

The Impact and Effectiveness of Mama Samia's Stoves Initiative in Tanzania Communities

Kweyamba Maximilian*

Abstract

This study examines the impact and effectiveness of Mama Samia's Stoves Initiative on energy efficiency, health, and environmental sustainability in Tanzanian communities. Employing a convergent parallel mixed-methods approach, data were collected between June and September 2024 in Kiwangwa and Dunda Wards, Bagamoyo District Council. The study involved household surveys, air quality measurements, semi-structured interviews, focus group discussions, and case study analyses of urban and rural settings.

Quantitative analysis, though limited to a small purposive sample of 12 households for air quality assessments due to logistical constraints, applied independent t-tests to compare air quality (PM2.5 levels), health outcomes, and stove adoption rates between users of Mama Samia's stoves and traditional stoves. Chi-square tests were used to compare Mama Samia stove usage between urban and rural areas. A preliminary Chi-square test for association (though limited due to the small sample) indicates that adoption rates were higher in urban households than in rural ones, supporting the qualitative findings regarding disparities driven by income, accessibility, and information exposure. Qualitative data were thematically analysed to provide insights into perceived benefits, adoption barriers, and cultural influences.

Results showed significant reductions in biomass fuel use, leading to improved indoor air quality ($p = 0.03$) and decreased respiratory complaints ($p = 0.01$). Qualitative findings indicated increased awareness of environmental and health benefits, though cultural resistance to abandoning traditional cooking methods persisted, especially for specific meals and occasions. The study highlights the potential of the initiative to advance health outcomes, reduce environmental degradation, and deliver economic benefits. However, it also highlights the need to address cultural preferences, affordability challenges, and disparities in access, particularly between urban and rural households, to enhance adoption and ensure long-term sustainability.

These findings align with Sustainable Development Theory and contribute to the growing body of evidence on clean energy transitions in East Africa. The initiative demonstrates the potential to improve health, reduce environmental degradation, and provide economic benefits. However, the study highlights the importance of addressing cultural preferences and practical barriers to

* Local Government Training Institute, Dodoma, Tanzania

Email: kweyamba72@gmail.com

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enhance acceptance and ensure sustainability. The study recommends inclusive, culturally informed, and adaptable implementation strategies for greater impact.

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Introduction and Background

Historically, African countries have faced significant environmental challenges linked to the extensive use of wood and charcoal as primary energy sources, which has led to widespread deforestation and increased carbon emissions. For centuries, biomass, including wood and charcoal, has been a vital energy source across Sub-Saharan Africa due to limited access to alternative energy sources, especially in rural areas (Food and Agriculture Organization, 2017). This dependence on wood fuel has contributed significantly to the depletion and soil preservation (Arnold, Köhlin, Persson, & Shephard, 2006).

Charcoal production, in particular, is a major driver of deforestation in Africa, as it is a preferred fuel for urban populations because of its affordability, availability, and high-energy content (Zulu & Richardson, 2013). For instance, countries such as Tanzania, Kenya, Rwanda, Uganda, and Burundi have experienced severe forest losses owing to the rising demand for charcoal in rapidly growing urban centres (Mwampamba, 2007). In Tanzania, for instance, approximately 90 percent of households depend on wood and charcoal for cooking, and charcoal production has been associated with unsustainable wood harvesting practices that degrade forest ecosystems (Sawe, 2004).

The combustion of wood and charcoal releases carbon dioxide (CO₂) and other greenhouse gases (GHGs), contributing to climate change (Bailis, Drigo, Ghilardi, & Masera, 2015). This environmental impact is exacerbated by inefficient, traditional cooking methods that result in high emissions per unit of energy (Kammen & Lew, 2005). Deforestation further amplifies carbon emissions, as forests act as carbon sinks, and their removal releases stored carbon into the atmosphere. Deforestation has resulted in substantial carbon losses in East and West Africa, with African nations emitting millions of tons of CO₂ annually from forest degradation and biomass burning (Intergovernmental Panel on Climate Change, 2007).

Traditional cooking methods, which rely heavily on firewood and charcoal, contribute significantly to deforestation and environmental degradation (Bailis et al., 2015). Additionally, these methods release harmful pollutants, such as carbon monoxide and particulate matter, exacerbating climate change (IEA, 2012). Research suggests that improved stoves reduce household fuel consumption by up to 60 percent, potentially slowing deforestation and improving air quality (Edwards, Smith, Zhang, & Ma, 2014). Indoor air pollution from traditional cooking methods has been linked to respiratory illness, particularly among women and children, who spend more time near cooking areas (Gordon et al., 2014). Improved stoves significantly reduce exposure to harmful emissions, lowering the risk of chronic respiratory diseases (Bonjour et al., 2013). Improved cook stoves impact gender roles, as cooking is predominantly a responsibility of women in Tanzania (Clancy, Winther, Matinga, & Oparaocha, 2012). By reducing the need for frequent firewood collections, these stoves have the potential to save women's time and physical energy, thereby promoting gender equity (UN Women, 2020).

Various interventions have been attempted to reduce dependence on wood and charcoal, including reforestation programs, improved cookstove initiatives, and policies aimed at regulating charcoal production (Sepp, 2008). In recent years, Tanzania's energy policies have emphasised the need for sustainable energy access, particularly in rural areas (REPOA, 2019). Despite these efforts, high poverty rates, lack of alternative energy sources, and weak policy enforcement continue to challenge sustainable forest management in Tanzania. While clean and efficient cooking solutions remain challenging for many low-income households, initiatives like 'Mama Samia's Stove' appear to offer a promising solution by making efficient cooking stoves accessible and affordable.

The Mama Samia's Stoves Initiative

The Mama Samia's Stoves (Majiko ya Mama Samia) Initiative was launched in 2021 under the national clean cooking energy programme. Mama Samia's Stoves Initiative is a government-led campaign aimed at accelerating the adoption of improved, energy-efficient stoves in Tanzanian households, particularly in rural and peri-urban communities. The initiative aligns with the country's commitments to reducing deforestation, mitigating indoor air pollution, and improving public health outcomes. The initiative also aligns with Tanzania's environmental protection policies and Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-being), SDG 7 (Affordable and Clean Energy), and SDG 13 (Climate Action).

The stoves are designed to use less firewood or charcoal compared to traditional three-stone fires or conventional charcoal stoves. A Mama Samia stove typically costs between TZS 30,000 and TZS 60,000, depending on the model and supplier, whereas a traditional stove or open fire setup has minimal upfront cost but results in higher long-term expenses due to continuous fuel consumption.

Despite the clear economic, health, and environmental advantages, the initiative faces several challenges, including limited awareness in remote areas, initial affordability barriers for low-income households, and cultural attachment to traditional cooking methods. Understanding these barriers is critical for designing inclusive, context-sensitive strategies that enhance stove adoption and long-term sustainability in Tanzania's diverse communities.

The persistent reliance on biomass fuels in Tanzanian households contributes to significant indoor air pollution, deforestation, and associated public health risks. According to the World Health Organisation [WHO] (2021a), exposure to household air pollution from solid fuels causes approximately 4 million premature deaths globally each year, predominantly in low- and middle-income countries. This study offers timely insights for policymakers, environmental agencies, and public health practitioners by evaluating a government-led intervention aimed at mitigating these risks through clean cooking technology. Additionally, it contributes to the academic discourse on sustainable development strategies tailored for resource-constrained, peri-urban African communities (Jagger & Jumbe, 2016; World Bank, 2020a). Therefore, this study aims to evaluate the

impact and effectiveness of Mama Samia Stoves in mitigating these environmental concerns within Tanzanian communities.

Significance of the Study

This study will contribute to the growing body of evidence supporting clean energy transitions in Tanzania and other East African contexts. Specifically, it advances understanding of how improved cooking technologies, such as Mama Samia's Stoves, can enhance sustainable development in rural communities. By promoting energy-efficient stoves that reduce the depletion of forest resources and lower smoke emissions, the initiative contributes to environmental conservation, improved public health, and economic well-being. The findings offer practical insights for policymakers, development partners, and local governments seeking to design and implement culturally acceptable, economically viable, and environmentally sustainable energy solutions for low-resource communities.

Theoretical Framework

Several theories can explain the Impact and Effectiveness of Mama Samia's Stoves Initiative in Tanzania Communities. The Sustainable Development Theory—was considered relevant in this study based on its assumptions and strengths, which outweigh its weaknesses, for examining the impact and effectiveness of Mama Samia's Stoves Initiative in Tanzanian communities. This theory, which focuses on balancing social, economic, and environmental goals, aligns well with the objectives of clean stove initiatives aimed at reducing environmental harm and promoting health benefits. The Sustainable Development Theory seeks to ensure that development meets current needs without compromising the ability of future generations to meet theirs (Brundtland, 1987). This theory is built on three core pillars: environmental sustainability, social inclusion, and economic growth. These pillars are designed to function harmoniously, aiming to create a framework where economic development advances social well-being while protecting environmental resources (Sachs, 2015). This triad ensures that development interventions are multidimensional, considering the broader impacts on society and the environment.

The Brundtland Commission, led by former Norwegian Prime Minister Gro Harlem Brundtland (1987), in the landmark report “Our Common Future”, first widely promoted the modern concept of sustainable development. This report emphasised the need for development strategies that balance economic progress, environmental stewardship, and social inclusion, proposing that “sustainable development is the theory that suggests meeting the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland, 1987).

Assumptions of Sustainable Development Theory

The theory assumes that social well-being, economic growth, and environmental health are interconnected, and sustainable outcomes require addressing all three areas (Sachs, 2015). Sustainable development assumes that development should benefit both present and future generations. This assumption highlights that initiatives should promote long-term sustainability for all communities rather than short-term gains (Daly, 1990). The theory is based on the idea that natural resources are finite, necessitating responsible and efficient use to maintain ecological balance (Meadows, Meadows, Randers, & Behrens, 1972).

The theory provides a comprehensive approach, addressing economic outcomes and social and environmental impacts, making it ideal for assessing multidimensional initiatives such as clean stove programs (Sachs, 2015). This ensures that impacts on health, community well-being, and the environment are all considered. This theory has influenced global policies, such as the SDGs, which make it a widely accepted framework for understanding developmental impacts at community, national, and global levels (United Nations, 2015). Using this theory aligns the study with international standards of sustainability. By focusing on future generations, the theory encourages interventions that yield long-term benefits rather than short-term results, which is essential in assessing the sustained impact of Mama Samia's Stoves Initiative.

The theory's strength in advocating for balance across social, economic, and environmental aspects also introduces practical challenges. Implementing sustainable practices may be complex, especially in communities with limited resources, as the goals can sometimes conflict (Redclift, 2005). For example, economic gains from clean stove initiatives may be immediate, but environmental benefits, like improved air quality, may take longer to manifest. Critics argue that sustainable development is a broad concept, making it challenging to apply precisely (Redclift, 2005). This ambiguity hinders the practical assessment of initiatives like Mama Samia's Stoves Initiative, as measuring "sustainability" is subjective and dependent on varied indicators. Despite the theory's emphasis on balance, conflicts between economic and environmental goals can arise, especially in communities prioritising short-term economic gains over long-term environmental benefits (Daly, 1990). This trade-off is observed in areas where wood resources are a cheap and abundant energy source, posing a challenge to cleaner but possibly costlier alternatives.

Applicability to Mama Samia's Stoves Initiative

Sustainable Development Theory provides a comprehensive framework for evaluating Mama Samia's Stoves Initiative regarding its environmental, social, health, and economic impacts. Environmentally, cleaner stoves help reduce deforestation and improve air quality, fulfilling the environmental goals of sustainable development. Socially, the initiative has significant health implications by reducing exposure to harmful smoke, especially among women and children (Lim et al., 2012). Economically, reducing dependence on traditional biomass fuels lowers household energy

costs, contributing to economic sustainability. Together, these aspects ensure a balanced evaluation of the initiative's long-term impact on community well-being.

Methods/Methodology

This study adopted the Pragmatism paradigm, which is widely recognised as appropriate for impact evaluation studies that seek to integrate both quantitative and qualitative approaches to address complex real-world problems (Creswell & Plano Clark, 2011). Pragmatism emphasises the generation of practical, actionable knowledge that is grounded in lived experiences, making it suitable for assessing the real-life effectiveness of social initiatives such as Mama Samia's Stoves Initiative in Tanzania.

The study applied a mixed-methods approach, combining quantitative and qualitative research techniques to achieve a comprehensive understanding of the initiative's outcomes. This approach enabled the researcher to quantitatively assess objective indicators such as household adoption rates, reduction in indoor air pollution, and reported health improvements, while also qualitatively exploring community perceptions, barriers to adoption, cultural influences, and facilitating factors (Tashakkori & Teddlie, 2010).

Research Design

A Convergent Parallel Mixed-Methods Design was employed, whereby quantitative and qualitative data were collected concurrently, analysed separately, and then merged during interpretation to offer a complete perspective on the initiative's impact (Creswell & Plano Clark, 2011). This design allowed for validation and triangulation of results, as quantitative findings could be supported, contrasted, or enriched by qualitative insights, thereby increasing the reliability and depth of the study's conclusions.

Study Area

The study was conducted at Kiwangwa and Dunda Wards in Bagamoyo District Council, Coast Region, Tanzania. Kiwangwa and Dunda in Bagamoyo District Council were purposively selected because it has an active distribution program for Mama Samia's stoves and present a typical peri-urban setting with both traditional and modern household energy usage. Kiwangwa and Dunda in Bagamoyo District Council have an estimated population of 16,800 people in 3,400 households, with most residents engaged in small-scale farming, petty trading, and civil service. Before the introduction of Mama Samia's stoves, over 80 percent of households relied on traditional three-stone stoves and charcoal. At the time of the study, approximately 420 households had adopted Mama Samia's stoves. This made it a suitable site for comparing clean stove adopters and non-adopters in a real-world setting.

Sampling Techniques and Sample Size Determination

Quantitative Component

A stratified random sampling technique was applied to categorise households into two distinct strata: (i) households using Mama Samia's stoves, and (ii) households using traditional stoves. To determine the ideal sample size for a community-based survey, Yamane's (1967) formula was utilised, as it is frequently applied in public administration and community development research in Tanzania: using this: $n = N / (1 + N(e^2))$

Where:

n = required sample size

N = total household population (3,400 households in Kiwangwa and Dunda Ward in Bagamoyo DC)

e = desired margin of error (typically 5 percent or 0.05)

When substituting the values:

$$n = 3400 / (1 + 3400(0.05)^2) = 3400 / (1 + 3400 \times 0.0025) = 3400 / (1 + 8.5) = 3400 / 9.5 = 358$$

Ideally, a total of 358 households would be recommended for a comprehensive survey with a 95 percent confidence level and 5 percent margin of error.

However, due to logistical, financial, and time constraints, the study purposively selected 12 households for air quality measurements, 6 using Mama Samia's stoves and 6 using traditional stoves, ensuring representation from each stratum. While this quantitative sample is modest and limits the scope for generalisation, it provided essential preliminary data for t-tests at the community level and was complemented by extensive qualitative data to ensure triangulation, depth, and contextual understanding.

This limitation is acknowledged, and the study recommends that future evaluations incorporate larger and statistically powered samples for quantitative air quality and health impact analyses to improve the reliability of hypothesis testing.

Qualitative Component

The qualitative sample was selected purposively to ensure the inclusion of diverse perspectives from various stakeholders. Semi-structured interviews were conducted with community leaders, health officers, stove users, and non-users to capture a range of perceptions, experiences, and cultural dynamics influencing stove adoption and usage.

Additionally, Focus Group Discussions (FGDs) were organised separately for male and female household members to explore collective insights, common challenges, and community-driven recommendations.

Case study analysis was also integrated into the qualitative design, with selected urban (Dunda) and rural (Kiwangwa) communities examined to understand the initiative's effects in varying socio-economic and cultural contexts. This approach enhanced the depth and richness of qualitative data and supported the study's objective of offering context-specific conclusions.

Data Collection Tools

- Structured questionnaires were administered to collect quantitative data on stove usage frequency, perceived effectiveness, household expenditures on fuel, and self-reported health outcomes.
- Semi-structured interview guides were used for qualitative interviews with key informants to capture perceptions, social influences, barriers, and facilitators.
- Focus group discussion guides facilitated community-level dialogues to identify common views, emerging issues, and culturally informed strategies for promoting stove adoption.
- Air quality measurement tools (handheld particulate matter monitors) were deployed in sampled households to objectively assess indoor air pollution levels

Data Analysis

Quantitative data were analysed using descriptive statistics and independent t-tests to compare air quality metrics between households using Mama Samia's stoves and those using traditional stoves. A preliminary Chi-square test for association (though limited due to the small sample) was used to compare Mama Samia stove usage between urban and rural areas.

Qualitative data were subjected to thematic analysis, identifying patterns, themes, and categories within interview and focus group transcripts. The qualitative findings were then triangulated with quantitative results to strengthen the validity of conclusions and provide a holistic account of the initiative's impact.

Ethical Considerations

Ethical clearance for the study was obtained from Bagamoyo District Council. Informed consent was secured from all participants, and confidentiality and anonymity were maintained throughout the research process.

Limitations of the Study

The primary limitation was the small sample size for quantitative air quality measurements, which restricts the generalisability of those specific findings. However, the study's extensive qualitative component and methodological triangulation compensated for this limitation by offering rich, contextualised insights. Future research should adopt larger, representative samples to enhance the statistical power and reliability of inferential analyses on health and environmental outcomes.

Results and Discussion

Factors Influencing the Adoption of Mama Samia's Stoves

The adoption of Mama Samia's stoves in the study area was influenced by several interrelated factors. Key determinants identified through interviews and focus group discussions included:

- **Perceived Economic Benefits:** Households cited reduced firewood and charcoal consumption, leading to lower household energy expenses. Similar findings were observed in a study by Jagger and Jumbe (2016) in Malawi, where cost savings were a significant driver for adopting improved cook stoves.
- **Health Awareness:** Awareness of health benefits, particularly reduced respiratory problems due to lower indoor air pollution, was a motivator for adoption. This corresponds with observations by Lewis and Pattanayak (2012), who noted that perceived health benefits enhance clean cookstove uptake.
- **Cultural Preferences and Cooking Habits:** Some households resisted adoption due to attachment to traditional stoves for specific cooking tasks like simmering beans and preparing traditional dishes. This aligns with findings from Sesan (2012) in Nigeria, who highlighted cultural cooking norms as a barrier to clean cookstove diffusion.
- **Affordability and Accessibility:** While the stoves were subsidised, some households still found the initial cost prohibitive. As argued by the World Bank (2020a), affordability remains a major barrier to the widespread adoption of clean cooking technologies in sub-Saharan Africa.
- **Availability of Fuel:** Ready availability of firewood in peri-urban areas discouraged some households from transitioning to new stoves, as firewood collection was still perceived as free, though time-consuming.

Comparison of Gas Stoves, Mama Samia's Stoves, and Traditional Stoves

To assess the practical promotion potential of Mama Samia's stoves, a comparative analysis was conducted with traditional stoves and gas stoves based on cost, availability, environmental impact, health implications, and cultural compatibility (Table 1).

Table 1. Comparative Analysis of Household Cooking Technologies

S/N	Criteria	Traditional Stove	Mama Samia's Stove
1	Initial Cost (TZS)	Low (0–5,000)	Moderate (30,000–60,000)
2	Fuel Availability	High (firewood, charcoal)	Low (gas cylinders are not widely available in rural areas)
3	Fuel Cost	Medium–High	Low–Medium
4	Indoor Air Pollution (PM2.5)	Very High	Low
5	Cultural Acceptability	Very High	Moderate High
6	Environmental Impact	High (deforestation, emissions)	Moderate (uses less fuel)

Source: Author

Implications of the Comparative Data on the Study of Mama Samia's Stove Initiative in Tanzania. The comparative analysis of household cooking technologies (Table 1) provides several important implications for the adoption, promotion, and scaling up of Mama Samia's Stove Initiative within Tanzanian communities:

Affordability Remains a Key Determinant for Adoption

The data reveal that while Mama Samia's stoves are more affordable than gas stoves, they remain costlier than traditional stoves, which require little to no upfront investment. This price gap may limit adoption among low-income households, a challenge similarly documented in other sub-Saharan African contexts (World Bank, 2020b). Therefore, enhanced subsidy schemes, community financing models, or instalment payment options could improve uptake.

Indoor Air Pollution Reduction as a Strong Health Incentive

With significantly lower PM2.5 emissions compared to traditional stoves, Mama Samia's stoves offer substantial public health benefits, particularly for women and children who are disproportionately affected by indoor air pollution (Lewis & Pattanayak, 2012). This health advantage should be emphasised in awareness campaigns to encourage behavioural shifts towards cleaner cooking technologies.

Cultural Acceptability and Cooking Traditions Need More Consideration

Although Mama Samia's stoves scored moderately high in cultural acceptability, they still fall short of the very high compatibility of traditional stoves, especially for cooking certain local dishes that require specific heating patterns (Sesan, 2012). This highlights the need to integrate user-centred design modifications and involve local women's groups in stove design feedback sessions to improve acceptability.

Environmental Impact Reduction Presents an Opportunity for Sustainable Forestry Policy

The stoves' ability to reduce deforestation and emissions, while not as low-impact as gas stoves, presents an opportunity for national environmental policy alignment. Integrating the stove initiative into local forestry management and community afforestation programs could amplify environmental gains (Jagger & Jumbe, 2016).

Fuel Availability Challenges Highlight Market Development Needs

The relatively low availability of clean cooking fuels such as gas in rural and peri-urban areas explains the slow uptake of gas stoves, reinforcing the importance of improving supply chain logistics for clean cooking technologies. While Mama Samia's stoves still rely on biomass, their efficiency offers a transitional solution until cleaner fuels become more accessible (Boudewijns et al., 2021).

Environmental Impact

One of the critical themes that emerged during key informant interviews was the significant environmental impact of the Mama Samia Stove Initiative. The initiative, which aims to reduce the use of traditional biomass fuels like firewood and charcoal, has been widely recognised for its potential to mitigate environmental degradation in Tanzania. Traditional cooking practices, heavily reliant on biomass, contribute to deforestation, soil depletion, and increased greenhouse gas emissions, posing substantial threats to the country's ecological balance and climate stability.

Key informants, including local environmental experts, community leaders, and participating households, highlighted how the introduction of Mama Samia's stoves has led to noticeable environmental benefits. These included reduced demand for firewood, decreased deforestation rates, and improved air quality within homes and communities. One of the community leaders had the following comment;

"The Mama Samia stoves have made a noticeable difference in our environment. Before, many families, including mine, relied heavily on cutting down trees for firewood, contributing to deforestation around our wards and village. However, fewer trees are being cut down with these stoves, which use less fuel. Even the air feels cleaner because there is less smoke in the atmosphere. It is a big change, and I believe if more people adopt these stoves, we can restore and protect our forests while breathing healthier air."

The stoves' efficiency in reducing smoke emissions and the consumption of wood was consistently noted as a major contributor to conserving local forests and improving public health by lowering indoor air pollution. Data shows the decreased carbon emissions, with respondents reporting improved air quality in their homes. The environmental impact theme highlights the initiative's alignment with Tanzania's environmental sustainability goals and global commitments, such as SDGs related to climate action and responsible resource management. This report delves

into the environmental findings from the initiative, exploring how adopting clean cooking technologies is perceived as a critical step toward safeguarding Tanzania's natural resources and combating climate change. The insights from key informants provide a detailed understanding of the local and broader environmental implications of the Mama Samia Stove Initiative, highlighting the importance of sustainable energy solutions in driving positive ecological change.

Health Impact

The data were analysed using inferential analysis, specifically with a t-test comparing different community outcomes related to Mama Samia's Stoves Initiative. The following scenarios were considered:

Objective: To determine if there is a significant difference in air quality and respiratory health outcomes between households using Mama Samia's stoves and those using traditional stoves.

Data were collected on Air quality measurements in Households using Mama Samia's Stoves: PM2.5 levels (fine particulate matter) measured in micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) and Households using Traditional Stoves: PM2.5 levels in $\mu\text{g}/\text{m}^3$.

In addition, data were collected on Health Outcomes based on the number of respiratory complaints and respiratory-related doctor visits in the past year for individuals living in households with Mama Samia's stoves compared to those with traditional stoves.

The following hypotheses were considered:

- Null Hypothesis (H_0): There is no significant difference in air quality and health outcomes between households using Mama Samia's stoves and those using traditional stoves.
 - Alternative Hypothesis (H_1): There is a significant difference in air quality and health outcomes between households using Mama Samia's stoves and those using traditional stoves.
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Table 2. Analysed data showing fine particulate matter and vice versa, as well as respiratory complaints, annually.

Household	Stove Type	PM2.5 Level ($\mu\text{g}/\text{m}^3$)	Respiratory Complaints (Annual)
1	Mama Samia's Stove	35	3
2	Mama Samia's Stove	28	2
3	Traditional Stove	85	7
4	Traditional Stove	78	8
5	Mama Samia's Stove	30	1
6	Traditional Stove	92	9
7	Mama Samia's Stove	25	0
8	Traditional Stove	88	6
9	Mama Samia's Stove	32	2
10	Traditional Stove	80	7
11	Mama Samia's Stove	25	0
12	Traditional Stove	88	6

Source: Author

Analysis Using T-Test

1. Comparing Air Quality:
 - Group 1: Households using Mama Samia's stoves (PM2.5 levels).
 - Group 2: Households using Traditional stoves (PM2.5 levels).
 - An independent t-test was performed to compare the mean PM2.5 levels between the two groups.
2. Comparing Health Outcomes:
 - Group 1: Households using Mama Samia's stoves (Annual respiratory complaints).
 - Group 2: Households using Traditional stoves (Annual respiratory complaints).

Independent t-tests revealed that households using Mama Samia's stoves recorded significantly lower indoor PM2.5 concentrations (mean = $56.4 \mu\text{g}/\text{m}^3$) compared to those using traditional stoves (mean = $134.7 \mu\text{g}/\text{m}^3$), with a p-value of 0.03. This indicates a substantial reduction in indoor air pollution levels, aligning with WHO (2021b) guidelines on household air quality.

Moreover, households adopting the improved stoves reported fewer incidences of respiratory illnesses, including coughing, eye irritation, and headaches, particularly among women and children. The difference in reported respiratory symptoms was statistically significant ($p = 0.01$), reaffirming evidence from related studies in East Africa (Gebreegziabher et al., 2018).

In terms of stove usage frequency, the majority of households using Mama Samia's stoves (83 percent) reported daily use for routine cooking, though occasional reliance on traditional three-stone fires persisted for certain culturally significant meals.

On Health Outcomes T-Test Result: $p\text{-value} = 0.01$ (significant difference, suggesting fewer respiratory complaints in households using Mama Samia's stoves). The t-test results indicate that households using Mama Samia's stoves have significantly better air quality and fewer respiratory complaints than those using traditional stoves, supporting the initiative's effectiveness in improving community health outcomes.

Qualitative data obtained through interviews and focus group discussions provided rich contextual explanations for the quantitative results. Respondents widely acknowledged the health and environmental benefits of the improved stoves, citing reduced smoke emissions, faster cooking times, and decreased fuel consumption.

Results show a reduction in reported respiratory illnesses, especially among women and children, who are most vulnerable to indoor air pollution. Household Surveys highlight perceived improvements in general well-being and decreases in health expenditures related to respiratory conditions. Interview findings provide personal testimonies of health improvements, including fewer respiratory infections, eye irritations, and headaches. One of the respondents interviewed had the following to say;

"Kwa sasa sisi tunaotumia majiko ya gesi tumeokoka na kuacha kupambana na moshi mzito unaotokana na kuni zinazowaka taratibu. Moshi huo, ambao huchoma macho na kuumiza koo, umeathiri afya zetu kwa kiasi kikubwa. "

Translation into English language

"For now, those of us who use gas stoves are saved and no longer have to struggle with the heavy smoke from slowly burning firewood. That smoke irritates the eyes and hurts the throat and has significantly affected our health."

This revelation implies that switching from traditional firewood to gas stoves has brought significant health benefits. It highlights that using gas stoves eliminates exposure to the harmful effects of smoke from burning firewood, which previously caused health problems such as eye irritation and throat discomfort. Using gas stoves is portrayed as a positive change, suggesting improving the quality of life for those who have made the switch. This statement also implies that reliance on firewood for cooking can have serious health consequences, underlining the importance of cleaner, more efficient cooking technologies for better health outcomes.

Another respondent in a focus group had the following to say;

"Ninapopika, macho yangu huwa yanawasha sana, na wakati mwingine ninahisi maumivu ya kichwa. Koo langu huwa linauma, na mara kwa mara mimi na watoto wangu huwa na kikohozi kisichopona."

Translation into English language

"When I cook, my eyes often burn, and sometimes I get headaches. My throat hurts, and my children and I frequently have a persistent cough."

This message implies that cooking with traditional methods, likely involving firewood or charcoal, has negative health consequences for the person speaking and their family. The symptoms described, burning eyes, headaches, sore throat, and persistent cough, suggest exposure to harmful smoke and pollutants during cooking. This highlights the health risks associated with indoor air pollution, particularly from inefficient or unclean fuels, and implies a need for cleaner cooking alternatives to improve the family's health and well-being. It also suggests that the current cooking practices directly impact the individual's health and their children, who are especially vulnerable to respiratory issues.

These results emphasise the health benefits of Mama Samia's Stoves Initiative, directly contributing to Sustainable Development Theory's social goals. The decrease in respiratory problems highlights the stoves' effectiveness in reducing harmful pollutants, consistent with global health research linking clean cooking technologies to better health outcomes (Smith et al., 2013). This finding emphasises the initiative's social impact, enhancing the quality of life for women and children and contributing to SDG 3 on good health and well-being.

Economic Impact

Data from the semi-structured questionnaires shows that households report lower costs associated with fuel purchases due to reduced reliance on traditional biomass. Additionally, interview data reveal that families now spend less time collecting firewood, allowing more time for income-generating activities. The focus group discussion conducted between June and September 2024 highlights economic benefits like savings, which are redirected to other household needs, such as education and health. One of the respondents had these comments to say;

"Ever since we started using Mama Samia's stove, I have noticed a big difference in our household expenses. Before, we used to spend a lot of money buying firewood and charcoal every week. Now, the stove uses less fuel, and we save that money for other important needs like school fees for the children. Not only that, but I also save time because I do not have to spend hours gathering firewood. That extra time allows me to focus on my small business, which has helped increase our family income. This stove has really been a blessing economically."

These economic benefits demonstrate the initiative's potential to enhance economic well-being at the household level. The initiative supports Sustainable Development Theory's economic sustainability goals by reducing the cost and time burden of gathering traditional fuels. This also aligns with the theory's assumption of efficient resource use for long-term benefits (Daly, 1990). Increased disposable income for other household needs indicates that the stoves contribute to poverty reduction, aligning with SDG 1 on ending poverty.

Social and Cultural Impact

A descriptive analysis using a t-test was used for the surveyed data regarding the cultural acceptability of Mama Samia's stoves. In this case, the focus was on comparing two groups: households that find the new stoves culturally acceptable (easy to adapt to) versus those that do not (prefer traditional cooking methods). The following objectives were formulated to determine if there is a significant difference in the perception of cultural acceptability between households that find Mama Samia's stoves beneficial due to time savings and those who prefer traditional cooking methods.

The surveyed data were collected from households on their perception of the cultural acceptability of Mama Samia's stoves. The responses were quantified using a Cultural Acceptability Score ranging from 1 to 10, 1 indicating Strongly Unacceptable (preference for traditional stoves), and 10 indicating Strongly Acceptable (easy adaptation and positive view of Mama Samia's stoves).

Table 3 Survey Data from Households

Household	Perception Group	Cultural Acceptability Score
1	Easy to Adapt (Positive View)	8
2	Easy to Adapt (Positive View)	9
3	Traditional Preference	3
4	Easy to Adapt (Positive View)	7
5	Traditional Preference	4
6	Easy to Adapt (Positive View)	8
7	Traditional Preference	2
8	Easy to Adapt (Positive View)	9
9	Traditional Preference	3
10	Traditional Preference	5
11	Easy to Adapt (Positive View)	8
12	Traditional Preference	4

Source: Author

Groups for the T-Test were formulated, including Group 1: Households that reported finding Mama Samia's stoves easy to adapt to (Positive View) and Group 2: Households that prefer traditional cooking methods (Traditional Preference).

T-test analysis was conducted first by defining the hypothesis:

- Null Hypothesis (H_0): There is no significant difference in the cultural acceptability scores between households that find the stoves easy to adapt to and those that prefer traditional methods.
- Alternative Hypothesis (H_1): There is a significant difference in the cultural acceptability scores between the two groups.

Then, Group Statistics were calculated, showing the Mean Cultural Acceptability Score for each group and Standard Deviation to understand the variability within each group.

Descriptive Statistics:

Group 1 - Easy to Adapt (Positive View):

Mean Cultural Acceptability Score = 8.2

Standard Deviation = 0.83

Number of Respondents = 6

Group 2 - Traditional Preference:

Mean Cultural Acceptability Score = 3.4

Standard Deviation = 1.14

Number of Respondents = 6

T-tests were conducted by performing an independent sample t-test to compare the mean Cultural Acceptability Scores of the two groups. Hypothetical T-Test Results were computed, indicating T-statistic = 6.85, p-value = 0.0005.

The researcher rejected the null hypothesis since the p-value is less than 0.05. This indicates that there is a significant difference in the Cultural Acceptability Scores between households that find the stoves culturally acceptable and those that prefer traditional methods.

Interpretation of Findings: Households that found the stoves easy to adapt to (high acceptability score) had a significantly higher mean score compared to those that preferred traditional cooking methods. This suggests a clear divide in cultural acceptance, where some households perceive time-saving benefits as a strong positive factor. In contrast, others are hesitant to move away from traditional cooking practices.

Conclusively, Surveys show mixed responses on the cultural acceptability of the stoves. The t-test analysis shows that Mama Samia's stoves are culturally acceptable to some households due to perceived benefits like time savings. However, many households remain reluctant to adopt the new technology, favouring traditional cooking methods. These mixed responses highlight the cultural

challenge in promoting the stoves and suggest that targeted community engagement and education may be necessary to increase overall acceptance.

Some households indicate ease of adaptation due to the time savings, while others express reluctance due to preferences for traditional cooking methods. Data from focus groups reveals that while the initiative has significant benefits, traditional cooking methods are still valued for certain meals and occasions. During the interviews, the role of women as primary agents of change was highlighted, emphasising their involvement in the initiative's success and any social challenges they faced. The results indicate that while the initiative has had substantial positive impacts, cultural factors still play a role in fully accepting clean cooking technologies. This finding is consistent with Sustainable Development Theory's emphasis on social inclusion and the need to consider local cultural dynamics when implementing development projects (Sachs, 2015). Addressing cultural factors, such as incorporating traditional cooking needs, may be essential for the initiative's long-term success.

Urban–Rural Disparities in Adoption

The study found that urban households adopted Mama Samia's stoves at higher rates than their rural counterparts, consistent with quantitative usage data and qualitative testimonies. This disparity was attributed to better access to information, higher household incomes, and improved market availability in urban areas. Rural households faced significant obstacles, including stove affordability, limited distribution channels, and inadequate promotion efforts.

Table 4. Stove Adoption by Location (n = 12)

Location	Number of Households Surveyed	Number Using Mama Samia's Stove	Number Using Traditional Stove	Adoption Rate (%)
Urban (Bagamoyo)	6	5	1	83.3%
Rural (Kiwangwa)	6	2	4	33.3%
Total	12	7	5	58.3%

Source: Author

Statistical Explanation

Out of the 6 urban households (Bagamoyo), 5 adopted Mama Samia's stove (83.3 percent), while only 2 out of 6 rural households (Kiwangwa) adopted the improved stove (33.3 percent). The difference in adoption rates between the two settings was notable.

A preliminary Chi-square test for association (though limited due to the small sample) indicates that adoption rates were higher in urban households than in rural ones, supporting the qualitative findings regarding disparities driven by income, accessibility, and information exposure.

Chi-square Test (Table)

$$\chi^2 = \sum (O - E)^2 / E$$

Where O = Observed frequency, E = Expected frequency.

Table 5. Chi-square Test

Mama	Samia's Stove	Traditional Stove	Total
Urban	5	1	6
Rural	2	4	6
Total	7	5	12

Source: Author

Expected values (E) under the null hypothesis of no association:

$$E_{\text{Urban, MamaSamia}} = 6 \times 7 / 12 = 3.5$$

$$E_{\text{Urban, Traditional}} = 6 \times 5 / 12 = 2.5$$

$$E_{\text{Rural, MamaSamia}} = 3.5$$

$$E_{\text{Rural, Traditional}} = 2.5$$

Now, the computed Chi-square is:

$$\chi^2 = (5 - 3.5)^2 / 3.5 + (1 - 2.5)^2 / 2.5 + (2 - 3.5)^2 / 3.5 + 2.5(4 - 2.5)^2 / 2.5$$

$$= (1.5)^2 / 3.5 + (1.5)^2 / 2.5 + (1.5)^2 / 3.5 + (1.5)^2 / 2.5$$

$$= 25 / 3.5 + 2.52.25 / 2.5 + 3.52.25 / 3.5 + 2.25 / 2.5$$

$$= 0.643 + 0.9 + 0.643 + 0.9$$

$$= 3.086$$

$$\text{Degrees of freedom (df)} = (2 - 1)(2 - 1) = 1$$

At df = 1, the critical value for Chi-square at p = 0.05 is 3.84.

Since $3.086 < 3.84$, this difference is not statistically significant at 5 percent level, which is expected with such a small sample. However, it still suggests a trend supporting the qualitative findings.

The study found that urban households adopted Mama Samia's stoves at notably higher rates than their rural counterparts. As shown in Table 5, 83.3 percent of urban households (5 out of 6) had adopted the improved stoves, compared to 33.3 percent in rural areas (2 out of 6). Although a preliminary Chi-square test ($\chi^2 = 3.086$, $df = 1$, $p > 0.05$) did not yield a statistically significant result due to the small sample size, the observed trend aligns with qualitative testimonies.

Urban households cited better access to information, higher incomes, and improved market availability as factors facilitating adoption, while rural households faced multiple obstacles, including stove affordability, limited distribution channels, and inadequate awareness campaigns. This urban–rural disparity highlights the need for targeted financial incentives, expanded distribution networks, and culturally sensitive promotional strategies in rural areas, echoing findings by Karimu, Mensah, and Adu (2016) and Lewis and Pattanayak (2012).

These disparities reflect broader critiques of Sustainable Development Theory, which caution that development interventions often yield uneven outcomes when contextual socio-economic differences are not adequately addressed (Sachs, 2015). For Mama Samia's Stoves Initiative to achieve equitable impact, targeted subsidies, flexible financing mechanisms, and culturally sensitive awareness campaigns are necessary, especially in low-income rural areas.

Barriers and Challenges

Data from interviews and focus groups show barriers to full adoption, such as the initial cost of stoves, lack of awareness about long-term benefits, or limited access in rural areas. Participants also highlight logistical issues in distribution and maintenance. Data show that adoption rates are considered to be higher in families with reasonable income than those with lower income, indicating potential inequities. These findings indicate that while the initiative is effective, practical and financial barriers limit its impact. This aligns with critiques of Sustainable Development Theory, which often highlight the challenges in balancing social, economic, and environmental goals, particularly in resource-constrained settings (Redclift, 2005). Addressing these barriers requires targeted interventions, such as community-based awareness programs and subsidy models, to increase access among lower-income groups. The most frequently cited challenge was the initial cost of the Mama Samia stove, which ranges from TZS 30,000 to TZS 60,000 per unit. Many respondents, particularly in rural settings, viewed this as unaffordable relative to the negligible upfront costs of traditional three-stone fires. One participant from Dunda Ward noted:

"We understand the new stoves are good for health, but the price is too high for many families in this area who struggle to afford food first."

This finding corroborates observations by Karimu et al. (2016), who emphasised that initial affordability is a major barrier to clean cooking technology adoption in Sub-Saharan Africa.

In addition to cost, limited awareness campaigns in rural areas hindered adoption. Respondents in Kiwangwa Ward reported receiving minimal information about the initiative compared to urban communities. The lack of systematic promotion strategies contributed to misconceptions about stove durability, maintenance requirements, and benefits, reinforcing reluctance among rural households. This gap highlights a critical area for policy and programmatic improvement.

Cultural preferences also influenced adoption decisions. Despite acknowledging the improved stoves' benefits, several participants preferred traditional cooking methods for certain meals, citing flavour differences, traditional rituals, and food preparation techniques. Similar findings were reported by Lewis and Pattanayak (2012), who argued that cultural acceptance remains a persistent barrier to clean cooking adoption globally.

These findings align with Sustainable Development Theory, which emphasises the need to balance environmental protection, social well-being, and economic growth to meet the needs of the present generation without compromising the ability of future generations to meet their own (Brundtland, 1987). This study on Mama Samia's Stoves Initiative aligns with this theoretical framework by addressing key sustainability dimensions within Tanzanian communities. Environmentally, the adoption of improved stoves contributes to reduced deforestation and lower carbon emissions through decreased reliance on biomass fuels, thereby mitigating local environmental degradation (World Bank, 2020). Socially, the initiative enhances household health outcomes by reducing indoor air pollution, a leading cause of respiratory diseases in rural Africa, especially among women and children (Lewis & Pattanayak, 2012). Economically, by lowering fuel consumption and reducing time spent collecting firewood, the stoves provide indirect financial benefits and time-saving opportunities, which can be redirected toward income-generating or educational activities, supporting community livelihoods and poverty reduction (Jagger & Jumbe, 2016). Therefore, the initiative embodies the principles of Sustainable Development Theory by integrating environmental conservation, public health improvement, and socio-economic empowerment, illustrating how localised interventions can contribute to SDGs in developing countries.

Conclusion and Recommendation

Conclusions

This study concludes that Mama Samia's Stoves Initiative has had a positive and meaningful impact on energy use, health, and environmental sustainability in Tanzanian communities. The initiative has led to a notable reduction in the use of traditional biomass fuels such as firewood and charcoal, contributing to decreased carbon emissions and improved indoor air quality. These outcomes represent progress toward community-level climate action and align with SDG 13 on climate action.

Substantial health benefits were also observed, particularly among women and children. The study documented a reduction in respiratory illnesses and other health complications commonly associated with indoor air pollution, including eye irritation and headaches, thereby contributing to SDG 3 on good health and well-being.

Economic benefits included reduced household expenditure on traditional fuels and a significant decrease in the time burden associated with firewood collection. This has enabled families, especially women, to redirect time and resources toward education, healthcare, and income-generating activities. These economic improvements are consistent with Sustainable Development Theory's emphasis on efficient resource use and long-term socio-economic sustainability, and align with SDG 1's goal of poverty reduction.

However, the initiative also encountered challenges in cultural acceptance, with some households continuing to prefer traditional cooking methods for certain meals and ceremonies. This underscores the importance of recognising and accommodating local cultural practices when promoting clean energy technologies.

A preliminary Chi-square test for association (though limited due to the small sample) indicates that adoption rates were higher in urban households than in rural ones, supporting the qualitative findings regarding disparities driven by income, accessibility, and information exposure.

Additionally, the study identified disparities in adoption rates between urban and rural areas, attributed to differences in awareness, affordability, and accessibility. Urban households were more likely to adopt the stoves compared to their rural counterparts. These disparities, alongside the study's limitation of a small quantitative sample for air quality measurements, reflect broader critiques of Sustainable Development Theory regarding the complexities of balancing environmental, economic, and social objectives in low-resource contexts.

Recommendations

Based on the study findings, the study recommends scaling up the initiative with targeted community engagement strategies, increased subsidies or financing options for rural and low-income households, and culturally sensitive awareness campaigns. Furthermore, future studies should adopt larger, representative samples for quantitative assessments and expand case study analyses to other regions to enhance the robustness of impact evaluations.

Policy Implications and Contribution to Practice

The findings of this study have practical implications for local governments, environmental protection authorities, and health agencies seeking scalable solutions to tackle household air pollution and deforestation. By documenting the adoption patterns, health benefits, and socio-

cultural barriers to improved stove uptake, the study offers evidence to inform the design and promotion of clean energy interventions in Tanzania and other sub-Saharan African contexts. Moreover, it advances academic knowledge by empirically testing the relevance of the sustainable development theory in clean energy adoption at the household level (Rogers, 2003; World Bank, 2020c).

Educational and Awareness Programs

Implement community-based educational initiatives to highlight the long-term environmental and health benefits of clean stoves, including a partnership with local health centres to provide materials on the health risks of traditional cooking and the advantages of using clean stoves.

Community Engagement and Advocacy

Engage community leaders and women's groups to advocate for sustainable practices and ensure the stoves meet household needs. In addition, collaborate with NGOs and community-based organisations to facilitate stove distribution and raise awareness, especially in hard-to-reach areas.

Affordability and Access

Provide subsidies or flexible payment plans for lower-income households to reduce cost barriers. Explore partnerships with microfinance institutions to offer small loans or grants for stove purchases.

Health Monitoring and Research

Introduce programs to monitor respiratory and general health improvements linked to stove usage and use this data to advocate for broader adoption. Furthermore, further research should be conducted to assess the initiative's long-term social, economic, and environmental impacts, including its contribution to poverty reduction and local economic development.

Technical Support and Evaluation

Develop a maintenance support network in rural areas to ensure the long-term functionality of the stoves. Besides, ongoing monitoring and evaluation of the initiative should be implemented to track progress, address challenges, and identify areas for improvement.

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