recognised that beyond the mapping, inter-agency collaboration is needed towards managing other contributory factors to flooding, such as drainage blockage and poor waste management.

In Mmolutsi (2025), the article titled Localising Global Climate Commitments: Challenges for Marginalised Communities in South African Cities. The manuscript examined the challenges of localising global climate commitments, specifically the Paris Agreement, within South Africa's marginalised informal settlements. Based on documental analysis, the study traced the Global–National–Local trajectory of climate governance. The analysis revealed persistent challenges in policy coherence, local capacity, and climate finance distribution, especially in addressing the vulnerabilities of informal settlements. One key takeaway towards enhancing the coherence of the Global–National–Local policy flow in the study, as it relates to the localisation of climate commitments in informal South Africa, was the need for multi-level coordination mechanisms that are strengthened by establishing national-to-local climate coordination platforms that will improve intergovernmental alignment, and embed climate adaptation frameworks within local governance systems. The importance of localising policies allows for the sustainable application and acceptability of such policies.

Positioning the issue within the communicative, advocacy, and radical thinking towards climate change, this special issue contains submissions that cut across all groups and societies as they relate to climate education and sensitisation. This special issue considers this critical issue as it aligns with the position of Van Eck et al. (2024). The argument was the need for climate science advocacy to redefine the boundaries of acceptable influence of values in scientific communication and offer practical strategies to move beyond the misleading myth of neutrality. The argument is that much evidence on climate response and mitigation across economies portrays 'researchers and scientists as prophets' and requires them to devise the best approach to engage society. These approaches must take into consideration the language of residents.

Recognising the importance of locally acceptable policies and climate actions, the publication of Zondi and Madzivhandila titled Climate Change Attitudes in South Africa: Evidence from Ward 6 Noodsburg, Ilembe District Municipality. The study provided a discussion on the need for the public, and in this case, residents in Noodsburg, to understand climate change. The study's focus was to understand the attitude of residents toward climate change. Key findings from the study were the mismatch and gap between climate change awareness and knowledge among residents in the local community. The authors recognise the need for improved climate messaging among the local populace. The authors alluded to the position that formulating climate change communication strategies – both for content development, and processes and structures of communication is critical for climate adaptation and mitigation. This, they believed, would contribute to improving climate psychology (attitude and mindset), education, and communication among residents.

In a related manner, Adegebo and Fadiya (2025) in 'Communicating Climate-Related Health Risks in Local Communities' argued that despite the universality of health exposure from climate anomalies, the 'climatic-jargon' used by experts in explaining climate change crises remains a limitation to understanding from non-experts. Approaching climate understanding from an inclusive perspective through the sample of children and the elderly, the

study investigated the communication tools used in disseminating climate-related health risks. Television channels remain a widely acceptable source of climate-related health information among both the young and the elderly in the study location. However, the gender profiling of the source of climate information revealed that adult males learnt about climate change and related health risks from online sources (research papers and webinars) or at school. In contrast, female respondents learned about climate change and related health risks from hospitals, traditional media, social media, and places of worship. It was recognised from the study that child respondents are critical of the framing and communication channels adopted in climate health risks. The recommendation of the study from children was the need for school outreach, newspapers, TV/radio game shows, and YouTube channels to adopt climate communication. In a similar vein, the authors recommended the need for children-friendly storybooks as a means of climate awareness and sensitisation.

To achieve this climate-driven ambition, Article 11 recognised the need for capacity-building under the Paris Agreement. To be more specific, the focus is on the role of young people play in climate change discourse. One of the manuscripts in this issue queries the young person's involvement through scientific and sociological steps towards tackling the climate crisis in our cities. In Bandura and Cherry (2020), they have alluded to the failed efforts of the adult generation in responding to climate change. They posit that the children's intuitive principles of change closely matched the formal principles of social–cognitive theory. Social media equips youth with unlimited reach and promotes large-scale environmental impact. Their ingenious practices provide the foundation for a powerful youth environmental movement (Bandura and Cherry, 2020:945). Most importantly, youth engagement and involvement in climate actions. This position emphasises the importance of the manuscript of Modiba et al. (2025) which was titled Leveraging Public Employment Programmes for an Inclusive Just Transition: Connecting Youth to the Green Economy through City-Led Partnerships in South Africa. The study alluded that public employment programmes (PEPs) are increasingly recognised as tools for advancing a just transition by addressing both unemployment and environmental sustainability. Thus, the authors iterate the need for city-led partnerships with stakeholders in the green economy through training as a sustainable and professional pathway to youth employment and empowerment. The argument was the need for youths to be actively engaged in the green economy. However, it was argued that for this to be sustainable, there is a need to reposition the EPWP as a more integrated employment and skills development platform. This can be done through deliberate institutional partnerships and funding.

Beyond the technology and communication of climate anomalies. Two manuscripts in the issue focus on the sociological perception of the climate issue. Rumutsa and Malinganiso's (2025) study – The Effects of Patriarchy on Climate Change Adaptation among Women in agro-based Mukangamwi Communal Rural Area in Bikita, Zimbabwe explored climate change adaptation from a gender lens. The study alluded to the patriarchal influence of local power in climate change adaptation among women in rural Zimbabwe. The study alluded to the nexus between culture, local institutions and climate rights of women in the local community of Zimbabwe. The study reveals that the patriarchal norms deeply influence the way climate change impacts women, particularly in communities where gender roles are rigidly defined. It was reported that, despite the role of women within the household economy, their voices and views as they relate to climate adaptation options are not captured. This is the reality despite the rich history of the Mukangamwi communal lands, in indigenous knowledge support systems in local adaptation. The importance of role description in climate change cannot be overemphasised. Aboagye (2025) in his publication – Who does what? Analysis of the roles of actors in affordable sanitation service delivery in informal settlements in Kumasi, Ghana. The author was focused on the role various actors play in environmental sanitation in the informal settlements of Kumasi, Ghana. The importance of role description is critical to collaborative planning towards improved urban management across Africa. The study's contribution to knowledge was a framework which centres on supporting households in informal communities. These tripartite affordable sanitation frameworks recognise the importance of creating an enabling environment, building capacity and partnership and a localised system of environmental advocacy and development.

CONCLUSION

The special issue recognises that various environmental stresses characterise residents and communities. This stress is further shaped by the climate change impact. However, essential to responding to climate change precarity

is building the capacity of local people and communities to respond to climate change individually. The ideology of climate change localism, which is characterised by a space-specific response system, was alluded to. Such a specific response includes the method of advocating and sensitising about climate change. This is evident in the need for a climate education approach that is class-specific (women, children, and informal settlers).

This special issue brings together eight articles that explore how local communities and specific sectors across Africa are grappling with the multifaceted impacts of climate change. The overarching theme is clear: climate change is not a distant threat—it is a lived reality affecting infrastructure, governance, and livelihoods at the local level. Collectively, this special issue emphasises the position that climate resilience in Africa demands localised strategies, sector-specific planning, inclusive governance, and bold communication. These can be achieved through infrastructure upgrades, maintenance, and/or reform, urban planning, localised policy alignment, or public engagement. The path forward lies in empowering communities to respond to climate change on their own terms—with the tools, knowledge, and support they need to thrive (see Figure 1).

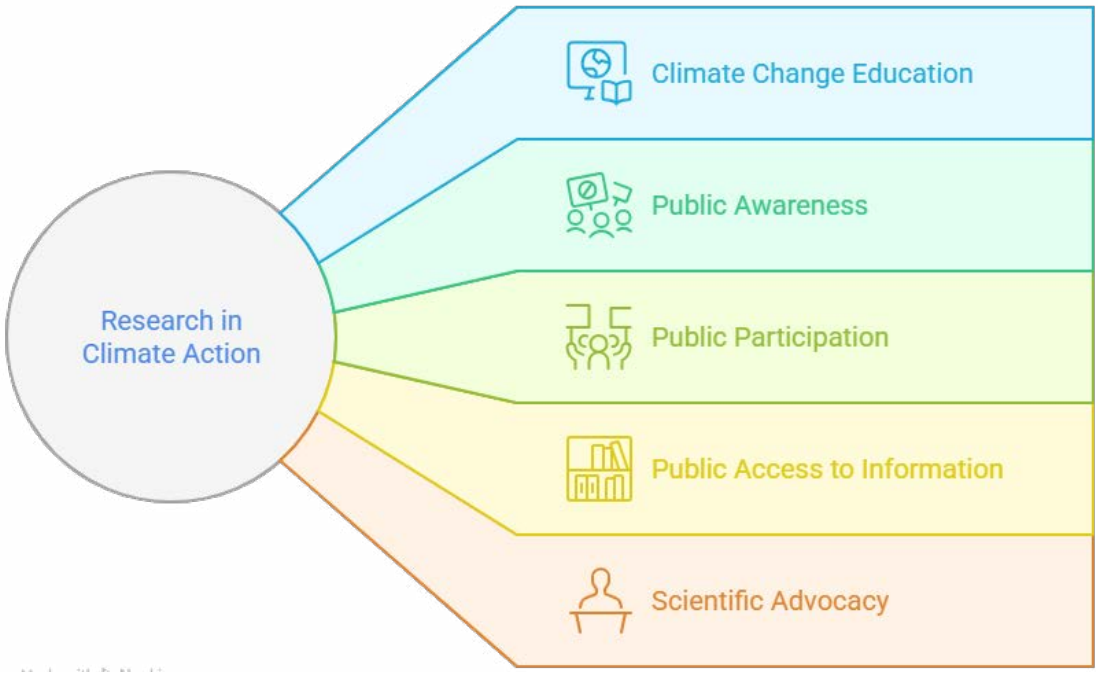

Figure 1: Unveiling the Multifaceted Role of Research in Climate Action
Source: Editor's Construct (2025)

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LOCALIZING GLOBAL CLIMATE COMMITMENTS: CHALLENGES FOR MARGINALIZED COMMUNITIES IN SOUTH AFRICAN CITIES

By K. C. Mmolutsi

Published 1 February 2026

ABSTRACT

This paper examines the challenges of localising global climate commitments, specifically the Paris Agreement, within South Africa's marginalised informal settlements. Employing a Global–National–Local analytical framework, the study explores how international agreements are translated into national policies, such as South Africa's Updated Nationally Determined Contributions (2021) and the Climate Change Act 22 of 2024, and subsequently implemented at the municipal level. Through qualitative content analysis of policy documents, implementation reports, and academic literature, the study identifies key barriers, including persistent policy fragmentation, the uneven allocation of climate finance (often misaligned with local needs), and limited institutionalisation of participatory governance in adaptation planning. While national policies advocate for urban resilience, poor implementation often leaves informal settlements behind. The paper concludes with actionable recommendations for bridging this divide, including enhancing multi-level coordination, allocating dedicated adaptation finance for informal settlements, and institutionalising community-led planning. These strategies aim to align global climate ambitions and equitable local outcomes.

KEY WORDS climate adaptation, marginalized communities, global–national–local policy alignment, climate finance, urban resilience.

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1. INTRODUCTION

Marginalised communities in South Africa's informal settlements face disproportionate climate risks due to spatial inequality, inadequate infrastructure, and weak governance (UN-Habitat, 2022). Rapid urbanisation, coupled with poor service delivery and fragile governance mechanisms, has elevated their exposure to climate-related hazards such as flooding, extreme heat, and disease outbreaks (Climate Policy Initiative [CPI], 2021). Although the Paris Agreement (UNFCCC, 2015) and South Africa's Updated Nationally Determined Contributions (NDCs, 2021) prioritise equitable adaptation, translating these commitments into tangible, community-level actions remains inconsistent. The 2022 UN-Habitat *World Cities Report* and South Africa's 2019 *National Climate Change Adaptation Strategy* both highlight persistent barriers to scaling localised and inclusive climate actions within vulnerable settlements. These challenges undermine efforts to achieve Sustainable Development Goal 11 (SDG 11), which emphasises the importance of inclusive, safe, resilient, and sustainable urban development.

This paper adopts a Global–National–Local analytical framework to examine how international climate agreements, such as the Paris Agreement, are interpreted through national policy instruments, including South Africa's Nationally Determined Contributions (NDCs) and the Climate Change Act 22 of 2024, and subsequently operationalised through municipal policies and interventions. However, this translation process is often uneven, hindered by institutional fragmentation, weak intergovernmental coordination, and under-resourced municipalities. The framework serves as a lens to identify points of misalignment, particularly in responding to the urgent needs of informal settlements. Accordingly, the paper explores how and why these breakdowns occur, focusing on institutional, financial, and participatory gaps. Although South Africa's Updated NDC (2021) and the Climate Change Act 22 of 2024 emphasise inclusive adaptation, adaptation funding remains disproportionately low compared to mitigation investments, with limited direct access at the local level (CPI, 2021; Oxfam, 2020).

Despite these systemic challenges, emerging local initiatives, such as retrofitting projects, decentralised renewable energy pilots, and community-led adaptation plans, illustrate the potential of localised climate action when supported by coherent policy, inclusive governance, and adequate finance (UN-Habitat, 2022; CPI, 2021). The Cradle to Cradle (C2C) model informs this analysis by promoting sustainable, circular solutions, such as retrofitting and decentralised energy systems, for informal settlements. The C2C model aligns with the Paris Agreement's goals by advancing resource efficiency and sustainability in adaptation strategies (UNFCCC, 2015). In the context of informal settlements, C2C principles offer guidance for infrastructure upgrades that minimise environmental harm while maximising social benefit. However, effective application of C2C principles requires participatory governance and dedicated funding, both frequently lacking in South Africa's climate response. By examining policy disconnects and proposing actionable solutions, this study contributes to the discourse on inclusive urban climate adaptation.

This study investigates the challenges of translating the commitments of the Paris Agreement into localised climate actions that benefit marginalised communities in South African cities. The central research question is as follows: *"How do governance, finance, and participation gaps hinder the localisation of global climate commitments in South Africa's informal settlements?"* To address this question, the study explores the institutional, socio-economic, and policy barriers limiting the effective implementation of global adaptation goals at the local level. It also assesses strategies for enhancing inclusivity, accountability, and resource distribution to strengthen climate resilience in vulnerable urban communities.

2. PROBLEM STATEMENT

Despite South Africa's progressive climate policy framework, informal settlements remain largely excluded from adaptation planning and financing. The localisation of global climate goals is uneven, particularly in informal settlements that are disproportionately vulnerable to climate impacts. The Climate Change Act 22 of 2024 aims to institutionalise adaptation and resilience-building at the municipal and provincial levels. However, its implementation is hindered by intergovernmental misalignment, weak coordination, and limited local capacity. These challenges disrupt the coherent translation of climate action from global to national to local levels. Key barriers include persistent policy fragmentation, limited institutional accountability, and a constrained understanding of participation, often reduced to consultation rather than genuine co-design or shared decision-making. Moreover, finance mismatches remain a critical obstacle: only around 10% of global climate finance targets adaptation, with minimal direct access for local governments (CPI, 2021; Oxfam, 2020).

Empirical studies have consistently shown that, while adaptation is prioritised at the national level, informal settlements are frequently excluded from funding and programmatic interventions. South Africa's National Climate Change Adaptation Strategy (NCCAS) highlights the enduring disconnect between national climate ambitions and the realities of vulnerable communities (Department of Forestry, Fisheries and the Environment [DFFE], 2019). Integrated Development Plans (IDPs) and Local Adaptation Plans (LAPs) often omit informal settlements, despite their acute exposure to intensifying climate risks. Furthermore, climate finance remains predominantly focused on mitigation, with limited investment in decentralised, community-specific

adaptation, especially initiatives aligned with Cradle to Cradle (C2C) principles. These systemic challenges are compounded by fragmented governance structures and a lack of institutionalised accountability at the local level.

This study investigates how global commitments such as the Paris Agreement are operationalised through South Africa's national frameworks and examines the institutional, financial, and participatory gaps that inhibit inclusive, locally grounded climate adaptation for marginalised urban communities.

3. LITERATURE REVIEW

3.1. Climate Resilience in Informal Settlements

Informal settlements are increasingly recognised as critical sites for climate adaptation due to their high exposure to environmental hazards and exclusion from formal urban planning (UN-Habitat, 2022; CPI, 2021). Globally, cities in the Global South, such as Dhaka, Lagos, and Rio de Janeiro, have adopted various strategies to integrate informal areas into climate risk reduction efforts. These include early warning systems, climate-resilient infrastructure, and community-based adaptation (CBA) initiatives (Alam et al., 2021; Carmin et al., 2020).

In contrast, South Africa's adaptation efforts lack institutionalised participation and decentralised financing mechanisms. Adaptation planning frequently excludes informal settlement communities, thereby reinforcing spatial marginalisation (UN-Habitat, 2022; Oxfam, 2020). According to UN-Habitat (2022), the effectiveness of climate action in informal settlements depends on context-specific interventions, particularly those co-designed with affected communities. Although South Africa's updated Nationally Determined Contributions (2021) and the Climate Change Act 22 of 2024 identify informal settlements as priority areas, implementation remains fragmented due to weak local capacity and inadequate policy translation. The *Climate Policy Initiative* (2021) further highlights that adaptation finance allocated to informal settlements is minimal compared to investments in mitigation-oriented megaprojects.

3.2. Comparative Insights from Other Developing Countries

International experiences offer valuable lessons on localising global climate commitments. In Bangladesh, local governments collaborate with NGOs to implement community-driven flood defences and climate-smart housing (Alam et. al., 2021). Brazil's National Adaptation Plan promotes urban agriculture and green infrastructure in favelas through municipal partnerships (Carmin et al., 2020). Kenya's Makueni County Climate Fund enables direct community input into local adaptation priorities. This model, now cited by global institutions as best practice, demonstrates the value of decentralised and participatory climate finance (UN-Habitat, 2022). These examples demonstrate that effective localisation of global climate goals requires strong subnational institutions, accessible finance, and institutionalised participatory governance. In contrast, South Africa presents a more fragmented institutional context, with limited devolution of adaptation mandates and constrained local implementation capacity.

3.3. Climate Finance and Resource Distribution

Recent global reports emphasise a persistent mismatch between climate finance flows and the adaptation needs of vulnerable populations. Adaptation receives less than 10% of global climate finance, with only a fraction reaching the local level (CPI, 2021). In South Africa, international funding is typically channelled toward national-level initiatives, leaving local governments under-resourced. While the Climate Change Act 22 of 2024 acknowledges the importance of targeted support for informal settlements, it lacks mechanisms to ensure direct funding allocation, thereby perpetuating structural inequities.

Oxfam (2020) notes that, without "readiness funding" and technical support, municipalities face considerable barriers in accessing climate finance mechanisms such as the Green Climate Fund. This financing gap weakens the potential for locally appropriate adaptation interventions and undermines the Paris Agreement's principle of equity.

3.4. Participatory Governance in Climate Adaptation

Participatory governance is increasingly recognised as central to effective climate adaptation. Mees et al. (2019) call for a shift from passive consultation to active power-sharing between communities and local governments. UN-Habitat (2022) similarly notes that "community-led planning processes are more effective in producing equitable climate outcomes," especially in vulnerable urban contexts.

South Africa's experience with participatory governance is mixed. In cities such as Durban and Cape Town, stakeholder involvement in Local Climate Action Plans is evident, yet these efforts often marginalise informal residents or rely heavily on NGOs to facilitate participation. Genuine co-production of climate solutions remains limited, highlighting a gap in operationalising the participatory principles of the Paris Agreement at the local level.

International models, such as participatory budgeting in Brazil and Kenya's Makueni model, demonstrate that institutionalising participation can lead to more inclusive and accountable climate responses. Entrenching these practices within South African municipalities is essential to advancing climate justice and ensuring that adaptation planning reflects the lived realities of marginalised communities.

4. RESEARCH METHODOLOGY

4.1. Research Design and Data Collection

This study adopts a qualitative content analysis approach, focusing on the global–national–local trajectory of climate policy implementation in South African cities. It is designed to explore how international climate commitments, notably the Paris Agreement, are interpreted within national policy frameworks and subsequently operationalised at the local level, particularly in marginalised urban communities. The primary data sources for the review were drawn from multiple governance scales as follows:

- Global: The Paris Agreement (UNFCCC, 2015) and selected UN-Habitat reports;
- National: South Africa's Updated Nationally Determined Contributions (2021), the Climate Change Act 22 of 2024, and the National Climate Change Adaptation Strategy (NCCAS);
- Local: Municipal Integrated Development Plans (IDPs), Spatial Development Frameworks (SDFs), Local Adaptation Plans (LAPs), and program reports from key initiatives such as the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) and housing retrofitting programs. These documents were sourced from four key metropolitan municipalities, that is, the City of Johannesburg, the City of Cape Town, eThekwini, and Ekurhuleni, to capture a diversity of local experiences.
- Academic and practitioner literature: Peer-reviewed articles and reports published between 2020 and 2025 on participatory governance, local adaptation, and urban climate finance.

The documents were selected based on their relevance to climate adaptation in informal settlements, public availability, and alignment with key themes identified in recent scholarship (e.g., DFFE, 2019; UN-Habitat, 2022). The study also integrates grey literature, including NGO assessments and monitoring and evaluation (M&E) reports, to incorporate practical insights into implementation challenges not typically reflected in formal policy documents.

While the study does not include primary interviews, this limitation is acknowledged and justified by the depth and policy orientation of the document review. Future research could benefit from engaging directly with municipal officials and community members to validate the findings and better capture the lived experiences of climate policy localisation.

4.2. Data Analysis

The collected documents were analysed using thematic content analysis, a structured method suited to qualitative data interpretation, which enables the identification of recurring themes and patterns. This methodological approach follows established principles of qualitative content analysis, as outlined by Kuckartz and Rädiker (2023). The analysis proceeded in several iterative stages.

The process began with repeated readings of the documents to gain familiarity with the content, followed by open coding. During this phase, key phrases, sentences, and paragraphs related to climate policy, spatial planning, governance, finance, and informal settlements were highlighted. These initial codes were then grouped into higher-level conceptual categories. For instance, references to issues such as "budget shortfalls" and the "absence of dedicated funding streams" were consolidated under a broader theme of "Climate Finance Allocation."

Once coding and categorisation were complete, each coded segment was interpreted within its broader textual and institutional context to preserve the nuance and intent of the original content. To strengthen the analytical rigour of the study, triangulation was employed across different document types, for example, by comparing national policies, municipal reports, and academic sources. This cross-source comparison enhanced the credibility and robustness of the findings.

The final phase involved identifying patterns and synthesising recurring themes across the categories to form the study's key insights. All analysis was conducted manually, without the use of specialised qualitative data analysis software or artificial intelligence tools. This ensured a more context-sensitive interpretation of meaning, particularly given the complex and multilayered nature of climate governance documents.

5. KEY FINDINGS

This section presents the findings of the study, organised under two overarching themes: the challenges in localising the Paris Agreement and the role of governance frameworks in strengthening urban climate resilience. The analysis shows ongoing gaps and new opportunities between global, national, and local climate policies.

5.1. Challenges in Localising the Paris Agreement Commitments

5.1.1. POLICY COHERENCE AND FRAGMENTATION

One of the most prominent findings is the lack of policy coherence between global climate goals and their local implementation. While South Africa's National Climate Change Adaptation Strategy (NCCAS) acknowledges informal settlements as priority areas, reflecting the equity and resilience imperatives of the Paris Agreement, this national policy intent often fails to materialise at the municipal level. This disconnect weakens the Global–National–Local policy chain. For example, the City of Johannesburg's

2021 Integrated Development Plan refers to climate adaptation in general terms but makes no direct mention of protecting informal settlements against climate risks, despite the national directive to do so. The plan states: "The City will mainstream climate change resilience, protect our scarce natural resources and embrace renewable, green solutions while delivering on core municipal services that are supported by well-maintained infrastructure networks, both new and existing" (City of Johannesburg Metropolitan Municipality, 2021, p. 25). Although the NCCAS mandates the integration of adaptation measures into city planning, the implementation of this directive is left to the discretion and capacity of individual municipalities. Consequently, policy translation remains uneven, resulting in fragmented planning processes where high-level ambitions fail to translate into actionable local strategies. The Climate Change Act 22 of 2024 attempts to address this by legally requiring municipalities to incorporate adaptation into spatial plans. Nevertheless, implementation remains inconsistent, especially regarding the specific vulnerabilities of informal settlements.

5.1.2. UNEVEN CLIMATE FINANCE ALLOCATION

The analysis further revealed a systemic bias in climate finance allocation, with a strong preference for large-scale mitigation-oriented initiatives such as utility-scale renewable energy projects. This prioritisation often comes at the expense of community-based adaptation efforts. Informal settlements, in particular, are frequently excluded from direct access to climate finance, which restricts the application of localised sustainability strategies based on Cradle to Cradle (C2C) principles, such as decentralised waste systems and green housing. As Oxfam (2020, p. 23) notes, "there is a lack of data on how much climate finance is being spent at the local level in partnership with local communities, but the limited data which does exist suggests it is very little." This observation aligns with Climate Policy Initiative's (2021) global findings, which indicate that less than 10% of tracked climate finance is directed toward adaptation, and an even smaller fraction reaches the local level. Moreover, municipalities often lack the technical capacity, institutional support, or enabling frameworks to develop bankable proposals for climate finance instruments like the Green Climate Fund. These constraints significantly limit their ability to implement locally relevant adaptation solutions.

5.1.3. LIMITED STAKEHOLDER INCLUSION IN DECISION-MAKING

Although participatory governance is a foundational principle of the Paris Agreement, national policies in South Africa have struggled to mandate and operationalise meaningful community participation at the local level. While the Climate Change Act 22 of 2024 contains provisions for stakeholder engagement, the reviewed documents suggest that this engagement is often superficial, comprising one-time consultations rather than sustained, co-productive planning processes. Marginalised urban communities are typically consulted but rarely empowered to influence climate policy direction meaningfully. An exception is Durban, where initiatives such as the "*iQhaza Lethu*" (Our Participation) project involve community-led mapping in informal settlements to better understand local needs and support upgrading efforts. However, such practices remain isolated and are not yet institutionalised across South African municipalities. This gap undermines inclusive climate action and weakens the localisation of Paris Agreement principles. As emphasised by Oxfam (2020), effective climate adaptation must be rooted in local participation, particularly in decisions that affect vulnerable populations.

5.2. The Role of Governance in Localising Climate Commitments

5.2.1. MISALIGNMENT BETWEEN NATIONAL MANDATES AND LOCAL CAPACITY

While national policy instruments, including the Climate Change Act 22 of 2024, provide a legal and strategic mandate for local adaptation, municipal governments often lack the institutional capacity to implement these frameworks effectively. The Organisation for Economic Co-operation and Development (OECD, 2023, p. 19) notes that "The development of adaptation-related expertise may be too costly for most local authorities. With the increasing frequency and intensity of climate variability and climate extremes, new and innovative adaptation knowledge and capacity are needed, going beyond what is available at most local levels". Essentially, the limited availability of technical knowledge, human resources, and institutional infrastructure at the local level hinders the operationalisation of national objectives. Additionally, inconsistent intergovernmental coordination, exacerbated by political turnover at the municipal level, further disrupts the continuity of climate action and undermines the translation of national intent into local practice.

5.2.2. WEAK ACCOUNTABILITY MECHANISMS

A notable gap across municipal plans is the lack of monitoring and accountability mechanisms to assess the local implementation of global climate commitments. Most Local Adaptation Plans (LAPs), where they exist, do not contain clear indicators, timelines, or enforcement tools. This reflects a broader challenge identified globally, as Christiansen et al. (2016, p. 4) observe: "There is no universally agreed method for monitoring and evaluating adaptation." The absence of standardised evaluation metrics limits the ability to assess adaptation progress or to make meaningful comparisons

across cities. Similarly, Klein, Macura, and Canales (2023) highlight that "data on project outputs and outcomes is not easily accessible or publicly available… evaluations of adaptation interventions are rare." These shortcomings significantly impede the capacity to track effectiveness or diagnose bottlenecks in localising climate policy, particularly in applying C2C principles. Without systematic monitoring and evaluation, adaptation strategies remain aspirational rather than actionable.

5.2.3. MISSED OPPORTUNITIES FOR CO-GOVERNANCE

The document analysis also found that the potential for institutionalising multi-stakeholder governance, widely recognised as critical for localisation, is largely unrealised. While some national frameworks gesture toward collaboration with civil society and the private sector, few municipalities have developed formalised or sustained mechanisms for inclusive governance. As Pfisterer and Van Tulder (2021, p. 46) argue, "where partnerships exist, they are typically short-term and project-based rather than embedded in governance structures." In contrast, international models such as Kenya's Makueni County Climate Fund and Brazil's participatory budgeting frameworks illustrate how inclusive governance structures can enhance the equity and effectiveness of local climate responses. These models offer valuable lessons for South Africa in bridging the gap between policy and practice.

6. CONCLUSION AND RECOMMENDATIONS

This study examined how global climate commitments, particularly those under the Paris Agreement, are interpreted through national frameworks and operationalised at the subnational level in South Africa. By tracing the Global–National–Local trajectory of climate governance, the analysis revealed persistent challenges in policy coherence, local capacity, and climate finance distribution, especially in addressing the vulnerabilities of informal settlements. While South Africa has developed progressive climate policy instruments, including the Climate Change Act 22 of 2024 and the Updated Nationally Determined Contributions (2021), the effective localisation of these commitments remains constrained. Informal settlements continue to be excluded from spatial planning frameworks, and most adaptation finance remains centrally allocated. Participatory governance, seen as a cornerstone of equitable climate resilience, is inconsistently applied and often limited to symbolic consultative exercises rather than enabling community leadership.

Despite these challenges, the study identified significant opportunities for transformative adaptation through localised, inclusive governance. International models such as Kenya's County Climate Funds and Brazil's participatory budgeting frameworks offer scalable lessons for decentralising climate planning and empowering local actors. Drawing on these insights, the following recommendations are proposed for enhancing the localisation of climate commitments in South Africa:

- Multi-level coordination mechanisms should be strengthened by establishing national-to-local climate coordination platforms. These platforms would clarify mandates, improve intergovernmental alignment, and embed climate adaptation frameworks (such as the Climate Change Act and NDC targets) within local governance systems, thereby enhancing the coherence of the Global–National–Local policy flow.
- Dedicated funding streams should be created to support adaptation in informal settlements. National climate budgets and international funding proposals should explicitly ring-fence resources for projects aligned with Cradle-to-Cradle principles, including decentralised service delivery and sustainable housing solutions. This would address the systemic exclusion of vulnerable communities from climate finance flows, especially large-scale adaptation investments.
- Municipal capacity must be bolstered through sustained investment in training, technical support, and institutional infrastructure. Local authorities require the tools and knowledge to conduct climate risk assessments, develop localised adaptation plans, and prepare funding proposals that are responsive to their specific contexts. This will empower municipalities to effectively operationalise national adaptation priorities within IDPs and LAPs, supporting Global-National-Local coherence.
- Participatory planning processes must be institutionalised. Municipalities should be mandated to co-develop Local Adaptation Plans with communities, civil society organisations, and other local stakeholders. Such processes should move beyond symbolic consultation and embody the principles of co-production, ensuring that local knowledge and priorities inform planning and implementation as required by the Paris Agreement.
- Monitoring and evaluation frameworks should be improved by integrating outcome-based indicators for urban adaptation into the national climate monitoring system. These indicators should include metrics specific to informal settlements and should be publicly accessible to promote transparency and accountability. This is crucial for tracking the effectiveness of interventions and identifying bottlenecks in localising global climate commitments.
- Finally, South Africa should explore opportunities to adapt successful localisation mechanisms from the Global

South. Piloting approaches modelled on Kenya's Makueni County Climate Fund and Brazil's participatory budgeting, appropriately tailored to the South African context, could support more inclusive and resilient adaptation pathways.

These recommendations should be interpreted in light of the study's methodological scope. As the analysis relied exclusively on publicly available policy and planning documents, it did not include primary data from local stakeholders or community members. While the selected documents were recent and relevant, their coverage and quality varied across municipalities, which may have influenced the depth of local insights. Moreover, given the evolving nature of climate policy, the findings are time-sensitive and should be revisited as implementation progresses.

Nevertheless, this study offers a timely and policy-relevant contribution to debates on climate localisation. It emphasises the importance not only of enacting robust national climate laws but also of ensuring that such frameworks are supported by political will, financial equity, local ownership, and institutional capacity. Future empirical research is urgently needed to track the impact of the *Climate Change Act 22 of 2024* on informal settlements and to inform strategies for inclusive and just climate transitions in South African cities.

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CLIMATE CHANGE ATTITUDES IN SOUTH AFRICA: EVIDENCE FROM WARD 6 NOODSBURG, ILEMBE DISTRICT MUNICIPALITY

By T. Zondi and T. Madzivhandila

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ABSTRACT

Climate change is becoming a growing concern globally, and developing countries are feeling the burden of its impacts. To respond to this successfully and for South Africa to navigate these changes, it will require a nuanced understanding of public opinion and understanding, for policy processes to take into account of individual concerns, and the lived realities of its citizens. The objective of the study is to examine the attitudes of residents in Noodsburg toward climate change. The study employed a qualitative research design. Key findings emanating from this study suggest that there is a gap between 'awareness' and 'knowledge' on climate change and that community members in Noodsburg rely on local ecological knowledge to provide information on the changing climate. These findings highlight the necessity for harnessing local knowledge to enhance community resilience and promote ecosystem-based adaptation strategies in the face of a changing climate.

KEY WORDS Climate Change, public attitudes, governance.

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1. INTRODUCTION

Climate change is expected to significantly impact South Africa, with resulting consequences for people, the economy, and ecosystems. Water is the primary medium through which the impact of climate change will be felt in South Africa and affect the demand across all sectors in the country (Department of Forestry, Fisheries and the Environment [DFFE], 2021). Climate change refers to long-term changes in the climate experienced in a particular region (Intergovernmental Panel on Climate Change [IPCC], 2023). Kahinda, Kapangaziwiri, Hughes, and Khakhu (2022) explains how climate change in South Africa will result in the following: changing rainfall patterns, the intensity of storms and the extremes of droughts and floods, increasing evaporation, changes in soil moisture and runoff, and thus water availability; changing water quality conditions (including the temperature of aquatic systems) and lastly increasing climate variability.

In this study, the term climate change means rapid climate change, which is being experienced due to human activities and the amplified production of greenhouse gases. The study argues that an essential municipal service delivery, such as water, is imperative for realising human rights in South Africa and enhancing the quality of life for the local citizenry. Despite the current complexities in service delivery, municipalities must align their developmental plans with the new legislation of local government to make informed and considered decisions. Patrick and Ernest. (2020) links how climate change significantly affects water availability and quality in South Africa through the changing rainfall patterns, rising temperatures, and more frequent droughts that some parts of the country are experiencing and exacerbating the existing inequalities in water access and framing water as both a climate and social justice issue.

Acknowledging this link is essential because people's attitudes toward climate change are often shaped by their lived experiences of water insecurity.

Roberts (2016) points out, there is a need to acknowledge the role that local governments play in mitigating climate change, and therefore policy decisions made must consider the potential implications of climate change initiatives. Moreover, it should be noted that given the country's socioeconomic dynamics, the climate change investment agenda must consider the economic realities of undertaking such initiatives. This is a point made by Khobai, Stungwa, Oliphant, Maphuto, and Mbua,(2024) that South Africa is trapped in the middle of the 'carbon divide, where on the one hand, they are a developed country with high carbon emissions and on the other hand, poverty, inequality, and unemployment continue to be rife which must be factored in when planning for climate change policy and that these cant be separated. The National Environmental Management Act (1998) states that the main umbrella objective of making environmental decisions lies in promoting sustainable development, that needs the incorporation of social, economic, and environmental factors in the planning and execution and assessment of decisions made.

2. CLIMATE CHANGE AND GOVERNANCE

The recently concluded COP 27 (Convention on Climate Change) meeting held in Egypt once again reemphasised the urgent desire to eliminate the pestilential threat that is carried by human-induced climate change. This threat in particular focuses on human-induced gas emissions (United Nations, 2022).

COP 27 was seen by many as a continuation of earlier initiatives such as the Kyoto Protocol of 1998, which resolved to encourage industrialised nations to reduce greenhouse gases (GHG) in line with agreed targets.

It is appropriate first to understand what the term climate change means to understand its impacts. As mentioned earlier, Climate change refers to the general increase in air temperatures worldwide (DFFE, 2021). Policymakers and scientists know for sure that climate change is the biggest threat to sustainable development everywhere; with that being said, unfortunately, the poorest and most vulnerable will feel the impacts significantly, especially those living in developing countries (UNFCC, 2016). The 2012 National Development Plan (NDP) emphasised that climate change is already impacting South Africa, with marked temperature and rainfall variations and rising sea levels (NPC, 2012). Climate change, therefore, poses a clear present threat to the stability of South Africa's economy and ecology.

Nhemachena et al. (2020) suggest that not all climate change impacts will be harmful to South Africa. However, it will be most likely that some areas in South Africa will benefit from the impacts, while others will experience detrimental effects like prolonged drought. It is, therefore, essential to look at both these scenarios when considering the future of water security in South Africa (Nhemachena et al., 2020). Stern (2016) has identified climate change as one of the two pressing issues facing humans, poverty. Stern (2016) points out that there is a considerable risk for a safe and thriving world in the future if these two issues are not addressed adequately and quickly.

In 2015, the 2030 Agenda for Sustainable Development was adopted by all United Nations member states. At the centre of the Agenda are 17 Sustainable Development Goals (SDGs), which set out the path to achieving a better and more sustainable future for all. One of the SDGs that are particularly relevant for this study Goal 13: *"Climate action-Take urgent action to combat climate change and its impacts."* This highlights the impact that climate change has globally on weather patterns, which are changing, sea levels are rising, weather events are becoming more extreme, and

greenhouse gas emissions are at their highest levels in history.

The South African government has recognised and is committed to providing water for South African citizens. In the constitution of the Republic of South Africa, section 152), it is noted that the core objectives of local government are "to ensure the provision of services sustainably," and section 27 (1) (b) states that the citizenry must have the "right of access to sufficient water." The local Government is the best place to start because it is the closest sphere to the communities. Local government is directly responsive to the needs of the different locals in different communities. The local government is responsible for providing such, which places a considerable challenge on ensuring that water is available to everyone (Muringa & Shava, 2025)

There is a need for multi-stakeholder processes for sustainability and governance when dealing with climate change. Scoones et al. (2018) assert that multistakeholder processes are crucial when dealing with governance within climate change. Public participation is an important end in a democratic society. Participation plays a key role in reflecting and creating citizenship, the public and public values, as mentioned above. Though public participation requires resources such as skill, time and money, it can create a number of advantages (Quick & Bryson, 2016: 3). The main element of public participation is the engagement of the public and making meaningful contributions to the decision-making process (Bester, 2020: 193). Public participation, therefore, provides the opportunity for communication between decision-makers and the public.

3. POLITICAL ECOLOGY

This paper utilises the political ecology approach because it questions the conceptual linkages between society and natural resources. Political ecology inhabits but one place of a broad field populated, in the main, by other social science disciplines. Environmental anthropology, environmental sociology, ecological economics, and environmental economics, among others, are, like political ecology, dedicated to understanding society's relations with the non-human world, and through the knowledge these disciplines create, they also seek to inform and give shape to environmental futures.

The arrival of political ecology as a critical framework happened during the 1960s. The anthropologist Eric Wolf is credited with formalizing the theory when he first coined the term political ecology in 1972 (Walker, 2005; Biersack, 2006). Most of the work that occurred during this period did not include political ecology. The analysis done took the form of the philosophy of political ecology. The term political ecology was made more famous by various authors in their work, such as Brookfield (1987) and Blaikie (1987), Bassett (1988), Bryant (1992), Escobar and Neumann (1992), during the 1980s.

The main concern of political ecology is understanding the relationship between social and environmental change. Political ecology draws on insights from a variety of environmentally related disciplines in the social and environmental sciences. Power plays a key role in the definitions of political ecology (Robbins, 2019). The outcomes of environmental change are often felt unevenly by different social groups. Robbins (2019) explains why and how this unevenness is generated, links political ecology to political economy and makes conflict and contestation over resources central to most analyses. Derman and Ferguson (2003) assert that power is a central focus of politics in political ecology. According to Derman and Ferguson (2003), one of the strengths of political ecology is its focus on the mutual constitution of social and environmental change.

The focus is on the relationship between people and their environment as a starting point and observations of environmental change. The central goal and dimension of political ecology, in theory, is to develop different modes of analysis that incorporate and relate to social and ecological variables. Another dimension of political ecology is to understand that environmental change results are often felt unevenly, and how this unevenness is generated links to political ecology. This means that contestation over natural resources and conflicts remains central to most analyses. This involves struggles at discursive levels, including local knowledge, environment, sustainability, and biodiversity (Derman and Ferguson, 2003). In conceptualising access to natural resources, they found that the various social relationships that constrain or enable such access are associated with "bundles of power" or complex and overlapping "webs of power."

4. THE CASE STUDY

Noodsburg, situated in the province of KwaZulu-Natal, falls within the iLembe District Municipality, which is located on the east coast of KwaZulu-Natal. This district is bordered by the eThekwini Metro to the south and the King Cetshwayo District to the north. The iLembe District Municipality shares borders with two other districts, namely uMgungundlovu and uMzinyathi. The district comprises four Local Municipalities: Mandeni, KwaDukuza, Ndwedwe, and Maphumulo. Ilembe District Municipality is strategically located along the Primary development corridor of the Province and between two strategic gateway points into the continent, namely Durban and Richards Bay harbours. To the South of the District is the King Shaka International Airport (KSIA) and the Dube Trade Port.

The commonly anticipated impacts associated with Climate Change, in general, include the warming temperatures and increases in the number, duration, and severity of heatwaves, which will lead to changes in the growth and distribution of plants, animals, and insects (IPCC, 2023). Some of these impacts have been experienced within the iLembe District in several areas, which then required the Municipality to make an effort to

avoid and adapt to possible climate change impacts. The municipality is battling to manage due to natural and human activities. It is the responsibility of the Environmental Management Unit, under the Planning and Integrated Development Plan, to encourage the management of these resources for the benefit of both current and future generations in line with the objectives of the National Environmental Management Act of 1998

The need assessment was conducted by the district and the DEA in previous years and it found that there is a lack of dedicated environmental management units in most municipalities, resulting in environmental functions placed within varying units of the municipal organizational structure; availability of the budget to perform environmental functions within municipalities; lack of understanding between environmental health and environmental management (Department of Environmental Affairs, 2019). This leads to dependence on environmental health practitioners to perform environmental management functions within municipalities.

5. RESEARCH METHODOLOGY

The study aimed to examine the attitudes of residents in Noodsburg toward climate change, utilising the data in Noodsburg. The focus was on recording and understanding the local knowledge, attitudes, and aspirations of the communities within the area. To do this, a qualitative method approach was adopted to collect as wide a range of data as possible. An investigation of climate change attitudes of residents in Noodsburg, ILembe district municipality, served as a departure point from which to critically examine the governance around water. The study employed a qualitative research design. The study worked with a purposive non-probability sample technique because it sought to obtain insights into climate change attitudes that exist in the iLembe District. The research employed a non-probability sampling method for the focus group participants, specifically utilising a haphazard/convenience technique.

Given the constraints of the study, such as limited time and resources, the convenience sampling method allows for a convenient selection of participants. The selection of participants was based on convenience and accessibility. Convenience sampling allows the researcher to select participants who are easily accessible and have relevant knowledge or experiences related to the research topic. Practicality, accessibility, and the exploratory nature of the study were prioritised. To gather new data on the subject matter, focus groups were conducted, involving individuals aged 18 and above who were South African residents living in Ward 6, Noodsburg.

The research team, along with the primary investigator, organised three focus groups, each comprising five members who were community leaders and participants from Ward 6 in Noodsburg, located within the iLembe District. Ward 6 was deliberately chosen due to the active presence of an environmental forum in the area, with its members being part of the ward committee. A pre-designed focus group interview schedule was used. Face-to-face semi-structured interviews were conducted with ILembe District municipality officials in the environmental and planning units. These key stakeholders are knowledgeable about the iLembe District Municipality and work on the ground with the ward committee members in the local government sector, as well as environmental issues.

The data gathered has been analysed and reported on within the context of the focus group discussions. Secondary data and desktop analysis were conducted, and they included books, and journal articles that have been used to discuss the study's conceptual and theoretical framework. The participants were guided by a moderator, who introduced the topics for discussion and helped the group participate in a lively and natural discussion.

These focus groups intended to interrogate and explore a few topics in greater detail.

6. RESULTS & DISCUSSION

This section presents the results, provides an interpretation of the findings, and offers a critical discussion in relation to the research objectives and existing literature. This section of the study interprets the findings through the lens of Political Ecology Theory. Political ecology foregrounds the role of power relations, social inequalities, and historical context in shaping both environmental change and community responses to it. In the context of climate change, this theoretical lens helps illuminate how structural factors such as governance systems, access to resources, and socio-economic marginalisation shape community perceptions and adaptive capacity. The analysis below reflects these dynamics, demonstrating that climate change perceptions are not formed in isolation, but are embedded in broader systems of power and local experience.

7. CLIMATE CHANGE

This section will address the study's research objectives, which are to critically examine the attitudes and perceptions held by the community in Noodsberg towards climate change through qualitative analysis. Participants in the focus group discussions that were conducted were asked, *"What is climate change or what do they think climate change is?"* One of the participants from the focus group responded and said,

"I am not sure, but I think it is the change of weather. As the years pass, I have noticed that the temperature is increasing. For instance, before, we knew that it would rain a lot between October and December, but that has changed. I do not know what causes it, but I know that things are no longer the same". (Focus Group 1, 2021)

Participants indicated that climate change has affected seasonal rainfall patterns by reducing the length of the

rainy periods as well as the amount of rain, with consequences on crop and livestock production. In all three FGDs, it was indicated that there had been a change in the onset of the rainy season from October to mid-December, whilst the end of the rainy season has shifted from March to April. Local leadership noted that the community used to receive early rain. The majority of participants, based on the above discussion, indicated that they have observed the onset of the rain season has shifted and is now shorter and that the amount of rainfall has been decreasing. Findings from this discussion indicate that local communities perceive that rainfall is decreasing whilst temperatures are increasing.

Ambiguities regarding the definition of climate change ought to be addressed for those outside the scientific community, as this enables public understanding of policy and legal frameworks implemented to address climate-related challenges. In this case, the FGD participants' understanding is closely aligned with the scientific concept of climate change as revealed by their interpretations that climate change is linked with changes in weather conditions and patterns. While some participants were able to give a definition or explain what climate change is, the majority of responses to the question about their understanding of climate change centred on the causes of climate change. For instance, one of the participants from the focus groups said,

"I think it is mainly we, the community, by being reckless and not paying attention to our environment, which is now causing climate change. Firstly, there are huge factories that manufacture goods and release emissions, which then cause climate change and severe weather patterns. Secondly, I think the people themselves cause it by not taking care of their own environment. If you look at the recent flooding we have experienced, instead of water flowing properly and drainage systems working efficiently, wasteful toxins and plastic bags in our drainage, which then block the water from flowing. It also creates a situation whereby the drainage is working efficiently, and that causes major problems for the people who are going to be affected by the water". (Focus Group 1, 2021)

This shows that there's some basic understanding and observations being made by the public about climate change. This suggests that there's some level of awareness and knowledge about the physical environment that they live in. These discussions in the focus group indicated or suggested a general awareness among the community elders and other community leaders that climate change and variability have also been a reality in the area. Unfortunately, the African continent has been identified as one of the parts of the world most vulnerable to the impacts of climate change (IPCC 2014). There is an indication here that some community members rely on their local ecological knowledge of climate patterns and impacts. The above responses indicated that most people might not have access to the radio or television to receive information about climate change. Based upon the above responses of the participants and information from the iLembe IDP, it's clear that not only is there a fragmented understanding of environmental management in the local sphere, but it also shows within the citizen ground floor level.

8. CLIMATE CHANGE CONCERNS

Climate change experts see water, specifically, to be at the centre of this vulnerability as the potential impacts on water due to climate change are projected to increase in magnitude, severity, and diversity (IPCC, 2023). South Africa is a water-scarce country, and water resources have been distributed unevenly. Participants were also asked if they are concerned about Climate Change, and what the main issues they are concerned about are. The majority of participants across all focus groups talked about water access being the main concern that they have. Participant one in group two said,

"My biggest concern is definitely water access, and we are not getting water the way we should be. Another thing, our leaders should, at all times, reach out to the community to warn us about the extreme water conditions because when it rains, it rains hard, but when it is hot, it is hot for a very long time. There is no balance, and we do not have information, which makes it worse".

Goal six of the seventeen SDGs focuses explicitly on freshwater, including Sustainable Development (SDG 6): *"Ensure availability and sustainable management of water and sanitation for all"* Goal 6 calls for improving water quality as well as for protecting and restoring water-related ecosystems (Hering, Maag & Schnoor, 2016). According to Water-U.N.'s (2018) synthesis report, the 2030 Agenda lists rising inequalities, natural resource depletion, environmental degradation, and climate change among the most significant challenges of our time. It recognises that social development and economic prosperity depend on the sustainable management of freshwater resources and ecosystems, and it highlights the integrated nature of SDGs. From the responses, it is clear that water access is definitely a concern for the community members; additionally, they also mentioned that their community leaders don't reach out and are not involved or communicate with them with regard to environmental issues.

While the majority of the responses centred around not having enough excess water resources, some responses that came out from the focus group discussions were concerned about the impacts on their livelihood system, which is a disturbance in their agricultural activities since they live in a rural area, some of the community members are dependent on farming for their household needs and are dependent on their crops for their subsistence needs. The discussion below with one of the participants in the focus group indicated that frequent extreme events, such as drought and increasing temperatures, affect soil moisture and surface water

availability for both domestic use and agriculture. One of the participants shared their main issues concerning climate change and said, *"One of the main issues concerning climate change is the vegetation. Since in rural areas, most of the people depend on vegetation to feed on as well as selling, shortage or too much of rain it causes the crops to suffer". (Focus Group 1, 2022)*

These findings explain that community members agree, extreme events related to climate change, such as prolonged dry periods and excessive temperatures, have affected agricultural activities and the biophysical environment. Respondents were also asked if they have noticed any changes in the area or community during the time that they have lived there, which may suggest that the climate is changing. This indicates that local ecological knowledge can provide information on the changing climate. Such information can complement scientific data to inform policy on best practices to build the adaptive capacity of rural communities. Participants also had an opportunity to share where they get their climate change information. When asked the question**,** *"Where do you get most of your current information on climate change?"* one person shared,

"Sometimes information on climate change is accessed on radio and television; however, there are people who do not have TVs and radios, so they are unable to access this information. Like today, we were told we might have heavy rainfalls; there are people who do not know that. You see, so it depends mainly on the type of life that those people live, but generally, they do not have the resources to access this sort of information." (Focus Group 1, 2022)

From these responses, it's clear that the majority of the community residents do not receive any information about environmental issues or climate change besides from the media. Some of the other responses give an indication that some community members still associate climate change information with weather forecast predictions. For instance, one of the participants said,

"We get it on television, radio and cell phones, as my colleagues have indicated. However, if one does not have access to any of these mediums, because there are residents who do not have any of them available. You ask your neighbour what the weather looking like tomorrow is".

The results confirm that there is a need for an education and awareness plan associated with Climate Change. The needs assessment that was conducted by the District and the DEA in previous years found that there is a lack of dedicated environmental management units in most municipalities, resulting in Environmental functions placed within varying units of the municipal organisational structure; availability of the budget to perform environmental functions within municipalities.

One is the various scales of political decision-making that has involved, two is the fragmented and unclear roles of state and non-state actors and lastly, the complex nature of the processes that lead to emissions of greenhouse gases (GHG) in the everyday processes of production and consumption. Participants were also asked, *"Do you think enough is being done by the South African government to take action on climate change?"* one of the participants answered,

"No, the government is not doing enough. In most instances, most of what the government is supposed to be doing for us is not being done. The government is dragging its feet when it comes to ensuring that we are safe and able to access water, and I do not know how long it plans to continue dragging its feet on this matter. We plead with the government to take responsibility and communicate with our local community leaders and ourselves as local residents in order to work together and ensure that we get the help we need."

There is an indication based on the response that information regarding climate change is hard to come by and that not enough is being done by the local leaders within the communities and government officials to inform residents about the latest developments in relation to climate. The lack of awareness of government initiatives is an important issue that must be addressed in climate change learning. Most of the participants shared the same sentiments and feel that there would be a difference if consultation processes are being implemented and people are being equipped with more information about environmental issues. This discussion highlights the lack of political will and understanding of the critical relationship between climate change and biodiversity issues and awareness. Based on this, it's clear that the government isn't doing enough, especially in sharing information. There is a sense that if the government is sharing information and educating the people in the community, people might know how to take care of the environment and will be informed and empowered to do better in the physical environment.

The findings in this study indicate a gap in climate change knowledge that requires to be addressed in any climate change learning initiative. Clayton *et al.* (2015a) advocated that understanding the issues around climate change facilitates better engagement and action. The participant also mentioned that the government has financial challenges, which is an issue in trying to combat the fight against climate change impacts.

9. ATTRIBUTION OF RESPONSIBILITY FOR CLIMATE CHANGE

The uptake of the new Constitution of the Republic of South Africa of 1996 hurried up the transformation of sectors in public service and was guided by the different policies and legislative instruments. Section One of the Constitution of 1996 requires that all public services be transformed and democratised following the values of human dignity, the achievement of equality, and the advancement of human rights and freedom. However, local government is still faced with the challenge of poor service delivery, lack of infrastructure, and identification of appropriate vehicles

for effective and efficient service delivery.

Climate change action is required from all levels of society by individuals, groups and governments (Butler *et al.*, 2015). Additionally, climate change actions can be enhanced at all levels, from individuals to governments (Murphy *et al.*, 2016). In this study, participants were asked, **"**Who do you think should be responsible for making any changes to lessen the impacts of climate change" one of the participants said,

"The municipality should be primarily responsible for ensuring that we have access to water and have reliable services. It should be the municipality because they have to ensure that if we do not have water in the river, then they should make provisions through water tanks to ensure that we do get water, and they should not limit it just once a week. It should at least be three times a week to make sure that we all get water, and it should be up to us to then save the provided water." Another participant from a different focus group said,

"I definitely think it is the municipality that should look to provide us with water. In doing so, the municipality should, in consultation with the residents, communicate when the water will be made available and ensure that on the agreed dates, water is available for people to access."

Some people are of the view that industry, scientists and individuals are responsible for addressing climate change, while others, in a recent South African study, indicated that government environmental departments are responsible for dealing with climate change (Pasquini *et al.*, 2013). The responses from this study suggest that the government, especially the local municipality, should be responsible for addressing climate change.

These findings support Kettle and Dow (2016) and Newell *et al.* (2015), who were also of the view that governments have a high degree of responsibility for solving climate change problems. Local governments are increasingly recognised as critical to climate change, given their roles in scaling up the adaptation of communities, households and civil society and in managing risk information and financing (Porter *et al.*, 2015). Another participant put it this way,

"We need to work together. Some trees consume a lot of water, which people plant without knowing. Sometimes the government chooses places where people use to plant their crops for building roads or warehouses. Working together can significantly lessen the impacts of climate change, especially on water."

Few participants who felt personally responsible for making any changes to lessen the impacts of climate change reflect the views of Capstick et al. (2015), who indicate that people are not likely to adopt pro-climate change behaviour unless they feel empowered to do so and also feel that others in society are also undertaking similar actions. This lag in climate change responsibility is cause for great concern and must be addressed in any climate change learning intervention, as the literature has clearly demonstrated that individual actions on climate change are also important and sorely needed. Participants were asked the question, *"would you be prepared to change your behaviour to reduce your contribution to climate change in any way"*

Participant one in group three said,

"As the community members, we should make sure that we do litter and also use the toilets given to our community in order to avoid the water resources (rivers) from getting dirt (water pollution), and that will reduce the number of water diseases. The community must have a dumping site to avoid the littering and burning of rubbish anywhere because that contributes to air pollution."

Participants in the focus group mentioned that the community needs to work together, which suggests that individuals are willing to change their behaviour provided that everybody else is changing their behaviour that way, they will be able to change their behaviour. From the above responses, there is an indication that some community members know what to do and know their needs in order to be able to contribute towards the reduction of their contribution to climate change. Community members are willing to change their behaviours and are willing to work together towards combating climate change.

Participants in group two made suggestions on how they can change their behaviour. Participant one in group two stated,

"I think the leaders maybe, in their respective levels should organise meetings and imbizo to give us guidance on how these things work because a majority of us really do not have the knowledge for it."

Based on the above response, climate change communications from authority sources and information that continue to the instructor are forced upon people who are likely to be successful. Participant four in group two responded,

"I also think it is hard to access information, but it would be easier if the councillors were to provide a place where we all meet maybe we schedule meetings which teach us about climate change so that we can know how it works and what to do and what not to do. On our part as local communities, we too can play our part by trying to stop any of the bad habits we have, which clearly are a contributing factor to this problem. I spoke about irresponsible behaviour earlier. Farming in areas we have been warned against comes to mind."

Participants expressed a lack of trust in government-led climate initiatives and viewed them as ineffective. This distrust toward state-led climate initiatives can be understood through the lens of political ecology, which highlights how historical governance failures and unequal power relations between the state and rural communities undermine environmental governance. Participants' perceptions reflect a recognition of structural exclusion from decision-making processes, reinforcing political ecology's emphasis on marginalisation

and contested authority in climate adaptation.

In view of these findings, the need for climate change learning for community members is substantiated and necessary as participants consider themselves as most trustworthy in taking action on climate change and the public must be actively involved in deciding what should be done about climate change. Therefore, such learning will also support more climate change actions, enabling the public to provide meaningful input when consulted and actively involved.

One of the barriers that may prevent pro-climate change actions is the lack of reliable information about climate change (Shackleton *et al.*, 2015). People's willingness to adapt to climate change is determined by their knowledge and understanding (Brügger *et al.*, 2015; Shi *et al.*, 2015). The public also needs access to information on climate change to support global initiatives Klenk *et al.* (2015) recommend that to improve the climate change response, it is necessary to engage stakeholders and share scientific information.

Several participants mentioned that they rarely receive information about climate change from government officials or local authorities. Instead, they rely on word-of-mouth or local radio. The limited access to formal climate information reported by participants points to deeper patterns of marginalisation and uneven power dynamics in how climate responses are structured. Viewed through a political ecology lens, this gap is not simply due to poor communication but reflects longstanding inequalities in who is included or excluded from state-led planning. The voices of rural communities are often overlooked in formal decision-making spaces, which reinforces their marginal position and limits their ability to participate meaningfully in adaptation efforts. As a result, access to climate knowledge remains uneven and continues to be shaped by broader political and economic forces.

Stern (2016) points out that there is a considerable risk for a safe and thriving world in the future if these two issues are not addressed adequately and quickly. Participants shared that their crops are suffering, they are not able to conduct their businesses to receive an income for their households, and they aren't able to meet their subsistent needs. Findings show that there is a gap between 'awareness' and 'knowledge' because the widespread familiarity with climate change-related topics did not result in adequate knowledge. Findings from these responses highlight the necessity for harnessing local knowledge to enhance community resilience and

10. POLICY IMPLICATIONS

Policymakers should focus on messages that depict the seriousness of climate change, the human contribution to the threat and also possible actions that can be taken to mitigate impacts. Public perceptions are well established as a key factor in support for climate change mitigation policies, and they tend to vary both within and between countries. It is essential to formulate climate change awareness policies and programmes that can reach all sections of the population, providing them with the necessary information about climate change, as well as information about mitigation measures at the level relevant to them. Communication of climate change impacts is processed through local communication repertoires involving both formal and informal modes of communication. This clearly implies that public perception and communication of climate change is largely contextual and locally situated.

The findings of this research bear important implications for formulating climate change communication strategies – both for content development, and processes and structures of communication. Communicators and educators should consider what patterns of public perceptions people have in their minds, and what are the possible impacts of climate change in the region. Emphasis on local impacts of climate change is a potential way to bring people into the discourses of climate change and possibly towards intended behavioural changes. Media and climate change communicators have mainly focused on some occasional events of extreme weather (e.g., storms). Public concern about climate change recedes once they are not exposed to extreme weather events for a long time. This type of communication approach has failed to address climate change as a continuous and long-lasting risk, which could affect other aspects of people's livelihood.

Accordingly, the wide-ranging effects of climate change on agriculture, the environment, human health, biodiversity, and other socioeconomic and related issues are not included in the discourses of climate change. Food security and attempts to eradicate poverty might be challenged because of the adverse effects of climate change in developing countries. Therefore, communication content on climate change should integrate these potential effects.

Any policy initiative to tackle the adverse impacts of climate change, enhance the resiliency of vulnerable people, and communicate the risks effectively to address local or regional aspects and the way local people perceive the risks. Promoting engagement around climate change, at both a formal level (public forums with government and private sector stakeholders, etc), as well as at a more informal level (community level programmes) with the view of finding best-localised solution strategies should be at the forefront of policy regulations. This indicates the necessity of a bottom-up approach for formulating policy strategies with due consideration of the desires and perceived knowledge of vulnerable people.

11. RECOMMENDATIONS

Addressing human behaviour and climate change requires interdisciplinary and integrated approaches. To successfully address climate change, every tool that is available must be used, drawing on expertise from all relevant

disciplines. Some segments of the policy and research community have already recognised that human behaviour will be critical in the fight against climate change. Key factors that interventions should target are as follows;

Communication plays an equally important role in sensitising climate change issues in people's. There should be a joint effort to make the climate change communique simpler, using images as well as more balanced approaches. The source of climate change information must come from scientific reports, the Department of Forestry, Fisheries and Environment, the UN and NGOs or media, as these were identified as the most reliable sources of climate change information. Make climate change initiatives more practical and, according to Aune et al. (2016) and Fernandez et al. (2016), attractive, convincing, relevant, and part of the normal routine or habit of daily life. Sustaining climate change learning initiatives over a longer period, and not for a limited period. Climate change experts must be invited to address the public; the lack of expertise is one of the major barriers that hinder effective climate change action.

Community members are to be consulted and involved when internal climate change programmes are developed so that their views are incorporated in developing climate change learning interventions.

Given that South Africa is a developing country with large proportions of poor and marginalised people, concerns such as unemployment and food scarcity are often more immediate than environmental concerns. Environmental issues should also be prioritised as one of the pressing challenges, so that attitudes towards climate change will change. To enhance coordination between local government and citizens, this study recommends the use of diverse communication and engagement tools which include, stakeholder roundtable sessions, public open houses across the region, a dedicated project web page, an online "do it yourself" consultation process, a social media campaign; promotion through an online blogging community, media advertising, a summary and analysis of all the feedback that was received.

12. CONCLUSION

This study examined the attitudes and perceptions held by the community in Noodsburg towards climate change through qualitative analysis. This study highlighted that limited access to climate information among rural communities is not merely a communication issue but reflects deeper structural inequalities. Using Political Ecology as an analytical lens, the findings demonstrate how power relations and historical patterns of marginalisation shape both the distribution of climate knowledge and the capacity of communities to respond. The uneven access to information and exclusion from formal decision-making processes reinforce the peripheral status of vulnerable groups, ultimately affecting how climate change is understood and addressed at the local level. These insights underscore the importance of inclusive, equity-driven approaches in climate communication and policy design.

The study found that attitudes and the ability to adapt to climate change are key ingredients for pro-climate change actions. There's a gap between "awareness" and "knowledge" as identified among the participants when they attempted to give detailed descriptions of the causes of climate change. Findings highlight the necessity for harnessing local knowledge to enhance community resilience and promote ecosystem-based adaptation strategies in the face of a changing climate. A lack of clarity on roles and responsibilities was identified. The wide scope and variety of methods recommended may help with the engagement of many residents and community groups, as well as businesses. It may also include voluntary associations and organisations, faith-based organisations, and labour groups. But it must be ensured that participants' feedback is accurately documented for consideration and that suggestions for policy changes are incorporated into the final policies. While each of the initiatives recommended is viewed as an example of best practices in open engagement, the best initiatives go beyond simply implementing an online discussion forum or using social media to engage citizens in government decision-making. The best initiatives in open engagement are iterative in nature.

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IMPACT OF CLIMATE CHANGE ON THE AVIATION INDUSTRY IN NIGERIA

By O.A. KANYIO

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ABSTRACT

Throughout the 21st century, severe and extreme weather events have led to climate change, bringing forth a high rate of occurrence in various countries of the world. The aviation sector significantly contributes to climate change, resulting in a profound impact on the industry itself.

This study examined the effects of climate change on the aviation industry in the three busiest airports in Nigeria by adopting qualitative research on four distinct themes. After analysing the collected material and presenting the results, thematic analysis was deployed using ATLAS.ti ti-9. Separate text files were created from the interviews that were recorded by transcription. The result demonstrated that as climate change increases, the impacts increase. It also shows that the effects of climate change on the aviation industry are exacerbated when aviation capacity is constrained. The study recommends that the aviation industry in Nigeria must be willing and ready to take prompt action to adapt and build resilience in the industry.

KEY WORDS Impact, climate change, aviation, airlines and airports.

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1. INTRODUCTION

The average weather condition or pattern is known as climate change (James et al., 2025). Currently, the rate of global warming is higher than it has ever been (Royal Society and the US National Academy of Sciences, 2020). Over time, increasing temperatures are changing weather patterns and disrupting the natural balance.

One of the main issues of the twenty-first century is climate change (CC) and its effects, which are becoming a warning. The alterations brought about by a new climate change adversely affect nearly all natural and man-made resources and systems (Gelete & Gokcekus, 2018). The aviation sector is a foremost contributor to climate change, and one of the hardest sectors to achieve greenhouse gas emission reductions (Ryley, Baumeister & Coutler, 2020). This resulted in the aviation industry being among the first to use weather as a basis for operational decision-making (Olabode, 2021).

Nigeria's tropical environment results in unique seasonal weather patterns that have a big influence on aviation (Mande, 2019) and was included among the nations pushing for carbon footprints for their airports to advance the International Civil Aviation Organisation's (ICAO) goal of zero emissions by the year 2050 (The Nation Newspaper, 2024). In Nigeria, the aviation industry is a multifaceted system comprising of network of government agencies such as Federal Airport Authority of Nigeria [FAAN], Nigerian Civil Aviation of Nigeria [NCAA], Nigerian Airspace Management Agency (NAMA), the Nigerian Safety Investigation Bureau [NISB], and the Nigerian Meteorological Agency [NiMet], airlines, infrastructure, and international affiliations.

Despite these, Nigeria's aviation industry remains increasingly vulnerable to the negative effects of weather-related climate change. This presents a significant threat to air travel and the aviation industry. The industry and its infrastructure systems are at risk from climate change because of their complexity and susceptibility to disruptive weather events. Furthermore, climate change impacts affect various sectors differently (Amit, Dilip, & Bishm, 2023). The aviation industry in Nigeria faces unique challenges, which are a threat to coastal airports like Murtala Muhammed International Airport in Lagos. In addition, despite the growing body of studies on climate change and its effects on flight operations, passenger security and safety in Nigeria, there is still a paucity in this field. Finally, extreme weather and climate change impacts create operational and business risks, affecting productivity and efficiency. Therefore, the purpose of this study is to evaluate how extreme weather affects Nigeria's aviation sector. The objectives of this research are to examine how severe weather affects airline operations and the economy, as well as how it affects airport operational performance, capacity and infrastructure (navigation equipment).

This study is significant to all the stakeholders in the industry, the private sector, government agencies, regulatory bodies, academics, and communities. It will provide a clear understanding of the extreme weather conditions unique to the aviation sector, their effects, proactive planning support, guidance for forming well-informed policies in infrastructure design, and an increase in operational effectiveness and security. It would facilitate the adoption of improved safety procedures and risk management for a more resilient and sustainable Nigerian aviation industry.

The study's geographic focus is Ikeja, Murtala Muhammed International Airport [MMIA], Ikeja, Lagos State, Nnamdi Azikiwe International Airport [NAIA], Abuja and Port-Harcourt International Airport [PHIA], Rivers State. This study is limited to weather-related climate change impacts peculiar to the industry in Nigeria.

2. LITERATURE REVIEW

2.1. Impact of Climate Change on the Aviation Industry

From the worldwide issue, numerous industries, including aviation, are significantly impacted by extreme weather and climate change in a number of ways (Adger, Arnell & Thompkins, 2005). The impact of climate change on the aviation business and economics was examined in the ICAO CAEP aviation and climate change factsheet (2020). Disruptive occurrences have a major short-term impact on business and the economy since they can cause delays, cancellations, and damage to infrastructure. Longer-term, slow but steady effects can have an impact on industry and the economy by altering traveller demand and causing infrastructure damage or loss, and on all aspects of operational performance such as scheduling, flight planning, connectivity of flights, safety planning and trajectory optimisation. Pümpel (2016) stressed that rainfall, wind and storm surges also affect drainage systems, flood runways, terminal buildings, ATC towers, electricity generators, communications infrastructure, navigational aids and fuel stockpiles at coastal airports. Kim, Pant, and Yamashita (2018) reiterated that extreme weather affects ground access to airports, impacts the operating activities of air transportation by disrupting ground operations, causing capacity reductions, delays, diversions, and cancellations, and poses safety risks to ground crew, airside vehicles, and aircraft operations with related financial consequences.

Németh, Švec, and Kandráč (2018) stressed that global climate changes have an impact on European aviation. Extreme weather conditions hurt aircraft performance, operating characteristics, air traffic flow, airport infrastructure such as terminals, runways, taxiways, car parks, fuel storage and navigation equipment, offsite ATC equipment, ground transport access, airport capacity and operations, causing delays, diversions and cancellations. Vogiatzis et al. (2021) argued that winds impact

airport infrastructure, leading to damage to infrastructure and aircraft at terminals, and risks for personnel. Moomen (2012) stated that extreme weather conditions lead to increased expenses.

In research conducted at Murtala Mohammed International Airport in Lagos, Nigeria, Weli and Ifediba (2014) opined that extreme weather conditions impact aircraft operations, resulting in flight delays, cancellations, and diversions. The impact of weather and climate on aviation operations at Aminu Kano International Airport, Nigeria, was investigated by Caroline (2015). The study found that 45% of the fluctuation in aircraft diversions was caused by meteorological hazards such as thunderstorms, severe rain, and dense dust haze.

3. METHODOLOGY

3.1. Study Areas

This study focused on three geographical areas situated in three states in Nigeria, namely Lagos state, the Federal Capital Territory, Abuja and Rivers state. Murtala Muhammed International Airport (MMIA) is in the suburb of Ikeja, 22km North-West of Lagos. It lies between latitude 6034'38" N and longitude 003019'16" E, about 20 kilometres from the centre of the city of Lagos. According to Ogundolapo (2014). The airport is situated on hundreds of hectares of landmass sandwiched between Ikeja, Agege, Shasha, Ejigbo, Mafoluku, and Oshodi communities in Lagos State. MMIA is the major airport serving the city of Lagos, South-Western Nigeria and the entire nation. It was constructed during World War II. Nnamdi Azikiwe International Airport (NAIA) is in the Bassa Community in the Abuja Municipal Area Council, Nigeria. It is about 49 km from the main town (Federal Airport Authority of Nigeria [FAAN], 2016). The airport is located at the reference coordinates. It lies between latitude 090 00'15'N and longitude 070 19'07'E and at an altitude of 314.98m. Port-Harcourt International Airport (PHIA) is located off Airport Road, Ogrila-Agwa road, Omagwa, a suburb of Port-Harcourt, the capital city of Rivers state in Nigeria (Elem, 2020). It is located on the outskirts of the metropolis and about 32 km away from the capital of Port-Harcourt and lies between latitude 5.0169° or 5°1'0.8" North and longitude 6.9502° or 6° 57' 0.6" East.

3.2. Research Design

A qualitative research design was used in this study to examine the trends, motivations, perspectives, and experiences that respondents have gained from their exposure to the subject under investigation.

3.3. Type and Sources of Data

Primary data was deployed. It was gathered and carried out via telephone interviews and structured in-person interviews.

3.4. Population

In this research, nine (9) interviewers were chosen, based on more than 10 years of experience in the field. This was based on the study by Mwangi (1998), who opined that employees with more than five (5) years of experience are highly experienced.

Table 1. Population of the Study

Professional Status	Numbers	Organization	Experience
Flight Operations Managers	3 (one from each airline)	Airlines	Many years of experience in theaviation industry in the fields of flight operations
Airport Operations Managers/ representative	3 (one each from the airport of study	Airport	Overseeing all airport terminals in the study areas
NiMet officials	3 (one from each airport of study	Airport	Provide timely and accurate weather information
Total	**9**		

Source: Author's Computation, 2025

3.5. Sampling Technique

The sampling technique was the judgment sampling method. This is also known as purposive sampling (Ebenezer & Piate, 2023). This approach was used because it gives the researcher immediate access to the target market. Although non-probability sampling, it helps to pick sample members knowledgeable about the topic (Palinkas, Horwitz, Green, Wisdom, Duan & Hoagwood, 2015). Additionally, it helps the researcher justify drawing generalisations from the study group, regardless of whether these generalisations are theoretical, analytical, or logical. It is helpful to locate information-rich sources while providing real-time results (Nikolopoulou, 2022). As a result, the researcher spoke with their intended audience directly and realised their goals. The researcher's preferences are the only factor used in sample selection. The researcher selected a representative sample from the airport managers, Nigerian Metrology Agency [NiMET], and heads of operations of three notable indigenous

commercial airlines in the study area, namely Air Peace, Arik Air, and Max Air (Alubankudi, Akpudo, Stephens, and Nwachukwu, 2023).

3.6. Method of Data Collection

An interview procedure with open-ended questions was used as the data collection strategy. This allowed for exploration and made it easier to gather the information needed to comprehend the subject. Additionally, each question's structure and language were carefully considered to enhance participant involvement and clarity. The data collection procedure was consistent for all interviewees labelled as participants. Participants interviewed acknowledged full understanding of the objective of the discussion and agreed that the oral interview could be recorded. Since protecting participants' privacy and anonymity was just as important as ethics, their identity was not crucial. The MMIA interviewee is labelled participant 1. For Abuja, it was labelled participant 2, and participant 3 for Por-Harcourt.

3.7. Procedure for Data Collection

In this study, the procedure for the collection of data was through personal observation, scheduled interviews with representatives of several agencies and other information extraction methods. The researcher conducted the interviews. Data was collected at specific times and places (offices) to ensure that the targeted respondents were contacted. To arrive at accurate and beneficial conclusions, every viewpoint on the many concerns was examined. First, the common responses to the different themes were coded, and then, the differences and similarities of the expressed opinions were listed.

4. RESULTS AND DISCUSSION

From the interviews, it was clear that most of the topics were agreed upon by the participants. Although they only disagree on a small number of issues. The study has five distinct themes, which are the extreme weather conditions caused by climate change; the business and economy of commercial passenger air transport on scheduled flights (operational cost and travel demand); operational performance of the airports (facilities management); airport capacity (apron capacity, airspace capacity/Terminal Maneuvering Areas [TMA], and Instrument Landing System); and aviation infrastructure (control tower and air navigation systems). These themes highlight the multifaceted nature of the aviation industry and its susceptibility to external factors. By examining these areas, stakeholders can better understand the challenges and opportunities ahead in the face of climate change and evolving market dynamics. At the airports of research, interviews were conducted with one NiMet official, airport management or representatives, and airline operations managers.

Theme 1: Interview on the Extreme Weather Conditions Prevalent in the Study Areas

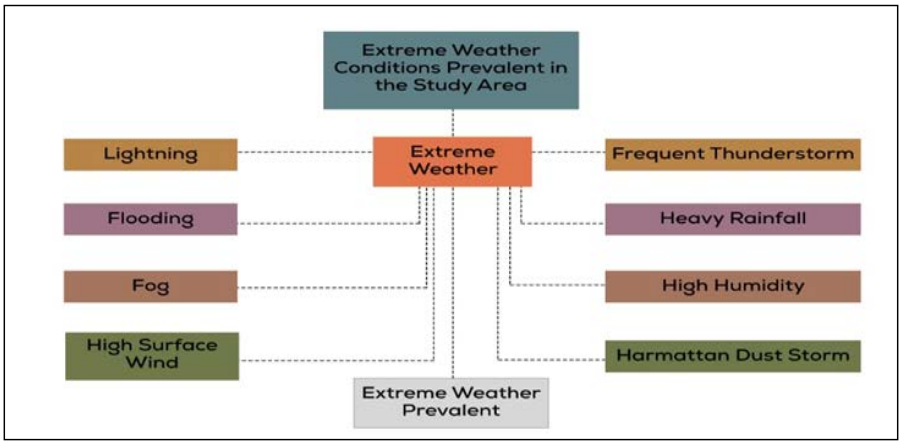
This was directed to the NiMet officials in each study area.

"…To be candid with you, the foremost weather conditions here in Lagos are Frequent thunderstorms & lightning, Heavy rainfall & flooding (experienced most especially April–October), High humidity affecting aircraft performance, Low visibility due to fog or rain and Tropical storms from the Atlantic due to the absolute location of Lagos State. I can say categorically that it has a grave impact on the aviation industry and the operations in nearly all airports in Nigeria, especially Nigeria's major international airports, with extreme effects in some cities. The predominant extreme weather conditions in Lagos zone affecting the aviation industry include harmattan, a dry and dusty wind, and thunderstorm…" (Participant 1).

"…Madam, I know you understand the research so well, but for the interview purpose, let me make it clear to you that at least in Abuja, we experience three major weather conditions which I can authoritatively say affect the aviation industry due to my years of experience at work and living here. Insha Allah, they are harmattan dust storms between December and February yearly, and sudden thunderstorms around May to September yearly. This is due to the season. It's rainy times and high surface winds are often experienced. This makes it extremely difficult for us to see clearly. Madam, here in the North, the fog and haze are typically really bad…" (Participant 2).

"…You know we in the southern Nigeria have our peculiarities. We are within the Delta region and close to the Atlantic Ocean, near the equator, as we are taught and have known and understood due to our service at the airport. Our major challenge with extreme weather is flooding… this is a result of our location in geography. Strong tropical rainstorms repeated, and, on many occasions, we have heavy thunderstorms that can be deafening, extended and can be seriously prolonged and most times lightning. If anybody tells you that it does not impact aviation, that person knows nothing. Na true true I dey talk (I speak the truth). E dey cause (it causes) poor visibility…" (Participant 3).

Figure 4.1: The Schematic Network showing the Prevalent Extreme Weather Conditions in the Study Areas.



In order of frequency, the foremost climate change weather conditions experienced are thunderstorms, which can either be sudden or heavy. Lightning and flooding. This supports the research of Abbas, Ojo, and Igbru (2012), who claimed that lightning and thunderstorms are the extreme weather occurrences linked to climate change in Nigeria. It also supported the findings of Aderinto and Dahunsi's (2008) study, which suggested that flooding due to rainfall was another important factor affecting the aviation sector, particularly air transport services, which can result in flight cancellations and delays.

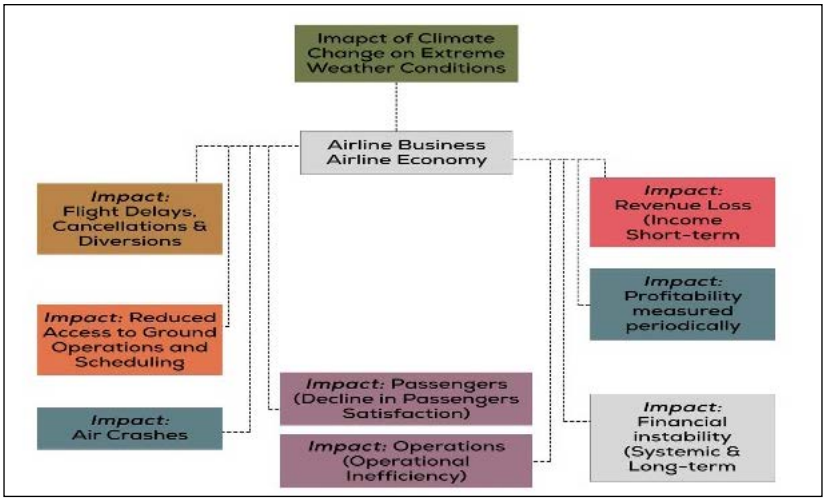
Theme 2: Interview on the Impact of CC on Airline Business and Economics

"…*As an air transport operator for mainly passengers, we perform operations to move people or goods from one location to another, and their logistics. It impacts our operations. We have heavy rainfall and flooding in Lagos. Common here. And most times, ma, it leads to hmm, flight delays, cancellations. We have thunderstorms and strong winds, which may lead to turbulence and reduce the number of takeoffs and landings per hour, leading to long flight paths, reducing access to ground operations and scheduling. Thunderstorms are also a major cause of air crashes experienced in this nation and globally, automatically leading to the closure of the operator's business. The impact has reduced air density. Really, though, the airline's finances, which comprise our income, are greatly impacted when this occurs. You know what revenue means to us. This can impact aircraft performance, especially during takeoff operations. That is, aircraft scheduling, crew management, and flight planning. These climate changes due to extreme weather conditions experienced have rendered some airlines in the country failed and failing establishments, while some were offering partial services…" (Participant 1)*

"…Due to these extreme weather events, numerous airlines have gone extinct. The outcome of all the extreme weather conditions is on the airline's final goal and objective of making a profit. It causes flight delays, re-routing, and reduces access to ground operations. We cannot make a profit without our revenue. Our business required a huge amount of capital investment to be competitive, stay on the ground and remain in business by operating our aircraft in profitable routes. Our load factor, financial success as measured by our RASK, CASK, flight rate, on-time performance, and our customers' opinion of our services and scheduling are all impacted by these harsh weather circumstances. Finally, when it leads to the loss of the aircraft and or passengers, it can lead to the end of the airline business and economics…" (Participant 2)

"…Yes. I earnestly believe that these issues discussed today have ruined many airlines in Nigeria, while the owners have gone bankruptcy. In all honesty and sincerity, Madam, climate change, because of extreme weather, has serious *implications on our business and economy, which is our revenue. It causes flight delays, and when this happens, its effects are on the business (disruptions of flights), and eventually our economy/we must refund to obey laid-down international rules and regulations. It often leads to flight cancellations with a business effect-distrust in our passengers, and economic effect-we are paying compensations. It also led to aircraft crashes. The 1987 air crash at Port-Harcourt Airport 1987 stated that the prevalent weather at the time of the crash was a thunderstorm. The Sosoliso air crash at the airport was attributable to the turbulent weather conditions. Today, nobody speaks of Sosoliso Airlines. It has gone down in history. Extreme weather leads to a low load factor and a smaller number of passenger tickets sold. You can guess the implication, madam. This is significant for our revenue. You know our profit margin is so slim and extremely low. Breaking even with all these climate change challenges affects our revenue and profit-making. Business and economy may go into a comatose and eventual death…" (Participant 3)*

Figure 4.2*:* Impact of Climate Change on Airline Business and Economics



****RASK:** *Revenue per Available Seat Kilometre.* ** **CASK:** *Cost per Available Seat Kilometre*

From the interview, extreme weather and climate change have impacted the airline business and economy, as they affect the parameters for efficiency and profitability. Every element of operational performance, including scheduling, flight planning, flight connectivity, safety, and trajectory optimisation, was influenced by the increasing weather volatility brought on by climate change. This corroborates the report of ICAO CAEP aviation and climate change factsheet (2020), which states that extreme weather conditions have a cost implication on the airline business, such as delayed or cancelled flights. This also validates the study of Flanagan et al. (2018), who stressed that climate change is reshaping design and operations globally.

Theme 3: Interview on the Impact of CC on the Operational Performance of the Airport

"…*Operational performance is crucial to a business's ability to survive. It is how competently and excellently a company carries out its core activities. In an airport business, it is how efficiently the airport facilitates air travel and related activities. Extreme weather and climate change events have hurt airport operational performance. It slows down the groundwork, as the workers on the ground can't work during lightning conditions. Aircraft service, baggage handling, fuelling, catering, cleaning, and maintenance are among the ground handling functions that are frozen, which ultimately has a significant effect on airport turnaround times and operations management. No synchronised operations of all the different performing areas at the airport. Finally, the impact is felt on revenue generation as operations are slowing down…" (Participant 1)*

"…Operations is a catch-all term for the core business process of any organisation or business. In an airport setting, operations reveals the comprehensive events within an airport. Operational performance is therefore the smooth and efficient functioning of the airlines, the passengers, business on-airport enterprises, visitors, and airport staff. The impact of climate change on the operational performance of airports will affect safety protocols, as it may slow turnaround times. It will reduce aircraft movement, ground handling activities, baggage handling, passenger processing, aircraft repairing and overhauling. Return on the huge investment might not be too good…" (Participant 2)

"…Operations deal with the organisation of the activities carried out in business. Operational performance of the airport speaks volumes. It is multidimensional. It entails the efficiency and effectiveness of an airport in carrying out its specific and mandatory functions. It reveals how the huge investment expended brings out the expected outcomes. The airside, landside, terminals, gates, and other operational aspects of an airport are all impacted by climate change. Ma'am, the effect is on aircraft ground handling, which makes sure that the aircraft is operated safely and effectively when on the ground. There will be inefficient operational flow, slow activities, hazardous and risky loading and unloading services, aircraft turnaround time is increased, and flight delays will be on the rampage, no strict safety procedures carried out, catering services, which ensure passengers' comfort are compromised, poor operations coordination, and fueling services will be impaired. As you rightly asked, all these hurt revenue generation…" (Participant 3).

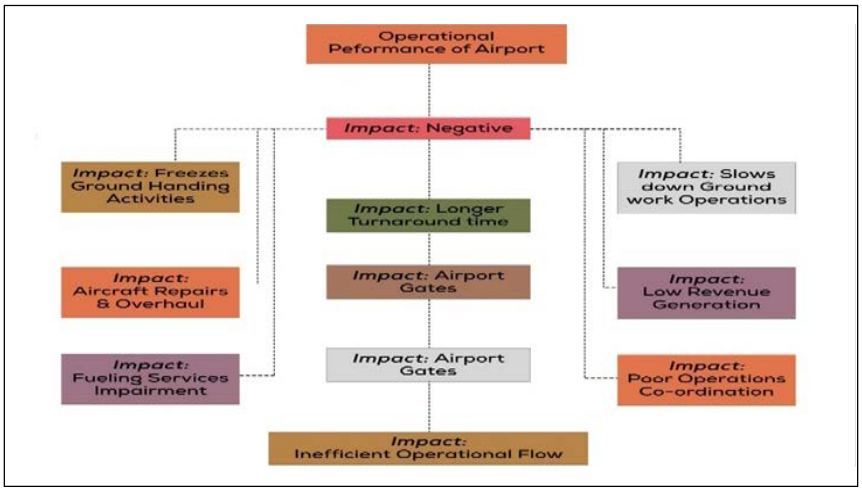


Figure 4.3: Impact of Climate Change on the Operational Performance of the Airport

Weather has an impact on all facets of airport operations as well as the economics and commerce of air travel. For instance, flight scheduling, baggage handling, catering, cleaning, and aircraft maintenance. In addition to the physical slowdown that occurs when people perform their duties in more difficult-than-normal conditions, extreme weather also causes traffic congestions at airports by obstructing air traffic control systems and causing aircraft saturation at departure, destination, or somewhere in between. Even in the best of weather, aircraft traffic delays are frequent, and they are certain to worsen when ice, snow, poor runway visibility, and severe crosswinds are present. Even the slightest interruption can have significant repercussions.

Theme 4: Interview on the Impact of CC on Airport Capacity

"…Thunderstorms and strong winds have an impact on airport capacity. It leads to the compacting of airspace capacity. This later affects air traffic control. Ma'am, it frequently forces air traffic control to redirect aircraft. It also has the resultant power to thin down air corridors. This limits the number of aircraft that can safely arrive or depart per hour. The impacts are low visibility, leading to unsafe flying conditions. When the airport is in its peak travel hours, the climate change events lead to a high volume of delayed or cancelled flights, and air traffic flow is slowed down or constrained. Ground operation is also impacted as it almost stops work or activities…" (Participant 1)

"…Reduced airspace capabilities resulted from the water problem at Abuja Airport a while back. This pointedly made the runways and taxiways not fit for use. With reduced activities and not fit runways and taxiways slows down arrival and departure charges. This also makes the time for departure superfluous…" (Participant 2).

"…The maximum number of aircraft operations, including takeoffs and landings, that an airport can handle within a given period, such as an hour or a day. The feasibility of integrating renewable energy sources into airports. The weather, aircraft mix, air traffic control regulations, and the actual design of the airport are some of the variables that might affect an airport's capacity, but extreme weather makes it worse. It impacts the number of aircraft operations per hour or day…" (Participant 3).

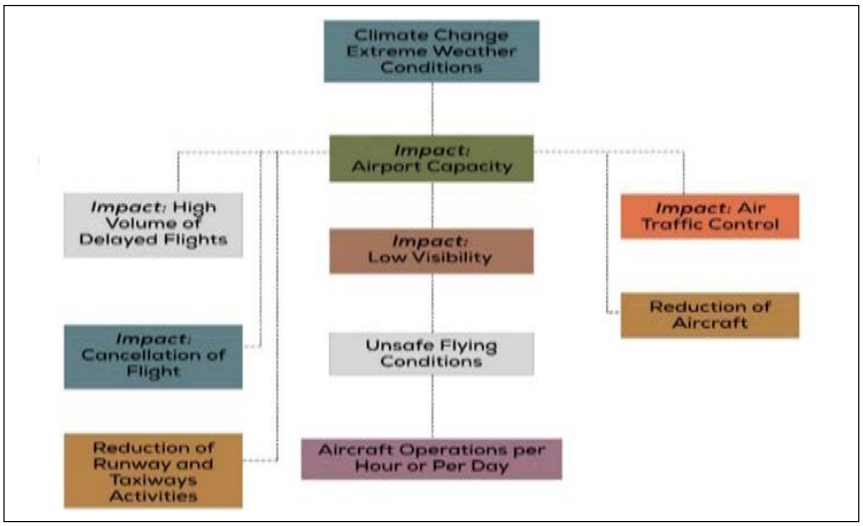


Figure 4.4: Impact of Climate Change on Airport Capacity

From the interview, extreme weather conditions can significantly reduce airport capacity**,** which refers to the number of aircraft operations (takeoffs and landings) an airport can handle within a given timeframe. It significantly reduces airport capacity leading to flight cancellations, delays, and diversions. These weather events disrupt various airport operations, including aircraft fueling, baggage handling, and maintenance, ultimately impacting the overall functioning of the airport and airspace. This corroborates with the study of Sasse and Hauf (2003), who insisted that these impacts are both direct (physical limitations) and indirect (safety protocols, regulatory constraints, and operational delays).

Theme 5: Interview on the Impact of CC on Aviation Infrastructure

"…A key major aviation infrastructure globally is the airport, its control tower, terminals, and hangars. Without these, the aviation industry is incomplete, while without our major customers, the airline operating at the airport, the aviation industry is not whole. The impact of climate change due to extreme weather conditions leads to flooded runways due to rainstorms and damaged terminals because of extreme winds, electrical disruptions due to thunderstorms leading to blackouts, and interruptions of activities of ground operations. Thunderstorms pose a serious risk to the aviation sector. It results in wind shear and turbulence. The airlines will have to temporarily move their operations to other airports as a result of this. It causes infrastructure to deteriorate quickly, age, and lose value. Due to flight cancellations and losses, it also has a significant effect on airport and airline income…." (Participant 1).

"…Weather events in Abuja may alter in frequency, intensity, or both. I recall when the airport in Abuja was flooded due to a heavy downpour. All aviation infrastructure is impacted by the severe thunderstorm with its concomitant lightning and thunder, hailstones, icing, low-level wind shear, fog, and harmattan dust haze. The air traffic control system was affected by climate change as a result of this weather…" (Participant 2)

These extreme weather and climate change events are severe for the aviation industry. It has a weighty impact on the sector. Severe weather conditions associated with thunderstorms and lightning, assuredly disrupt aviation infrastructure. Lightning strikes at the airport can damage terminal buildings, cut down communication systems, and electrical circuits, potentially disrupting airport operations. The severity of thunder creates harmful and unsafe situations for aircraft, an essential aviation infrastructure, impact on tarmac and natural infrastructure, which are the ground crew personnel…" (Participant 3)

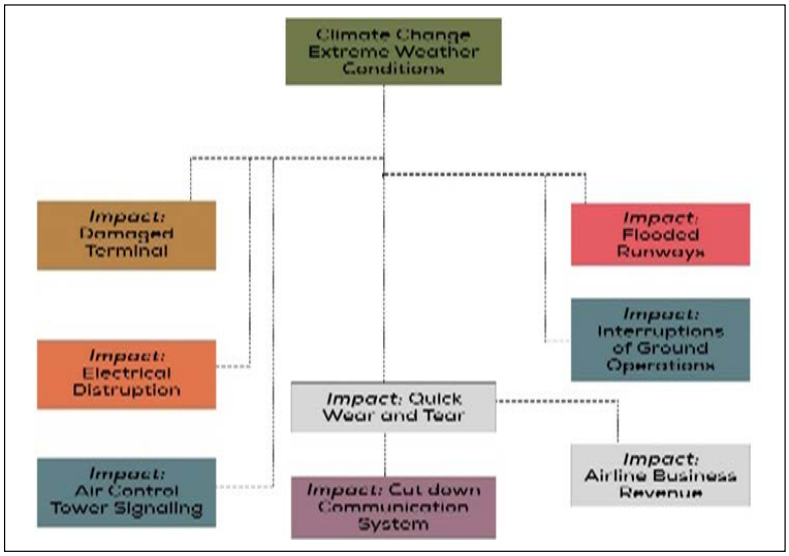


Figure 4.5*:* The Semantic Network showing the different Impact of Climate Change on Aviation Infrastructure

From the report, extreme weather conditions significantly affect aviation infrastructure. It spans through immediate operational disruptions of the air control tower, damaged terminal, cutting down of the communication system, long-term infrastructure stress, safety concerns, and economic losses. The heavy rainfall/ Flooding causes waterlogging, erosion, and debris on runways. The domestic aviation industry is also impacted by airport infrastructure issues brought on by climate change and extreme weather. This is supported by the work of Sylva and Amah (2021) who stated in their study that the consequence of extreme weather on aviation infrastructure led to poor airport infrastructure, inadequate provision of power, breakdown in communication, inadequate number and small fleet sizes of aircrafts, lack of perimeter fencing of airports and poor technology, which eventually trickles down to domestic airlines.

5. DISCUSSION OF FINDINGS

Findings from the research revealed that no discrepancy exists between the prevailing extreme weather conditions and the impact identified in the three study areas. This shows that the aviation industry in the study areas has a serious role in ensuring environmental stability, socio-economic planning and disaster risk reduction. This corroborates with the report of the World Meteorological Organisation [WMO] (2020), which elucidated that a region with no difference in stands to benefit from better-quality and enhanced environmental resilience has coordinated economic planning that supports integrated responses to extreme weather conditions or threats. In addition, homogeneous weather conditions enhance early warning systems and response mechanisms to be put in place. This also agrees with the report of the Intergovernmental Panel on Climate Change [IPCC] (2021) which states that uniform weather makes it easier for the aviation industry and airport system to implement early warning systems and response plans. The study also found that the effects of

climate change and extreme weather on the airline industry and economy are multifaceted, affecting the fragile systems that support airline operations and financial sustainability.

At the business level, it manifests in flight delays, cancellations, diversions, reduced access to ground operations and scheduling, low number of take-offs and landings per hour. All of these jeopardise service dependability, which has detrimental effects on passenger satisfaction. At the economy level, it leads to operational inefficiency due to financial losses, as airlines bear the burden of ticket refunds, stranded passengers' accommodation, and extra charges to the airport. All these result in tightening the profit margins, leading to financial instability, which might reduce investor confidence. This corroborates with the report of the International Civil Aviation Organisation [ICAO] (2016), which stated that the airline industry is extremely vulnerable to the intensifying effects of extreme weather conditions, leading to low productivity or efficiency, increased operational risks and financial losses from grounded flights, and increased insurance premiums.

Findings revealed that extreme weather conditions driven by climate change pose significant threats to airport operations, capacity and infrastructure. This corroborates with the study of the United Nations Office for Disaster Risk Reduction [UNDRR] (2015). The study maintained that airports and their infrastructure are particularly vulnerable to extreme weather. The study emphasised that this happens especially in many international airports near coastlines and are increasingly exposed to flooding, citing Lagos, Bangkok and New York airports as examples. In addition, extreme weather disrupts the smooth operations and performance of the airport by having negative impacts manifesting as longer turn-around time, inefficient operational flow, poor operations coordination, slowing down groundwork operations and low revenue generation. This validates the study of Balakrishnan & Donohue (2008), who declared that extreme weather reduces on-time performance and schedule reliability.

Extreme weather impacts airport capacity by restraining the actual capacity of the airports from numerous magnitudes by contributing to a high level of delays, cancellation of flights, reduction of runways and taxiways activities leading to increased runway occupancy times, and shrinking available slots for airlines, low visibility, unsafe flying conditions, and limiting air traffic activities. These put the aviation infrastructure's capacity efficiency, dependability, and safety at risk, necessitating delays, detours, or cancellations. This confirms the study of Balakrishnan and Donohue (2008); Kulesa (2003), who emphasised how climate change-driven extreme weather events reveal airports' procedural and physical weaknesses, lowering the system's overall capacity and efficiency. In addition, extreme weather driven by climate change poses significant impacts to the physical infrastructure of airports as it accelerates the runways, taxiways, terminals and navigation systems depreciation. These infrastructure damages increase maintenance costs. This revalidates the study of Balakrishnan & Donohue (2008), which elucidates that airport infrastructural damages because of extreme weather led to high maintenance costs and necessitate expensive climate adaptation strategies by airport management. This climate change-induced extreme weather condition compromises the functionality, safety, durability, and financial sustainability of airports (Mills and Andrey, 2002).

6. CONCLUSION

The study concludes that, like in other countries throughout the world, Nigeria's aviation business is affected in multiple ways by climate change-related extreme weather conditions**.** This includes effects on flight operations, airport infrastructure, and overall air traffic management. As a result, stakeholders must develop adaptive strategies to mitigate these challenges and ensure the sustainability of the aviation sector. By investing in resilient infrastructure and adopting innovative technologies, the industry can better navigate the uncertainties posed by a changing climate while continuing to support economic growth and connectivity.

7. RECOMMENDATIONS

Based on the findings, the aviation industry urgently needs aggressive policy and infrastructure adaptation, given the rising occurrence and intensity of extreme weather events due to climate change. The Nigerian Civil Aviation Authority [NCAA], in partnership with the Federal Airport Authority of Nigeria [FAAN] should develop and implement resilience framework that will mandate climate risk assessments for all major airports, conduct risk assessments of their new and existing infrastructure to lower risks and expenses, adapt capacity management models, and guarantee future punctuality and regularity in the aviation industry and establish infrastructure adoption plans like the climate-smart air traffic control systems, and storm resilient terminals. Moreover, investing in weather monitoring equipment, technologies, and other logical systems should be a top priority for the Ministry of Aviation, meteorology agencies, and other planning units due to operational sensitivity. Furthermore, the Ministry of Aviation should adopt policies that integrate climate adaptation into aviation planning. This will aid in protecting the infrastructure, maintaining airport capacity, and ensuring long-term airline operational sustainability.

Airline operators should strengthen their operative agility by purchasing aircraft with cutting-edge avionics and weather resilience or prediction technologies, invest in smarter weather forecasting by incorporating real-time meteorological data into their flight planning system, and take proactive measures to alleviate weather risks, invest in decision-support systems, have robust financial planning, which can protect both their business reputation and revenue generation, while aligning their operations with

international best practices outlined by the International Civil Aviation Organisation.

Conclusively, the Nigerian government should start seeing extreme weather conditions as not inconveniences that happen occasionally to aviation industry operations, but understand that it is a strategic threat to the entire industry and ensure the training and re-training of meteorological personnel in the aviation sector, often to considerably lessen the effects of overstrain in weather observation and reporting. The implication is that this will help the industry navigate these conditions ahead, emerge stronger, safer and more adaptive to the changing climate, while improving the airport by making its operation efficient.

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CLIMATE CHANGE AND MEGACITIES: FLOODING ALONG THE URBANISING ATLANTIC COASTLINE OF LAGOS, NIGERIA

By D. Ayodele-Olajire, J. Oluwaleye, O. Gbadegesin, and A. Gbadegesin

Published 1 February 2026

ABSTRACT

The identification of risk regions is important for prioritising their risk mitigation and response efforts. In this paper, we simulate flooding and identify flood-prone as well as inundation areas between 1986 and 2023 in Lagos, Nigeria, using geospatial tools available in the Digital Earth Africa (DEA) Sandbox. By leveraging satellite imagery from Landsat and Sentinel-2 through the Water_extent_WOFS and Water_extent_sentinel notebooks, we evaluated long-term and seasonal water extent using the Modified Normalised Difference Water Index (MNDWI). A 3D terrain model was developed to assess water flow, accumulation, and coastal inundation risk. Also, through document analysis, we identified key policy options that can be strengthened within the study area. Overall, we found that some areas that were inundated with water before 2023 were revealed to be land in 2023, suggesting that water has either receded from these regions or they are being sandfilled. Meanwhile, some areas that were inundated before 2023 have remained flooded to date. These areas might have certain characteristics, such as natural depressions or poor drainage, that make them more prone to prolonged water presence. Also, we found new areas that have only become flooded in recent times, possibly due to changes in land use, climate patterns, or other factors. The implementation of the DEA sandbox geospatial resources shows the utility of the toolbox for environmental resource monitoring and city planning. With respect to the developing Lagos Megacity, our findings highlight the importance of paying attention to the flood-prone areas of the city to ensure sustainable megacity development. The paper concludes with recommendations for policy, urban planning and climate adaptation.

KEY WORDS Sea-level rise, low-lying areas, policy and planning, coastal inundation, sustainability.

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1. INTRODUCTION

Among the effects of climate change are the melting of glaciers, leading to sea-level rise and more intense storm surges, which pose a serious threat to island nations, coastal regions, and low-lying communities. In densely populated coastal cities, the effects of climate change are particularly acute. In such cases, there are serious and increasing risks due to a combination of rising sea levels, extreme weather, and flaws in current infrastructure. Lagos, Nigeria, which has rapidly grown into a coastal megacity, is one of the most affected areas in the world. Its low elevation and dense population greatly increase its susceptibility to environmental changes and associated hazards. Another significant impact of climate change is the redistribution and altered timing of water resources, resulting in recurrent floods, prolonged droughts, irregular rainfall patterns, and more intense thunderstorms, with different regions experiencing varied manifestations of these effects (Ayodele-Olajire and Olusola, 2022). For instance, the Intergovernmental Panel on Climate Change (IPCC) predicted that humid regions would generally face more intense rainfall, while arid regions could become even drier, experiencing extended droughts (Bates et al., 2008). While climate change manifests in many ways, one of the greatest concerns for scientists is the crossing of critical thresholds necessary for maintaining balance within the Earth system (Rockström et al., 2009). In 2019, thousands of scientists collectively declared a climate emergency (Ripple et al., 2020). This declaration, alongside the ongoing efforts of the United Nations Framework Convention on Climate Change (UNFCCC), has helped ensure that nations are increasingly aware of—and are potentially taking action on—the urgent issue of climate change.

Both research and lived experience point to climate change as a harbinger of numerous threats to life (Gbadegesin et al., 2011). These threats include fatalities from coastal inundation and flooding, the spread of diseases, and security risks stemming from climate-induced migration, among others. Coastal inundation (also referred to as flooding) is one of the most frequent and costly natural disasters globally. It occurs when seawater submerges dry, low-lying coastal areas due to a combination of climatic and environmental factors. Specifically, coastal inundation can result from moderate to strong winds over water, extremely high tides, or tsunamis caused by undersea earthquakes. The impact of this hazard is further exacerbated in areas with impervious surfaces and limited vegetation cover (Ajayi et al., 2012). Additional factors that can intensify the severity of coastal inundation include inadequate stormwater drainage systems, rapid urbanisation, and poorly regulated construction in floodplains despite existing planning restrictions (Adeloye & Rustum, 2011). Defined in another way, coastal flooding is a temporary condition that leads to the partial or complete inundation of normally dry land due to tidal overflow (Jeb & Aggarwal, 2008). Low-lying coastal areas are particularly vulnerable to such events.

Lagos is known to be vulnerable to coastal flooding, but long-term studies that examine flooding trends in a way that can aid urban planning and climate adaptation initiatives are lacking. Most studies tend to either address broad climate impacts or focus on specific flooding events (Elias & Omojola, 2014; Omenai & Ayodele, 2014; Isiaka et al., 2023). To address this gap, we utilise the Digital Earth Africa (DEA) sandbox to evaluate the extent, vulnerability, and risk of coastal inundation along a portion of the Atlantic coastline by simulating flooding events and their corresponding inundation between 1986 and 2023. Understanding inundation characteristics is important for providing solutions for urban planning and climate adaptation. We also review and present policy options for developing coastal megacities such as Lagos, with respect to urbanisation and flood events, against the background of climate change.

2. CLIMATE CHANGE, URBANIZATION, AND COASTAL VULNERABILITY IN MEGACITIES

In coastal megacities, land use changes significantly as a result of urbanisation, which is fueled by population growth and economic advancement. This includes practices such as constructing densely populated structures in low-lying areas, reclaiming wetlands, and altering natural drainage systems. Although these activities can spur economic growth, they often disrupt the natural equilibrium of ecosystems and increase cities' susceptibility to climate change effects, including storm surges, rising sea levels, and altered rainfall patterns (Seto et al., 2012). Urban development in these coastal megacities is often accelerated, posing a threat to long-term sustainability and environmental preservation.

Flooding in Lagos State has increasingly become an annual occurrence, unlike in previous decades. Numerous studies attribute this growing frequency of floods to the effects of climate change (Douglas et al., 2008; Omenai & Ayodele, 2013; Elias & Omojola, 2014). Flooding poses a significant risk, affecting millions of people each year along Nigeria's coastal regions (Nimi, 2021). Lagos State is particularly vulnerable, as it experiences all three major types of urban flooding: flooding caused by poor drainage systems, flooding from inundated floodplains, and coastal flooding (Douglas et al., 2008). Each of these flood types is further intensified by the impacts of climate change, making the situation increasingly dire.

Lagos State has certain peculiarities that have made the problem of flooding almost intractable. It has the least land area among states in Nigeria but is arguably the most populated (Oyalowo, 2022). Thus, there is a high population density in most parts of Lagos on land that is either low-lying and close to the Atlantic coast, floodplains close to the lagoons and creeks, or areas with poor drainage and waste management. The

state's peculiarities extend to some of the economic activities that contribute to its GDP, for example, sand mining and land-filling to promote real estate. These activities, though profitable in an economic sense, can increase threats to life from climate-exacerbated flood risks if they are not conducted in an environmentally sustainable manner. It is troubling that, at present, these activities serve to increase the number of people vulnerable to climate change impacts and at risk of life and property losses.

Several studies in Lagos emphasise the significant threat flooding poses to communities, lives, and properties. For example, Fashae and Onafeso (2011) demonstrate that the coastal extent of Lagos decreased from 1.64 km² in 1999 to 0.89 km² in 2009, marking an annual loss of approximately 0.075 km² due to sea-level rise induced by climate change. Another study by Omenai and Ayodele (2014), which focused on the Eti-Osa and Ibeju-Lekki areas, found that approximately 83.5% of the area is highly vulnerable to climate change hazards, particularly coastal inundation and flooding, based on factors such as proximity to water bodies and elevation above sea level. More recently, Isiaka et al. (2023) suggested that nearly 70% of the total land area in Lagos is highly to moderately susceptible to flooding. In the case of Lagos State, a closer examination reveals that while certain environmental risks exist independently of climate change, they are aggravated by its effects. For example, Lagos is not inherently low-lying due to climate change; however, the threat of coastal inundation has intensified due to the predicted increase in the intensity of storm surges in the tropics, which is linked to climate change. Coastal inundation mapping is important for proper land-use planning and for identifying coastal areas at risk of inundation under extreme circumstances. Furthermore, coastal inundation mapping helps administrators and planners identify risk regions and prioritise mitigation and response efforts through charts and maps that are simple to understand and quick to access (Alemu & Belachew, 2011).

3. METHODOLOGY

3.1. Study Area

Lagos, situated at an average elevation of just 1.5 meters above sea level, is a densely populated, low-lying metropolis characterised by a flat terrain (Omenai & Ayodele, 2013; Ajibade, 2017). It is one of the world's 14 coastal megacities and ranks among the top 20 locations most vulnerable to coastal inundation (Sojobi et al., 2016). The city faces multiple environmental and developmental challenges, including deforestation, unplanned urbanisation, uncontrolled wetland reclamation, encroachment on drainage channels, and rapid population growth (Sada & Odemerho, 1988). More than 54% of Lagos's developed areas lack proper drainage networks, and existing systems are often poorly maintained (Otokiti et al., 2022). Coastal flooding has become increasingly common during both of the city's annual rainy seasons, with the heaviest rainfall typically occurring between April and July (Ikuemonisan & Ozebo, 2020). The city's vulnerability is further exacerbated by its low elevation, subsiding land, and severe drainage issues—often worsened by clogged drainage systems. These conditions result in the rapid accumulation of water following sea-level rise, heavy rainfall, or storms (Adeloye & Rustum, 2011).

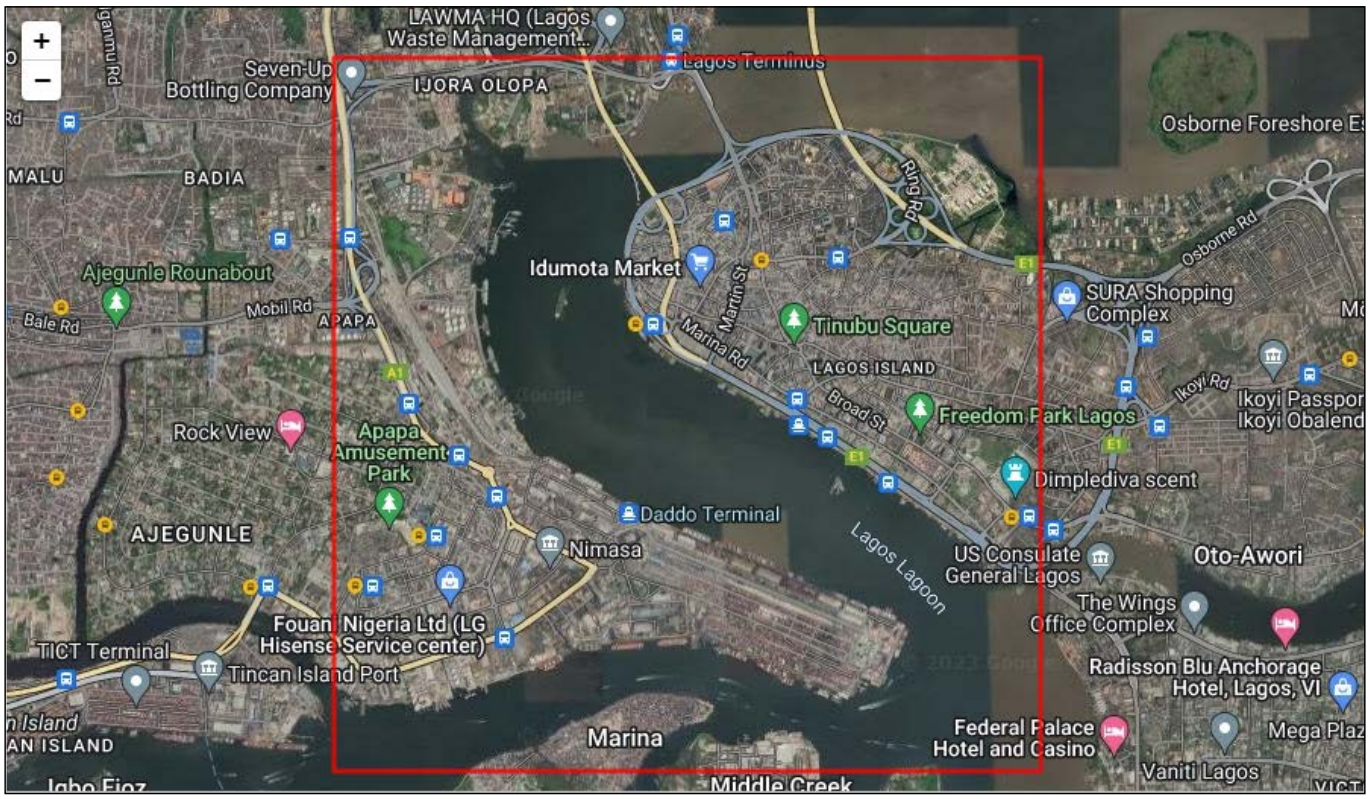
As a developing megacity, Lagos continues to see development projects such as the state's transportation-network improvement initiatives, the Eko Atlantic City—a modern city within the city—the Dangote Refinery (the first privately owned refinery in Nigeria), among others. Although urban and developmental challenges such as high population density, housing deficits, and water, air, and land pollution require solutions that fulfil both the letter and spirit of sustainable development, what is often observed is an underlying "maximum" rather than "optimum" profit motive. Thus, in Lagos, it appears that the man–nature relationship aligns with the human-as-despot school of thought, combined with undefined and unrefined capitalism—conditions that can only serve as a time bomb for vulnerable populations.

3.2. Data Collection

This study utilises the Digital Earth Africa (DEA) sandbox technique for coastal inundation mapping to simulate floods in a controlled setting (Killough et al., 2022)—secondary data. High-resolution digital elevation models (DEMs) are integrated into the DEA analytical environment to produce a three-dimensional representation of the study area. The DEA framework requires this 3D viewpoint to assess patterns of water flow, extent, and accumulation, thereby improving the precision of coastal inundation simulations. The DEA platform was selected because of its unique advantages, which are valuable for this comprehensive long-term study. It provides easy access to decades' worth of fully analysed satellite imagery from Sentinel-2 (beginning in 2015) and Landsat (beginning in 1986). As a result, the time and computational effort required for data preparation and collection are greatly reduced. DEA is a cloud-based system that eliminates the need for powerful local computing resources while handling large geospatial datasets.

Two Python notebooks from the Digital Earth Africa Sandbox were used to evaluate the extent of inundation: Water_extent_WOFS and Water_extent_sentinel; the former uses data from Sentinel-2, while the latter uses data from Landsat. The Landsat and Sentinel data used were delineated according to the study area of interest (Figure 1). The major strength of using DEA is that it provides robust open-source tools along with long-term historical satellite data that is ready for analysis. One limitation is the possibility of cloud cover–related data gaps and the absence of precise flood depth measurements.

Documents regarding the policy dimensions of climate change and the environment within the study area context were sourced online (Lagos State Ministry of Environment, 2014; Lagos State Environmental Protection Agency, n.d.; Lagos Waste Management Authority, n.d.; FSD Africa, 2025).



Area of Interest (Lagos Island)		Park		Supermarket		Point, location		Bus, Taxi	
Civic building		Restaurant		Train, rail		Shopping Center			

Figure 1: Delineation of Study Area of Interest (AOI)[1]

3.3. Data Analysis

Flood simulation was conducted to examine the extent of inundation from 1986 to 2023, analyse the Modified Normalised Difference Water Index (MNDWI), and assess seasonal water extent in the DEA Sandbox. Two notebooks in the DEA Sandbox were used: Water_extent_WOFS and Water_extent_sentinel. The former utilises data from Landsat images, while the latter uses data from Sentinel-2 satellites. Python codes were employed throughout the analysis, with Matplotlib used for visualising the results (Krause et al., 2021). Satellite imagery is used by Water Observations from Space (WOFS) to determine the locations and frequency of surface water observations. For long-term water extent analysis, this product offers a strong scientific basis. Likewise, the MNDWI is a validated spectral index that effectively distinguishes water bodies, making it especially useful for evaluating seasonal variations. The DEA Sandbox represents a relatively new technique, which has not yet been applied to the study and simulation of coastal inundation in the study area. All the codes used in the analysis are provided in the Appendix. Lastly, the policy and institutional dimension of this study was conducted through thematic analysis of policy documents relating to climate change and the environment.

In the next section, the results from the two notebooks mentioned in the previous section are presented. The notebooks have four sub-indicators, which include: spatial extent of water-related ecosystems, quantity of water contained within these ecosystems, quality of water within these ecosystems, and health or state of these ecosystems. The WOFS notebook provides insight into the longer-term extent of water bodies.

[1] Some localities at the Northern part of the study AOI include: Ijora Olopa, Idunmota Market, Lagos Terminus. Some localities at the East include: Tinubu Square, Freedom Park. Some locaties towards the Southern part include: Marina, Nimasa, Daddo Terminal.

This is complemented by the second notebook (Water_extent_sentinel), which focuses on more recent water extents at seasonal time intervals (Krause et al., 2021). Finally, policy and institutional responses to flooding as a climate change threat were deduced from document analysis.

4. RESULTS AND DISCUSSION

4.1. Mapping longer-term changes in water extent with Water Observation from Space (WOFS)

The results indicate a significant increase in water occurrence over time. The years 2000 and 2020 recorded the lowest and highest annual occurrences of water, respectively (Figure 2). Five images, spaced five years apart, were selected as a case study. These findings suggest a shift in water patterns and an increase in water content, which may indicate a trend of rising flooding or water-related events over time. From 1988 to 2000, the water area extent was the lowest, whereas from 2010 through 2023, the water content was notably higher (Figures 3 and 4). The water inundation observed in 1986 was relatively lower than that in 2022, highlighting a noticeable difference in the severity of flooding or water levels between these two years (Figure 5). An animated time series showing annual water extent and inundation is available on the website created for this study: https://floodcheck.netlify.app

The water inundation map from 1986 to 2023 illustrates changes in water distribution over time. The blue-colored areas represent locations that experienced water in both 1986 and 2023, indicating consistent water presence throughout the years. These areas may represent bodies of water or regions prone to flooding. In contrast, the yellow areas represent locations that had water in 1986 but no longer have water in 2023. This could suggest changes such as water bodies drying up or human interventions, like land reclamation, altering the natural flow of water. Lastly, the green areas represent locations that had no water in 1986 but have water in 2023. The map shows a higher concentration of green areas compared to others (Figure 6), indicating that flooding has predominantly occurred in these green areas.

Table 1: Average proportion of water coverage extents in the study area of interest from 2017 to 2023 (values range from 0 (no water) to 1 (completely covered by water)

Years	Water Coverage Extent (mean)	Minimum water extent	Maximum water extent
2017	0.38	0.00	1.00
2018	0.39	0.00	1.00
2019	0.37	0.00	1.00
2020	0.39	0.00	1.00
2021	0.39	0.00	1.00
2022	0.38	0.00	1.00

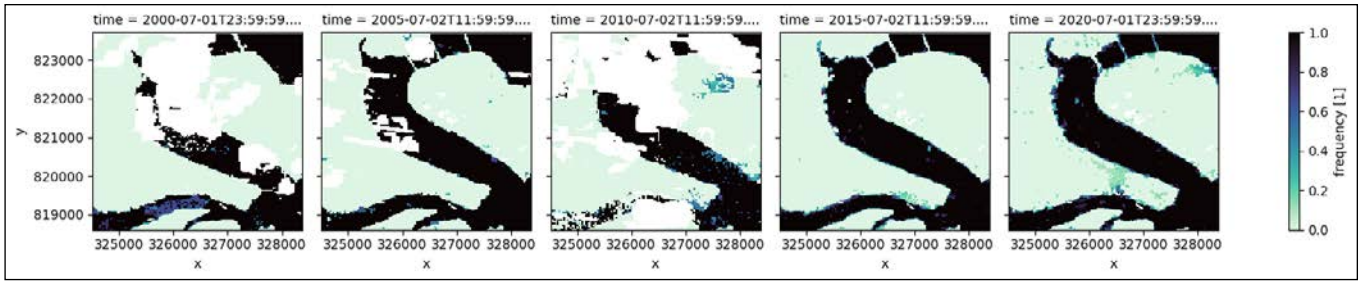


Figure 2: Annual Water Observation from Space summary (WOFS). The black areas represent areas that have been inundated with water, with the year 2020 and 2015 being the most inundated.

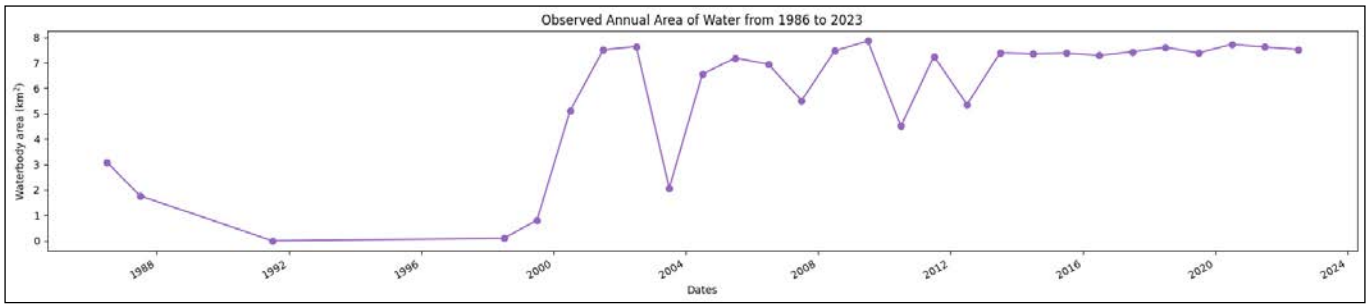


Figure 3: Observed Annual area of water from 1986 to 2023. There was a low annual area of water from 1992 to 2000 before a gradual increase occurred. There were sharp declines in the annual area of water in 2004, 2011, and 2013.

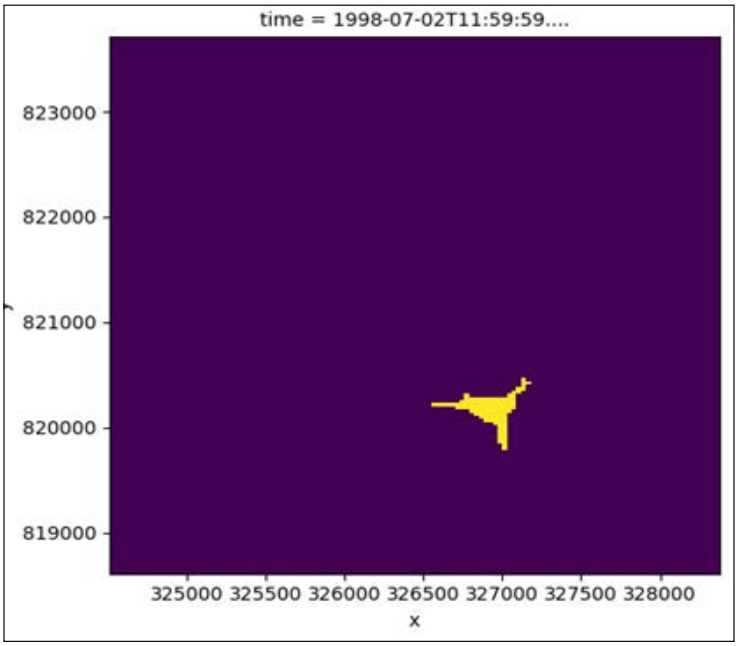


Figure 4: Minimum annual water extent (1998). The yellowish area indicates the presence of water

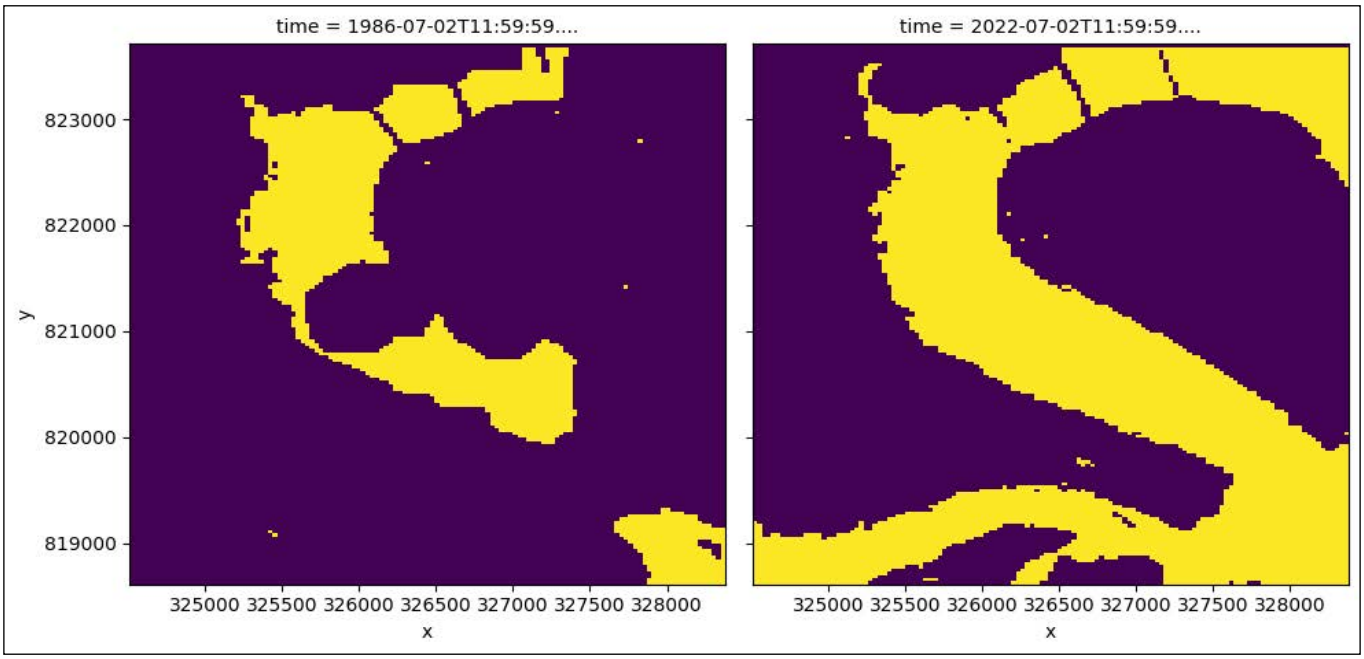


Figure 5: Annual extent of water from 1986 to 2023. There was a larger annual extent of water in 2023 compare to 1986.

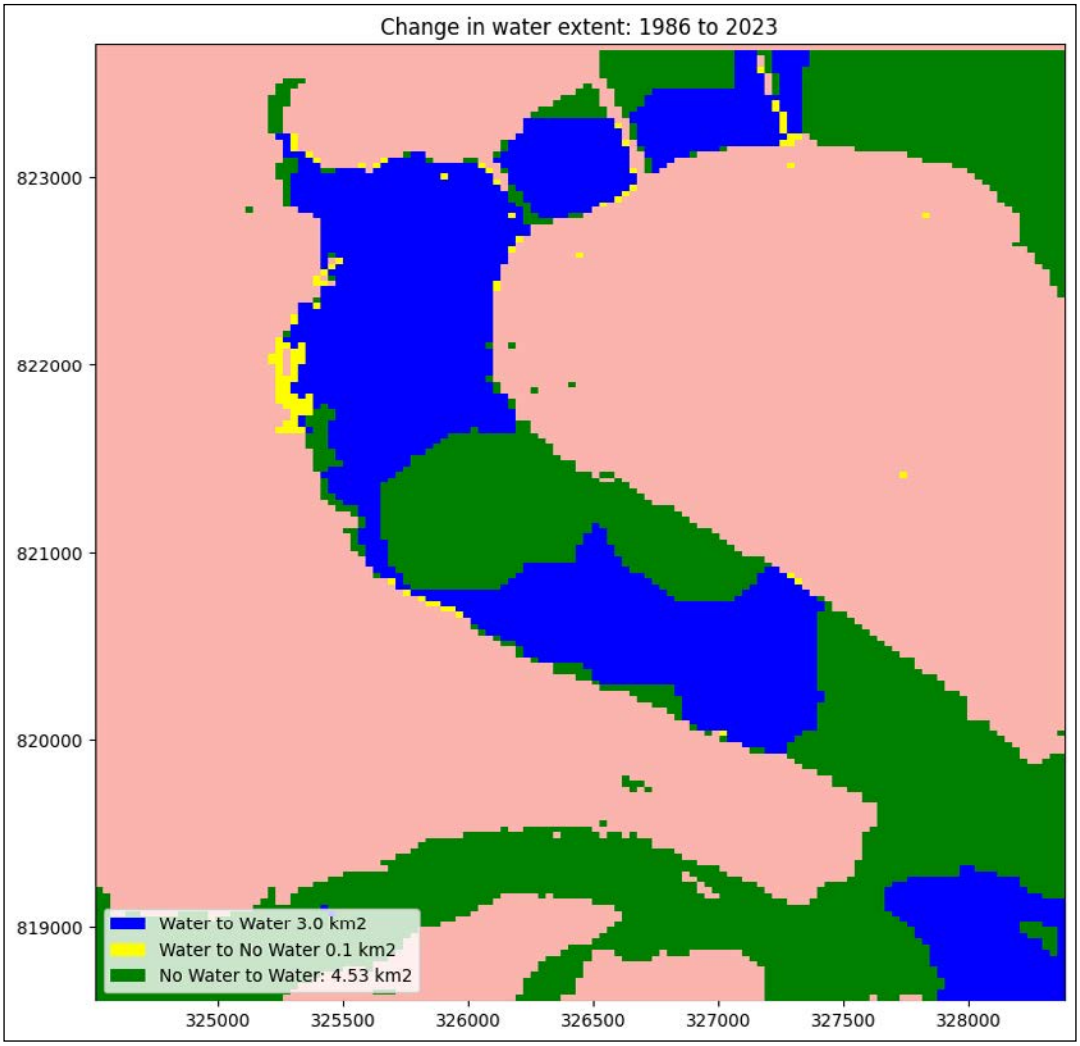


Figure 6: Change in water extent and inundation between the years 1986 and 20232

4.2. Determining seasonal extent of water bodies with Sentinel-2

The variation in seasonal water content can be observed from January 17, 2016, to December 1, 2023. Specifically, June 1, 2018, experienced the highest water inundation, while December 1, 2023, had the lowest water extent. The Modified Normalized Difference Water Index (MNDWI) seasonal time series indicates that the seasonal water area has varied over time. In 2018, the seasonal periods had the largest water area, indicating a significant presence of water (Figure 7). In contrast, the later seasonal periods of 2023 had the smallest water area, suggesting a decrease in water extent. These fluctuations in water areas may be linked to the occurrence of flooding, with 2018 experiencing higher levels of flooding compared to 2023. Figure 8 compares the years with the minimum and maximum water inundation (2023 and 2018, respectively).

In 2018, the study area was mostly covered with water, as indicated by the yellow areas. However, by 2023, these yellow areas had been replaced by land, suggesting that water had receded from these regions. On the other hand, the blue areas still contained water in 2023, meaning they had remained flooded over the years. These areas may have certain characteristics, such as natural depressions or poor drainage, that make them more prone to prolonged water presence. Interestingly, the green areas indicate flooded regions in 2023, even though they had no water presence in 2018. This suggests that new areas have become flooded over time, possibly due to changes in land use, climate patterns, or other factors. It would be worth investigating the reasons behind this new flooding to better understand the dynamics of water distribution in the study area.

The fact that the yellow areas are more extensive than the blue and green areas indicates a positive trend of water receding from certain regions (Figures 11, 12). This could be seen as a potential improvement in terms of flood mitigation or land management.

[2] The blue areas represent the areas where water was present in 1986 and still contain water in 2023. The yellow areas represent where there was presence of water in 1986 but do not contain water anymore in 2023. The green areas represent areas that has no water in 1986 but contains water now in 2023, these areas has been flooded over time. Increase in water extent has occurred in the North and towards the South of the study AOI.

The particular seasonal period with the highest water inundation occurred on June 1, 2018, while the seasonal period with the lowest water extent occurred on December 1, 2023 (Figure 10). Figure 12 shows more yellow areas, indicating that most of the regions covered by water in 2018 have now been replaced by land areas in 2023. The blue areas represent regions covered by water in 2018 that still contain water in 2023. The green areas represent flooded regions, as there was no water presence in those areas in 2018. The animated time series of the seasonal water extent is shown on the website created for this study: https://floodcheck.netlify.app.

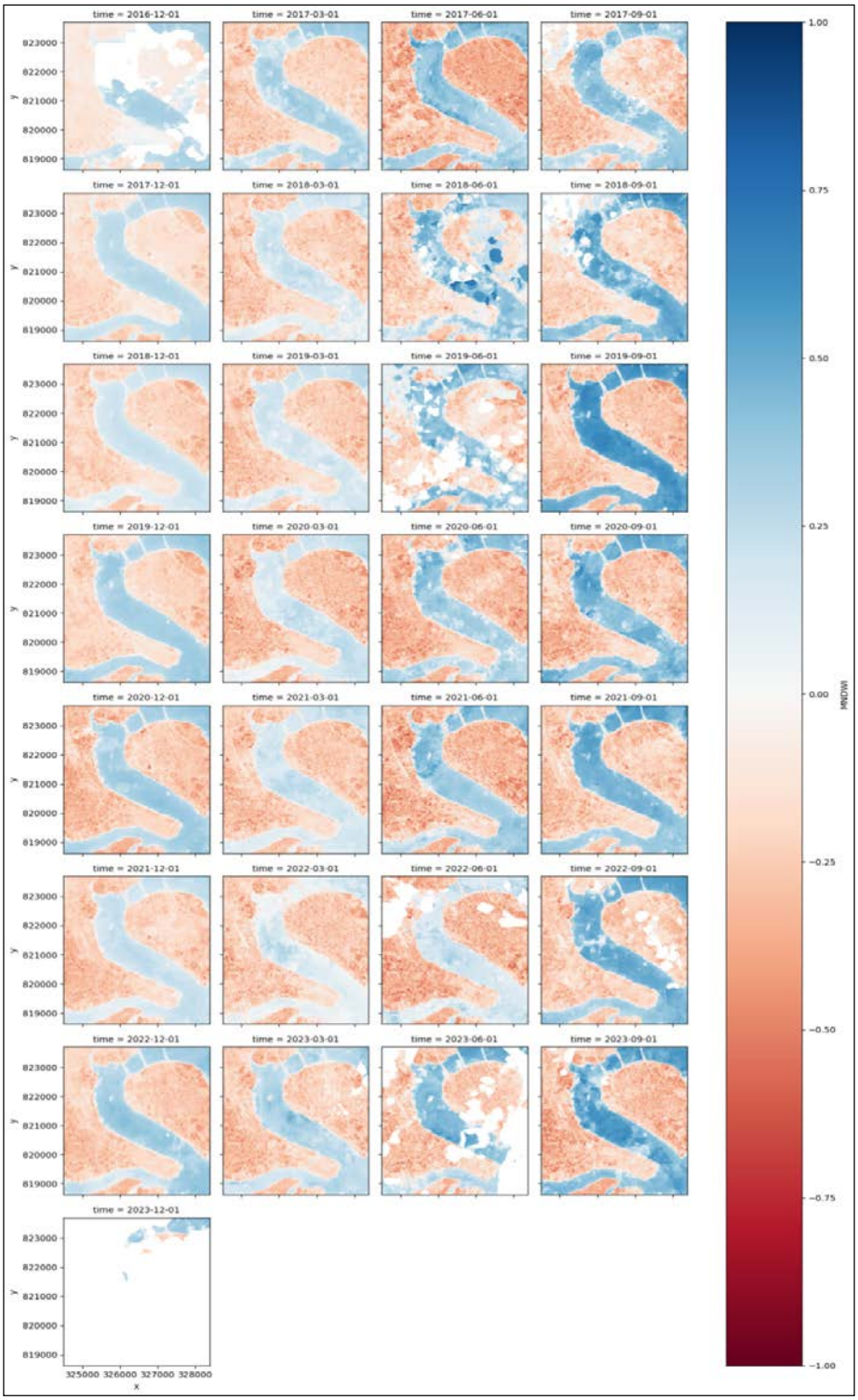


Figure 7: Modified Normalised Difference Water Index (MNDWI) Seasonal Time-series from December 2016 to December 20233

[3] The blue and slightly white colored areas represent the flooded areas while the reddish areas represent places that have not been flooded. Water inundation has occurred more during the 2018 seasonal periods compared to others.

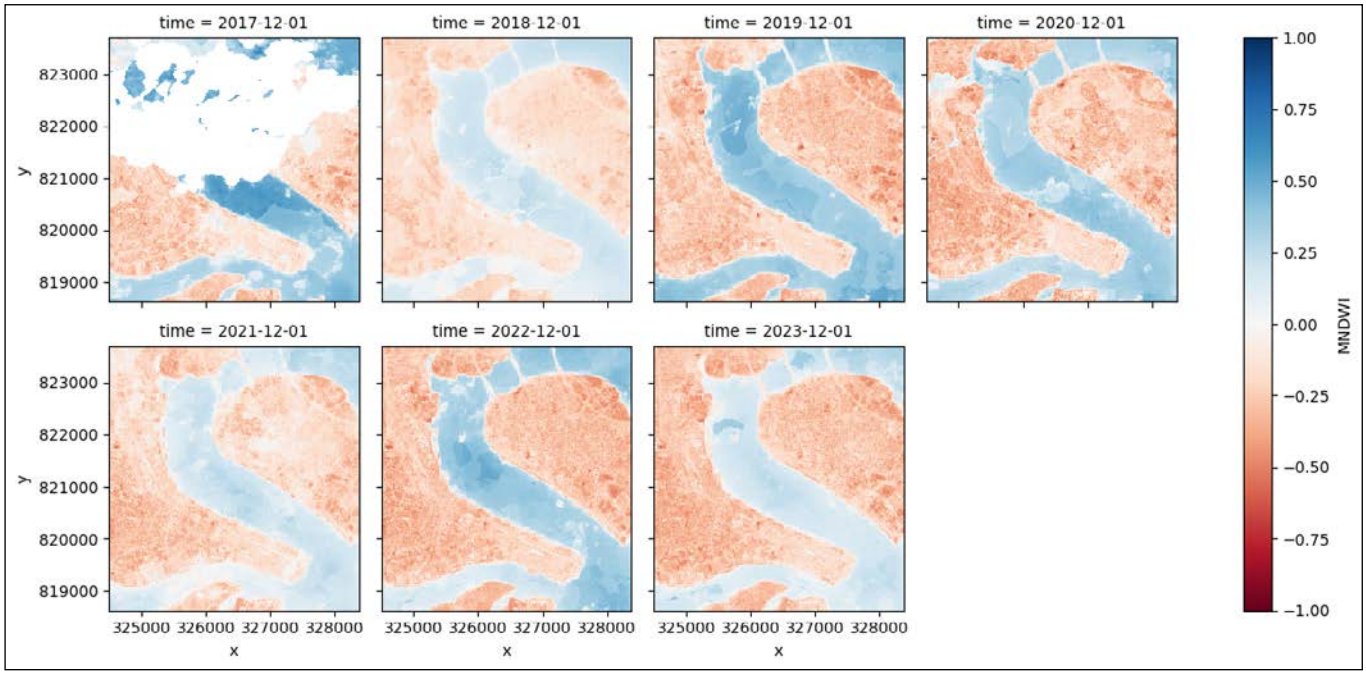


Figure 8: December's seasonal water extents from 2017 to 2023

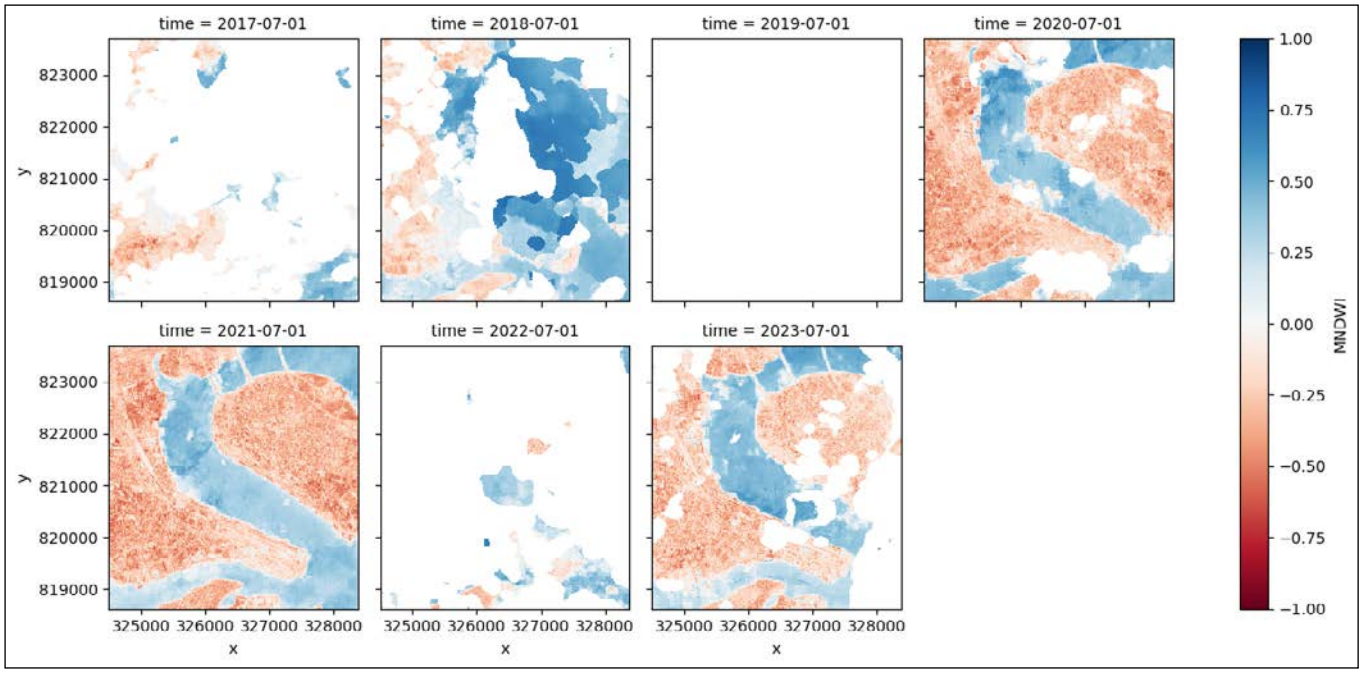


Figure 9: July's seasonal water extents from 2017 to 2023

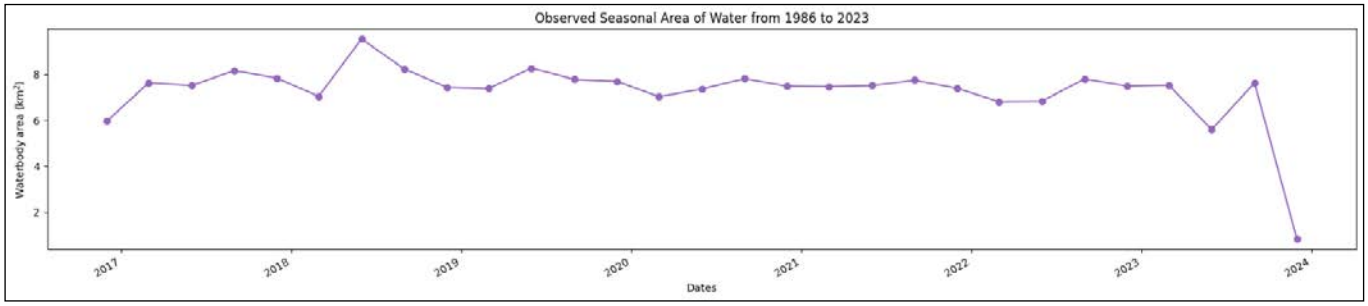


Figure 10: Plot showing observed seasonal area of water from 1986 to 2023. The year with the highest seasonal area of water is 2018, in contrast to 2023.

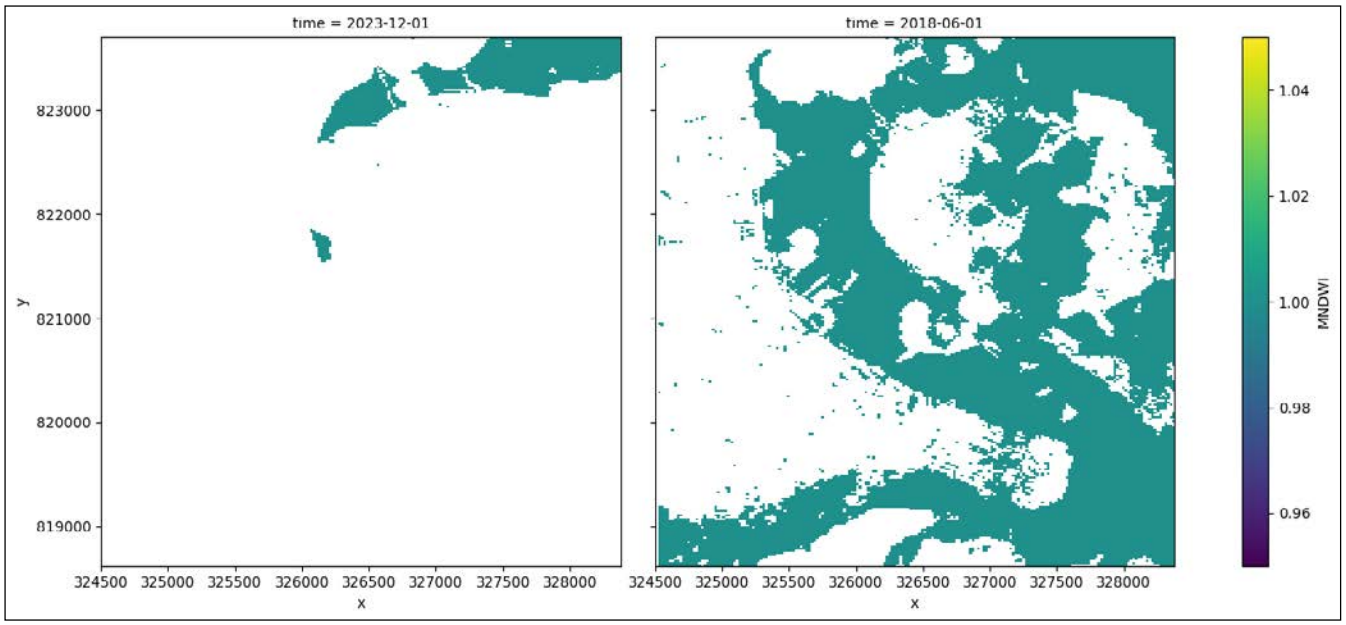


Figure 11: Plot water extent of MNDWI for the minimum and maximum seasonal periods. The year 2023 had the lowest MNDWI, while 2018 had the highest.

4.3. Enhancing Policy and Institutional Responses to Flooding as a Climate Change Threat in Lagos State, Nigeria.

Given that blocked drainage and improper waste management are non-climatic factors contributing to flooding in Lagos, reviewing the existing institutional framework could be beneficial for assessing the robustness of the current system in addressing the climate exacerbation of the problem. This section provides a review of the institutions related to climate change and waste management in Lagos, Nigeria.

4.3.1. OFFICE OF DRAINAGE SERVICES (ODS)

Lagos State Ministry of the Environment: The ODS is involved in dredging silted streams and drainage channels to combat flooding in Lagos State. Three drainage master plans were designed between 1974–1998, with Priority 1 works implemented. A total of 676,603.55 metric tons of silt were cleared from existing collector drains and canals in 2008 to improve hydraulic efficiency and carrying capacity. Between 2007–2011, 169 drainages were dredged and 124 lined with concrete, with 45 more expected to be lined by 2015. According to the Digital Earth Africa (DEA) analysis, the increasing number of water events (Figure 3) and the emergence of new flood-prone areas (Figure 6) underscore the growing difficulties the ODS is facing. While its efforts to line drains and dredge are commendable, our data from 1986 to 2023 show that flooding is becoming more frequent and intense, suggesting that these current approaches might not be sufficient to address the effects of climate change and rapid urbanisation.

Continuity from one government to another is especially important for sustaining the impacts of this institution. Canal networks across Lagos—such as the Macgregor, Achapo, and System 5 canals, among others (Filani, 2012)—need to be kept clear and properly dredged from time to time so that backed-up drains do not cause intractable flooding. This intervention is especially crucial with recent forecasts of above-average rainfall—partly attributable to climate change.

4.3.2. LAGOS STATE EMERGENCY MANAGEMENT AGENCY (LASEMA):

The Local Emergency Management Committee (LEMC) was established in 2014 under LASEMA, with 774 members from all wards, agencies, and community groups. The LEMC supports the Disaster Risk Reduction Convention of Kobe, Japan, by striving to reduce risk through knowledge, innovation, and education. The Agency's flood preparedness efforts focus on mapping risk and hazards, collaborating with agencies such as the Nigerian Meteorological Agency (NiMet), Lagos State Environmental Protection Agency (LASEPA), Ministry of Physical Planning and Urban Development (MPPUD), and others. For flood mitigation, early warning systems are activated to educate people on emergency response. Stockpiling of resources and the building of relief camps are used for flood response. Lastly, a survey of flood victims is conducted for recovery purposes. LASEMA's early warning systems and community-focused response efforts are critical, as evidenced by the rapid emergence of new flood-prone zones and the ongoing flooding in certain regions (shown by the blue areas in Figure 6). To address the

difficulties these areas face, prompt and targeted interventions are required.

All the foregoing activities are commendable. Specifically, bottom-up, community-based emergency response and interventions need to be promoted and prioritized for sustainable emergency management outcomes. Climate action that builds resilience, to a large extent, requires bottom-up, community-based solutions. Thus, following this approach to emergency response will help build the resilience of Lagos to climate change hazards while promoting sustainable emergency management.

4.3.3. LAGOS STATE WASTE MANAGEMENT AUTHORITY (LAWMA):

Population expansion not only leads to spatial growth but also results in the generation of waste, particularly municipal solid waste (MSW). In Lagos, approximately 10,000 tons of solid waste are generated daily, with a per capita generation rate of 0.65 kg/person/day. The rapid generation of MSW poses significant challenges to the financial and technical capacities of LAWMA in effectively managing waste in a sanitary manner. As a consequence, solid waste remains uncollected and is indiscriminately dumped in water bodies, air spaces of buildings, open lands, road verges, and public drains. The presence of littered waste becomes a permanent and unsightly feature of the urban landscape. As demonstrated by the DEA results, the overall increase in inundation and the continued presence of water in historically flooded areas (blue regions in Figure 6) suggest the effects of poor waste management.

Lagos is yet to fully resolve the problem of waste management, such as the indiscriminate dumping of waste in water bodies. Given the impact of waste in clogging drains—thereby exacerbating floods—and the release of greenhouse gases (GHGs) from dump sites (contributing to climate change), a systems approach involving a broad spectrum of stakeholders in a solution-curating exercise may be needed. Stakeholders should include not only government and private sector representatives but also researchers, community-based organizations (CBOs), non-governmental organizations (NGOs), consultants, and the general citizenry.

4.3.4. LAGOS STATE CLIMATE CHANGE ADAPTATION STRATEGY (LAS-CCAS)

The LAS-CCAS was developed to strengthen the proactive measures already undertaken by the State Government in tackling the issue of climate change. The ultimate goal of the programme is to reduce vulnerabilities, enhance resilience, and improve adaptive capacity to climate change in Lagos State. By doing so, it aims to mitigate the detrimental impacts that disproportionately affect marginalized groups such as the poor, elderly, women, children, and persons with disabilities (PWDs).

Our results highlight the necessity of flexible planning to adjust to the shifting patterns of flooding and point to areas with increasing risks. The strategy's objective of lowering vulnerabilities and enhancing resilience in the face of these difficulties is well aligned with these findings. Similar to the approach suggested for waste management, the efforts of LAS-CCAS may need to be opened up more to include the 'people' being planned for. Also, funding for research in this area will make it possible to generate solutions that are specific and appropriate to the Lagos context.

4.4. The Pursuit of Sustainable Solutions

To address the threats to life posed by climate-exacerbated flood risks, it is crucial for Lagos State to promote climate change mitigation, adaptation, and resilience-building activities (collectively known as climate action) across its development initiatives. In order to effectively combat climate change, measures that reduce greenhouse gas emissions—which cause global warming and sea level rise—are essential. Enforcing stronger energy-efficient regulations and improving waste management procedures are some important tactics. The state has taken commendable steps, such as instituting an annual International Climate Change Summit since 2010 and developing its second Lagos Climate Action Plan. However, there still seems to be a disconnect between development projects and sustainable outcomes in Lagos. Bolarinwa (2023), on one hand, and Solanke (2020) and ICIR (2022), on the other, provide insightful critiques of the political ecology and environmental impacts of projects such as Eko Atlantic City and the Dangote Refinery, respectively. In light of the challenges they identify, true climate action would require, for example, that the Eko Atlantic City project tangibly contribute to mitigating and adapting to climate change, particularly for the most vulnerable populations. Similarly, the Dangote Refinery should be operated in a manner that does not contribute to the increase in global temperatures, thereby exacerbating climate change.

Specifically with respect to flooding in Lagos, maintaining consistency in addressing the underlying factors is essential to achieving the desired outcome of significantly reducing flood incidents. The key word here is consistency. At the same time, it is important to tackle the specific causes of the various types of urban flooding. For example, regular clearing and desilting of drains, along with ensuring that waste does not enter the drainage systems, would help mitigate flooding caused by poor drainage. Additionally, enforcing a floodplain management plan to regulate land use, as well as encouraging the development of flood-resistant or floating structures around floodplains, could help manage floodplain inundation. Finally, adopting a multidimensional approach—integrating structural, policy-based, and community-level strategies—may be the most effective way to mitigate coastal flooding.

Pertinent to this paper are the following questions: How much environmental stewardship is incorporated into solving the city's problems and executing development projects? Taking into account that climate change exacerbates existing vulnerabilities, what would happen if current vulnerabilities (outside the influence of climate) increase? At the very least, it can be expected that climate change would worsen these increased vulnerabilities. Meanwhile, are development projects being executed solely as a reflection of humanity's dominance over nature? How should climate action be financed in the face of other important state spending priorities? How can a public–private–citizen partnership be developed to build a resilient city? How can the highlighted peculiarities of Lagos State be transformed into solutions for building a sustainable, climate-resilient city? Properly addressing these questions and revisiting the plans of ongoing projects may help the state in achieving its goals of a climate-resilient city.

5. CONCLUSION

In this paper, we utilized the Digital Earth Africa (DEA) Sandbox to evaluate the extent, vulnerability, and risk of coastal inundation in order to understand inundation characteristics in the growing megacity of Lagos, Nigeria, for urban planning and climate adaptation. Flood simulation of the study area between 1986 and 2023 reveals that some areas previously inundated with water were identified as land in 2023, suggesting that water has either receded from these regions or they have been sand-filled. Meanwhile, certain areas that were inundated prior to 2023 have remained consistently flooded. These regions may possess specific characteristics, such as natural depressions or poor drainage, making them more susceptible to prolonged water presence. Additionally, new areas have recently become flooded, possibly due to changes in land use, climate patterns, or other contributing factors. The implementation of the DEA Sandbox geospatial resources demonstrates the utility of this toolbox for environmental resource monitoring and urban planning. In the context of the rapidly developing Lagos Megacity, our findings underscore the importance of addressing flood-prone areas to support sustainable urban development.

Overall, the study reveals a significant increase in water occurrence and inundation over time, with 2020 recording the highest annual water presence and 2000 the lowest. Analysis of five case-study images spaced five years apart highlights a shift in water distribution patterns, indicating a possible trend of increasing flood events. Between 1988 and 2000, water extent was at its lowest, whereas from 2010 to 2023, a notable rise in water content was observed. A comparison of 1986 and 2022 further underscores the intensification of water inundation in recent years. Spatial analysis of water distribution from 1986 to 2023 shows consistent flooding in some areas, water recession in others, and the emergence of new flood-prone zones, likely due to changes in land use or climate conditions. Seasonal analysis using the Modified Normalized Difference Water Index (MNDWI) indicates June 1, 2018, as the period of highest water inundation, while December 1, 2023, recorded the lowest. These seasonal fluctuations reflect the complex dynamics of flooding in the study area, with 2018 standing out as a peak flood year. While some areas have shown improvement in flood mitigation, the emergence of new flood zones highlights the need for continuous monitoring and targeted interventions. Our results offer clear, evidence-based recommendations for policymakers and urban planners in Lagos. They highlight the escalating difficulties and the urgent need for a more proactive, data-driven approach to urban development. This strategy should include effective policy implementation, sustainable land use planning, and a drive for climate-resilient development.

To effectively address flooding in Lagos—especially as climate change worsens the situation—it is crucial to assess whether existing institutional frameworks are robust enough to manage both climatic and non-climatic drivers such as blocked drainage and poor waste management. The Office of Drainage Services has made significant infrastructural efforts, including dredging and concrete lining of drains, but maintaining continuity across administrations is key to long-term impact, especially given climate change projections of heavier rainfall. The Lagos State Emergency Management Agency (LASEMA) supports disaster risk reduction through early warning systems, hazard mapping, and community-level emergency response; however, enhancing community-based resilience strategies will better align with climate adaptation goals. The Lagos Waste Management Authority (LAWMA) faces mounting challenges from the rapid growth in solid waste, which clogs drains and worsens flooding, indicating a need for a systemic, multi-stakeholder approach that includes community participation. While the Lagos State Climate Change Adaptation Strategy (LAS-CCAS) outlines a solid framework for resilience, its effectiveness would be greatly improved by increasing public involvement and investing in localized research to ensure context-specific solutions.

Finally, to address the growing threat of climate-exacerbated flood risks in Lagos State, it is essential to integrate climate change mitigation, adaptation, and resilience—collectively known as climate action—into all aspects of development. While Lagos has made notable strides, such as hosting an annual International Climate Change Summit since 2010 and formulating a second Climate Action Plan, a strong connection between development projects and sustainable outcomes remains lacking. Regarding flooding, consistent and targeted interventions—such as clearing drains, preventing waste blockage, enforcing floodplain management, and exploring multidimensional solutions—are crucial for reducing flood incidences across the state.

6. DISCLOSURE

A version of this paper was presented at the 10th Summit of the Association of Lagos State Retired Heads of Service and Permanent Secretaries (ALARHOSPS).

7. ACKNOWLEDGEMENTS

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8. CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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10. APPENDIX

Mapping longer-term changes in water extent with Water Observation From Space (WOFS)

First Step: Load Packages

```
%matplotlib inline
# Force GeoPandas to use Shapely instead of PyGEOS
# In a future release, GeoPandas will switch to using Shapely by default.
import os
os.environ[‹USE_PYGEOS›] = ‹0›
import datacube
import numpy as np
import xarray as xr
import seaborn as sns
import geopandas as gpd
import matplotlib.pyplot as plt
from IPython.display import Image
from matplotlib.colors import ListedColormap
from matplotlib.patches import Patch
from datacube.utils.geometry import Geometry

from deafrica_tools.bandindices import calculate_indices
from deafrica_tools.plotting import display_map, xr_animation
from deafrica_tools.spatial import xr_rasterize
from deafrica_tools.areaofinterest import define_area
```

Second Step: Connect to Datacube

```
dc = datacube.Datacube(app=›water_extent›)
```

Third Step: Select Location

```
# Method 1: Specify the latitude, longitude, and buffer
aoi = define_area(lat=6.4499982, lon=3.3833318, buffer= 0.02)
#Create a geopolygon and geodataframe of the area of interest
geopolygon = Geometry(aoi[«features»][0][«geometry»],
crs=»epsg:4326»)
geopolygon_gdf = gpd.GeoDataFrame(geometry=[geopolygon],
crs=geopolygon.crs)
# Get the latitude and longitude range of the geopolygon
lat_range = (geopolygon_gdf.total_bounds[1], geopolygon_gdf.total_
bounds[3])
lon_range = (geopolygon_gdf.total_bounds[0], geopolygon_gdf.total_
bounds[2])
# Define the start year and end year
start_year = ‹1986›
end_year = ‹2023›
```

Fourth Step: Load WOFS annual summaries

```
#Create a query object
query = {
   ‹x›: lon_range,
   ‹y›: lat_range,
   ‹resolution›: (30 ,30-),
   ‹output_crs›:›EPSG:6933›,
   ‹time›: (start_year, end_year),
}

#load wofs
ds = dc.load(product=»wofs_ls_summary_annual»,
        **query)
print(ds)
```

Fifth Step: Clip datasets to the shape of the area of interest

```
#Rasterise the area of interest polygon
aoi_raster = xr_rasterize(gdf=geopolygon_gdf, da=ds, crs=ds.crs)
#Mask the dataset to the rasterised area of interest
ds = ds.where(aoi_raster == 1)
```

Sixth Step: Facet subset plot of the annual WOFS summaries

```
ds.isel(time=[5,10,15,20,25]).frequency.plot(col=›time›, col_wrap=5,
cmap=sns.color_palette(«mako_r», as_cmap=True));
```

Seventh Step: Animating time series

```
out_path = ‹annual_water_frequency.gif›

xr_animation(ds=ds,
        output_path=out_path,
        interval=400,
        bands=[‹frequency›],
        show_text=›WOfS Annual Summary›,
        show_date = ‹%Y›,
        width_pixels=300,
        annotation_kwargs={‹fontsize›: 15},
        imshow_kwargs={‹cmap›: sns.color_palette(«mako_r», as_
cmap=True), ‹vmin›: 0.0, ‹vmax›: 0.9},
        colorbar_kwargs={‹colors›: ‹black›},
        show_colorbar=False)

# Plot animated gif
plt.close()
Image(filename=out_path)
```

Eighth Step: Calculate the annual area of water extent

```
pixel_length = query[«resolution»][1]  # in metres
m_per_km = 1000  # conversion from metres to kilometres
area_per_pixel = pixel_length**2 / m_per_km**2
```

Ninth Step: Threshold WOFS annual frequency to classify water/not-water

```
water_threshold = 0.20

#threshold
water_extent = ds.frequency > water_threshold

#calculate area
ds_valid_water_area = water_extent.sum(dim=[‹x›, ‹y›]) * area_per_pixel
```

Tenth Step: Plot the annual area of Open water

```
plt.figure(figsize=(4 ,18))
ds_valid_water_area.plot(marker=›o›, color=›9467#bd›)
plt.title(f›Observed Annual Area of Water from {start_year} to {end_
year}›)
plt.xlabel(‹Dates›)
plt.ylabel(‹Waterbody area (km$^$2)›)
plt.tight_layout()
```

Eleventh Step: Determine minimum and maximum water extent

```
min_water_area_date, max_water_area_date =  min(ds_valid_water_area),
max(ds_valid_water_area)
time_xr = xr.DataArray([min_water_area_date.time.values, max_water_
area_date.time.values], dims=[«time»])

print(time_xr)
```

Twelfth Step: Plot the dates when the minimum and maximum water extent occur

```
water_extent.sel(time=time_xr).plot.imshow(col=»time», col_wrap=2,
figsize=(6 ,14));
```

Thirteenth Step: Compare two time periods

```
baseline_time = ‹1986›
analysis_time = ‹2021›

baseline_ds, analysis_ds = ds_valid_water_area.sel(time=baseline_time,
```

```
method =›nearest›), ds_valid_water_area.sel(time=analysis_time, method
=›nearest›)
```

Fourteenth Step: Plot water extent for the two chosen periods

```
compare = water_extent.sel(time=[baseline_ds.time.values, analysis_
ds.time.values])

compare.plot(col=»time»,col_wrap=2,figsize=(5 ,10), cmap=›viridis›,
add_colorbar=False);
```

Fifteenth Step: Calculate the change for the two nominated periods

```
analyse_total_value = compare.isel(time=1).astype(int)
change = analyse_total_value - compare.isel(time=0).astype(int)

water_appeared = change.where(change == 1)
permanent_water = change.where((change == 0) & (analyse_total_value
== 1))
permanent_land = change.where((change == 0) & (analyse_total_value
== 0))
water_disappeared = change.where(change == 1-)


total_area = analyse_total_value.count().values * area_per_pixel
water_apperaed_area = water_appeared.count().values * area_per_pixel
permanent_water_area = permanent_water.count().values * area_per_
pixel
water_disappeared_area = water_disappeared.count().values * area_per_
pixel
```

Sixteenth Step: Plot water variables to visualize result

```
water_appeared_color = «Green»
water_disappeared_color = «Yellow»
stable_color = «Blue»
land_color = «Brown»

fig, ax = plt.subplots(1 ,1, figsize=(10 ,10))

compare[1].plot.imshow(cmap=»Pastel1»,
                       add_colorbar=False,
                       add_labels=False,
                       ax=ax)
water_appeared.plot.imshow(
  cmap=ListedColormap([water_appeared_color]),
  add_colorbar=False,
  add_labels=False,
  ax=ax,
)
water_disappeared.plot.imshow(
  cmap=ListedColormap([water_disappeared_color]),
  add_colorbar=False,
  add_labels=False,
  ax=ax,
)
permanent_water.plot.imshow(cmap=ListedColormap([stable_color]),
                  add_colorbar=False,
                  add_labels=False,
                  ax=ax)

plt.legend(
  [
    Patch(facecolor=stable_color),
    Patch(facecolor=water_disappeared_color),
    Patch(facecolor=water_appeared_color),
    Patch(facecolor=land_color),
  ],
  [
    f»Water to Water {round(permanent_water_area, 2)} km2»,
    f»Water to No Water {round(water_disappeared_area, 2)} km2»,
    f»No Water to Water: {round(water_apperaed_area, 2)} km2»,
  ],
  loc=»lower left»,
)

plt.title(«Change in water extent: « + baseline_time + « to « + analysis_
time);
```

3.3.4.2. Determining seasonal extent of water bodies with Sentinel2-
First Step: Load packages

```
%matplotlib inline

# Force GeoPandas to use Shapely instead of PyGEOS
# In a future release, GeoPandas will switch to using Shapely by default.
import os
os.environ[‹USE_PYGEOS›] = ‹0›

import datacube
import matplotlib.pyplot as plt
import numpy as np
import xarray as xr
import geopandas as gpd
from IPython.display import Image
from matplotlib.colors import ListedColormap
from matplotlib.patches import Patch

from datacube.utils.geometry import Geometry
from deafrica_tools.datahandling import load_ard
from deafrica_tools.bandindices import calculate_indices
from deafrica_tools.plotting import display_map, xr_animation
from deafrica_tools.dask import create_local_dask_cluster
from deafrica_tools.spatial import xr_rasterize
from deafrica_tools.areaofinterest import define_area
```

Second Step: Connect to data cube

```
dc = datacube.Datacube(app=›water_extent›)
```

Third Step: Select Location

```
# Method 1: Specify the latitude, longitude, and buffer
aoi = define_area(lat=6.4499982, lon=3.3833318, buffer=0.02)

# Method 2: Use a polygon as a GeoJSON or Esri Shapefile.
# aoi = define_area(vector_path=›aoi.shp›)

#Create a geopolygon and geodataframe of the area of interest
geopolygon = Geometry(aoi[«features»][0][«geometry»],
crs=»epsg:4326»)
geopolygon_gdf = gpd.GeoDataFrame(geometry=[geopolygon],
crs=geopolygon.crs)

# Get the latitude and longitude range of the geopolygon
lat_range = (geopolygon_gdf.total_bounds[1], geopolygon_gdf.total_
bounds[3])
lon_range = (geopolygon_gdf.total_bounds[0], geopolygon_gdf.total_
bounds[2])


# Define the start year and end year
start_year = ‹1986›
end_year = ‹2023›
```

Fourth Step: View the area of Interest on an interactive map

```
display_map(lon_range, lat_range)
```

Fifth Step: Load cloud-masked satellite data

```
#Create a query object
query = {
   ‹x›: lon_range,
   ‹y›: lat_range,
   ‹resolution›: (20 ,20-),
   ‹output_crs›:›EPSG:6933›,
   ‹time›: (start_year, end_year),
   ‹dask_chunks›:{‹time›:1,›x›:500,›y›:500}
}

#load Sentinel 2 data
ds = load_ard(dc=dc,
        products=[‹s2_l2a›],
        measurements=[‹green›,›swir_1›],
        mask_filters=[(«opening», 3),(«dilation», 2)], #improve cloud
mask
        group_by=›solar_day›,
        **query)

print(ds)
```

Sixth Step: Clip the datasets to the shape of the area of interest

```
#Rasterise the area of interest polygon
aoi_raster = xr_rasterize(gdf=geopolygon_gdf, da=ds, crs=ds.crs)
#Mask the dataset to the rasterised area of interest
ds = ds.where(aoi_raster == 1)
```

Seventh Step: Calculate the MNDWI water index

```
# Calculate the chosen vegetation proxy index and add it to the loaded
data set
ds = calculate_indices(ds=ds, index=›MNDWI›, satellite_mission=›s2›,
drop=True)
```

Eighth Step: Resample time series

```
%%time
sample_frequency=»QS-DEC»  # quarterly starting in DEC, i.e. seasonal

#resample using medians
print(‹calculating MNDWI seasonal medians...›)
mndwi = ds[‹MNDWI›].resample(time=sample_frequency).median().
compute()
```

Nineth Step: Facet plot the MNDWI time-steps

```
mndwi.plot(col=›time›, col_wrap=4, cmap=›RdBu›, vmax=1, vmin=1-);
```

Tenth Step: Animating time series

```
out_path = ‹water_extent.gif›

xr_animation(ds=mndwi.to_dataset(name=›MNDWI›),
        output_path=out_path,
        bands = [‹MNDWI›],
        show_text = ‹Seasonal MNDWI›,
        interval=500,
        width_pixels=300,
        show_colorbar=True,
        imshow_kwargs={‹cmap›:›RdBu›,›vmin›: 0.5-, ‹vmax›: 0.5},
        colorbar_kwargs={‹colors›: ‹black›}
       )

# Plot animated gif
plt.close()
Image(filename=out_path)
```

Eleventh Step: Calculate the area per pixel

```
pixel_length = query[«resolution»][1]  # in metres
m_per_km = 1000  # conversion from metres to kilometres
area_per_pixel = pixel_length**2 / m_per_km**2
```

Twelfth Step: Calculating the extent of water

```
water = mndwi.where(mndwi > 0, np.nan)
area_ds = water.where(np.isnan(water),1)
ds_valid_water_area = area_ds.sum(dim=[‹x›, ‹y›]) * area_per_pixel
```

Thirteenth Step: Plot seasonal time series from the Start year to End year

```
plt.figure(figsize=(4 ,18))
ds_valid_water_area.plot(marker=›o›, color=›9467#bd›)
plt.title(f›Observed Seasonal Area of Water from {start_year} to {end_
year}›)
plt.xlabel(‹Dates›)
plt.ylabel(‹Waterbody area (km$^$2)›)
plt.tight_layout()
```

Fourteenth Step: Determine minimum and maximum water extent

```
min_water_area_date, max_water_area_date =  min(ds_valid_water_area),
max(ds_valid_water_area)
time_xr = xr.DataArray([min_water_area_date.time.values, max_water_
area_date.time.values], dims=[«time»])

print(time_xr)
```

Fifteenth Step: Plot the dates when the min and max water extent occur

```
area_ds.sel(time=time_xr).plot.imshow(col=»time», col_wrap=2,
figsize=(6 ,14))
```

Sixteenth Step: Compare two time periods

```
baseline_time = ‹1986›
analysis_time = ‹2023›

baseline_ds, analysis_ds = ds_valid_water_area.sel(time=baseline_time,
method =›nearest›), ds_valid_water_area.sel(time=analysis_time, method
=›nearest›)

time_xr = xr.DataArray([baseline_ds.time.values, analysis_ds.time.
values], dims=[«time»])
```

Seventeenth Step: Plot water extent of the MNDWI product for the two chosen periods

```
area_ds.sel(time=time_xr).plot(col=»time», col_wrap=2, robust=True,
figsize=(5 ,10), cmap=›viridis›, add_colorbar=False);
```

Eighteenth Step: Calculating the change for the two nominated periods

```
# The two period Extract the two periods(Baseline and analysis) dataset
from
ds_selected = area_ds.where(area_ds == 0 ,1).sel(time=time_xr)

analyse_total_value = ds_selected[1]
change = analyse_total_value - ds_selected[0]

water_appeared = change.where(change == 1)
permanent_water = change.where((change == 0) & (analyse_total_value
== 1))
permanent_land = change.where((change == 0) & (analyse_total_value
== 0))
water_disappeared = change.where(change == 1-)

total_area = analyse_total_value.count().values * area_per_pixel
water_apperaed_area = water_appeared.count().values * area_per_pixel
permanent_water_area = permanent_water.count().values * area_per_
pixel
water_disappeared_area = water_disappeared.count().values * area_per_
pixel
```

Nineteenth Step: Water variables are plotted to visualized the result

```
water_appeared_color = «Green»
water_disappeared_color = «Yellow»
stable_color = «Blue»
land_color = «Brown»

fig, ax = plt.subplots(1 ,1, figsize=(10 ,10))

ds_selected[1].plot.imshow(cmap=»Pastel1»,
                           add_colorbar=False,
                           add_labels=False,
                           ax=ax)
water_appeared.plot.imshow(
  cmap=ListedColormap([water_appeared_color]),
  add_colorbar=False,
  add_labels=False,
  ax=ax,
)
water_disappeared.plot.imshow(
  cmap=ListedColormap([water_disappeared_color]),
  add_colorbar=False,
  add_labels=False,
  ax=ax,
)
permanent_water.plot.imshow(cmap=ListedColormap([stable_color]),
                    add_colorbar=False,
                    add_labels=False,
                    ax=ax)

plt.legend(
  [
    Patch(facecolor=stable_color),
    Patch(facecolor=water_disappeared_color),
    Patch(facecolor=water_appeared_color),
    Patch(facecolor=land_color),
  ],
  [
    f»Water to Water {round(permanent_water_area, 2)} km2»,
    f»Water to No Water {round(water_disappeared_area, 2)} km2»,
    f»No Water to Water: {round(water_apperaed_area, 2)} km2»,
  ],
  loc=»lower left»,
)

plt.title(«Change in water extent: « + baseline_time + « to « + analysis_
time);
```

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LEVERAGING PUBLIC EMPLOYMENT PROGRAMMES FOR AN INCLUSIVE JUST TRANSITION: CONNECTING YOUTH TO THE GREEN ECONOMY THROUGH CITY-LED PARTNERSHIPS IN SOUTH AFRICA

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ABSTRACT

Public employment programmes (PEPs) are increasingly recognised as tools for advancing a just transition by addressing both unemployment and environmental sustainability. Youth unemployment remains a pressing challenge globally, and South Africa is no exception. Youth unemployment has increased from 36.8% in 2014 to 45.5% in 2024, a dynamic that has been exacerbated by climate change and socio-economic shocks such as the COVID-19 pandemic. The green economy offers potential for inclusive growth, and programmes like the Expanded Public Works Programme (EPWP) provide temporary jobs and training, creating opportunities to engage youth in green projects. Drawing on key stakeholder interviews and document analysis, this paper examines how South African cities are incorporating youth into EPWP green economy initiatives. It finds that despite policy momentum, cities face challenges in attracting and retaining youth in EPWP initiatives due to a lack of career development pathways, limited alignment with existing skills and unaccredited training opportunities. The paper argues that city-led partnerships with stakeholders in the green economy can improve training quality, build professional pathways and enhance the long-term impact of EPWP on youth employment and empowerment in a just transition context.

KEY WORDS Just transition, green economy, public employment programmes, EPWP, youth unemployment, city-led partnerships.

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1. INTRODUCTION

Climate change is one of the most pressing global challenges of the 21st century, with far-reaching implications for the environment, human wellbeing and economic systems. The intensification of climate-related events such as droughts, floods and heatwaves does not only exacerbated existing environmental vulnerabilities but also deepens structural inequalities, disproportionately affecting marginalised groups and communities (ILO, 2018;2023). The global south has been hardest hit by these intersecting challenges, exposing the urgent need for policies that not only reduce carbon emissions but also promote inclusive economic recovery and social protection.

In this context, the just transition has gained prominence as a critical framework for navigating the shift to low-carbon, climate-resilient and inclusive societies (Ward, 2018; Culwick Fatti, 2021). It foregrounds the imperative of ensuring that climate action is socially inclusive and economically equitable. A just transition is grounded in principles of equity, redistribution and participation, ensuring that those vulnerable to climate and economic shocks are not left behind in the shift to a low-carbon economy (Swilling et al., 2015; Bhorat et al., 2024; TIPS, 2025).

The green economy has emerged as a critical pathway for advancing the just transition, offering the promise of environmentally sustainable growth, improved resource efficiency and inclusive job creation. However, realising this potential is not without challenges. The shift towards greener industries may lead to job losses in carbon-intensive sectors, particularly in the global south, where unemployment remains high and social protection systems are often weak. Scholars argue that such trade-offs are indicative of shortcomings in policy planning, targeted investment and institutional coordination. For the green economy to serve as an inclusive driver of socio-economic transformation, it must be underpinned by comprehensive training systems and strong labour protections among other factors (Rosemberg, 2010; Hammer et al., 2016; ILO, 2023; 2024; Bhorat et al., 2024; Njokwe et al., 2025; TIPS, 2025). These elements are essential to ensuring that marginalised groups, especially youth, are equipped with the skills and support needed to participate meaningfully in emerging green sectors.

The South African youth unemployment figures were substantially high even before the COVID-19 pandemic, rising from 58.1% in Q4 of 2019 to 63.2% in Q4 of 2020 for the 15-24 age group. For individuals aged 25-34 years, unemployment increased from 35.6% to 41.2% during the same period (Stats SA, 2019; 2020). By Q4 of 2024, these rates decreased slightly to 59.6% and 39.4%, respectively (Stats SA, 2025). The global youth unemployment rate was 12% and 8.9% for Sub-Saharan Africa in 2024 (IOL, 2025), both well below the South African unemployment rate, which was recently recorded at 45.5% for ages 15- 34 (StatsSA, 2025). Several key structural factors are driving this crisis, including an outdated education system, rapidly evolving demands of the labour market, an increasing number of youth not in employment, education, or training (NEET), delayed labour market entry, entry into lower-quality jobs and prolonged or repeated spells of unemployment or inactivity (De Lannoy et al., 2018; ILO, 2018; 2022; Webb, 2021; Dawson, 2022).

Public employment programmes (PEPs) are increasingly recognised as tools for advancing a just transition and offering a practical mechanism to accelerate youth employment in the green economy. While existing literature acknowledges the potential of PEPs to address unemployment and climate adaptation (Rosemberg, 2010; ILO, 2018), gaps persist in understanding how cities of the global south are translating this into tangible results. This paper draws on desktop research and key stakeholder interviews to examine how seven metropolitan cities in South Africa are utilising the Expanded Public Works Programme (EPWP) to support an inclusive just transition by leveraging green economy initiatives to generate employment and skilling opportunities for the youth.

The key objectives of the paper are to assess the implementation of EPWP projects in South African cities and their integration with youth needs to create green job opportunities; identify the systemic barriers that hinder youth participation in city-led green projects; analyse the role of multi-stakeholder partnerships in delivering PEP initiatives and highlight existing opportunities within the green economy that South African cities, as well as other cities elsewhere, can leverage to enhance youth participation in PEPs while prioritising meaningful work opportunities, skills development, clear exit pathways and support mechanisms.

Following the introduction, the paper is organised into six sections. Section two outlines the research methods employed to collect and analyse the data. Section three presents a literature review that examines the intersection of youth unemployment, the green economy and PEPs to achieve an inclusive, just transition. Section four provides an overview of the South African just transition policy landscape. Section five examines the experiences of seven South African cities in implementing green economy projects, with specific attention to the extent of youth participation and inclusion in these initiatives. It also links EPWP projects to existing initiatives and identifies key actors within the green economy that cities can leverage and collaborate with to advance inclusive employment and training opportunities for youth. Section six presents the paper's conclusions and offers policy recommendations for strengthening the EPWP and broader PEPs as tools for a just and inclusive green transition.

2. RESEARCH METHODS

This paper draws on findings from a broader research project commissioned by the South African Cities Network (SACN) in 2022 that explored ways in which the EPWP can be leveraged to empower the future workforce in South African cities, with a specific focus on youth and persons with disabilities in the digital and green economies. The study employed a mixed-methods approach comprising desktop research and semi-structured interviews with key stakeholders. Desktop research was used to gather and synthesise data from government reports, policy documents, academic literature and relevant organisational material. This method allowed for the identification of key actors providing training and employment opportunities in the green economy, mapping of youth participation in EPWP green economy initiatives and the analysis of national and international best practice case studies that have successfully facilitated youth participation in PEPs.

A range of EPWP documents, including business plans, implementation reports and internal assessments, were also analysed to gain insights into how the programme is operationalised across different cities in South Africa. In addition, international institutional sources, including the International Labour Organisation (ILO), United Nations Environment Programme (UNEP) and United Nations Development Programme (UNDP), were analysed to provide a credible foundation for the study and to contextualise global developments in green economy and PEPs initiatives. This was complemented by official statistics from Statistics South Africa (StatsSA), which were used to support evidence-based analysis of youth unemployment trends. Additionally, academic literature and policy reports were incorporated to enrich the analysis and ensure a comprehensive understanding of both global and local dynamics.

Semi-structured interviews were conducted between May and June 2022 with EPWP officials in seven[1] South African cities with functioning EPWP units. The objectives of these interviews were to understand cities' experiences with implementing public employment projects, capacity building, opportunities and challenges with implementing green economy projects, and identifying stakeholders in the green economy space that can act as potential collaborators. In addition, stakeholders from national government departments such as the Department of Public Works and Infrastructure (DPWI), Department of Forestry, Fisheries and the Environment (DFFE), Department of Science and Innovation (DSI) and The Presidency were also interviewed. Interviews also included other actors such as the National Youth Development Agency (NYDA) and the ILO. The interviews provided valuable insights into current PEP green economy projects implemented by cities in South Africa and internationally, the types of training and work opportunities available to youth and the partnerships and resources mobilised to support inclusive programme delivery. This mixed-methods approach enabled a nuanced understanding of the challenges and opportunities related to youth participation in the green economy through PEP initiatives.

The interview transcripts and key documents were coded into thematic areas to identify recurring patterns that aligned with the research objectives. This thematic coding ensured that the data could be interpreted according to each research objective, thereby assisting in drawing out implications for the study.

[1] Interviews were conducted with the officials from City of Johannesburg, City of Ekurhuleni, eThekwini, Buffalo City, Nelson Mandela Bay and City of Cape Town metropolitan municipalities and Msunduzi municipality.

3. ADDRESSING YOUTH UNEMPLOYMENT THROUGH PEPS TO ACHIEVE AN INCLUSIVE, JUST TRANSITION IN THE GREEN ECONOMY

As the global climate crisis intensifies, there is growing recognition that responses must go beyond environmental sustainability to address deepening socio-economic inequalities (Swilling et al., 2015; Ward, 2018; Culwick Fatti, 2021; TIPS, 2025). The intersecting literature on youth unemployment, just transition, green economy and PEPs offers a multidimensional approach to respond to ecological breakdown and socio-economic precarity. This literature shapes emerging discourses around inclusive and equitable development in the context of the just transition, particularly in highly unequal societies such as South Africa.

3.1. Youth unemployment

Global trends reveal that youth unemployment rates remain disproportionately high compared to the adult working age group. A significant portion of youth are classified as NEET, reflecting systemic barriers to labour market entry. Furthermore, gender disparities persist, with 28.2% of young women falling into the NEET category compared to just 13.1% of young men (IOL, 2025). In sub-Saharan Africa, the main concern is not just the chronically high youth unemployment rates but the prevalence of precarious work among all working-age groups of working age. According to the ILO (2023), most of the working-age population is largely trapped in informal or insecure employment, earning well below the median wage.

In South Africa, youth remain systematically marginalised and vulnerable to various socio-economic challenges at both macro and micro levels (De Lannoy et al., 2018). This exclusion can be traced back to the apartheid era, and the post-democratic government has struggled to meaningfully address it (Arora et al.,

2006; Public Servants Association, 2024; Mutsila, 2025). Meaningful economic growth path demands higher-level skill sets at a pace that the education sector has not been able to match. This has resulted in a mismatch between the skills required in the labour market and those possessed by youth. Compounding this issue are high rates of school dropouts before matriculating, poor quality basic education and insufficient development of basic literacy and numeracy skills, with a profound impact on labour market participation.

According to StatsSA (2025), youth unemployment has increased from 36.8% in 2014 to 45.5% in 2024 (Stats SA, 2025). A strong correlation between educational attainment and unemployment is notable, as the statistics show that unemployment is highest for youth without a matric (42.6%) and lowest for those with a graduate degree (3.1%) (StatsSA, 2025). However, in recent years, graduates are also finding it harder to secure employment. This reflects a further fracturing of existing structural challenges, such as shrinking labour absorption rates, an oversaturated labour market and other systemic barriers such as low skill sets and high NEET rates. This calls for transformative interventions, a coordinated multi-stakeholder approach while simultaneously enhancing access to good quality education, expanding vocational training and stimulating labour-intensive sectors (De Lannoy et al., 2018)

3.2. The just transition and the green economy as an avenue for job creation

The just transition agenda has gained increasing global relevance since the early 2000s, particularly as the urgency to combat climate change has intensified (Swilling et al., 2015; Ward, 2018). The COVID-19 pandemic and climate-induced disasters have compounded existing vulnerabilities, particularly in cities of the global south. These disruptions highlight the need for a just transition that goes beyond decarbonisation to incorporate inclusive economic recovery and social protection.

The just transition refers to the move away from fossil fuel dependence to more sustainable energy and production models, guided by principles of equity and redistribution (Culwick Fatti, 2021; Bhorat et al., 2024; TIPS, 2025). Scholars argue that environmental degradation tends to exacerbate poverty, inequality and unemployment, especially in already marginalised contexts. Therefore, climate policies must be “job literate” (Rosemberg, 2010: 129), anticipating and addressing the employment and social impacts of environmental reforms, particularly in fossil-dependent economies where the risk of exclusion and injustice is high (Swilling et al., 2015; Ward, 2018; Montmasson-Clair, 2019; TIPS, 2025).

The agenda advocates for the inclusion of workers and communities that are most at risk from the green transition (UNDP, 2018; ILO, 2023; 2024; TIPS, 2025). This involves creating decent green jobs, reskilling and upskilling the workforce and ensuring access to social protection. In countries with high unemployment and economic inequality, these measures are especially critical.

The green economy has gained attention as a high growth sector and a strategic pathway towards achieving the just transition (COSATU, 2011; Ge and Zhi, 2016; Bakhshi et al., 2017; ILO, 2018; 2023; 2024; Dladla, 2020; Harambee, 2025; Njokwe et al., 2025; TIPS, 2025). ILO (2023) defines the green economy as employment opportunities that contribute to environmental preservation or restoration, spanning both conventional sectors such as manufacturing and construction, as well as newer industries like renewable energy and energy efficiency.

Despite its promise, the green economy is not without contestation, particularly regarding its employment implications. Research points to a duality where green job creation can be accompanied by job displacement in carbon-intensive sectors (Martinez-Fernandez et al., 2010; Ge and Zhi, 2016; Ward, 2018; ILO, 2023; 2024). These concerns raise the question of whether the green economy inherently promotes the just transition or simply shifts economic costs onto vulnerable workers and communities.

The shift towards low-carbon economies demands a significant transformation of skills ecosystems to prepare workers, particularly marginalised groups, for emerging opportunities. Targeted investment in skills development is critical for enabling equitable access to current and future green jobs (Hammer et al., 2016; Bakhshi et al., 2017; ILO, 2018; 2023; 2024; UNDP, 2018; Strietska-Ilina et al., 2021; Essa and Philip, 2024; UNEP, 2025; TIPS, 2025). This includes vocational training, technical education and lifelong learning frameworks that reflect the dynamic demands of green sectors. Furthermore, responsive curricula and supportive policy environments can enhance participation in green skills programs. The ILO (2018: unpaginated) calls for “anticipatory skills strategies” that align training supply with current and future industry demands, particularly in sectors such as renewable energy, sustainable agriculture, waste management and green construction.

3.3. Using PEPs to achieve an inclusive just transition in the green economy

PEPs are increasingly recognised as tools to address unemployment and foster an inclusive just transition by integrating ecological restoration, community-based adaptation and green development. International agencies such as the ILO, UNEP and UNDP note that when well-designed, these programmes can facilitate structural change by creating green jobs, building community assets and supporting skills development. PEPs can offer state-led mechanism to generate employment while addressing climate change impacts through direct, often short-term employment and social protection to marginalised groups (McCord, 2012;

ILO, 2018; Dladla, 2020; SACN, 2022a; 2022b).

However, PEPs are seldom designed with climate objectives at their core, and national climate strategies often overlook the valuable role these programmes can play in supporting mitigation, adaptation and environmental conservation (Essa and Philip, 2024). When strategically coordinated, PEPs can be scaled up to align with climate priorities, enhance the effectiveness of climate action while simultaneously promoting social inclusion and protecting vulnerable communities.

PEPs have the potential to provide state-supported, purposeful job opportunities in communities experiencing wider socio-economic consequences of employment declines linked to the just transition (Essa and Philip, 2024). These initiatives can be designed to match the existing skills of the unemployed and those who have lost their jobs, helping to cushion both income disruption and the social and emotional strain associated with joblessness and insecurity.

Beyond South Africa, a range of PEPs have been implemented, each shaped by distinct national priorities, socio-economic contexts and institutional capacities. These models provide valuable insights that can inform South African initiatives. Examples of such initiatives include India's Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), Rwanda's Vision 2020 *Umurenge* Programme (VUP) and Brazil's *Bolsa Verde* (Green Grant) programme.

Both India's MGNREGA and Rwanda's VUP incorporate green components, yet they differ significantly in scope and design. MGNREGA guarantees 100 days of unskilled manual labour per rural household annually, and while not originally a climate-focused initiative, it has increasingly supported ecologically beneficial activities such as drought proofing, water conservation and land regeneration (Reddy, Reddy and Bantilan, 2014; Das, 2016). It specifically targets marginalised groups, including women and scheduled castes and tribes, and some states have started integrating skills development.

In contrast, Rwanda's VUP is more holistically embedded in the country's climate and development strategies, targeting the poorest households with public works projects that explicitly support climate resilience (Williams et al., 2020). It incorporates gender considerations and pays attention to the working conditions of participants, recognising that the just transition must go beyond job creation to address the quality and inclusivity of work. Unlike MGNREGA, VUP includes pathways for graduation from poverty through cash transfers and vocational training, offering participants skills for a competitive edge post-programme (Gahamanyi and Kettlewell, 2015).

Bolsa Verde in Brazil, while not a PEP in the traditional sense, offers a model that links social protection to environmental conservation through conditional cash transfers (Oxfam, 2020). It specifically targets rural communities living in environmentally sensitive areas and ties financial support to natural resources preservation. It differs from MGNREGA and VUP in that it does not involve direct employment or labour-based service provision but instead relies on incentivising environmental stewardship among vulnerable populations.

Despite their successes, these PEPs and others face several implementation challenges that limit their effectiveness in achieving the just transition. These include short-term funding cycles, limited integration with national green strategies, offering insufficient skills development or economic mobility, focusing on unskilled manual labour, corruption and political instability (McCord, 2012; Reddy, Reddy and Bantilan, 2014; Gahamanyi and Kettlewell, 2015; Das, 2016; Oxfam, 2020; Williams et al., 2020). Moreover, the lack of gender-sensitive and youth-responsive design in some of these programmes risks deepening labour market exclusions. To address these challenges, some authors recommend the restructuring of PEPs from temporary safety nets into long-term platforms that support sustainable livelihoods and the development of green skills (McCord, 2012; ILO, 2021).

4. SOUTH AFRICA'S JUST TRANSITION POLICY LANDSCAPE

Since the early 2000s, South Africa has made important strides in developing laws and policies to support the just transition and green economy (see table 1 in Appendix). Despite this progress, a key limitation persists, which is the absence of a unified regulatory framework that consolidates the various dimensions of green economic development. Instead, a fragmented policy environment, comprising over 30 discrete policies, strategies, Acts and frameworks, has evolved over the past decade (Swilling et al., 2015; PAGE, 2017; Ward, 2018; DEFF, DTI&C and DSI, 2020; RSA, 2020; PCC, 2022; RSA, 2024; Department of Mineral Resources and Energy, 2025). This has impeded the emergence of a coherent green economy agenda (ILO, 2018), thereby limiting the potential for integrated, scalable PEPs at the city level.

Nonetheless, from the mid-2000s onward, South Africa's energy and industrial policy began to reflect a shift towards more sustainable development priorities. The introduction of instruments such as the Green Economy Inventory and Green Skills Frameworks from 2015 signalled the growing need to align workforce development with green transition imperatives. Given the country's dependence on natural resources, industrial policy - particularly through successive Industrial Policy Action Plans (IPAPs) - has been instrumental in steering industry towards sustainability and promoting the green economy agenda. These plans have promoted renewable energy, resource efficiency and circular economy principles. However, these efforts remain largely siloed and sector-specific, lacking integration into a cohesive national

or subnational economic strategy. A persistent contradiction is evident in the ongoing policy and financial support for fossil fuels, even as renewable energy receives increased attention (DEFF, DTI&C, DSI, 2020).

The Environmental Sector Skills Plan (ESSP), first introduced in 2010 and updated in 2020, provides a more direct entry point for localised, employment-driven interventions that cities can undertake. The plan specifically highlights the potential of the Environmental and Culture Sector within the EPWP. It puts forward three key recommendations relevant to city-led public employment schemes: 1) establish clear pathways from short-term public employment to sustainable formal employment; 2) align structured training with National Qualifications Framework (NQF) levels and 3) tailor skilling programmes to emerging green economy demands.

In the early 2020s, policy momentum shifted toward embedding justice and equity in the decarbonisation process. This shift was formally captured in the National Development Plan (NPC, 2012) and institutionalised through the establishment of the Presidential Climate Commission (PCC). South Africa emerged as one of the first countries to secure international commitments under the Just Energy Transition (JET) initiative. The JET Framework and accompanying Investment Plan offer a strategic basis for prioritising inclusive, climate-resilient investments, many of which have direct implications for city-level PEPs, particularly in areas such as local infrastructure, energy services and urban environmental management.

Recent legislative developments through the Climate Change Act (2024) (PCC, 2022) and the South African Renewable Energy Masterplan (SAREM), have further solidified the policy environment. The Climate Change Act introduces enforceable national climate targets, institutional accountability and legal grounding for the just transition. Meanwhile, SAREM lays out a comprehensive industrial and skills development roadmap for renewable energy, positioning South Africa as a regional energy hub and potential manufacturer of clean technologies.

In this evolving policy landscape, cities are uniquely positioned to operationalise the green transition at the grassroots level. Key opportunities lie in leveraging EPWP frameworks to establish structured pathways into green employment, particularly through partnerships with local training institutions and private sector stakeholders. Aligning local skills development initiatives with national frameworks such as the ESSP and SAREM can promote coherence and support long-term employability. There is also potential to pilot just transition job creation initiatives in vulnerable communities, integrated with municipal climate adaptation and infrastructure plans. Additionally, cities can attract investment through the JET Investment Plan to scale up nature-based solutions, urban greening and decentralised energy projects, sectors well-suited to labour-intensive public employment. Additionally, collaboration with national agencies and international donors can support the design of inclusive programmes that simultaneously enhance urban resilience, reduce unemployment and address skills mismatches. By aligning with evolving policy priorities and leveraging national instruments, cities can serve as critical platforms for delivering equitable, employment-intensive components of South Africa's just transition.

5. SOUTH AFRICAN CITIES' EXPERIENCES OF IMPLEMENTING YOUTH-FOCUSED EPWP GREEN ECONOMY PROJECTS

5.1. EPWP

The South African EPWP is a PEP designed to offer short-term work and training opportunities for unemployed individuals, targeting women, youth and persons with disabilities (DPWI, 2009; Dladla, 2020; SACN, 2022a; 2022b). Introduced in 2004, the programme operates across four main sectors, namely, infrastructure, environment and culture, social and non-state. The EPWP was intended to tackle unemployment by encouraging community-driven public works and promoting labour-intensive public spending. The programme also focuses on skills development and the delivery of essential public assets and services (DPWI, 2009; SACN, 2022a).

Over time, the EPWP has expanded the number of participants and improved the programme outcomes. The first phase (2004-2009) targeted the creation of one million work opportunities across the four sectors, with employment equity goals of 40% women, 30% youth and 2% persons with disabilities (DPWI, 2009). Outcomes of the programme were assessed based on whether participants exited the programme into employment, further education or training or self-employment. The second phase (2009–2014) set a goal of 4.5 million work opportunities and maintained the same demographic targets. At the end of this phase, over 4 million work opportunities were created and participants' average annual earnings were increased (DPWI, 2019).

In the third phase (2014–2019), targets for women were adjusted to 55%, 45% youth and 2% persons with disabilities. By the end of the phase, approximately 3.75 million work opportunities had been delivered against an initial benchmark of one million, representing 75% of the overall goal for the designated groups (DPWI, 2019). The fourth phase (2019–2024) raised the women participation target to 60%, while maintaining the youth and PWD targets (DPWI, 2019; SACN, 2022a).

Despite its notable achievements in providing short-term employment and tackling poverty, EPWP continues to face several structural and operational challenges. One persistent issue is the limited availability of accredited training, which undermines the programme's capacity to facilitate skills development and improve labour market outcomes.

This concern is echoed in the literature on PEPs, indicating that without meaningful investment in accredited training pathways, PEPs are unlikely to contribute substantially to long-term employment prospects (McCord, 2012; Reddy et al., 2014; Gahamanyi and Kettlewell, 2015; Das, 2016; Dladla, 2020; WIliams et al., 2020; Essa and Phillip, 2024). Financial constraints at the municipal level further restrict the ability to integrate such training, resulting in limited human capital accumulation among participants.

In addition to training limitations, underperformance in meeting key demographic targets, particularly those related to youth, and under-expenditure of allocated budgets have been recurrent concerns (DPWI, 2019; SACN, 2022a). These shortcomings reflect broader governance and implementation challenges that have long been noted in the PEPs literature. McCord (2012) observes that fragmented coordination, capacity limitations at the local government level and inadequate monitoring systems often inhibit effective delivery and impact of programmes.

The above challenges were further compounded by the outbreak of the COVID-19 pandemic in 2020. As documented by the SACN (2022a; 2022b), several EPWP projects were suspended or delayed as resources and personnel were redirected toward pandemic-related public health functions. In sectors such as infrastructure, activities halted during the national lockdown in March 2020, resulting in a significant loss of income for participants. The pandemic not only exposed the fragility of the EPWP's implementation model but also reinforced the argument that PEPs must be better integrated with social protection systems to ensure continuity during emergencies (McCord, 2012; ILO, 2021; Essa and Phillip, 2024). Therefore, Phase IV (2019-2024) signalled a potential reorientation of the EPWP, placing greater emphasis on social protection and inclusion and exploring opportunities linked to emerging economic sectors such as the green economy, with a particular focus on enhancing youth participation (DPWI, 2019).

5.2. Youth participation in EPWP green economy projects

South African cities are implementing several green economy projects through the EPWP. The EPWP Phase IV (2019-2024) prioritised several project typologies compatible with the green economy, such as sustainable land-based livelihoods, coastal management, waste management, parks and beautification and sustainable energy (SACN, 2022a; 2022b).

Phase IV of the programme set a youth participation target of 45%, and while many South African cities have reportedly met this benchmark, others continue to face significant challenges in attracting and retaining youth participants (DPWI, 2019; SACN, 2022a; 2022b). This difficulty is especially pronounced in green economy initiatives, which, despite their growing relevance, have struggled to appeal to youth. National department reviews and City assessments consistently highlight the lack of youth uptake as a critical barrier to the success of green-focused initiatives (SACN, 2022b; DPWI, 2019).

Interviews with key stakeholders, including EPWP officials, national departments, international organisations and youth development entities, echo these concerns, attributing the low participation rates to several factors. A primary issue is the limited and often reductive conceptualisation of the green economy among programme implementers. For many officials, green economy work is narrowly understood as involving the maintenance of parks, urban farming, the removal of alien vegetation, and the cleaning and general upkeep of public spaces. This framing reinforces a perception of green economy work as low-skilled, routine and primarily aesthetic, rather than as a strategic component of a broader economic transition or sustainable urban development pathway.

5.2.1. NATURE OF JOB OPPORTUNITIES

Although youth are identified as a key target group within the EPWP, attracting them to green economy initiatives remains a persistent challenge. One of the central issues lies in the nature of the employment opportunities offered. These roles are often short-term, low-paying and characterised by manual labour in environments perceived as physically demanding and lacking professional prestige. As one official explained, "the youth associate green economy projects with dirt and unfavourable working conditions with limited prospects for professionalisation" (EPWP official 2, personal communication, May 10, 2022). This perception is not unique to EPWP, but other studies elsewhere have shown that for young people, employment attractiveness is linked not only to immediate income but also to the perceived potential for skills development, upward mobility and long-term career advancement (Webb, 2021; Dawson, 2022; Essa and Phillip, 2024). Consequently, initiatives that are considered menial fail to resonate with youth aspirations, contributing to low participation in green economy initiatives.

This reflects broader critiques of the EPWP's design, which has traditionally focused on short-term, labour-intensive employment without adequately embedding pathways for professionalisation or skills upgrading (DPWI, 2019; SACN, 2022a; 2022b). While the green economy presents a strategic opportunity for inclusive development and environmental sustainability, its implementation within the EPWP often fails to move beyond conventional public works modalities, such as cleaning, park maintenance or invasive plant removal, thus narrowing its appeal among the youth.

A further complicating factor is the widespread but often misplaced expectation that participation in EPWP projects may lead to permanent employment within municipalities.

Although the programme clearly communicates its temporary nature, several instances of EPWP participants being absorbed into permanent roles have contributed to the belief that such transitions are common or likely. As one official stated, "we've seen participants on EPWP move from general workers to being fully absorbed as permanent employees in the city" (EPWP official 6, personal communication, May 4, 2022). These expectations create a potential source of disillusionment and undermine the programme's credibility over time, particularly for youth desperate for long-term opportunities.

Moreover, the prevailing framing of public employment as unskilled work limits the programme's capacity to respond to South Africa's structural unemployment crisis, particularly among youth. Integrating more skilled roles into programme design could enhance the relevance and quality of outcomes, both in terms of service delivery and individual career development (Essa and Phillip, 2024). As noted in literature, PEPs can act as vehicles for inclusive green transitions, but only if they are underpinned by professional exposure and linkages to growth sectors of the economy among other factors (Reddy et al., 2014; Das, 2016; Dladla, 2020; Oxfam, 2020; Williams et al., 2020; ILO, 2021; UNEP, 2025). In this context, a reimagined EPWP that offers meaningful, skill-intensive green work could not only attract greater youth participation but also contribute to broader goals of economic transformation and environmental resilience.

5.2.2. RECRUITMENT DYNAMICS

Recruitment practices for the EPWP differ widely across municipalities, reflecting varying levels of institutional capacity, governance and political influence. In more structured contexts, municipalities have established formal mechanisms to promote fairness and transparency in the recruitment process. For instance, Nelson Mandela Bay operates a dedicated office that runs targeted programmes for vulnerable groups, including youth. Similarly, the City of Cape Town has institutionalised its recruitment approach through a formal policy underpinned by a digital Jobseekers Database, which contains over 600,000 registered jobseekers. According to the municipality's policy, EPWP projects must select participants from this database unless a valid justification is provided. The Jobseekers Database is used by the EPWP unit to select candidates according to project-specific criteria, enabling a more standardised, fairer and accountable selection process.

In contrast, several municipalities continue to grapple with significant recruitment challenges. Political interference remains a persistent issue. In Buffalo City for example, outgoing ward councillors reportedly inflated project numbers by enrolling participants without proper documentation shortly before the end of their terms. These unauthorised additions created serious administrative complications for the incoming council, which was unable to cancel existing contracts, thereby straining project oversight and operational management. Such cases highlight the vulnerability of PEPs to local political dynamics, especially in the absence of strong institutional safeguards (McCord, 2012; Reddy et al., 2014; Das, 2016).

In some municipalities, community-based recruitment mechanisms, such as lottery systems administered through ward structures have been adopted. These are intended to promote equitable access to employment opportunities by ensuring random selection among unemployed participants. While the principle of fairness underpins these approaches, their effectiveness depends heavily on the transparency and credibility of the local actors involved. Without adequate monitoring and accountability frameworks, even community-driven systems risk being compromised by informal or politically motivated practices.

5.2.3. TRAINING AND SKILLS DEVELOPMENT IN GREEN ECONOMY PROJECTS

The stakeholders interviewed relayed that one of the critiques of the programme is its inability to provide participants with relevant and accredited training. Training provision within the EPWP is primarily supported by the National Skills Fund under the Department of Higher Education and Training, yet its implementation across South African cities remains uneven and underfunded (SACN, 2022a). In many municipalities, training tends to be linked to specific projects, delivered in a predominantly informal manner and remains unaccredited. As one official explained: "We did not train them except for when the training was done on site. So, in other words, they wouldn't have any certification that would say they have acquired the expertise" (EPWP official 2, personal communication, May 10, 2022). The unaccredited nature of the training undermines participants' ability to leverage their experience for future employment in the labour market.

EPWP training is often conducted by internal municipal staff or departmental officials, with content tailored to project-specific tasks. For instance, in green economy initiatives, this has included on-site training on how to identify and remove alien plants. While such training provides immediate functionality for project delivery, its nature limits recognition outside the EPWP, thereby constraining participants' post-programme employment prospects. This pattern is consistent with findings in the literature that unaccredited and non-transferable training fails to significantly enhance labour market outcomes for PEP participants upon programme exit (McCord, 2012; Reddy et al., 2014; Das, 2016; Williams et al., 2020; ILO, 2021; Strietska-Ilina et al., 2021).

However, the training component within EPWP remains under debate. As highlighted by key informants from national departments and The Presidency, a growing body of evidence

questions the long-term efficacy of short-course, non-integrated training, especially in contexts of weak labour demand. One of the interviewees relayed that, "evidence has shown that employers in South Africa tend to value work experience more than certificates, particularly when the latter are obtained in low-intensity, short-term contexts." (Official from The Presidency, personal communication, May 18, 2025). There is also concern that skills not applied soon after training are quickly lost, resulting in minimal long-term benefit for the participants.

These insights raise critical questions about the balance between investment in training and employment outcomes in PEPs. While accredited, high-quality training can expand labour market access, the literature cautions against meaningless training where such efforts may not translate into employment prospects (Reddy et al., 2014; Essa and Philip, 2024; Njokwe et al., 2025). This highlights the importance of integrating skilled workers and creating peer-to-peer learning environments on EPWP sites, as well as rethinking the assumption that training certificates alone can drive employability post programme in a stagnant labour market.

Another persistent challenge that limits training prospects is the constrained funding environment. Cities frequently report an inability to finance formal training, given the emphasis on maximising employment numbers with limited budgets. As one official noted: "We don't have a budget for training on EPWP, as a municipality we are struggling to fund the training" (EPWP official 1, personal communication, May 6, 2022). These pressures intensified during the COVID-19 pandemic, which led to budget reallocations toward emergency services and disrupted planned training and employment activities (SACN, 2022a; 2022b).

Rapid rollout requirements often prioritise the disbursement of funds and employment generation over the integration of skills development. As one official noted, "we had five months to deliver R12 billion worth of public employment, and there was no possibility of integrating effective training within that time frame" (EPWP official, personal communication, May 18, 2022). Such trade-offs raise important questions about the balance between immediate job creation and the strategic objectives of green economic transformation through accredited skills development. As highlighted in the literature, PEPs are most impactful when embedded in systems that foster continuous learning, cross-sectoral collaboration and institutional support beyond short-term employment and training cycles (McCord, 2012; Reddy et al., 2014; Das, 2016; Dladla, 2020; Williams et al., 2020).

Despite these constraints, some cities have developed more structured training approaches. In Nelson Mandela Bay, officials reported that all EPWP training providers are accredited, forming part of a deliberate exit strategy aimed at enhancing participants' employability post-programme. Similarly, Cape Town has implemented a tiered training model aligned with participants' educational levels. For those without Grade 12, foundational skills such as adult literacy, financial management and environmental basics are prioritised. Those with higher qualifications are offered more advanced modules, including personal leadership development and technical training in environmental management such as dune rehabilitation, under the Kader Asmal programme. Another example is the Buffalo City Municipality's East London beachfront and eco-park redevelopment initiative. In this project, participants with a background in agriculture or horticulture received formal, structured training, while unskilled participants were enrolled in a six-month programme in environmental maintenance. This layered model exemplifies the kind of targeted and developmental approach to training that offers post-programme prospects for EPWP participants.

5.2.4. LIMITED INVOLVEMENT OF EPWP UNITS IN GREEN ECONOMY PROJECTS CONCEPTUALISATION

A key challenge in the implementation of EPWP green economy projects is the limited involvement of EPWP units in the initial conceptualisation and planning stages. Instead, line departments such as Economic Development and Infrastructure independently design projects and only engage the EPWP unit at a later stage to provide labour. This fragmented approach limits the ability of the EPWP units to influence project design in ways that align with their developmental objectives of enhancing youth participation. As one official explained, "Their [line departments] request is usually along the lines of: EPWP, you can support us by providing human capital for this project" (EPWP official 3, personal communication, May 5, 2022). Another official echoed this sentiment, noting that project plans are often finalised before EPWP is consulted: "We don't really conceptualise the projects or get involved in that process. My role has been to assist in getting labour for the projects" (EPWP official 2, personal communication, May 10, 2022). This siloed model of implementation weakens integration between employment creation, prioritising marginalised groups and the developmental goals of green economy initiatives.

5.2.5. MULTI-STAKEHOLDER PARTNERSHIPS AND INSTITUTIONAL COORDINATION

EPWP green economy projects are often implemented through collaborations with sectoral line departments and, in some instances, national government departments. However, collaboration with the private sector remains limited and fragmented, with only a few cities managing to establish such partnerships. Where these partnerships exist, private sector involvement tends to be ad hoc, often taking the form of short-term financial support rather than long-term

institutional collaboration. For example, in eThekwini, the EPWP unit collaborated with Albaraka Bank to support a community garden project. The bank sponsored farming inputs, managed produce revenues through a community account and facilitated local reinvestment through its upliftment programme. While this partnership allowed for temporary employment and agricultural training of EPWP participants, the initiative was discontinued once the bank's funding lapsed. A key constraint is that many municipalities lack the administrative capacity and dedicated financial mechanisms to maintain cross-sectoral collaboration beyond the lifespan of specific projects (SACN, 2022a; 2022b).

Partnerships with higher education institutions have also been leveraged in some cities, although these relationships are often transactional rather than collaborative. In Cape Town, for instance, the city partnered with the University of Western Cape to deliver accredited training to EPWP participants. While this training added value, it remained limited in scale, and the university functioned more as a contracted service provider rather than a partner.

A more promising example of institutional innovation is from Buffalo City Metropolitan Municipality (BCMM), where persistent challenges in urban waste management prompted a unique multi-stakeholder response. As documented in the BCMM Tourism Development Strategy, poor waste management has undermined the city's attractiveness to investors and visitors. In response, BCMM formalised a partnership through a Memorandum of Understanding with the Border-Kei Chamber of Business (BKCOB) and the Buffalo City Metropolitan Development Agency (BCMDA), establishing the Waste and Environmental Management Action Committee (WEMAC). This initiative exemplifies a co-governance model that brings together municipal departments, business associations and PEP to address environmental and economic priorities simultaneously.

One of WEMAC's flagship interventions, the Static Buy Back Centre (BBC) project under the Call2Action campaign, integrates EPWP participants with recycling facilities. Unlike earlier, short-lived pilot projects, this initiative achieved relative sustainability by aligning public employment with private sector investment and donor support. Since 2019, private partners have contributed over R9.8 million to BCMM's recycling sector, with organisations like Polyco providing additional funding and technical support. This multi-scalar model has not only diverted over 1,000 tons of recyclable waste from landfills but also stimulated local green entrepreneurship and formalised employment in the recycling value chain.

5.3. Opportunities for leveraging programmes and partnerships to enhance youth employment and skills development in the green economy

South African cities have access to a range of programmes and stakeholders that can be strategically mobilised to expand training and employment opportunities for youth within the green economy. The green economy presents substantial potential for job creation, particularly for young people, offering pathways that address both environmental sustainability and socio-economic inclusion (ILO, 2018; Presidential Climate Commission, 2022; Harambee, 2025). By engaging with relevant stakeholders and aligning with national frameworks and initiatives, municipalities can implement labour-intensive, localised initiatives that build foundational skills and foster long-term labour market integration.

Nationally, government-led initiatives such as the Presidential Employment Stimulus and programmes coordinated by the Department of Cooperative Governance and Traditional Affairs provide municipalities with opportunities to integrate community education and skills development into employment interventions. These initiatives span enterprise and labour value chains and are adaptable to the EPWP model, enabling cities to deliver targeted youth employment projects. In addition, international examples provide valuable insights. For instance, a youth-focused project in Mali successfully employed digital tools to identify solid waste hotspots, demonstrating how technological innovation can enhance environmental management while engaging youth in innovative job opportunities (World Bank, 2021).

Within South Africa, partnerships with stakeholders such as the South African Renewable Energy Technology Centre (SARETEC) (2025), the Groen Sebenza Programme (SANBI, 2022), and Harambee (2025) have shown how co-creation between public, private and civil society actors can deliver structured training and work placement opportunities aligned with green economy goals.

South Africa's training and education system also plays a vital role in supporting youth participation in the green economy. Institutions such as Sector Education and Training Authorities (SETAs), Technical and Vocational Education and Training (TVET) colleges and universities are central to the development and delivery of both accredited and non-accredited training. SETAs have the mandate to facilitate sector-specific skills planning and work placements, which can be leveraged to ensure that green economy programmes offer market-relevant competencies.

Furthermore, funding instruments such as the National Treasury's Neighbourhood Development Partnership Grant offer municipalities a mechanism to finance green infrastructure and employment projects. Accessing and leveraging such funds requires alignment with integrated development planning and often benefits from partnerships with the private sector and non-governmental organisations. By utilising these financial and institutional resources in conjunction with the EPWP framework, cities can create more durable and developmental employment

pathways, especially for youth, within the evolving landscape of the green economy.

6. CONCLUSION

This paper has examined the implementation of the EPWP in South African cities, with a focus on youth participation in green economy initiatives. While the EPWP continues to provide short-term employment, its contribution to long-term labour market outcomes, particularly for youth, remains uneven. Evidence from city case studies points to persistent limitations in project design, nature of jobs, recruitment transparency and the provision of accredited training. These structural constraints, compounded by fiscal pressures and fragmented institutional arrangements, diminish the EPWP's developmental potential within the just transition and green economy contexts.

From a policy perspective, the findings underscore the need to reposition the EPWP as a more integrated employment and skills development platform. This includes involving EPWP units in the early stages of green project design, institutionalising partnerships with a range of stakeholders such as SETAs, TVETs and universities; and formalising collaboration with the private sector and civil society actors. Financing tools, like the Neighbourhood Development Partnership Grant, should be leveraged not only for infrastructure delivery but also to expand accredited, market-relevant training for green jobs. Without such systemic shifts, green economy projects risk reinforcing the low-skill, short-term character of traditional public works, limiting their transformative potential for youth.

Future research should examine the longitudinal impacts of youth participation in EPWP green economy projects and assess how different governance configurations affect outcomes across cities. Comparative studies of PEPs in other cities of the global south, especially those incorporating digital tools or climate finance, could enrich understandings of how local governments mediate between employment and skills development imperative and environmental goals. As cities become central arenas for implementing just transitions, PEPs like the EPWP must evolve to serve as vehicles not only for short-term relief but for inclusive, future-oriented urban development that enhance youth participation.

7. APPENDIX

Table 1: SA's green economy policy evolution

Time frame	Strategy/ Plan/ Policy	Support to the green economy
2000- 2005	▪ Renewable energy strategy ▪ National energy efficiency strategy	▪ Reduce overall energy demand and introduce alternate renewable energy sources.
2006-2011	▪ National Energy Act ▪ Industrial Policy Action Plan 2 ▪ Integrated Resource Plan ▪ Environmental Sector Skills Plan ▪ National Development Plan ▪ Green Economy Accord	▪ Pave the way for diverse energy resources. ▪ Promote 'green' and energy saving industries. ▪ National energy plan including generation sources, reduced GHG, affordability. ▪ Comprehensive skills plan for the environmental sector. ▪ Highlights transition to a low-carbon economy. ▪ A national commitment to a green economy.
2012-2017	▪ Long term adaptation strategy ▪ Carbon Tax Policy Paper ▪ Green Economy Inventory ▪ Green Skills Framework	▪ Opens the door for GHG reduction through tax policy ▪ Scenarios and key responses to climate change. ▪ Sectoral and spatial list and taxonomy of green initiatives in SA. ▪ Skills required by the green economy in the future.
2018-2025	▪ Just Energy Transition (JET) Framework ▪ Just Energy Transition - Investment Plan (JET-IP) ▪ Integrated Resource Plan ▪ Carbon Tax Act ▪ Climate Change Act ▪ South African Renewable Energy Masterplan	▪ Shared vision for shifting to an equitable, zero-carbon economy by 2050. ▪ Focuses on the investments needed, particularly in the energy sector, for the energy transition for the period - 2023-2027. ▪ The IRP defines the optimal mix for energy generation over the long term, guiding infrastructure investment factoring in energy security, cost, technologies, environmental sustainability and economic development. ▪ Primarily aims to incentivise behaviour by internalising environmental costs, ensuring major polluters in industry, energy and transport sectors pay for GHG emissions. ▪ The Act hardwires the just transition into SA's legal and policy frameworks toward a low-carbon, climate resilient economy. ▪ Guides how SA's renewable energy and storage industry should be built, and jobs should be created through green industrialisation.

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THE EFFECTS OF PATRIARCHY ON CLIMATE CHANGE ADAPTATION AMONG WOMEN IN AGRO-BASED MUKANGAMWI COMMUNAL RURAL AREA IN BIKITA, ZIMBABWE

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ABSTRACT

Climate change poses significant risks to rural communities dependent on agriculture, with women often disproportionately affected due to entrenched patriarchal systems. This study examines how patriarchy influences climate change adaptation among women in Ward 9 of Mukangamwi Communal Lands in Bikita, Zimbabwe. Using a mixed-methods approach, the research relied on qualitative data collection through field observations and semi-structured interviews with 22 women participants. Quantitative techniques were applied only during data analysis to support the interpretation of results through basic statistical presentation. The study explored the gendered dimensions of climate adaptation, revealing that patriarchal norms limit women's access to land, resources, and decision-making platforms, thereby constraining their ability to respond effectively to climate impacts. Observations revealed that women are often excluded from participating in community meetings, with their involvement limited to supporting roles when sessions are being held, such as cooking and fetching water. In addition, they shoulder the majority of agricultural and household duties, often working considerably longer hours than their male counterparts. These intersecting vulnerabilities also have direct and indirect implications for women's Sexual and Reproductive Health and Rights (SRHR). The findings underscore the need for gender-responsive adaptation strategies that challenge patriarchal barriers in the Mukangamwi Communal area, promote inclusive participation, and integrate local knowledge with scientific approaches to strengthen community resilience, foster equitable climate governance, and ultimately improve Sexual and Reproductive Health and Rights (SRHR).

KEY WORDS Adaptation, Climate Change, Gender Inequality, Patriarchy, Resilience, Rural Zimbabwe, Sustainable Development, Women.

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1. INTRODUCTION

Climate change is one of the most pressing global challenges of the 21st century, posing a direct threat to ecosystems, human health, food systems, water security, and socio-economic development (Brauch *et al.,* 2017). The increased frequency and intensity of extreme weather events, such as droughts, floods, and heatwaves, have disrupted livelihoods across continents, with developing countries bearing the brunt due to limited adaptive capacities (Jha and Dev, 2024). Birkman *et al.* (2022) noted that while climate change is a universal phenomenon, its effects are deeply unequal and often exacerbate existing social, economic, and political inequalities. Within this landscape, gender has emerged as a critical dimension in understanding climate vulnerability and resilience. In addition, the impacts of climate change intersect strongly with Sexual and Reproductive Health and Rights (SRHR). Disruptions caused by extreme weather events often limit access to health facilities, compromise maternal and child health services, and increase vulnerabilities such as gender-based violence, early marriages, and unplanned pregnancies (Schaaf *et al*., 2021).

Across the African continent, climate change has already begun to reshape patterns of rainfall, increase average temperatures, and alter growing seasons, posing significant threats to food security and water availability (Ofori *et al*., 2021). According to Christiaensen (2017), families in rural Africa rely more on agriculture compared to other parts of the developing world. The continent's heavy reliance on rain-fed agriculture makes it particularly susceptible to climatic shocks (ibid). Moreover, the consequences of environmental degradation, prolonged droughts, and flooding have placed immense strain on both ecosystems and human systems. However, within African communities, these effects are not experienced homogeneously. Rao *et al* (2019) opined that gendered power dynamics significantly influence who has access to resources. This opinion is supported by Mersha and Van Laerhoven (2016), who also iterate that those who cannot make decisions bear the burden of adapting to climate variability. Women, particularly in rural areas, often face structural barriers that limit their ability to respond effectively to climate induced stresses, despite their central role in water management and food production (Christiaensen 2017).

In the Southern African Development Community (SADC) region, climate change has intensified existing socio-economic challenges such as poverty, land degradation, and water scarcity (Nhamo 2019). Rural communities are increasingly experiencing the effects of shifting agro-ecological zones, erratic rainfall, and extreme temperatures, with many households struggling to maintain sustainable livelihoods (ibid). Gender disparities remain pronounced, with women often lacking secure land tenure, access to extension services, credit facilities, and decision-making platforms (Shah 2022). These inequalities reduce their ability to adapt and build resilience, despite their wealth of local environmental knowledge and adaptive practices. Onwutuebe (2019) expressed the same sentiment and is of the notion that the persistent exclusion of women in climate discourse and governance structures reflects deeper patriarchal systems that govern rural societies, promoting women's marginalisation.

Zimbabwe, like many other countries in the SADC region, is highly vulnerable to the adverse effects of climate change. The country has experienced increasing climatic variability over the past decades, characterised by prolonged dry spells, declining rainfall, and recurrent droughts, particularly in its rural and semi-arid regions Frischen et al., 2020). Agriculture, which remains the backbone of the Zimbabwean economy, is largely dependent on rainfall and is dominated by smallholder farmers, the majority of whom are women (Tekwa 2023). Yet, despite their significant contributions to agricultural production and household sustenance, women also continue to face multiple layers of exclusion. Patriarchal norms deeply embedded in Zimbabwean rural communities limit women's access to land, financial resources, agricultural inputs, and extension services, thereby compromising their adaptive capacity and long-term resilience (Chigwenya and Ndhlovu 2016).

This paper focuses on Ward 9 in the Mukangamwi Communal Lands, a rural community in Zimbabwe's Masvingo Province. It examines how patriarchal structures influence the impacts of climate change and shape women's experiences in their efforts to adapt. By triangulating the themes of climate change, gender, and patriarchy, the study seeks to uncover the gendered dimensions of adaptation and the systemic barriers that hinder effective climate change responses among women. The study also highlights how these challenges intersect with Sexual and Reproductive Health and Rights (SRHR).

2. RESEARCH PROBLEM

In Mukangamwi Communal Lands, male dominance restricts the ability of women to implement effective climate adaptation strategies. Without targeted policies that address disparities, women will continue to face greater risks from climate change, hindering efforts to build equitable and sustainable resilience in rural communities.

3. RESEARCH AIM

The main aim of this study is to explore how patriarchal structures influence climate change adaptation among women in the agro-based Mukangamwi Communal Rural Area of Zimbabwe.

4. RESEARCH OBJECTIVE

To investigate how patriarchal norms influence climate adaptation strategies and resiliency in Mukangamwi Communal lands in Zimbabwe.

5. LITERATURE REVIEW

This section reviews existing literature on the intersection of gender, patriarchy, and climate change adaptation, with a specific focus on rural and agro-based communities. It explores how patriarchal structures shape women's access to resources, participation in decision-making, and overall adaptive capacity in the face of climate change.

6. THEORETICAL FRAMEWORK

The study is underpinned by Patriarchal Bargain Theory and Feminist Political Ecology (FPE) as the theoretical and epistemological framework to better understand the effects of patriarchy on climate change adaptation and resilience among women in the agro-based Mukangamwi Communal Rural Area in Zimbabwe.

6.1. Patriarchal Bargain Theory

This theory, introduced by Deniz Kandiyoti (1988), explains how women strategically navigate patriarchal systems to gain security, protection, and provision in the face of existing gender inequalities. Kandiyoti (2020) further asserts that women in deeply patriarchal societies often conform to traditional gender roles in exchange for stability, which includes access to resources, social approval, and economic support. These bargains, however, reinforce structures that limit women's agency, particularly in the context of climate change adaptation, resilience, and the realisation of their Sexual and Reproductive Health and Rights (SRHR). According to Ambjörnsson (2011), women who rely on male-controlled resources are unable to make independent climate adaptation decisions. Furthermore, patriarchal bargains exclude women from governance and decision-making spaces, leaving their specific vulnerabilities unaddressed in policy discussions.

The theory offers a valuable perspective in understanding how gendered power dynamics shape climate vulnerabilities. While these bargains provide women with immediate security, they ultimately reinforce a system that limits their autonomy and resilience. Breaking away from these structures is essential to ensure that women have the power to make independent adaptation decisions, secure their livelihoods, and actively participate in shaping climate policies that affect their futures.

6.2. Feminist Political Ecology (FPE) Theory

FPE theory provides a critical lens for understanding how gender, power, and environmental issues intersect, particularly in the context of climate change adaptation and resilience. The multi-scalar framework is not attributed to a single author and was formally introduced in the early 1990s. It argues that environmental challenges are deeply embedded in social structures, where power relations shape access to resources, decision-making, and adaptive capacities.

One of the central arguments of FPE is that gendered vulnerabilities are not just a result of biological differences but are socially constructed through power relations that prioritise male dominance over resources. In many societies, men control land and economic resources, leaving women dependent on male relatives for access to livelihoods. This can be linked to women's ability to adapt to climate change, and the framework validates that their adaptation is thus constrained by laws, traditions, and social norms that limit their decision-making power. For example, while women are often responsible for agricultural work, they rarely own the land they farm. This lack of ownership makes it difficult for them to implement long-term adaptation strategies, such as investing in soil conservation techniques or accessing climate adaptation funds.

The theory further reveals how climate change exacerbates existing gender inequalities and how patriarchal power structures limit women's ability to adapt. Addressing these challenges requires gender-sensitive policies that ensure women's secure access to land, resources, and decision-making platforms. By recognising women as key players in climate resilience and implementing policies that dismantle structural barriers, societies can move toward more equitable and effective climate adaptation strategies.

6.3. Gendered Impacts of Climate Change

The impacts of climate change at a macro level will extremely affect socio-economic sectors, with gendered consequences intensifying vulnerabilities for women (Brauch *et al.,* 2017). Evidence from terrestrial and marine ecosystems globally highlights how natural systems, critical to livelihoods, are deteriorating due to rising surface temperatures (Li and Thompson 2021). For instance, melting polar ice and permafrost in the Arctic have heightened flooding and coastal salinisation (ibid.), disrupting communities where women often bear primary responsibility for water and food provision. These environmental shifts exacerbate women's labour burdens, as they travel farther to secure resources amid scarcity.

Climate change is projected to reduce arable land while increasing aridity, droughts, and desertification (Chappell and Agnew 2004). Njuki (2019) reveals that in Africa, women contribute an estimated 60–80% of labour in agricultural activities. Rural women also shoulder a heavier and more multifaceted labour burden compared to men, encompassing not only farm work but also unpaid household duties such as food preparation and gathering fuel and water, tasks that are intensified by environmental pressures (Njuki *et al*., 2019). This unbalanced responsibility renders women acutely vulnerable to climate induced resource scarcity, as droughts, deforestation, or shifting rainfall patterns exacerbate their daily struggles to meet household needs. Declining crop yields and water scarcity amplify food insecurity, deepening women's

caregiving roles as they struggle to nourish households (Nhemachena 2020; Jha and Dev 2024). Simultaneously, extreme weather events like floods and droughts destabilise economies, heightening risks of displacement and poverty for women, who are overrepresented among the world's poor (Birkmann *et al*. 2022). Meeting the 70% increase in food production required by 2050, as mentioned in Dawson (2016), hinges on addressing gendered inequalities in land access, technology, and decision-making.

Biodiversity loss, driven by rising temperatures, further undermines women's resilience. Species and ecosystem declines (Schneider *et al*. 2007) disrupt traditional practices such as foraging for medicinal plants, a role often managed by women. Projections suggest 20–30% of species could vanish if temperatures rise by 1.5–2.5°C (Midgley *et al.* 2002), eroding natural resources women rely on for nutrition, income, and cultural practices. Thuiller *et al*. (2006) warn of 50% biodiversity loss by 2100, which could destabilise food webs and medicinal systems, burdening women with caregiving and survival responsibilities in degraded environments.

6.4. Understanding Patriarchal Norms

Patriarchy is a deeply rooted social system wherein men predominantly occupy positions of power and control in both public and private spheres (Sultana 2012). Sultana (2012) highlights that these include roles in political leadership, economic authority, religious instruction, property ownership, and decision-making at the household and community levels. In a patriarchal system, societal values, institutions, and norms are constructed in ways that uphold male dominance while systematically marginalising women and other gender minorities (Murray, 1990; Hooks, 2014).

The term "patriarchy" originates from the Greek word *patriarkhēs*, meaning "rule of the father," which historically reflects how families and societies have been structured around paternal authority. Zeeshan and Aliefendioğlu (2024) disclose that patriarchy manifests in everyday life through unequal access to resources, restricted mobility, limited decision-making power for women, and reinforcement of gendered divisions of labour.

Murray (1990) conceived of patriarchy as a system that is both private and public. The term "private patriarchy" describes male domination in the home, which is frequently typified by women performing unpaid domestic work, having control over reproduction, and having the final say in family decisions. In contrast, public patriarchy is observable in institutional contexts, such as governments, workplaces, and places of worship, where men predominate in leadership positions and influence laws in ways that support gender inequality. According to feminist scholars like Hooks (2014), patriarchy is a belief system that teaches men and women that male dominance is normal and acceptable, rather than just a system of men holding power. Internalised from a young age, this ideology is strengthened by socialisation, education, the media, religion, and the law.

7. CULTURAL, RELIGIOUS, AND INSTITUTIONAL REINFORCEMENT OF PATRIARCHY

In many societies, culture and religion have been key vehicles through which patriarchal norms are legitimised and sustained (Hooks 2014). Traditional gender roles often assign women to caregiving, domestic tasks, and reproductive responsibilities, while men are expected to be providers, protectors, and decision-makers (Kabeer, 1999). These expectations, although rooted in long-standing cultural values and moral guidance, can limit women's autonomy and justify their exclusion from leadership and public life.

Religious texts have also historically played a central role in shaping gender roles. For instance, in the Christian tradition, the Bible in Ephesians 5:23 states, *"For the husband is the head of the wife as Christ is the head of the church, his body, of which he is the Saviour"* (New International Version). The authors believe that this verse was intended to promote mutual respect and responsibility in marriage, emphasising a model of loving leadership and partnership. However, over time, certain interpretations and applications of this and similar verses have been used to reinforce male dominance and female subordination in both private and public domains, as also supported by Phiri & Nadar (2009). This has, in some cases, led to systemic disadvantages for women, particularly when male leadership is no longer accompanied by the protective and supportive responsibilities originally emphasised.

In the modern context, especially in low-income and rural settings, socioeconomic changes have strained traditional gender roles. Many men, due to limited employment opportunities, are unable to fulfil the expected role of sole breadwinners (Akanle 2018). As a result, women have increasingly taken up economic responsibilities, often without corresponding shifts in power or recognition in decision-making structures. According to Akanle (2018), this mismatch has created tensions and further entrenched gender-based inequalities. Moreso, as women remain underrepresented in public leadership and land governance, even while bearing significant household and community burdens.

Globally, patriarchal norms have been institutionalised over centuries. In colonial Africa, systems of governance reinforced male dominance by formalising male land ownership and excluding women from decision-making platforms (Makoni et al., 2023). For example, the colonial administration in Zimbabwe centralised land distribution to male heads of households, thereby marginalising women from land rights. These systems not only entrenched patriarchal values but also became

embedded in post-colonial legal and governance frameworks (ibid).

Legal systems, even when outwardly neutral, often reflect these patriarchal assumptions. In many customary law contexts across Africa, including Zimbabwe, women are still treated as legal minors, unable to inherit property or represent their households in communal matters (Makoni et al., 2023). Similarly, economic institutions frequently undervalue women's contributions, particularly in the informal sector and subsistence farming, further reinforcing gender-based disparities in income and access to resources (FAO, 2021).

Moreover, education systems, which ideally serve as tools for empowerment and social mobility, often reproduce gender biases. In rural settings, girls are less likely to attend or complete school, particularly in the face of economic hardship, early marriage, or pregnancy. Even when girls attend school, societal expectations often steer them towards "feminine" subjects, limiting their participation in science, technology, engineering, and agriculture—fields critical for building climate resilience and economic independence (UNESCO, 2022). This further limits their opportunities to contribute meaningfully to adaptation strategies and decision making in their communities.

8. CONSEQUENCES OF PATRIARCHAL NORMS ON CLIMATE CHANGE ADAPTATION

Patriarchal norms deeply influence the way climate change impacts women, particularly in communities where gender roles are rigidly defined. These norms often limit women's access to resources, decision-making processes, as mentioned by Makoni *et al*. (2023) and Zeeshan and Aliefendioğlu (2024). This also excludes them from opportunities for capacity building, all of which are critical for effective climate change adaptation. Despite their central role in coping with climate-related stresses, women in some communities are still being excluded from decision-making processes at local, national, and international levels. Patriarchal norms render women less visible in policy discussions, which are typically dominated by male leaders or representatives. This exclusion significantly undermines women's coping mechanisms, as policies and adaptation strategies are often designed without considering their specific needs, knowledge, and expertise (Djoudi *et al*., 2016).

In many societies, women are responsible for household tasks such as water collection, food production, and caregiving. These roles not only expose women to the immediate effects of climate change, such as droughts, flooding, and crop failure, but also limit their ability to diversify livelihoods or access adaptive technologies. For instance, when water sources become scarce due to changing rainfall patterns, women bear the burden of finding and transporting water, a task that becomes more physically demanding and time-consuming as climate stressors intensify (Agarwal, 2010; Nhemachena, 2020). Similarly, food insecurity, exacerbated by changing weather patterns, affects women, who are often the primary caregivers and food providers in their households (Kabeer, 1999).

Furthermore, women's limited access to education and financial resources further hinders their ability to effectively adapt to climate change. For example, without access to education or training in sustainable agricultural practices or climate-resilient technologies, women struggle to implement long-term adaptation strategies (Kabeer, 2012). Onwutuebe (2019) corroborated that patriarchal structures thus create a cycle of disadvantage, where women's vulnerability to climate change is compounded by their marginalisation from the very processes that could enhance their adaptive capacity. As a result, the consequences of patriarchal norms in the context of climate change are far-reaching. Women are not only disproportionately affected by climate stresses, but they also face institutional and social barriers that prevent them from accessing the resources and opportunities necessary for effective adaptation (Phiri and Nadar 2009). This limits their ability to cope with climate change, not just in the short term, but in the long term as well, creating a cycle of vulnerability that is difficult to break. Addressing these gender disparities in climate change adaptation is critical, as empowering women and including them in decision-making processes can significantly enhance the resilience of communities as a whole (Bryan *et al.,* 2024).

One of the more subtle but equally damaging ways that patriarchal norms hinder climate resilience is through the restriction of women's access to knowledge systems, training platforms, and adaptive technologies. Knowledge is a critical component of effective climate adaptation—whether it's information about early warning systems, sustainable farming techniques, or financial literacy related to crop insurance or disaster preparedness. However, women, especially in patriarchal and rural settings, are systematically excluded from such knowledge networks due to socio-cultural barriers, mobility constraints, and institutional neglect (Adeola *et al.,* 2023).

In South Asia, for example, the intersection of gender, caste, and class has created multilayered vulnerabilities for women in the context of climate adaptation. In Bangladesh and India, it has been well-documented that women's participation in community-based disaster preparedness or climate training initiatives is often hindered by cultural norms that restrict their public presence and mobility (Rao *et al*., 2020). Rao further enlightens that in many rural villages, women are expected to remain within the domestic sphere, limiting their ability to attend village meetings, workshops, or training sessions held at community centres—spaces often dominated by men. As a result, women are less likely to receive early warnings about floods, cyclones, or other environmental risks, and are often the

last to evacuate or prepare (Cannon, 2002).

The exclusion of women from agricultural extension services—which are often the main conduits of climate-smart practices—is another key example of patriarchal norms curtailing adaptive capacity. Agricultural extension agents are typically male, and their outreach is primarily directed at male farmers, who are seen as the "heads of households" and main landowners (Mehar *et al*., 2016). This approach ignores the reality that women make up a significant proportion of the agricultural workforce in most developing countries, and are often responsible for the cultivation of food crops, livestock care, and household food security (FAO, 2021).

In many cases, even when women are present during training or outreach sessions, the format, content, and delivery are not tailored to their needs, literacy levels, or time constraints. Women's domestic workloads often prevent them from attending long or distant sessions, and sessions conducted in male-dominated environments may discourage open participation due to fear of social sanction or embarrassment (Carr & Thompson, 2014). This silencing of women in knowledge exchange platforms ultimately leads to a gender gap in climate resilience and innovation adoption.

In addition to institutional barriers, the internalisation of patriarchal ideologies can also reduce women's participation in adaptive strategies. In deeply patriarchal contexts, women themselves may not view their contributions or knowledge as valuable, which inhibits their engagement in adaptation planning or public discourse. This self-censorship, a product of generations of socialisation, diminishes the community's overall adaptive potential by sidelining women's experiential knowledge of the environment and their nuanced understanding of resource management (Rao *et al*., 2020).

9. METHODOLOGY

This study adopted a mixed-methods approach by combining qualitative and quantitative elements. Qualitative methods were used for data collection, specifically through in-depth interviews with 22 women in Mukangamwi Communal Lands, to gather rich, contextual insights into how patriarchal norms influence climate adaptation strategies and resiliency. The women were selected using the snowballing technique, as the researchers aimed to interview women engaged in vegetable cultivation. Field observations further supported the qualitative findings. While no quantitative methods were used during data collection, quantitative techniques were applied during data analysis to support the interpretation of findings through basic statistical presentations. This approach ensured a comprehensive understanding of the research objective by linking lived experiences to measurable outcomes, highlighting the structural barriers women face in adapting to climate change. The data was collected from November 2024 to January 2025, specifically in Ward 9 Mukangamwi Communal Lands in Bikita, Zimbabwe.

10. ETHICAL CONSIDERATIONS

Participants were fully informed about the purpose of the study, selection criteria, and their rights through a letter of informed consent. Participation was voluntary, with the option to withdraw at any time. Confidentiality and anonymity were strictly maintained, and all data were accurately reported and properly referenced.

11. RESULTS AND DISCUSSION

This section presents and interprets the findings of the study on how patriarchal norms influence women's climate change adaptation strategies in Ward 9, Mukangamwi Communal Lands. The results are drawn from in-depth interviews and field observations, with supporting analysis used to highlight key patterns. The discussion integrates these findings with existing literature to explore the gendered dimensions of climate vulnerability and adaptation, focusing on access to resources, decision-making, and the division of labour.

The results of the study reveal that polygamous family setups in Mukangamwi Village are common. Of the 22 respondents, 4 indicated that they were in polygamous marriages, while 12 were in monogamous marriages, and 6 were single. Of the 22 women, 16 were married, and only 6 had no spouses.

Grounded on the data collected in Mukangamwi, the authors consider that in the face of climate change, patriarchal bargains manifest in ways that shape gendered vulnerabilities. Women with husbands are generally less vulnerable than single women because their provisions are guaranteed, and they do not have to struggle as much to secure resources for survival. Married women in both polygamous and monogamous families rely on their husbands for land, food, and financial security, which provides a layer of protection against climate induced shocks such as droughts and food shortages. However, this reliance also means that their ability to make independent adaptation choices is restricted, as articulated by Ambjörnsson (2011). When crises occur, women who lack decision-making power must depend on their husbands' choices, which may not always prioritise sustainable climate adaptation strategies.

In Mukangamwi, it is the man who has the decision-making power in both polygamous and monogamous households as well as in the

communities, and ultimately, climate adaptation strategies. For example, they decide which crops to plant, when to plant, and how to spend agricultural earnings. Women are expected to be submissive and not challenge what the household head has decided.

It can be deduced that women, despite their intimate knowledge of daily farming realities, are rarely consulted. One woman lamented that;

I am never allowed to decide what we should buy; the man, as the head of the house, decides on everything, and I just have to dance to his tune, even when the decision is not the best.

A poignant story emerged from another female respondent who indicated that she suggested her husband plant drought-resistant small grains instead of maize in the 2023 rain season, but was dismissed, and that year the area was affected by a drought. This illustrates the core of Patriarchal Bargain Theory: women in Mukangamwi have modulated their contributions within permissible boundaries, often deferring to male authority to preserve household harmony. Yet this deferment can be maladaptive, especially as climate shocks demand rapid behavioural shifts and innovation. The very hierarchies that have historically stabilised family roles now inhibit resilience.

Leadership roles in Mukangamwi are overwhelmingly male. Women are expected to serve in supportive roles, and speaking in public forums can be seen as a challenge to male authority. As one elder remarked,

"A woman who talks too much is not respected. Even her husband will be ashamed."

Such attitudes discourage women from asserting themselves in public decision-making spaces. This internalised patriarchy is a core component of the patriarchal bargain: silence and subservience are rewarded with social acceptance and perceived stability. FPE critiques this silence as not natural but produced through generations of cultural conditioning and exclusion. The result is a community in which women know how best to adapt but are unable to shape the policies or practices that govern adaptation.

The findings paradoxically reveal that, despite women being at the forefront of managing household and environmental stresses, often working hands-on for extended hours while men retreat to socialise, their knowledge and daily experiences are undervalued. This reflects a disconnect between the critical roles women play in sustaining households and the recognition of their contributions. In the Mukangamwi communal lands, as in many rural settings across Zimbabwe, women possess rich indigenous knowledge systems that support local adaptation, and this is supported by Adeola *et al.* (2023). This includes expertise in food preservation techniques (e.g., drying vegetables and grains), water harvesting, soil fertility management, and natural resource stewardship (ibid). Unfortunately, these contributions are frequently overlooked due to such gendered hierarchies entrenched in both traditional leadership structures and local development committees.

The researchers also observed that community meetings are often male-dominated, with women either excluded from participation or silenced through cultural expectations of deference and submission. One of the respondents cited that;

As men hold meetings, we are supposed to be cooking and serving them; we are not even allowed to sit where men sit to discuss.

Education and capacity-building initiatives are vital for empowering women to take control of their climate adaptation needs. Training programs that equip women with skills in sustainable agriculture, water conservation, and renewable energy can enhance their autonomy and reduce dependence on patriarchal structures for survival. This aligns with Carr & Thompson (2014), who noted that women's domestic responsibilities often prevent them from attending lengthy or distant sessions. Additionally, sessions held in male-dominated spaces may deter women from participating openly due to concerns about social sanction or embarrassment.

The absence of women from meetings, workshops, and decision-making platforms not only reflects deep gender inequality but also undermines community resilience, as highlighted by Chigwenya and Ndhlovu (2016). The literature review reveals that numerous scholars emphasise the importance of including women's perspectives in climate adaptation strategies to enhance interventions' sustainability, relevance, and local ownership (Adeola *et al.,* 2023). However, this principle is not being applied in Mukangamwi, where women's voices remain excluded mainly from key climate decision-making processes.

Institutional language around "household heads" frequently excludes female-headed households or frames them as deviations from the norm. This structural blindness reinforces gendered exclusions. FPE urges a rethinking of institutions not as neutral but as deeply political spaces where power is contested and reproduced. Integrating women's voices requires inviting them to meetings and reshaping the structures that define participation.

12. WOMEN'S VULNERABILITIES IN MUKANGAMWI COMMUNAL LANDS

Across most responses, women emerged as the most vulnerable group in the community. Gender-based disparities significantly contribute to this vulnerability, particularly in female-headed households, which are more exposed to the impacts of climate change. Limited access to education and information further constrains women's ability to adapt effectively, a situation compounded by cultural beliefs that marginalise women and deem them

less important in societal structures. In Mukangamwi, vulnerability is also widespread due to heavy dependence on rapidly depleting natural resources.

Rural communities have been among the hardest hit by economic hardships, with many households lacking formal employment and living below the poverty line. Poor soil quality further undermines agricultural productivity, increasing food insecurity and vulnerability. Orphans face a unique set of challenges, often losing access to family land due to intra-family disputes, leaving them without a stable means of livelihood. Similarly, widows experience land dispossession and social exclusion as a result of patriarchal customs, which prevent them from fully participating in community life.

Both widows and orphans are frequently excluded from knowledge-sharing platforms and community-based adaptation initiatives, leaving them ill-equipped to cope with the changing climate. The community's limited economic opportunities and lack of institutional support, particularly from government structures, further exacerbate their vulnerability. Prolonged dry spells and increasingly arid conditions have intensified climate impacts, leaving the already marginalised population in an even more precarious position. The interplay of social, cultural, political, and economic factors collectively heightens the community's exposure to climate-related risks.

Land and Financial Resource Rights Among Women

It was also noted that the customary land tenure governs Mukangamwi Communal Lands and is male-biased, allocating land rights through patrilineal inheritance systems. In the area, men are seen as the legitimate landholders, while women are expected to access land through their fathers, husbands, or male relatives. This echoes the conceptual framework of the Patriarchal Bargain Theory, which posits that women, operating under male-dominated systems, often accept subservient roles in exchange for access to certain privileges or protections. The notion also converges with Machingura (2021), who discloses that such an arrangement severely limits the autonomy of widows, divorced women, and unmarried women, who often find themselves excluded from land allocation processes controlled by traditional authorities, such as village heads and chiefs.

In Mukangamwi, land and financial resource ownership are both fundamentally gendered, shaped by a matrix of cultural, historical, and institutional forces that render women disadvantaged. Land, as a critical resource for agricultural productivity and climate adaptation, remains firmly in the hands of men. The data collected from the study reflects this deeply entrenched gender inequality. The majority of the female respondents indicated that they did not own the land they cultivated. Instead, they accessed land through male relatives, fathers, brothers, husbands, or only upon widowhood when one has male children, and even then, access remains tenuous.

8 women indicated that they do not own land, while 14 own land. Among the 14, most indicated that they owned the land through their husbands, relatives, or children. In Mukangamwi, women comply with male land ownership as a means of maintaining their place within the household economy. However, this bargain becomes increasingly precarious in the face of climate change, where decisions over land use and adaptive strategies must be swift, flexible, and innovative—traits hampered by women's insecure tenure.

The significance of having a male child is also a crucial aspect of patriarchal bargains in Mukangamwi, particularly in land inheritance and climate resilience. In many societies, land is traditionally passed down through the male lineage, ensuring that the family name and ownership remain intact. Women who bear only daughters face a precarious future, as male relatives can take their land to maintain the family surname and uphold patriarchal inheritance systems. Without male heirs, women risk losing access to land and resources, making them even more vulnerable to climate-related disasters. This uncertainty forces many women to comply with patriarchal norms, ensuring they align with societal expectations in hopes of securing long-term provision through their husbands or sons.

Financial resources are similarly restricted. Most women in Mukangamwi lack formal collateral and are excluded from mainstream credit systems or rotating savings and credit associations (ROSCAs), commonly known locally as *mikando*. This exclusion not only limits women's ability to invest in adaptation strategies but also silences their participation in climate-resilient development. Feminist Political Ecology (FPE) theory contextualises this marginalisation within a broader critique of how political and economic institutions reinforce gendered access to resources. FPE challenges the assumption that women are simply passive victims of environmental change, highlighting instead the institutional processes that actively produce and sustain their vulnerability.

Such insecure land tenure in Mukangamwi prevents women from making long-term investments in climate adaptation strategies, such as agroforestry, contour ploughing, or the establishment of irrigation systems. Without assurance of land control, the women are disincentivised from engaging in climate-resilient farming practices that require labour and capital. This dynamic reflects a broader pattern of structural disempowerment, where women's adaptation strategies to climate risks are jeopardised by their exclusion from formal and informal systems of resource governance.

13. TRADITIONAL GENDER ROLES IN RURAL COMMUNITIES

Gender roles in Mukangamwi are deeply rooted in traditional norms that assign reproductive, productive, and community responsibilities along gender lines. Kandiyoti (2020) supports this observation, noting that women bear the brunt of domestic and subsistence tasks such as water collection, food preparation, childrearing, and agricultural labour, roles that intensify under climate induced stress. These insights align with field observations in Mukangamwi, where rural women are overburdened with caregiving and household responsibilities, particularly during periods of environmental disruption. Tasks such as fetching water, collecting firewood, preparing meals, and caring for children and the sick are highly feminised. During droughts or periods of water scarcity, women often travel long distances to secure water, frequently putting their health and safety at risk (Nhemachena, 2020). These risks can have indirect implications for their Sexual and Reproductive Health and Rights (SRHR), particularly when women are pregnant, menstruating, or unable to protect themselves, making them more vulnerable to abuse, including the risk of sexual violence and rape.

Declining water levels and the premature drying up of wells before the onset of the next rainy season highlight the increasing unreliability of traditional water sources. Such trends are consistent with observed climate change impacts, particularly prolonged dry spells and erratic rainfall patterns, which are exacerbating water insecurity in vulnerable rural communities. It was noted that women often work longer hours than men, rising early to fetch water and working fields until dusk. The dual demands of reproductive and productive labour leave women with little time for participating in governance or training programs.

As one woman explained, "We do the gardening, we cook, we walk long distances for water, but when they call meetings, they don't think we should be there."

Despite systemic exclusions, women in Mukangamwi are central to household and community-level climate adaptation. The study found that 85% of households practised vegetable gardening, with women leading these initiatives. This is in tandem with Njuki (2019), who reveals that in Africa, women contribute an estimated 60–80% of labour in agricultural activities. These gardens, often located near boreholes or wetlands, provided essential nutritional and economic support during droughts. The following plates 1 and 2 show the gardens being manned by women in Mukangamwi.

Plate 1: Chomolia vegetable grown

Plate 2: Beans

Photographs showing vegetables grown in Mukangamwi Communal lands

The thriving vegetable gardens in Mukangamwi are a testament to the gardeners' expertise and practical knowledge. Researchers observed that women are primarily responsible for watering these gardens. As highlighted by Agarwal (2010) and Nhemachena (2020), when water sources become scarce, it is women who shoulder the burden of sourcing and transporting water. Beyond irrigation, women are also implementing climate change adaptation strategies such as mulching to retain soil moisture and suppress weeds, as well as repurposing plastic water bottles to simulate drip irrigation systems—a low-cost, water-efficient technique. These practices reflect a deep, context-specific ecological knowledge, acquired through daily interaction with their environment rather than through formal education. However, despite their critical role in climate resilience at the grassroots level, women remain underrepresented

in formal climate governance in Mukangamwi. This exclusion is not due to a lack of interest or capability, but rather to persistent socio-cultural and institutional barriers that limit their participation in decision-making spaces.

14. CONCLUSION

In conclusion, the study highlights that patriarchy, manifested through cultural norms, institutional practices, and structural inequalities, significantly limits women's ability to adapt to climate change in the Mukangamwi Communal Area. Efforts to build resilient communities must dismantle these gendered barriers and intentionally centre women's voices, knowledge, and leadership in climate governance. Recognising and supporting women's adaptive strategies, along with safeguarding their Sexual and Reproductive Health and Rights (SRHR), is not only essential for equity but also critical for achieving sustainable and inclusive climate resilience.

15. RECOMMENDATIONS

To address these challenges and promote more equitable climate resilience, the following recommendations are proposed. These suggestions aim to dismantle structural inequalities, empower women, and integrate essential considerations such as Sexual and Reproductive Health and Rights (SRHR) into climate adaptation frameworks. By prioritising these areas, it is possible to enhance women's agency and ensure a more inclusive approach to climate resilience.

- Promote Gender-Responsive Climate Policies:
- National and local climate adaptation frameworks should be designed to be gender-responsive, ensuring that women's voices, roles, and needs are actively included in decision-making processes. This includes incorporating women's leadership in climate governance and acknowledging their unique contributions to climate resilience.
- To dismantle patriarchy in a community, there is a need for a multifaceted approach that combines education, policy, and cultural transformation. Communities should prioritise awareness and education programmes that challenge gender stereotypes from an early age, ensuring that both men and women are sensitised to equality and mutual respect.
- Empower Women with Access to Land, Resources, and Financial Services:
- To enhance women's capacity to adapt to climate change, policies should ensure equal access to land ownership and financial resources. This will allow women to invest in sustainable agricultural practices and climate resilience strategies, addressing the gendered barriers that limit their economic agency.
- Integrate SRHR into Climate Adaptation Strategies:
- Climate adaptation programs must incorporate SRHR considerations, ensuring that women's health, safety, and rights are protected during climate induced stress. This includes addressing issues like maternal health, gender-based violence, and ensuring women's access to reproductive health services in times of crisis.

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COMMUNICATING CLIMATE-RELATED HEALTH RISKS IN LOCAL COMMUNITIES

BY B.O. Adegebo and A.A. Fadiya

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ABSTRACT

Scientific reports on climate-related health risks contain large amounts of information and academic jargon that are often difficult to understand by non-experts. Effectively communicating the health consequences of climate change in simplified contexts remains crucial for raising local awareness and enhancing individual and community response to climate-related health initiatives, especially in tropical cities. Using two purposefully designed semi-structured questionnaires administered to 150 respondents randomly selected across targeted groups, including children and adolescents, adults, and the elderly in Ado-Ekiti, an emerging city in Southwest Nigeria, this study investigates the communication tools that can most effectively disseminate information on climate-related health risks on a more personal level. It examines the communication barriers that limit people's access, understanding and attitudes toward climate-related health information. The study's findings could provide valuable insights that can improve how climate-related health concerns and mitigation policies are communicated to local communities, ultimately reducing population health risks.

KEY WORDS Climate Change, Health Vulnerabilities, Risk Communication, Local Communities, Nigeria.

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1. INTRODUCTION

The scientific discourse on the health consequences of climate change shows that there are complex, direct, and indirect pathways by which the changing climate is affecting human health and well-being globally. These health impacts are brought on by human exposure to climate variations and extreme weather events, including heatwaves, flooding, and windstorms (Rocque et al., 2021). The indirect health effects of prolonged exposure to intense heat include physiological discomfort due to heat stress, heat exhaustion, and dehydration (Adegebo, 2022), as well as more subtle but deadly health effects such as the exacerbation of chronic illnesses like mental illnesses, cardiovascular, respiratory, and kidney diseases (Wagner et al., 2021; Deglon et al., 2023). Extreme weather events can have a direct effect on human health through physical injuries from windstorms and flooding, as well as illnesses and deaths linked to these extreme weather events (Suhr and Steinert, 2022). Food insecurity and nutritional issues are two more intricate ways that climate change is affecting human health through its effects on agricultural systems (Sorgho et al., 2020). It is evident from climate reports by the Intergovernmental Panel on Climate Change (IPCC) that anthropogenic climate change, rapid urbanisation, population increase, and urban heat islands will amplify these health impacts in the years to come, as the frequency and duration of extreme weather events are predicted to increase (IPCC, 2022).

While everyone is at risk, the projected impact varies geographically and demographically due to the combined effects of extreme weather events, exposure duration, and socio-economic factors that render certain regions more susceptible to climate-related health risks. For instance, countries in West Africa, such as Nigeria, have been recognised as the most vulnerable to health effects associated with climate change. This is due to observed and anticipated climate trends, the rapid pace of urbanisation, and intricate developmental issues (Aliyu and Amadu, 2017; Sylla et al, 2016; Adelekan et al., 2022). Fast-growing tropical cities in West Africa are particularly noted as major hotspots for climate-related health impacts (IPCC, 2022). Individuals with poor socioeconomic status, children, the elderly, outdoor workers, people with a chronic illness or disability, and women are among the vulnerable groups that are highly concentrated in these cities (Barry et al., 2018). This may have an impact on local communities' and individuals' ability to anticipate, manage, adjust to, and recover from health impacts associated with climate change.

To create awareness and build resilience to the inevitable impacts of climate change, the concept of framing, which explains how the presentation of information about a particular issue can affect an individual's perception and understanding of that issue, is one of the widely used concepts in risk communication (Guenther et al., 2024; Badullovich et al., 2020). Framing climate change as a public health problem and effectively communicating the health risks can encourage individuals and vulnerable communities to take climate action and policies seriously. It is suggested that climate risk communication should be framed to provide adequate information on the urgent need to address anthropogenic drivers of climate change at both individual and collective scales, as well as adaptation strategies and protective behaviours to reduce exposure and health vulnerabilities (Janković and Schultz, 2017). Increasing public knowledge, understanding, attitude, and response to climate-related information, efforts, and policies largely depend on effective risk communication (Maibach et al., 2011). It is also possible to promote group efforts in mitigation and adaptation measures by clearly defining and conveying the link between human health and climate change, as well as the health effects of climate change in local communities, and targeting groups (Glaas et al. 2015; Peters et al. 2022). Therefore, communication materials used for disseminating information on climate-related health risks are expected to be easy to understand and relatable to the targeted population. For example, the use of short or summarised messages and graphics may be easier to comprehend than long messages with complex scientific terms (Terrado et al. 2018; Sheshi and Yisa, 2024). Kreslake et al. (2016) noted that risk communication materials such as graphics and short messages used to explain climate-related health risks were found to be effective in influencing protective behaviours in vulnerable persons. Similarly, communicating short-term climate-related health risks has been found to improve individual and population responses to extreme weather events, such as heatwaves, flooding, and hurricanes, rather than long-term health risks (MacIntyre et al., 2019). This implies that individuals may respond positively to climate-related health mitigation strategies that address immediate risks perceived as personal, rather than long-term climate projections and risks.

Over the years, climate change awareness has been increasing in several West African countries, especially Nigeria, but not without scepticism. One of the main causes of inaction or indifference is still a lack of understanding of the threats posed by climate change (Olorunfemi, 2009). Previous studies have evaluated how media frame climate-related risks and the response of their audience (Adekola and Lamond, 2018; Ogundele and Sodeinde, 2025; Nwafor and Aghaebe, 2025). Even though people's perceptions of the risks associated with climate change vary greatly, many Nigerians living in large cities have experienced several climate-related events over the years, including flooding, windstorms, drought, and sea level rise, which have had negative impacts on their health and increased the number of vector-borne illnesses and injuries (Raimi et al., 2021; Mfon et al., 2022; Umar and Gray, 2023; Abdulwahab et al., 2024). This has raised the nation's awareness of climate change, influenced the population's

risk perception and emphasised the importance of taking preventative measures. Given the development and accessibility of digital technology, communication channels used for information dissemination remain vital for successful risk communication, in addition to framing climate-related health risks for targeted populations. This is to ensure that preventive information, and not just emergency information, is well disseminated in local communities. Depending on how information about climate change and human health is presented and conveyed, targeted groups can have a better understanding of climate-related health issues, such as the individual activities that might increase population risk.

Despite perceived tolerance to heat, it is still essential to appropriately frame and effectively communicate both the direct and indirect impact of exposure to climate variations and extreme weather events on human health, particularly the long-lasting but subtle effects of extreme heat exposure to vulnerable populations in many Nigerian cities. Various communication tools have been employed to raise awareness about the changing climate and how it affects diverse systems, such as health and agriculture (Ouedraogo et al., 2018; Ofoegbu and New, 2022; Sheshi and Yisa, 2024). Advancements in digital technology have also made media and social network platforms invaluable for disseminating climate-related information, but not without challenges (Ogwezi and Umukoro, 2020; Nwafor and Aghaebe, 2025). However, disparities in socioeconomic status, language, individual health, neighbourhood infrastructure, and personal digital technology use can influence how climate-related health information is accessed, trusted, and used (Aririguzoh et al., 2021; Nweze et al., 2023; Oramah et al., 2025). While large cities in Nigeria may focus on urban modification and mitigation strategies to address climate-related health impacts, emerging cities still have the opportunity to effectively plan urban morphology and develop vital public infrastructure, including transportation, energy, and waste management systems, that can cater for population growth while creating jobs and a sustainable, climate-friendly environment. There is also an opportunity to incorporate climate-related information at developmental stages as cities expand, to provide useful information on "what is where and why." Effectively communicating climate change information, health risks and adaptation strategies, particularly to vulnerable populations in these emerging cities, can help improve how climate-related initiatives are understood, appreciated, prioritised, and implemented.

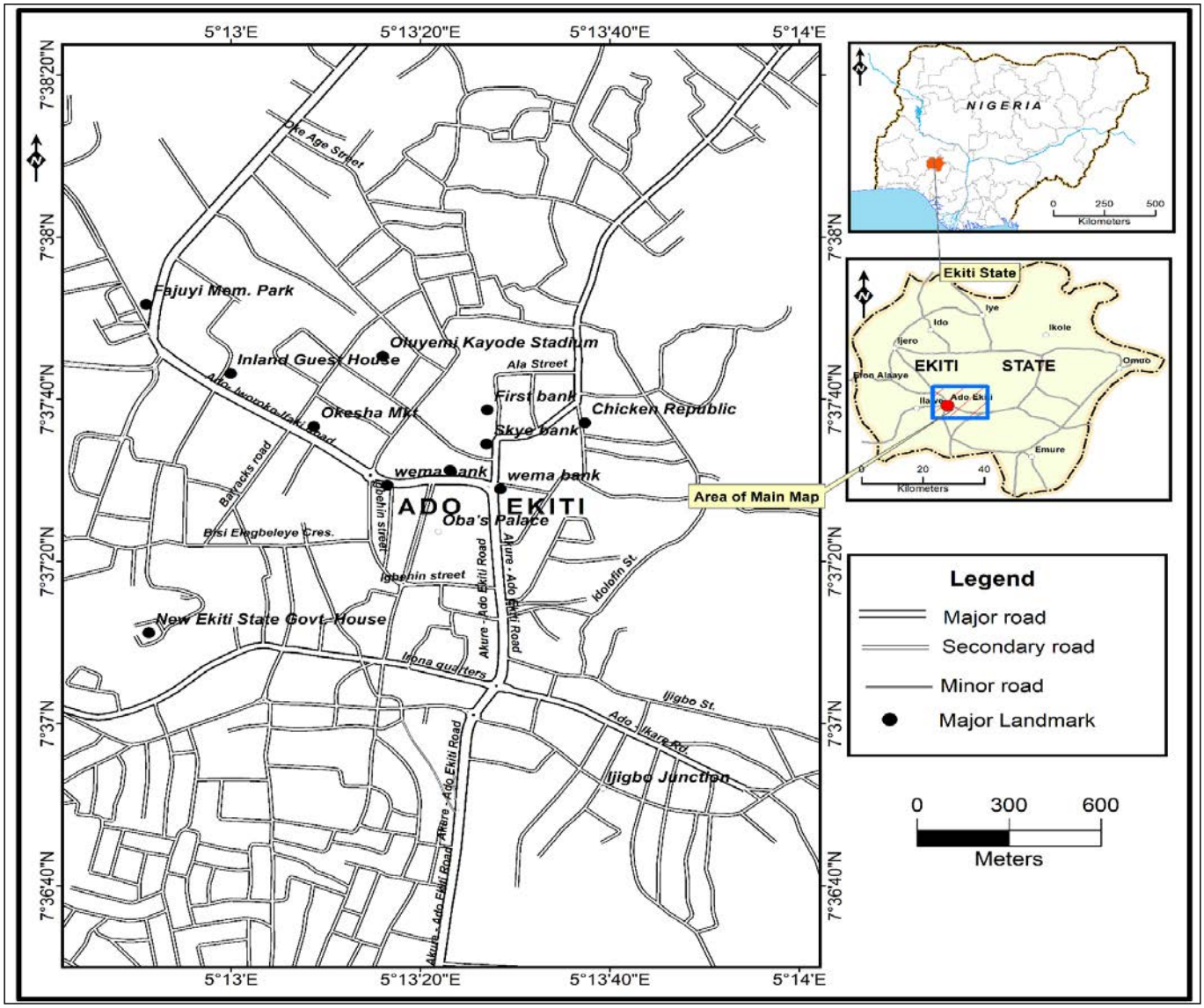
To better inform vulnerable groups, such as children, young people, and the elderly, about the health risks associated with climate change on a more personal level, this study examined the most effective communication channels in Ado-Ekiti, an emerging city in South West Nigeria. The study also examines current communication barriers that restrict people's and communities' access, understanding, attitudes, and responses to climate-related health information and mitigation initiatives. This can provide valuable information on climate and health communication strategies and improve how both short-term and long-term climate-related health information and interventions are disseminated in terms of context, communication channel and target population. It can also enhance an individual's climate perception, protective behaviours, and attitude towards government-led initiatives in their immediate environment.

2. MATERIALS AND METHODS

2.1. Study Area

Ado-Ekiti is an emerging city in south western Nigeria located between Latitude 7o34' and 7o44' N and Longitude 5o11' and 5o18' E (Figure 1). The city emerged as a major Yoruba city and state capital of Ekiti State following the creation of the state in 1996. The city has a total landmass area of approximately 345.25 km², with elevations ranging between 335m in the southeastern part of the city and about 730m in the southwestern part of the city (Adebayo, 1993). Ado-Ekiti's dual role as a state capital and local government area (LGA) has influenced the rapid increase in population, with an influx of people from satellite towns and rural areas driven by both infrastructural development and educational facilities. This resulted in the expansion of the city, characterised by growing built-up areas and a loss of vegetated land (Olofin and Oluwadare 2022). In 2006, the National Population Census (NPC) reported the city's population as approximately 308,621, with a population density of 43,986 persons per kilometre (NPC, 2006). According to the Ekiti State Local Government Statistics report for 2020, this population has grown significantly over the last two decades. It is currently estimated to be around 541,521. Ado-Ekiti is facing its fair share of environmental problems brought on by urbanisation and the effects of climate change (Aladelokun and Ajayi 2014; Owolabi and Adebayo 2013; Olofin and Oluwadare 2022). The city has a tropical wet and dry climate, with its wet season running from April to October and the dry season from November to March. The mean annual temperature ranges between 21 °C and 28 °C, with February and March being the hottest months.

Figure 1: Map of Ado Ekiti Metropolis



Source: Authors (2024)

2.2 Data Collection

This study employed two purposefully designed semi-structured questionnaires: one for children and adolescents between ages 8 and 18 years, and the other for young adults (18 years and above) and the elderly. A total of 150 respondents were randomly selected (50 respondents for the children/adolescent group and 100 respondents for the young adults and elderly persons). Children and adolescents were provided with consent forms to be filled out by their parents or guardians before the survey was conducted, while individual consent was obtained from adult participants. The questionnaires were used to obtain information on the level of awareness of climate change impact on human health, sources from which information on climate-related health impacts were received, how well the information source is trusted and understood, what communication tool and how easily accessible the information is, and what they plan to do with the information received to reduce climate-induced health risk. Data collection was conducted between January and March 2024. Out of the 150 questionnaires, 145 were valid for analysis (46 for children/adolescents and 99 for adult/elderly respondents). All statistical analyses to determine associations between sociodemographic characteristics and information sources/tools, as well as barriers, were carried out using Microsoft Excel and the Statistical Package for the Social Sciences (SPSS v. 21.0).

3. RESULTS

3.1. Demographic characteristics of respondents

The survey result (Table 1) shows that out of the 99 adult respondents, 43.4 per cent were between the ages of 18 and 25, and 22.2 per cent were above 60 years old. The majority of these respondents (55.6%) were female, and the proportion of married and single individuals (49.5%) was equal. Only 11.1% of respondents were from the Igbo tribe, compared to over 80% of Yoruba respondents. Since over 75% of these respondents were postsecondary institution graduates, the majority were educated. While 26.3 per cent of them were unemployed, a small percentage were in business or trade (24.2%), civil or public service (20.2%), artisanal work (9.1%), and pensioners (11.1%).

Table 1: Socio-demographic characteristics of Adult/Elderly respondents (n=99)

Indicator	Frequency	Percent
Age (Years)		
18-25	43	43.4
26-40	16	16.2
41-50	15	15.2
51-60	3	3.0
Above 60	22	22.2
Sex		
Male	44	44.4
Female	55	55.6
Marital Status		
Single	49	49.5
Married	49	49.5
Separated	1	1.0
Religion		
Christianity	82	82.8
Islam	15	15.2
Traditional	2	2.0
Ethnicity		
Yoruba	80	80.8
Igbo	11	11.1
Hausa	1	1.0
Others	7	7.1
Education		
No Formal Education	5	5.1
Primary	3	3.0
Secondary	12	12.1
Tertiary	75	75.8
Others	4	4.0
Occupation		
Civil/Public servant	20	20.2
Others	9	9.1
Artisan	9	9.1
Retiree	11	11.1

Indicator	Frequency	Percent
Trading/Business	24	24.2
Unemployed	26	26.3
Work Environment		
Indoor	25	25.3
Outdoor	45	45.5
Others (both)	29	29.3

Source: Field work, 2024

Out of the 46 participants who were children/adolescents, the survey result (Table 2) shows that the majority (47.8%) were between the ages of 15 and 18 years, and many of these children (52.2%) were below 14 years old. Over 90% of the respondents were in secondary school (91.3%) and from the Yoruba tribe (93.5%).

Table 2: Demographic characteristics of Children/Adolescents participants (n=46)

Indicator	Frequency	Percent
Age (Years)		
Less than 14	24	52.2
15-17	22	47.8
Sex		
Male	25	54.3
Female	21	45.7
Religion		
Christianity	39	84.8
Islam	7	15.2
Ethnicity		
Hausa	2	4.3
Igbo	1	2.2
Yoruba	43	93.5
Education		
Primary	4	8.7
Secondary	42	91.3

Source: Field work, 2024

3.2. Climate change awareness and potential health impacts

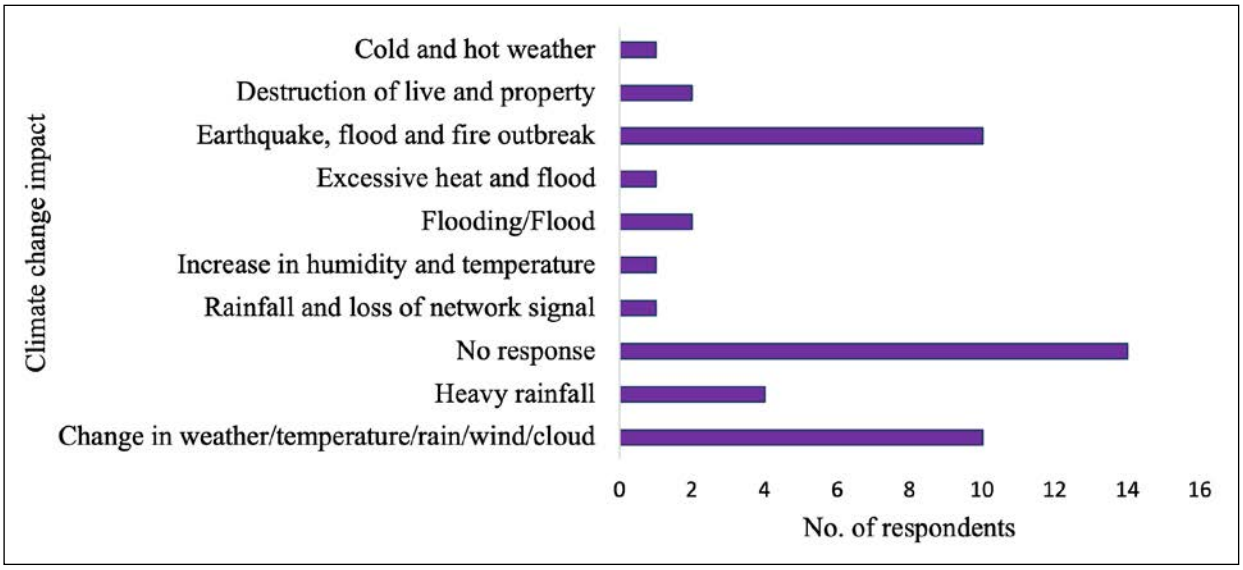
The majority of adult respondents between the ages of 18 and 25 (58.1%), and 41 and 50 years (86.7%) were familiar with the term climate change, while many (69.6%) of the children less than 18 years were familiar with the term climate change (see Table 3). The perceived impacts of climate change among children and adult respondents are presented in Figures 2 and 3.

Table 3: Level of familiarity with climate change and impacts among children and adult respondents

	Age (Years)	Not familiar (%)	Familiar (%)
Are you familiar with the term Climate Change?	**Below 18**	30.4	69.6
	18-25	41.9	58.1
	26-40	50	50
	41-50	13.3	86.7
	51-60	0	100
	Above 60	40.9	59.1

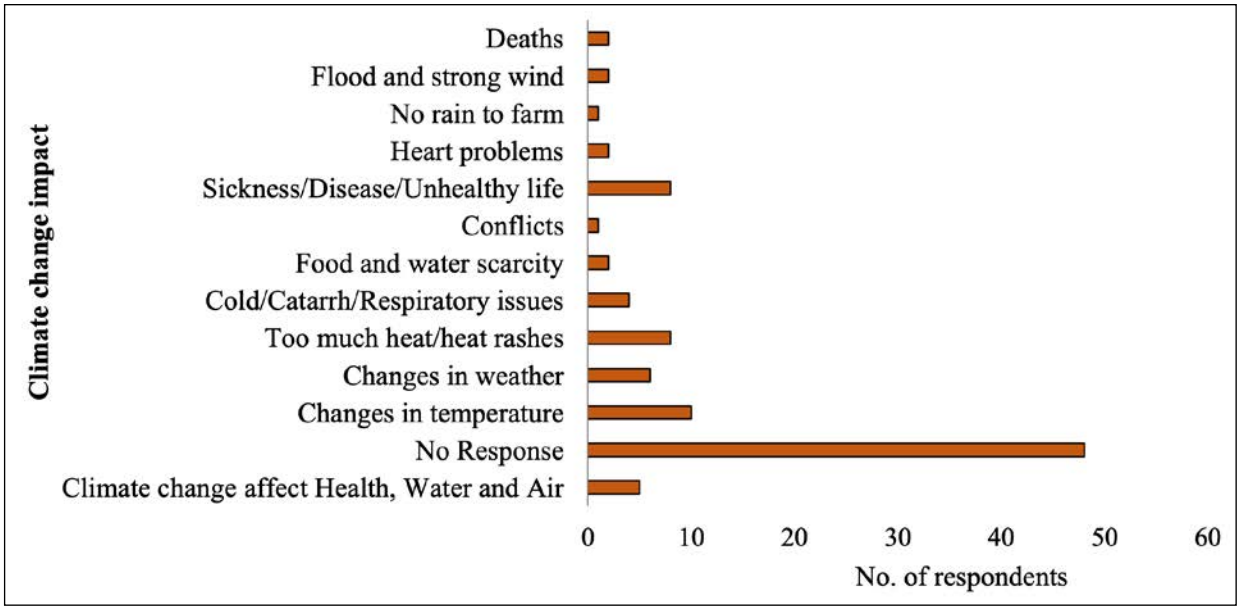
Source: Field work, 2024

Figure 2: Perceived impacts of climate change among children/adolescents



Source: Field work, 2024

Figure 3: Perceived impacts of climate change among adults/elderly respondents



Source: Field work, 2024

Out of the 46 respondents who were children, 95.7% indicated that they were familiar with the potential threat climate change poses to their health, and a large proportion of the adult respondents were also aware that climate change can affect their individual health.

Table 4: **Level of familiarity with the potential health impacts of climate change**

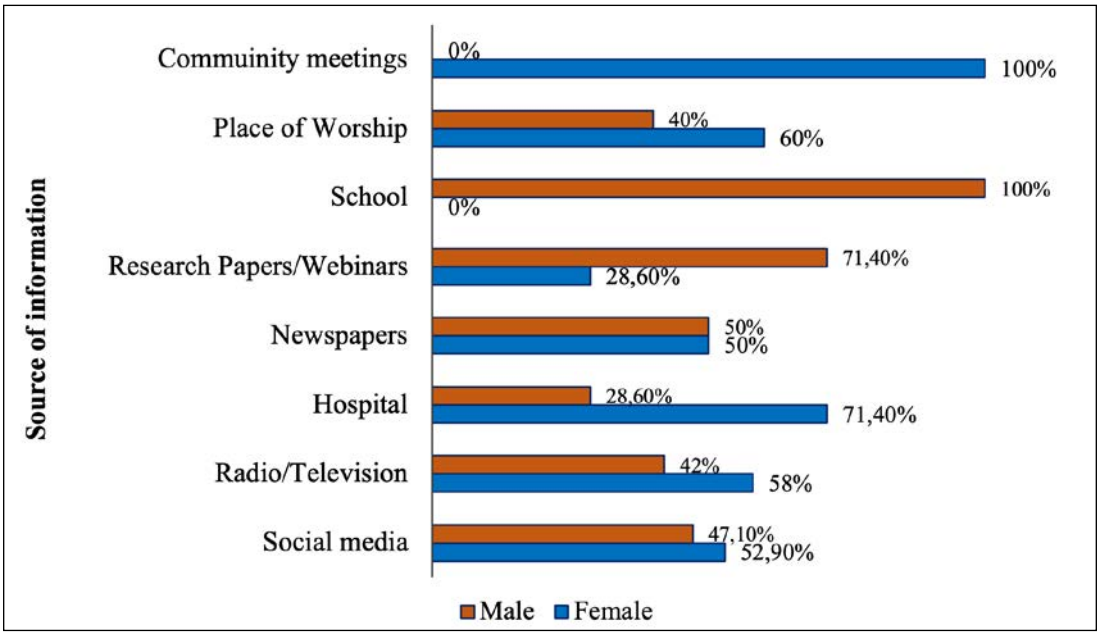
	Age (Years)	Not Familiar (%)	Very Familiar (%)
How familiar are you with the potential health impacts of climate change on human health?	**Below 18**	4.3	95.7
	18-25	20.9	79.1
	26-40	31.3	68.7
	41-50	20.0	80.0
	51-60	0	100
	Above 60	18.2	81.8

Source: Field work, 2024

3.3. Sources of information on climate change and potential health impacts

The result of the survey (Figure 4) shows that there are several sources of information on climate change and potential health impacts by sex. Most female adult respondents indicated that community meetings (100%), hospitals (71.4%), place of worship (60%), radio/television (58%) and social media (52.9%) were major sources of information on climate-related health impacts, while school (100%) and research papers/webinars (71.4%) were major sources for male adult respondents.

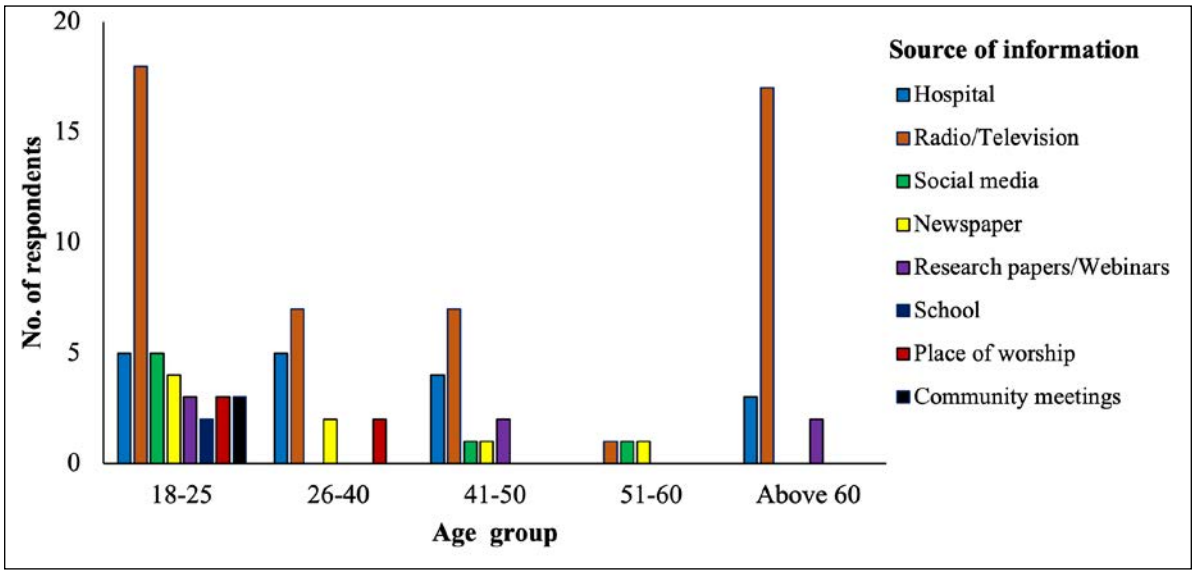
Figure 4: Sources of climate-related health information among adult respondents by sex



Source: Field work, 2024

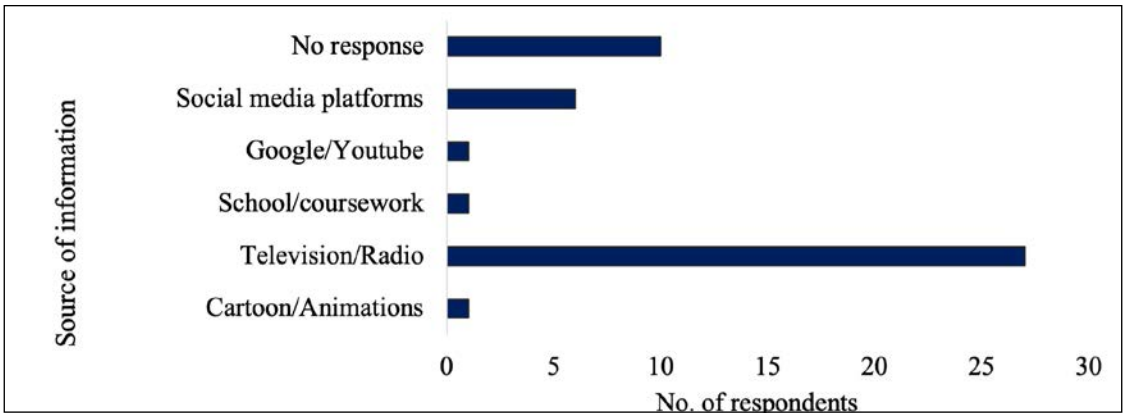
The results (Figures 5 & 6) show that the majority of respondents across each target group obtain their information from local radio and television channels.

Figure 5: Sources of climate-related health information among adult respondents by age



Source: Field work, 2024

Figure 6: Sources of climate-related health information among children/adolescents



Source: Field work, 2024

The result (Table 5) shows that a large proportion (97.8%) of respondents who were children believe what they read or hear from their information sources, and 34.8% of these children/adolescents do not question anyone about what they read or hear.

Table 5: Credibility of climate-related health information among children/adolescents

		No. of respondents	Per cent (%)
Do you believe what you read or hear about climate change impacts on human health from these information sources?	**Yes**	45	97.80
	No	1	2.20
Did you ask anyone about what you read or heard about the climate change impact on human health?	**Yes**	30	65.2
	No	16	34.8

Source: Field work, 2024

Out of the 99 adult respondents, 47 respondents indicated that they found climate-related health information from local radio/ television channels very credible (Table 6).

Table 6: Credibility of climate-related health information among adult respondents

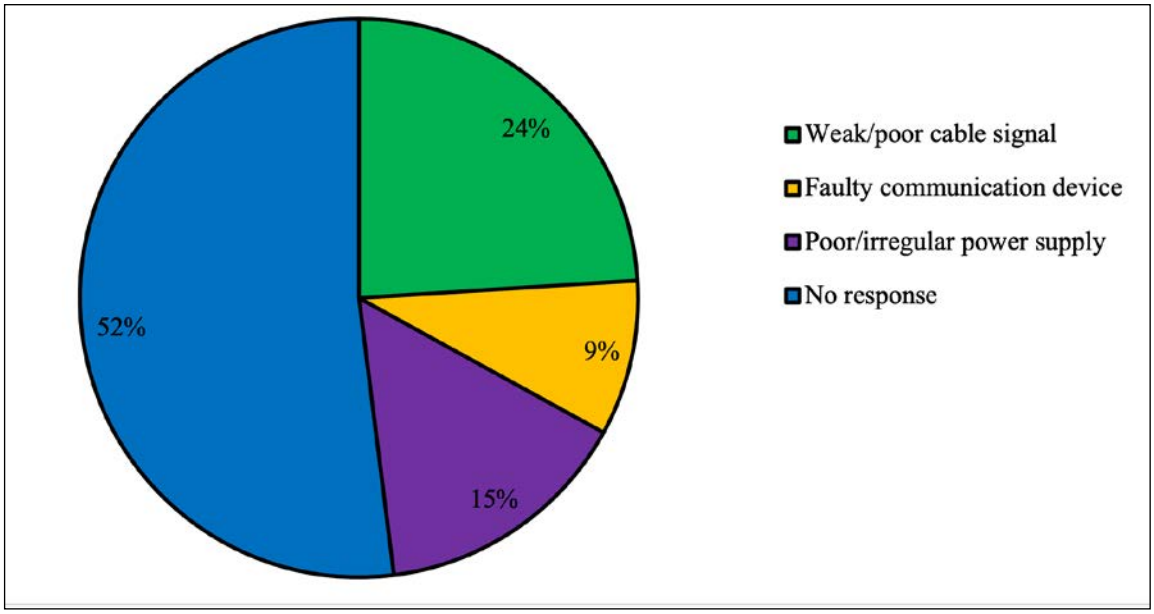
Source of information	Not credible	Slightly credible	Very credible
Hospital	1	0	16
Radio/Television	2	0	47
Social media	2	5	0
Newspaper	3	5	0
Research papers/webinars	4	3	0
School	0	2	0
Place of Worship	5	0	0
Community meetings	2	1	0

Source: Field work, 2024

3.4. Challenges limiting access to climate-related health information

Out of the 46 respondents who were children, 11 (24%) of them indicated that the major challenge limiting access to climate-related health information was poor electricity supply and weak cable signals (Figure 7).

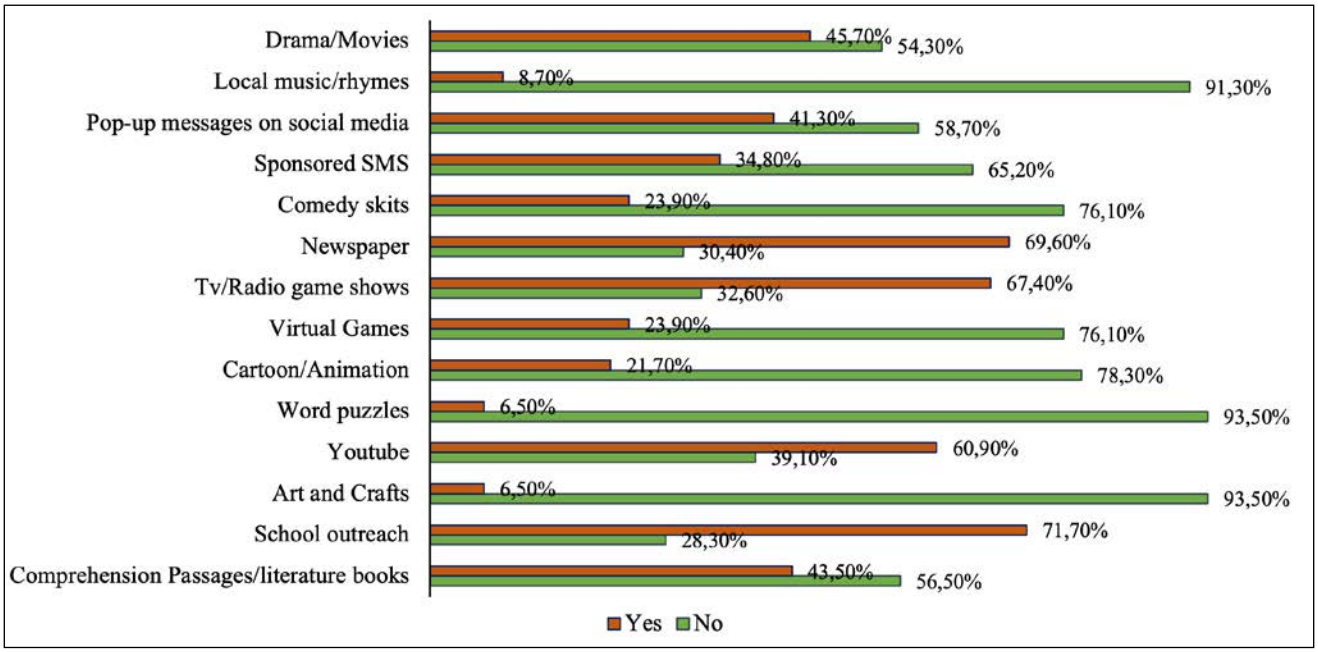
Figure 7: Limitations to climate-related health information among children/adolescents



Source: Field work, 2024

The result (Figure 8) shows the recommended choice of communication tools to improve climate-related information among children/adolescents. The majority thought that school outreach (71.7%), Newspapers (69.6%), TV/radio game shows (67.4%) and YouTube channels (60.9%) are primary communication tools that can be adopted in disseminating climate-related health information.

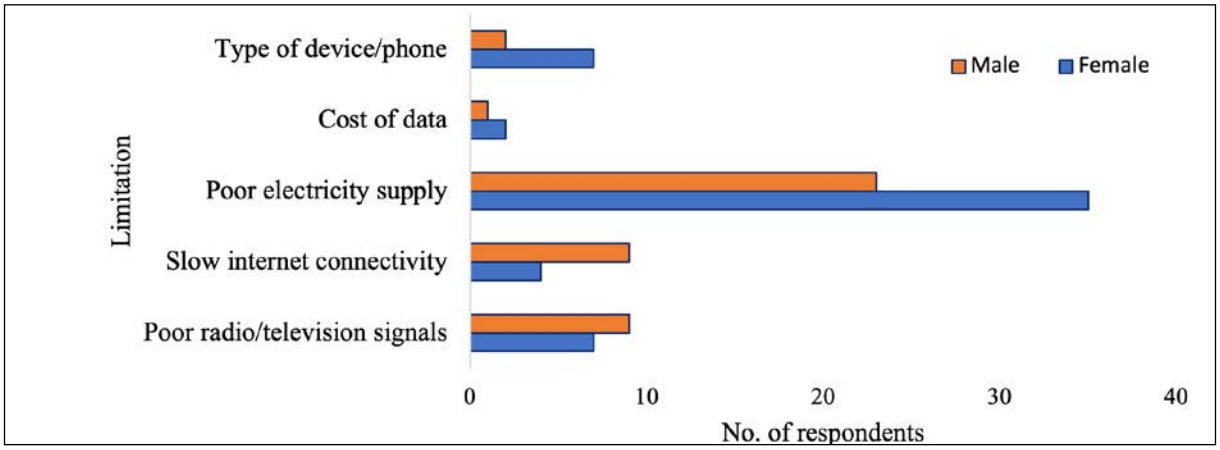
Figure 8: Sources of climate-related health information among children/adolescents



Source: Field work, 2024

The result (Figure 9) shows the major challenges that limit access to climate-related health information among adult respondents. The majority of adult respondents (F=35: 63.6%), Male = 23 (52.3%), indicated that poor electricity supply remains the major challenge limiting access to climate-related health information.

Figure 9: Limitations to climate-related health information among adult respondents



Source: Field work, 2024

4. DISCUSSION

Globally, climate change and its effects on human health have been raised as public health issues. The information that is available to an individual, their level of comprehension of that knowledge, and the perceived reliability of the information sources, however, may all influence how they perceive the health risks associated with climate change. This study assessed the best ways to communicate with targeted populations in an emerging Nigerian city about the health risks associated with climate change, as well as the barriers that prevent people from accessing, understanding, and reacting to climate-related information. The study's findings made it clear that, despite being familiar with the term "climate change," children who participated in the survey, the majority of whom were in secondary school, had very little knowledge about the phenomenon and its health effects. It was also clear that adult respondents lacked sufficient understanding regarding climate change and its direct and indirect effects on human health, even though they could recognise some effects. This may influence their general attitude and reaction to climate-related issues. Considering that the vast majority of the sampled adult participants were under 25 and above 60 years, and literate, it was anticipated that contemporary communication channels would be rationally more effective given the technological advancements in Nigerian communication techniques, as shown by the existing literature (Ogwezi and Umukoro, 2020; Nwafor and Aghaebe, 2025). The study's findings, however, show that the traditional media, including newspapers, radio and television channels, remain a widely acceptable source of climate-related health information among both the young and the elderly in the study location. This implies that, regardless of age, gender, or social status, the traditional media continues to have a significant impact on the spread of important information, including that about the health impacts of climate change. The way traditional media present climate-related concerns and engage their audience is probably the cause of this (Adekola and Lamond, 2018; Devi et al., 2022; Ogundele and Sodeinde, 2025).

The study also revealed that the sources of climate-related health information differed by gender among adult respondents, with most adult male respondents learning about climate change and related health risks from online sources (research papers and webinars) or at school, while female respondents learned about climate change and related health risks from hospitals, traditional media, social media, and places of worship. This suggests that the context in which risks are perceived can vary. Reliable information sources and well-understood narratives are also necessary for effective risk communication. The study's findings demonstrated that, despite the availability of a variety of information sources on climate change and health concerns, adults regarded traditional media and hospitals as reliable information sources. While most children get their information about climate change from social media and traditional media, they tend to believe it without consulting an adult or asking questions. Also, their perception about climate change impacts in their locality was shallow, with responses relating to environmental challenges observed on social media in other environments, such as earthquakes. This shows how different people see and interpret the same information in different contexts, even when they are exposed to it from the same source. This is seen in how children and adults responded to questions about the effects of climate change.

The study also examined the communication barriers that individuals and local communities face when trying to access climate and health-related information. The study's findings showed that most of the adult respondents highlighted unpredictable electricity supply/power outage as a major difficulty in getting information on climate and health issues in Ado-Ekiti. Although there are radio sets that run on batteries, the cost of regularly buying batteries for the preferred communication devices (e.g. radio) is another main challenge. Similarly, respondents' access to and attitudes toward climate change problems are impacted by weak radio and television signals in the sampled areas. Children are irritated by the poor internet connection, which was also noted. This shows that the lack of proper neighbourhood infrastructure is a significant problem in many developing Nigerian cities, even though framing and communication channels are essential for disseminating health risks associated with climate change. Addressing these challenges, the majority of children who participated in the survey recommended school outreach, newspapers, TV/radio game shows and YouTube channels as the main communication channels that can be used to spread health information about climate change. These tools were suggested as a way to improve information about climate change among children and adolescents. Short dramas or films and literary books or textbook comprehension passages were also suggested as communication tools. Accurate information on climate-related health risks can be given, and their curiosity in finding additional relevant information can be piqued with the use of these suggested communication strategies.

5. CONCLUSION

Building resilience on both an individual and community level depends on effectively conveying the health concerns connected with climate change. The context and risk that climate information presents may be simple for many professionals to understand, but without properly framing the context for targeted populations and using easily accessible communication tools to disseminate the information, it may be difficult, particularly for children and non-professionals to understand. Information on health risks associated with climate change can raise local awareness, but it may not be sufficient to

motivate individual climate action if the content and communication strategies or channels used do not resonate with the target audience on a more personal level. Therefore, emerging cities in West Africa, and Nigeria in particular, should increase the effectiveness of communication tools for communicating health and climate risks, especially in rural and semi-urban communities, by offering vulnerable people messages that are clear, innovative, easily accessible, and tailored to their needs.

6. RECOMMENDATIONS

Based on the findings of this study, frequent school outreach could help bring climate-related health information closer to children, who are less likely to seek out such information. Using comic books, debates, comedy skits, and games (radio quizzes, talk shows, newspaper puzzles and crosswords) to spread messages, as well as engage online influencers and celebrities that have a significant impact on kids and teens, to help spread the word about the health dangers of climate change while also providing some fun. In a similar vein, climate-related health lessons can be included in children-friendly storybooks and approved literature, as well as comprehension passages or essay writing topics can help children and teens learn while they're in school.

Since there are a variety of information channels, simultaneously communicating climate-related health risks on these communication channels can also enhance information dissemination to the target audience. While infrastructural challenges may be a major barrier to getting informed about the health impacts of climate change, collaborative outreach programs such as health talks in places of worship, the workplace and communities by a team of climate/ environment advocates and health professionals can also help disseminate information effectively in local communities.

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WHO DOES WHAT? ANALYSIS OF THE ROLES OF ACTORS IN AFFORDABLE SANITATION SERVICE DELIVERY IN INFORMAL SETTLEMENTS IN KUMASI, GHANA

By P.D. ABOAGYE

Published 1 February 2026

ABSTRACT

Evidence suggests that the majority of people living in informal settlements lack affordable basic sanitation services. This situation has been explored in numerous development discourses worldwide. Previous studies have argued for harnessing the potential of local actors involved in delivering sanitation services to provide affordable sanitation to informal settlements. However, limited research has focused on the specific roles sanitation service providers play in delivering affordable sanitation services in informal settlements. This study employs a qualitative approach, drawing on document reviews and semi-structured interviews, to ascertain the roles of sanitation service delivery actors in delivering affordable sanitation services to informal dwellers. The results show a tripartite system of collaboration in the delivery of affordable sanitation service in informal settlements in Kumasi, Ghana. With regard to specific roles, the findings reveal that the state plays a planning, regulatory, and policy-making role, whereas non-state actors mostly spearhead the delivery of sanitation services through financing, advocacy, management, research, training, and capacity building. The study emphasizes the crucial role of diverse actors in service provision and stresses enhanced coordination among these actors through effective participatory approaches in the delivery of affordable sanitation services to informal urban communities.

KEY WORDS: Informal settlements, Actors, Sanitation Service, Affordable, Kumasi.

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1. INTRODUCTION

Informal settlements are often characterized by poor housing, overcrowding, insanitary conditions, squalor, and increasing poverty. It has been noted that a large number of urban residents living in informal settlements lack improved sanitation. Improved sanitation is seen as a fundamental human right, and it offers economic benefits that often exceed its cost). Target 6.2 of the Sustainable Development Goals (SDGs) demands that governments and stakeholders achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, with much emphasis on the needs of women and girls, by the end of 2030 (United Nations, 2018). Lack of proper sanitation, especially in informal settlements, contributes to a high incidence of diarrhoea and cholera (Nguyen et al., 2021; Sinharoy et al., 2019). This has impelled governments and stakeholders in developing countries to place much importance on improved sanitation.

A report by the WHO indicates that over 1.5 billion people worldwide lack access to basic sanitation services, such as private toilets or latrines (WHO, 2023). In low- and middle-income countries, only 30% of the population has access to basic sanitation services (WHO, 2023). Conventional literature has highlighted enormous challenges in providing adequate sanitation services in informal settlements at both the micro (individual households) and macro (community and public)[1] levels1 (Sprouse et al., 2025). Regarding these challenges, Schrecongost and Wong (2015) highlighted four impediments to the provision of improved sanitation services in informal settlements. These include little evidence about the scale and nature of the problem; little or no advocacy; inadequate financial capability; and security of tenure on the part of residents. They noted that these challenges are often a result of a weak, implicitly adverse political commitment to ensure adequate sanitation services in informal settlements. Limited or shared sanitation, often characterized as substandard, has become the main option for most urban informal dwellers due to barriers such as insecurity of land tenure, overcrowding and high population density, among others (Sprouse et al., 2025).

Arguably, governments' posture on infrastructure and service provision in informal communities is often complex and elusive. Many scholars submit that informal communities are often overlooked in service provision by city authorities (Borofsky and Caprotti, 2025; Chumo et al., 2025). This phenomenon is attributable to a lack of proper urban governance systems, including the absence of legal recognition and official data, which makes the responsibility for service provision unclear. However, recognizing basic infrastructure and services as public goods, thereby improving people's well-being, necessitated public expenditure on service provision for informal communities (Gaisie et al., 2018). Subsequently, governments in many developing countries, especially in Africa, have historically assumed the role of providing services to informal communities, usually provided entirely for free or heavily subsidized. In South Africa, for instance, the government's Informal Settlements Upgrading Programme and the Finance Linked Individual Subsidy Programme provide basic services such as water, electricity, and basic sanitation, as well as housing subsidies for informal dwellers, respectively (Mgidlana et al., 2025). This nature of service provision often leads to a lack of ownership among beneficiary communities and households. Thus, publicly owned and operated infrastructure, like sanitation facilities, is often characterized by poor maintenance, mismanagement and inefficiencies (Ewnetu and Seo, 2025). It is asserted that such issues have led to the shift towards more commercial-driven or private provision of infrastructure in order to ensure efficiency, enhance innovation and enforce standards that ensure the well-being of people (Ewnetu and Seo, 2025; Gaisie et al., 2018).

In general, the private sector is touted as more efficient at delivering infrastructure and services (World Bank, 2012). However, private companies are often more profit-oriented and may not necessarily consider the public health implications of providing affordable sanitation services or readily see the public good relevance of serving informal communities. Consequently, this necessitated pro-poor Public-Private Partnerships (PPPs) in the delivery of basic infrastructure and services, which continues to be a major model for service provision to informal and low-income urban communities (Muheirwe et al., 2024; Tanveer et al., 2025). Besides PPPs, Civil Society Organizations (CSOs) and Non-Governmental Organizations (NGOs), through donor-sponsored funding, play a very active role in infrastructure and service provision to informal communities (Borofsky and Caprotti, 2025; Muheirwe et al., 2024). The various models of service provision to informal communities use different levels of participation to engage beneficiaries. Certainly, this engenders several conversations about the complex interactions among the actors involved in delivering sanitation services to informal and low-income urban communities.

The above discourse shows that recent scholarship has increasingly highlighted the provision of infrastructure and services in informal settlements. Despite this growing body of work, important questions in service provision in informal settlements remain underexplored, particularly regarding the specific roles actors play in delivering affordable sanitation services. Using two informal communities in Kumasi as a case study, this paper seeks to achieve the following objectives: (1) examine the typologies of actors in the delivery of affordable sanitation in informal communities in Kumasi, Ghana, and (2) analyze the roles that sanitation delivery actors play in the quest to deliver affordable

[1] Communal toilets are usually located within residential neighborhoods and shared by multiple households within a community. Public toilets are usually located in public areas of the city, such as bus terminals and markets.

sanitation services to informal dwellers in Kumasi, Ghana. Further, the paper conceptualizes the nature of actors' roles in sanitation service delivery in informal settlements in Kumasi. The results presented in this paper are expected to contribute to efforts towards slum and informal settlement upgrading by guiding sanitation service delivery planning, design, and policy-making in developing countries.

2. INFORMAL SETTLEMENTS IN GHANA – GROWTH, MANAGEMENT, AND SANITATION SERVICE PROVISION

2.1. The growth and management of informal settlements in Ghana

Over the years, Ghana has introduced measures to regulate the use of land resources to achieve desired human settlements. For instance, by 1892, a Town Planning Ordinance was passed to regulate the development of towns, the siting and construction of individual structures, and the promotion of sanitation and public health within the Gold Coast Colony (now Ghana) (Mensah, 2010). In recent years, the decentralization system of Ghana and the quest of successive governments to improve and guide the planning, development, and management of settlements, has led to the enactment of new laws, including the Local Governance Act (Act 936) of 2016, the Land Use and Spatial Planning Act, (Act 925) of 2016 to regulate physical developments in the country (Gaisie et al., 2018). However, these laws and regulations have not been able to curb the sprouting of informal settlements in Ghana.

This is largely blamed on the lack of enforcement of laws and regulations, and on the inability of city authorities to manage the rapid urban expansion, which has not been commensurate with infrastructure provision (Hakeem et al., 2022).

According to the existing literature, four main factors have been identified as triggers for the growth of informal settlements in urban areas (Centre on Housing Rights and Evictions (COHRE), 1995; Sietchiping, 2004; Mensah, 2010; Gaisie et al., 2018). They encompass physical, socio-economic, socio-cultural, and institutional factors. Physical factors may include advantageous locations of areas and the nature of the land that the dwellers occupy. Also, socio-economic factors such as low levels of education, low income, unemployment, high rent, migration, and social connections. Socio-cultural factors such as religious beliefs, traditional systems and family ties may also contribute to why dwellers settle on illegal and unplanned lands. Institutional factors may include corruption, bureaucracies, and inadequate enforcement of regulations. In addition to these factors, Mensah (2010) asserted that political and historical factors have also caused the rise of informal settlements in urban areas, especially in Ghana. There is also an apparent lack of political will to stop the emergence of informal settlements and the expansion of existing ones.

The Centre on Housing Rights and Evictions (COHRE) found, in a study of informal settlements in Ghana, that rural-urban migration is one of the drivers of growth in these settlements. They reported that this type of informal settlement exists in places such as Agbogbloshie[2], an area in Accra that grew significantly when people from conflict areas in northern Ghana migrated to the capital city to escape the tribal conflict of 1995. Several scholars also report that the inadequacy of rural employment opportunities, cycles of economic contraction, an absence of effective urban planning, and private sector preference in building luxurious and high-end apartments for rent are some of the influences on people's decision to reside in informal settlements in Ghana (Azunre et al., 2021; Hakeem et al., 2022).

Afranie (2013) identified three main forms of informal settlements in Ghana, as shown in Table 1. He asserted that the forms of informal settlements in Ghana comprise migrant communities or "Zongos"[3], Indigenous communities, and newly emerging squatter communities. In addition, Gaisie et al. (2018) identified a fourth form of informal settlement called "unauthorized subdivision settlements", which exist in many urban areas in Ghana. This form of informal settlement is characterized by large agricultural lands that are subdivided into residential plots for housing developments without observing local planning laws and regulations.

Table 1: Types of Informal Settlements in Ghana

Typology	Land Status	Housing Quality	Infrastructure	Housing Status
Indigenous Communities	Traditional Homes	Mixed	Fairly good	Without Permits
Migrant Community (Zongo)	Released by the landowner	Poor	Poor to Good	Without Permits
Newly Emerging Squatter Community	Illegal (No title)	Very Poor	Non-existent	Without permits

Source: Afranie, 2013

[2] Densely populated (103/km2) Informal settlement near the center of Accra (capital city of Ghana) with an estimated population of 40,000 people.

[3] A migrant community found in almost every urban area in Ghana with heterogeneous ethnic groups and the majority being Muslims (Casentini, 2018; Afranie, 2013).

The management of informal settlements in Ghana predates the independence era, when their emergence became imminent. During the pre-independence era, the British government implemented housing schemes to improve the health and sanitation conditions in informal settlements. Housing estates were built in Kumasi in the early 20th century after a cholera outbreak, and in Accra after an earthquake in 1939 (Acquaah-Harrison, 2004). Other housing estates were built to provide housing for low-income earners in Accra, Kumasi, Takoradi, and Cape Coast. It is worth noting that these estates were provided with basic water and sanitation services on a communal basis (Acquaah-Harrisson, 2014). By extension, this has had a subtle influence on the provision of water and sanitation services to low-income and informal urban communities in Ghana. Until the recent SDGs era, most interventions targeting informal and low-income urban communities focused on providing communal or shared sanitation facilities. Over time, due to urbanization and population growth, several of these communities have expanded without a commensurate increase in basic infrastructure and social amenities (Peprah et al., 2015).

2.2. Sanitation Service Delivery to Informal Communities in Ghana – An Overview

Until the 1980s, urban sanitation in Ghana was managed through a decentralized system (Thrift, 2007). City councils were mandated to build, control, and maintain public toilets and to manage waste-treatment areas for residents, mostly at the state's expense. Local government authorities, which were responsible for sanitation, were mandated to ensure the installation and adoption of domestic latrines by enforcing bylaws on sanitation facilities provided by landlords. These were the main attempts by the state to help communities access improved sanitation.

The structure of sanitation service delivery in Ghana has been largely shaped by political regimes, leading to changes in service delivery modes. The World Bank (2004) postulated that, since the early 1990s, local government authorities have been attempting to reduce reliance on public latrines for household toilet delivery by vigorously collaborating with families. Also, historical accounts posit that inefficient management and challenges with communal and public toilets across the country, hitherto managed by local authorities, led to the privatization of public toilet management and maintenance in the early 1990s (Ayee & Crook, 2003). Yet, as of the late 2000s, available data indicate that the total access to basic sanitation service in Ghana was estimated at 21% (GSS, 2018). Consequently, limited access to basic sanitation, especially in low-income areas, including informal urban communities, led to greater involvement of the private sector in the sanitation service delivery value chain (Thrift, 2007). This led to a radical transformation in access to sanitation services, with people living in informal communities relying on private vendors.

Over the years, safely managed sanitation has received relatively less attention, partly due to underinvestment in the sector (Appiah-Effah et al., 2019). Although Ghana gained notable progress in expanding access to safe water supply by 2022, improvements in basic sanitation lagged significantly, with only 29% of Ghanaians having access within the same period – an increase from 21% in 2018, but still markedly low relative to water provision (Abu et al., 2024). While informal settlement upgrading has received increased government attention with the establishment of specific ministries and the strengthening of relevant bylaws, local authorities consistently refuse to adequately extend sanitation services to informal settlements because of their illegality and informal nature (Doe and Aboagye, 2022; Nkrumah Agyabeng and Preko, 2021). The situation has contributed to the prevalence of diseases, including cholera, malaria, and genitourinary infections within these communities (Ayelazuno and Tetteh, 2025). Ghana also faces the risk of not attaining the SDGs 6 and 11, which seek to ensure "clean water and sanitation for all" and make "cities and human settlements inclusive, safe, resilient, and sustainable", respectively. Accordingly, informal dwellers are left to rely primarily on non-state actors, such as sanitation entrepreneurs operating public toilets, NGOs, and CSOs (Doe and Aboagye, 2022). Others also depend on local artisans to construct compound and household sanitation facilities, amid issues with land tenure and a lack of funds. (Antwi-Agyei et al., 2020). Whereas this situation depicts a failure by the state to adequately provide basic sanitation services to the people, it also presents a collaborative pathway in which the state's efforts can be enhanced by non-state actors' activities. Interventions by non-state actors are often relevant for complementing governments' efforts to increase access to improved sanitation services in informal communities.

Notably, a plethora of studies have espoused the contributions of non-state actors, such as development partners, CSOs, NGOs, and private companies, in providing opportunities for informal urban communities in Ghana and across many African countries to access basic sanitation services over the past years (Abu et al., 2024; Asumadu et al., 2023; Chumo et al., 2022). A common limitation across these studies is the failure to critically explore the nature of existing collaboration and the specific roles of state and non-state actors in providing affordable sanitation services in informal settlements. Clarifying these roles, particularly in urban settlements that are complex to govern, helps identify existing structures that can be leveraged for efficient informal settlement upgrading. It will also provide an understanding of areas where support mechanisms to enhance actors' efficient contributions may fall short.

3. METHODS AND STUDY AREAS

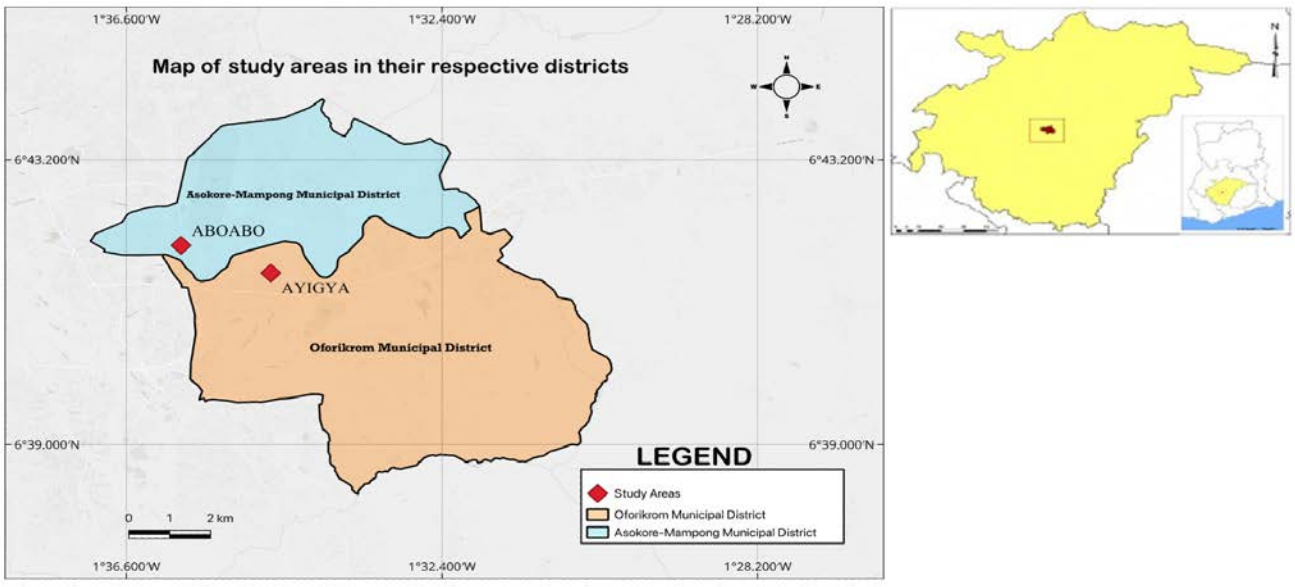
3.1. Study Setting

The study areas (Aboabo and Ayigya) are two informal settlements in Kumasi, Ghana's second largest city. The most current data on Kumasi depicts rapid urban population growth and accompanying complex features (including access to toilet facilities, types of toilet facilities, affordability, and operation of faecal sludge treatment facilities) in providing sanitation service to low-income households (Ghana Statistical Service, 2014; Cobbinah et al., 2019; Doe & Aboagye, 2020). The study areas were purposively selected in Kumasi due to conventional knowledge of their severe sanitation challenges, despite benefiting from various sanitation interventions and projects (Kumasi Metropolitan Assembly, 2011; 2017; WSUP, 2014; Adubofour et al., 2013; Asokore-Mampong Municipal Health Directorate, 2016; Basiru et al., 2018).

Aboabo is a migrant community, with a majority of its inhabitants coming from the northern parts of Ghana to Kumasi. The residents of Aboabo have, over the years, built and occupied unauthorized permanent structures. Aboabo has an estimated population of 60,136, with a mean household size of six, making it one of the largest communities in the Asokore Mampong Municipality (GSS, 2014). It is characterized by inadequate sanitary conditions, largely attributable to the insufficient provision of sanitation facilities to complement the growing population in the area and weak enforcement of local sanitation by-laws (Basiru et al., 2018).

The second case study area, Ayigya, is an indigenous informal settlement with an estimated population of 55,476 (GSS, 2014). A larger part of the community has developed organically due to natural population growth, low-cost housing, and migration (Takyi et al., 2021), preceding the planning of the area. Most households in these organically developed settlements lack private toilet facilities and, as a result, rely on public facilities (Doe & Aboagye, 2020). Figure 1 shows the location of the selected study areas in their respective Municipalities.

Figure 1: Location of the study areas (Source: Author's Construct, 2025).



3.2. Methods

The study generally adopted a qualitative research approach, involving a case study and an in-depth document review to comprehensively ascertain the roles of actors in affordable sanitation delivery in the two informal settlements in Kumasi. According to Maxwell (2012), the qualitative research strategy has a flexible structure that helps present a thorough and appropriate analysis of issues such as the roles, methods, and procedures of sanitation delivery in complex settings, such as informal settlements. In this respect, the qualitative strategy captures these dynamics and gives respondents the freedom and flexibility to respond to the complex issue. The case study enabled a flexible description and in-depth understanding of the actors and their roles in the sanitation service delivery value chain in the study areas (Coombs, 2022). Using the case study approach makes it possible for the findings and recommendations of this study to be generalized for similar contexts and adapted for designing and managing sanitation policies and interventions in other informal settlements (Bunkar et al., 2024).

3.2.1. SAMPLE SIZE AND SAMPLING PROCEDURE

A multi-stage sampling procedure was adopted for this study. The first stage involved purposively selecting Kumasi because of the city's rapidly growing population, the complex nature of delivering sanitation services to its informal areas, and its relatively better performance in faecal sludge management, as found by Furlong & Mensah (2015). The second stage involved sampling informal areas with extreme sanitation challenges but have benefited from or are benefiting from various sanitation interventions and projects. A review of literature and analysis of the areas led to the purposive selection of Aboabo and Ayigya as case study areas. At the third stage, 15 institutions known by prior research to be key actors and play critical roles in the sanitation delivery value chain in the two study areas were purposively selected for interviewing. These institutions included the Environmental Health and Sanitation Departments (EHSDs) of the municipalities and the Development Planning Units (DPUs) of the two municipalities. Also, micro-finance institutions, NGOs and CSOs, local artisans, and private latrine desludging companies. Heads of these selected institutions, who were assumed to have relevant knowledge on the subject matter, were interviewed. One official was selected from each institution of the two municipalities – Oforikrom (Ayigya) and Asokore Mampong (Aboabo). However, one NGO official was interviewed for the study. This is because prior expert information on the study areas revealed that only one recognized NGO is involved in sanitation service delivery in the two municipalities. It was then imperative to interview only one NGO to avoid duplicate data. Table 2 depicts the total number of participants selected for the study. Given that these institutions are the primary actors in delivering sanitation services in Kumasi, their inclusion in the study was crucial.

Table 2: Number of respondents from institutions interviewed

Institution	No. of Respondents
Environmental Health and Sanitation Department	2
Development Planning Unit	2
Local Artisans	4
Private Latrine Emptying Companies	2
Non- Non-Governmental Organizations	1
Civil Society Organizations	2
Community-based financial institutions	2
Total	**15**

The semi-structured interview technique was used to interview respondents from these institutions. The semi-structured interviews provided sufficient flexibility in engaging with the various agencies while addressing key aspects of the study (Cobbinah & Aboagye, 2017). The semi-structured interview guides were informed by a literature review of concepts and theories on the research topic. The guide considered only thematic items related to the study's objectives. The instruments were simple, unambiguous, and avoided leading questions. Although the instruments were written in English, they were translated into Twi (the local language) during engagements with local artisans and respondents from private latrine-emptying companies. This is because the local artisans and the respondents from private latrine-emptying companies interviewed as part of the study were not conversant in English. With the respondents' consent, all interviews were audio-recorded, along with notes taken.

Additionally, secondary data were retrieved from relevant published and unpublished sources, including institutional and administrative reports and media reports. Key data collected include the activities required for sanitation delivery and the roles and efforts of relevant actors in executing these activities to facilitate the provision of sanitation services. Data from transcribed interviews and secondary sources were analyzed using the thematic analysis method. Using inductive and deductive coding, preliminary codes were assigned to the data to describe the content. Further, different themes were sought, reviewed and used for the analysis. As espoused by Nowell et al. (2017), the use of thematic analysis helps researchers to generate unanticipated insights and summarize key features of large amounts of data collected. Informed consent from the respondents was received during the data collection, as expected in common research ethics.

4. FINDINGS AND DISCUSSIONS

Sanitation service delivery in informal settlements exhibits unique characteristics compared to other settlements. Data from the study indicate that sanitation service delivery and its management in informal communities in Kumasi are shared responsibilities between the state and non-state actors (including private sanitation entrepreneurs, private waste management companies, CSOs, NGOs, financial institutions, and local artisans). The analysis of the specific roles played by state and non-state actors revealed distinct yet complementary roles. The study shows specific areas where the state is playing a leading role, and where non-state actors are also playing complementary roles in facilitating access to affordable sanitation services for informal communities.

4.1. Main roles of state agencies in the delivery of affordable sanitation services in informal communities

4.1.1. REGULATORY ROLE OF THE STATE IN ENSURING ACCESS TO SANITATION

Generally, the state's role in sanitation delivery includes formulating WASH policies, setting standards and guidelines, enforcing, and providing technical backstopping at the local level. The study found that the state plays a regulatory role in the management and delivery of sanitation services within the study areas. Interactions with the Environmental Health and Sanitation Department (EHSD) and the Development Planning Unit (DPU) revealed the state's supervisory role in ensuring the effective and efficient provision of affordable sanitation services in the two study areas. The government's regulatory role is evident in the EHSD's activities in the two study areas, including inspections, corrections, and abatements of nuisances related to household sanitation services. For instance, the department ensures proper desludging of septic tanks from household and public toilets for treatment. This regulatory role of the state is embedded in the updated National Environmental Sanitation Policy, which holds the state responsible for enforcing sanitation rules and regulations (Ministry of Environment, Science, Technology, and Innovation, 2017). In responding to the key roles of the state in sanitation service delivery and management, the EHSD in the two areas asserted that:

Our [EHSD] main role is that anytime we find out that septic tanks are full, we make sure the households empty/desludge them. If households/public toilet owners refuse to desludge, they risk being taken to court by our department [EHSD]. For the public toilets, when the septic tanks are full, they alert the department [EHSD], and we issue a letter to them for the desludging process. However, it is not really compulsory to always alert the department [EHSD] when you want to embark on desludging. However, when it is full, and they don't desludge, we [EHSD] step in and order them to desludge it (EHSD respondent, Asokore Mampong Municipal Assembly).

We [EHSD] are responsible for going into houses to inspect, correct, and abate nuisances. Those who will prove stubborn will be summoned to the law court (EHSD respondent, Oforikrom Municipal Assembly).

Further, the study's findings indicate that before a permit is issued for the construction of a new house, the MA, through the EHSD, ensures compliance with the Municipality's sanitation bylaws. The byelaws concerning liquid waste state that every house must have a toilet, with one designated toilet facility for each occupant. This is done to reduce future pressure on public facilities and to provide households with access to improved sanitation facilities.

4.1.2. PLANNING, COMMUNITY MOBILISATION, AND DEMAND GENERATION

At the local government level, the DPU serves as the secretariat for the District Planning Coordinating Unit (DPCU), which is responsible for preparing the District Medium-Term Development Plans (MTDPs), Annual Action Plans, and Monitoring and Evaluation (M&E) Plans to monitor planned activities. According to the respondents, these plans often include sanitation projects geared towards improving sanitation infrastructure in the MAs. The study found that the MAs supervise such projects in the municipality through the EHSD and the Physical Planning Department (PPD). Again, it was observed that this role of the MAs has not directly delivered sanitation facilities to households in informal communities, but rather through demand-generation activities, and most households are recognizing the need to acquire household toilets. The EHSD plays a key role in demand generation by educating families on the need to acquire affordable, safe household toilet facilities. This is consistent with the World Bank's (2004) assertion that, since the early 1990s, local government authorities, in their efforts to increase access to household toilets and reduce overdependence on public latrines, have been collaborating with families to educate them on the need for household toilet facilities. The EHSD also conducts siting for household toilet construction and encourages the use of improved toilet technologies such as the Kumasi Ventilated Improved Pit (KVIP), Ventilated Improved Pit (VIP), Aqua Privy, and Water Closet (WC). These findings confirm previous studies that assert that government stakeholders provide an enabling environment for sanitation delivery in informal settlements rather than directly delivering sanitation facilities (African Ministers' Council on Water, 2015).

4.1.3. BUILDING LOCAL CAPACITY AND PARTNERSHIPS

The study found that the state partners with various development agencies to deliver affordable sanitation services in the study areas. Through this role, the state can connect artisans trained by NGOs and CSOs to prospective households seeking to install a toilet facility. This saves the household time and money that would have been spent contacting an artisan. Also, it helps create jobs for local artisans and supports local businesses. Evidently, this role reflects the government's efforts to create an enabling environment for non-state actors to provide households with safe, affordable sanitation services (Shaheen, 2021). Beyond that, the study also revealed that the MAs have strategic partnerships with CSOs and academic institutions towards research into sanitation delivery and technology development.

The study also revealed that the emptying or desludging of septic tanks has been left to private sanitation service providers registered with the KMA as Vacuum Tanker Operators (VTOs). This means their activities are directly regulated by the KMA. The VTO's role in the sanitation service value chain is basically to empty, transport and dispose of faecal sludge. However, it was revealed that these companies play additional roles, including advocacy and awareness-raising, educating households and public toilet managers on the safe management of toilet facilities. They also offer technical advice on maintaining septic tanks. In responding to this, the respondents asserted that:

Yes, we [EHSD] have NBU [No Business as Usual] in collaboration with MAs Toilet companies, the Clean Team and WSUP (EHSD respondent, Asokore Mampong Municipal Assembly).

Yes, we [EHSD] collaborate with "KNUST (for research), WASUP and Clean Team for research, advocacy and the provision of affordable sanitation service (EHSD respondent, Oforikrom Municipal Assembly).

4.2. Main roles of non-state actors in affordable sanitation service delivery in informal communities

4.2.1. DEMAND GENERATION

The study discovered that the main non-state actors involved in delivering affordable sanitation services in the study areas are CSOs, NGOs, local financial institutions, and local artisans. The interviews revealed that CSOs' main roles include demand generation and marketing affordable sanitation services. At Ayigya, for instance, the study revealed that a CSO called Clean Team Toilets provides affordable toilet technologies to households. This finding aligns with studies by Mansour and Esseku (2017), who argue that increased efforts by CSOs in Ghana's WASH sector have led to the emergence of affordable, improved sanitation technologies and services that meet the needs of informal communities. The CSOs embark on sensitization programs to educate households on the need to have their own toilet facility. CSOs used radio advertisements, community durbars, institutional visits, and house-to-house visits to generate demand and market affordable household toilets. This increased the delivery of affordable sanitation services in the study areas. This was evident in the number of affordable toilets delivered to households by a CSO, Clean Team, working in the two study areas. Although the majority of households in the two study areas have no access to household toilet facilities and depend on public toilets (Doe & Aboagye, 2020), the study discovered that the Clean Team, at the time of the study, had provided about 126 affordable container-based toilet facilities to households in Ayigya and about 100 in Aboabo. In responding to the activities of CSOs in the delivery of sanitation services in the municipalities, the respondents stated as follows:

We [CSOs] tell them how affordable having their own household toilet will be rather than accessing public toilets. We [COSs] also educate them on the environmental hazards that emanate from open defecation (CSO respondent, Ayigya).

4.2.2. TRAINING OF LOCAL ARTISANS/ BUSINESSES

In addition, the study found that CSOs and NGOs (e.g., WSUP) were involved in training service providers, such as local artisans, and in supporting them in introducing innovative, affordable sanitation options for informal communities. The study revealed that WSUP had trained about 50 local artisans within the municipalities who operate in collaboration with the MA and their Unit Committee members. Again, it was observed that a CSO in Aboabo began training local artisans to install modern toilet technologies, such as biogas toilets, in individual households. A peculiar social business practiced by the CSO in Aboabo, which seemed to help deliver household toilets, is to provide households with toilets on a hire-purchase basis. The study also reveals that the Clean Team is implementing a non-sewered sanitation system.

We [CSO] provide affordable toilet facilities to households in informal settlements and improvised communities. We provide biogas toilet facilities for them on a hire-purchase basis, which is, we [CSO] install the toilets for them, and they pay in instalments over time. We [CSO] also train local artisans to be able to install the biogas toilets. Currently, we [CSO] have trained and educated about 200 people in the Municipality on ensuring that they have toilet systems in their homes and also to keep their environment clean for a healthy living. We [CSO] also use the radio and various public forums to train people on ways and means to keep their environment clean and free of open defecation (CSO respondent, Aboabo).

Moreover, it was observed that the local artisans were mainly responsible for the construction and maintenance of household and public toilets in the areas. These local artisans include masons, plumbers and carpenters. The study revealed that, apart from the identified and trained local artisans trained by

CSOs and NGOs, most local artisans who construct toilet facilities in the study areas had no formal training. Interactions with these local artisans revealed that they acquired their skills through apprenticeship, leaving them lacking the necessary skills for the construction of emerging affordable toilet technologies. Interviews with the artisans show that most of the materials used to construct toilet facilities are sourced locally. Materials such as cement, sand, iron rods, wire-mesh, PVC pipes, wood, nails and roofing sheets are manufactured locally, whilst toilet organic solvents and ceramic toilet bowls are mostly imported from China. It was revealed that most of these local artisans do not belong to any association that is related to their work. The findings show that local artisans can only construct toilet facilities such as KVIP/VIP, WC, Aqua-Privy latrines, and Pit Latrines. However, the artisans revealed and expressed their readiness to learn and provide modern and affordable toilet technologies if they are identified and trained, as captured succinctly below:

I don't have the required skills and capacity to construct those toilets. I have made up my mind to learn how to construct it (Mason, Aboabo).

I have now decided to learn the construction of the Biogas latrines. I am not constructing them because I don't have the skills to do so (Plumber, Ayigya).

4.2.3. ADVOCACY AND DEVELOPMENT OF AFFORDABLE SANITATION TECHNOLOGY OPTIONS

The increasing demand for affordable sanitation services in Ghana led to the establishment of various sanitation-related NGOs. Findings from the study indicated that NGOs in the study area engaged in research, training, advocacy and the delivery of modern toilet technologies to households. For instance, the analysis showed that a few international NGOs work in Water and Sanitation provision in Kumasi (Furlong & Mensah, 2015). These NGOs support efforts to increase access to affordable toilet technologies and potable water, and to build capacity for efficient faecal sludge management.

According to a respondent:

For us at this NGO, we continue to explore various ways to provide affordable and improved sanitation services to the urban poor. In our quest to provide affordable sanitation services, we brought in various toilet technologies, and our technologies are currently one of the affordable ones in the market (NGO respondent, Kumasi).

4.2.4. SANITATION SERVICE FINANCING

The study revealed that the only known financial institution providing soft loans for the construction of low-cost toilet technologies in the two study areas is Sinapi Aba Savings and Loans Bank. However, it was revealed that most households feel reluctant to access their loans due to high interest rates (about 16% - 36% per annum). This finding confirms existing research, which espouses that high interest rates on loans and credit facilities significantly increase the water and sanitation access gap and highlights financing and investment challenges within the sector (Machete and Marques, 2021). Apart from Sinapi Aba Savings and Loans Bank, the study did not find any known community-based financial institution that has loan facilities to be accessed for sanitation services. Interactions with other community-based financial institutions in the study areas revealed that they offer loan facilities accessible to any qualified individual or group. However, their loans are not designed specifically for sanitation services. Some of the institutions interviewed explained that:

Our loans are open. You tell us the purpose for coming for the loan; we will assess you and see if you qualify based on your ability to generate funds to pay back the loan. We don't have specific loans for sanitation development, but if you have the capacity to pay back, we will give you the loan for you to use it for whatever you want to use it for. The client should have a regular income that he/she can use to pay back the loan (Community–based financial institution, Aboabo).

We don't have specific loans or credit facilities for sanitation development, but we have a housing development policy that qualified candidates can access. It is not named a sanitation credit facility or loan. We wish those who are saving with us and have the intention to build household toilets will come and access the loans (Community–based financial institution, Ayigya).

Nevertheless, the study's findings showed that existing community-based financial institutions in Ayigya are ready to introduce sanitation service finance schemes to provide affordable sanitation. In expressing their motivation to help in financing sanitation development, they asserted that:

Our motivation is that, as human beings, we need to live in a clean environment for healthy living. Aside from making a profit from the venture, I think healthy individuals make a great country, so this will motivate us (Community–based financial institution, Ayigya).

On the contrary, the community-based financial institutions interviewed in Aboabo did not express any plans to introduce financing schemes for affordable sanitation service provision in the area. It was revealed that there was no motivation for the financial institution to introduce sanitation development finance schemes. The interviewee explained that:

Elsewhere, grants are given to banks specifically for sanitation development, especially the building of toilets. So, if those grants are given to us, we will do so, or if there is a reduced rate for our cost of funds, then why not? Currently, the rates are high, and we need to put them into a business venture that will generate equally high profits for us to be able to pay. So, for now, we are not motivated enough to channel our loans to sanitation (Community–based financial institution, Aboabo).

The above implies that households in informal settlements in Kumasi rarely access loan or credit facilities for sanitation development. This is largely due to the absence of collateral and the lack of documented tenure among low-income households when accessing loan/credit facilities (Balana et al., 2022). The results, however, indicate that CSOs play a crucial role in helping households access loans from financial institutions to acquire affordable toilet facilities. They also collaborate with other NGOs to market affordable toilets to households. One of the respondents explained that:

We aid them financially to access loans in order to acquire a toilet facility. We are currently working in collaboration with Sinapi Abi Savings and Loans to give loans to individual households for sanitation development. We have been able to acquire toilet facilities for about 10 households in the Municipality, including Ayigya (CSO respondent, Ayigya).

4.3. Conceptualizing the provision of affordable sanitation services in informal settlements in Kumasi

The conceptual framework aims to provide a synthesis of the roles of the sanitation service delivery institutions selected for the study. It was established in the study that the provision of sanitation services relies on state and non-state actors in the sanitation service value chain, and each plays a vital role at a certain stage in the chain. In the conceptual framework, the non-state actors are categorized into social actors (NGOs and CSOs) and private-sector entities (local artisans, community-based financial institutions). The study revealed that the demand side in the sanitation service delivery value chain is the household. The supply side includes state and non-state actors (including local artisans, NGOs, CSOs, community-based financial institutions, and VTOs).

The synthesis showed a tripartite framework of functions in which three main role categories, each supporting the provision of affordable sanitation, are played by state and non-state actors (Figure 2). These roles include creating an enabling environment to support service delivery, capacity building and partnerships required to deliver services, and advocacy and development of the sanitation business. In terms of interrelationships among the roles, the state sets the agenda by creating an enabling environment, including policies, strategies, regulations, and projects that aim to deliver sanitation services to informal communities. Such an enabling environment is created to provide technical guidelines for the provision of sanitation services. Non-state actors, including community-based financial services, also provide loans and credit facilities to households to create an enabling environment and reduce the financial burden of affordable sanitation service delivery in informal communities.

Advocacy and the development of sanitation businesses provide significant support in delivering sanitation services. The study showed that non-state actors (including NGOs and CSOs) usually engage in advocacy to generate attention, raise awareness of the sanitation challenges faced by residents of informal communities, and call for action. In the same way, non-state actors equally undertake demand generation and community mobilization activities to trigger residents of informal communities to act on their sanitation situation. Further, non-state actors establish sanitation businesses that serve as a channel for delivering affordable sanitation products and services to informal communities. Through innovation, appropriate technology options and services are designed by non-state actors, such as local artisans, CSOs, and NGOs, to fit the socio-economic context of informal communities. State actors, such as local authorities, play a key role in advocacy and demand generation by educating families on the importance of installing affordable, safe household sanitation facilities.

Another major interrelationship exists in capacity building and partnership for the delivery of sanitation services. The complex nature of sanitation service provision shows that the government cannot deliver alone, and in recent times, non-state actors, mainly NGOs and CSOs, have often entered into partnerships with the state to train and build the capacity of local artisans to develop and deliver affordable sanitation services. In addition to the above, state and non-state actors, such as academic institutions, provide support through research into various affordable sanitation technologies. Over the years, such studies have provided insight into the context and sanitation needs of informal settlements.

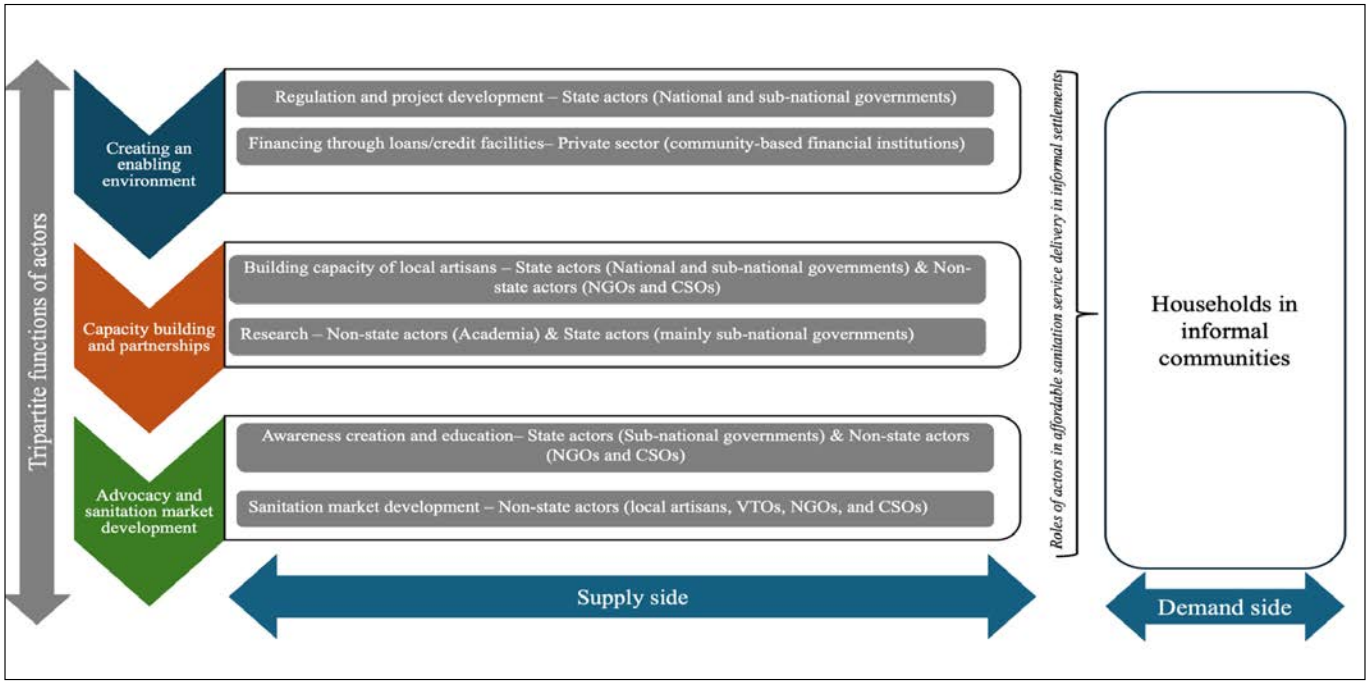


Figure 2: A conceptual framework of the tripartite functions and actors' roles in affordable sanitation service provision in informal settlements in Kumasi (Source: Author's Construct, 2025)

5. CONCLUSION

Access to affordable sanitation services remains critical to the socio-economic development of informal dwellers and to achieving SDG 6. However, little is known about the typology of actors and their unique roles in delivering affordable sanitation services to informal communities. This study provides a better understanding of the value chain, the actors involved, and their roles in delivering affordable sanitation services to informal settlements in Kumasi, Ghana. This research has become more imperative due to the vulnerabilities and exclusion faced by informal settlements in various cities across the globe.

The study revealed that various institutions collectively provide different services along the sanitation service value chain. The study is clear that no single actor can manage sanitation delivery in informal settlements. The state plays peculiar roles, and the same is true of non-state actors. However, the supply-side roles played by the state and non-state actors are not mutually exclusive, and thus, it is necessary to harmonize these relationships to offer affordable sanitation services to informal settlements. For instance, the study showed that the state plays a supervisory, demand generation, marketing of affordable sanitation, advocacy and law enforcement roles in the sanitation service delivery chain. The effectiveness of this role can prevent or limit collective-action challenges. In effect, over the years, due to advocacy by CSOs, NGOs, and CBOs in the study areas, the state has begun taking initiatives to improve sanitation in informal communities. Again, non-state actors have partnered with local authorities to introduce affordable toilet technologies suitable for households in informal settlements. These toilet options are affordable and best fit for the available spaces in informal communities. The study observed that the private sector engages in the delivery of sanitation services, advocacy, marketing and demand generation, research and training of service providers who construct latrines in the various communities. This shows a kind of public-private partnership in the delivery of affordable sanitation services in informal settlements in Kumasi.

Financing for sanitation remains a critical barrier to accessing safe, affordable sanitation in informal communities. However, the study found traces of a collective-action challenge regarding the absence of motivation in the form of grants or funds for community-based financial institutions to introduce and make accessible loans/ credit facilities for affordable sanitation service provision. These are useful enabling environment issues that will require policy direction from the state. Interestingly, existing local authorities lack financing mechanisms, such as subsidies, to support households interested in acquiring household toilets. Households in such areas are usually vulnerable and marginalized, and as such, will require some financial support to acquire safe and affordable toilet facilities. In some instances, such households may not be able to afford sanitation facilities. In the public health interest, such households must be identified through a transparent, community-based selection process and provided with a full subsidy to acquire a household toilet. It is expected that the state, through further collaborations with the non-state actors, can design subsidy support mechanisms that can support households obtain toilet facilities.

The study recommends placing strong emphasis on developing the capacity and capabilities of actors in the sanitation service market. These capacities and capabilities should include, but not be limited to, increasing the number of local artisans trained in emerging affordable sanitation services, as well as in funds, grants, and logistics. This recommendation has the potential to increase the number of toilets constructed in informal communities each year and to provide numerous affordable toilet options and opportunities for households in informal settlements. The study also calls for strengthening stakeholder coordination and the use of participatory approaches to effectively deliver sanitation services that meet the needs of informal dwellers.

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