

Analyzing the Factors that Drive Household Cookstove Use and the Challenges with
Implementation of Alternative Cookstoves Pemba Island, Tanzania



Mabel DeGrandpre

Academic Director: Dr. Jonathan R. Walz

Advisors: Mbarouk Mussa Omar and Andrea Baudoin Farah

School for International Training and Colorado State University

Coastal Ecology and Natural Resource Management Zanzibar

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Table of Contents

1.	Acknowledgements	2
2.	Abstract	3
3.	Introduction	4
4.	Background	5
5.	Methods	14
6.	Results	19
7.	Discussion	32
8.	Conclusion	38
9.	Bibliography.....	41
10.	Appendix	45

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Abstract

This study focuses on the determinants of cookstove use and the health impacts of cookstoves on community members in Pemba, Tanzania. With a secondary focus of how these factors impact the adoption of “clean” cookstoves, specifically those introduced by the NGO Community Forest Pemba (CFP). This study was conducted in Wete District on Pemba Island, Tanzania. Using a qualitative approach with semi-structured interviews and biographical sketch methodology, 29 total interviews were conducted, which illuminated the prevalence of each of the five stove types observed and the additional considerations associated with each stove type. Interview data revealed that many households continue to use the three stone fire (TSF) due to its ability to provide large amounts of food, affordability, and familiarity across generations, despite users displaying awareness of the health risks associated with the stove type. The CFP cookstove initiative is briefly analyzed and displayed potential for reducing household fuel use and providing income to coop participants. Together these findings display the importance of analyzing historical contexts, financial barriers, labor burdens, and health perceptions when investigating the social and practical factors that complicate the widespread adoption of alternative cookstove types.

Swahili Translation:

Dhahania

Utafiti huu unazingatia hali halisi na mitazamo ya majiko miongoni mwa wanajamii kisiwani Pemba. Kwa kuzingatia zaidi jinsi hali halisi na mitazamo ya matumizi ya jiko la kupikia inavyoingiliana na mpango wa jiko la ‘Pemba Community Forest’. Utafiti huu ufananyika katika Wilaya ya Wete katika Kisiwa cha Pemba Tanzania. Kwa kutumia mbinu ya ubora na usaili uliopangwa nusu na mbinu ya mchoro wa wasifu jumla ya mahojiano 29 yalifanyika ambayo yaliangazia umuhimu wa majiko ya asilia aina ya mawe matatu (TSF), uelewa juu ya athari za kiafya za majiko, na athari jiko la Jumuiya ya Misitu Pemba (CFP) kwa wanajamii wawalielezea vipingamizi walipojadili TSF ambayo ilianguzia umuhimu wa kitamaduni na kikwazo kinachowezekana cha mabadiliko ya majiko mbadala. Athari za kiafya zilijadiliwa na waliohojiwa ili kutkuongeza ufahamu katika. Jukumu la CFP katika kubadilisha maisha ya wanajamii kwa kuwaelimisha juu ya utengenezaji wa jiko lilionyeshmbadala wa kupitia mahojiano na wanavikundi wa vyama ushirika.

Waliohojiwa Utafiti huu walipata mwangaza katika kufafanua matumizi ya jiko kupitia mitazamo yao.

Introduction

Home cooking on Pemba Island, Tanzania, is not only a daily activity but also deeply rooted in cultural and subsistence practices (Walsh, 2009). Many households rely on biomass burning stoves, which have been linked to indoor air pollution, deforestation, and increased labor burdens (Kaputo et al., 2023, 10). Despite these issues, people continue to rely on stoves that exclusively use biomass fuel sources for reasons that need to be explored. To combat the issues linked to biomass burning cookstoves, the non-government organization, Community Forest Pemba, started a program to train community members on how to produce “clean” cookstoves throughout Pemba Island, a predominantly rural island off the Tanzanian coast (Community Forests Pemba, n.d.). This study investigates the question: What are the determinants for use and health impacts of the most commonly used cookstoves among community members in Pemba? With a secondary question of how these factors impact the adoption of “clean” cookstoves?

To address these questions, I developed a qualitative social research methodology based on biographical sketches and interviews to dive into the personal and generational factors that determine which stove types are used in a household. In addition, the impact of stoves on health, fuel usage, and time allocation will be explored for different stove types to see if they are considered when choosing stove types. These factors will be compared between people who use common stove types and specialized stove types that are designed by the NGO Community Forest Pemba, which has been teaching locals to build their own “clean” stoves from clay. This comparison will provide insight into the deciding factors for stove use which will illuminate the barriers for widespread adoption of different cookstove types. By collecting data on lived experiences, this study creates a more comprehensive understanding the determinants of stove use and the impacts of the Clean Stove Initiative. This study is significant because it will inform

local and global agencies of the deciding factors for stove usage and the potential repercussions of these choices in areas similar to Pemba Island. It will also provide essential information to improve the future efforts to integrate alternative stove types into households on Pemba Island.

Background

This background section 1) outlines the history of stove use in Sub-Saharan Africa and introduces the cultural significance of common stove types; 2) provides information on the health impacts that have been linked to biomass burning stove types; 3) introduces the study site of Pemba Island Tanzania, 4) briefly discusses the Clean Cookstove Initiative organized by Community Forest Pemba.

Important Topics

The three main topics being outlined in this section are the impact of cookstoves in Sub-Saharan Africa, the role of Community Forest Pemba, and health with cookstoves.

Cookstoves in Sub-Saharan Africa

The development of cookstoves in Sub-Saharan Africa can be traced back to over 12,000 years ago with the use of the three-stone fire or *mafiga* in Swahili (Kaputo et al., 2023, 11). This cooking mechanism includes an arrangement of three stones around a fire, which allows cookware to balance above the fire. These cookstoves use biomass fuel such as wood, and dead plants. Three-stone fire cookstoves are low cost and accessible given the availability of materials close to communities, making them the easiest choice for cooking (Kaputo et al., 2023, 11). However, this method of cooking is highly inefficient with a loss of up to 80% of heat energy through dissipation (the open structure of the cookstove causes fuel to burn quickly at lower temperatures) and has been linked to high levels of indoor air pollution, which makes it dangerous for health over time (Pelizan et al., 2019, p. 4; Kaputo et al., 2023, 10).

In addition to air pollution the TSF cookstoves require consistent collection of wood to allow for daily use. One study done in Kenya found that women predominantly take on this burden spending on average three hours a week collecting wood on top of their other weekly responsibilities. The effort required to collect enough wood for the week was considered highly exhausting, making it hard to complete any other tasks for the rest of the day (Njenga et al., 2021, p. 5). In this study, they also found that there is a serious risk of injury from collecting firewood as it is a labor-intensive task. One woman from the study shared that she fell and broke her arm collecting firewood which made her reliant on her neighbors to provide her with wood to use for cooking. This injury also impacted her ability to earn income, which came from selling vegetables (Njenga et al., 2021, p. 5). Additional similar stories are shared in the article which illuminates that collecting firewood is not only a time sink but a high-risk activity for the women in rural Kenya.

Low consumption cookstoves, sometimes referred to as “efficient cookstoves” are designed to optimize biomass fuel use and reduce the amount of smoke released as seen in Figure 1. These cookstoves reduce the amount of fuel necessary for cooking, which in turn has an impact on the amount of time and money allocated to providing fuel. These stoves are designed to reduce airflow, allowing for fuel to last longer, resulting in lower fuel consumption. However, low consumption cookstove technologies are often unavailable in the areas that mainly use the three stone fire cooking method as they require either manufacturing infrastructure or importation. Furthermore, the initial investment in the low consumption cookstove of around USD 5 to USD 20 has been found to be an additional limiting factor (Andrews & Borgerhoff Mulder, 2022). In a study done in North Central Ethiopia, 66.7% of people interviewed stated that the reason low consumption cookstoves were not used in their homes was because of

financial strain (Eshetu, 2014, 141). Because of these limitations less than one-third of households that primarily rely on biomass fuel use these cookstoves (Bensch et al., 2021, 883).



Figure 1: Image of a low consumption cookstove also known as a “clay efficient cookstove” designed by Community Forest Pemba (DeGrandpre, 2025).

Other alternative cookstoves are also used in Sub Saharan Africa and have been gaining popularity in recent years. Some of these include charcoal, gas, and electric cookstoves (Pelizan et al., 2019, p. 3). Out of these alternative stove types, charcoal has become the most common as charcoal is accessible in both urban and rural areas. However, this method is not efficient and requires high amounts of wood to create enough charcoal to fuel a cookstove. A paper from the Business School of Navarra found that 10.8 kg of wood produces the same amount of energy as 3.6 kg of charcoal which requires 30 kg of wood to be produced (Pelizan et al., 2019, p. 5). Gas stoves that used LPG or petroleum fuels are less common in Sub Saharan Africa which has been

attributed to a lack of accessibility and affordability of these fuel types. This issue has been described as a loop where there is lack of fuel accessibility because there is a lack of demand, but the demand does not increase because the products are inaccessible (Pelizan et al., 2019, p. 6). Electric Stoves are even more uncommon in Sub Saharan Africa specifically in rural areas because of the lack of electric connectivity. Though the areas with access to electricity continue to increase it still is low in many countries. A prime example is Tanzania which has had a 14.4% increase in connectivity access from 2015-2016 which brought the rate of connectivity to 42.8% which is still less than half the population (Pelizan et al., 2019, p. 3).

The Tanzanian government has recently started an initiative to distribute electric cookstoves to rural areas with the goal of reducing the use of biomass burning cookstoves. This initiative is supported by both government funding and the Tanzania Electric Supply Company also known as Tanesco. The initiative was put into action on August 14th, 2025 a year after the previous president Samia Suluhu Hassan shared that he aims to “lift the firewood burden from women” through using alternative fuel sources. The end goal of this effort is to facilitate the transition to alternative cooking methods so that four out of five Tanzanians citizens cook with more sustainable stove types by 2034 (*Tanesco Champions Clean Cooking with Subsidised Electric Stoves*, 2025, p. 1). The initial wave will include the distribution 11,000 electric stoves however efforts like these in the past have been slow to be enacted and uneven in their distribution (Schunder & Bagchi-Sen, 2019, p. 3).

Health and Cookstoves

The impact of solid fuel source burning kills more than 4 million people annually worldwide, which is a larger number than the combined amount of people who die from malaria and AIDS each year (Fact Sheet about Malaria, n.d.) (Hiv, n.d.) (Aemro et al., 2021, 1). Using

inefficient cookstoves contributes to this issue as they release high levels of smoke, which is detrimental to human respiratory systems (Aemro et al., 2021, 2). In addition to respiratory problems, indoor air pollution is tied to other negative health impacts such as pregnancy complications, headaches, irritated eyes, and can contribute to back pain in people of all ages (Gilya, 2019, 12). The communities that appear to be at the highest risk of health impacts from biomass burning cookstoves are in rural areas. This is due to a lack of access to alternative cookstove technologies and fuel sources such as electricity (Schunder & Bagchi-Sen, 2019, p. 3).

The use of fuel-efficient stoves has been shown to reduce the negative impacts of cooking indoors as they reduce the number of airborne pollutants such as carbon monoxide, acid gas, and organic carbon particulate matter (Mitchell et al., 2020, 1593). In Tanzania, the main cooking fuel sources are wood and charcoal (Tanzania, 2024). Wood smoke, if not fully combusted, contains more than 200 different organic compounds, making it the most concerning fuel sources for human health (Bede-Ojimadu and Orisakwe, 2020, 1). The use of low consumption stoves increases the level of combustion of fuel, which lowers the amount of these dangerous particles. With higher levels of combustion, the amount of fuel needed is reduced, which lowers the time women spend collecting fuel. This helps to prevent women from experiencing injuries associated with collecting wood.

Study Area

Pemba is one of the two main islands comprising the semiautonomous Zanzibar Archipelago, alongside Unguja. Located 60 km off the coast of mainland Tanzania and 50 km North of Unguja, Pemba is home to more than 500,000 people as of a 2022 survey, and its population has grown more than 25% since 2012 (The United Republic of Tanzania, 2022, 2). The districts and population within Pemba are Mkoani (135,052), Chake-Chake (136,298),

Micheweni (123,379), and Wete (148,712) (Brinkhoff, 2023). The predominant religion is Islam, with Swahili being the primary language (Middleton, 1992). Pemba has a large rural population, which has a level of impoverishment of around 55% according to a household budget survey from 2015 (World Bank, 2017). Though specific annual income figures are not available for Pemba Island specifically there is a rough estimate of average monthly income from the Anker Research Network which is USD 200 monthly and USD 2,400 annually.

The Island was labeled the “green island,” by the Omani Arabs that settled there in the 19th century - a label that has continued to be used – because of its dense vegetation and intensive agricultural practices (Walsh, 2009). Pemba has two main rainy seasons; one with short rains in the months of November and December, called *Vuli*, and another with long rains falling from March to May, called *Masika*. These rains allow for the diversity of crops grown in Pemba, such as cloves, bananas, sweet potatoes, yams, cassava, maize, and a variety of other vegetables (Walsh, 2009). Agriculture is the backbone of local livelihoods, whether through subsistence farming - where women play significant roles (United Republic of Tanzania, 2023, 41)- or cash crop farming, mainly through clove and rubber plantations (Walsh, 2009). Clove is critical for the spice trade, which has resulted in regulations limiting the cutting of clove trees. In addition to agriculture, the domestic market for wood is a large source of income for many residents, contributing to an annual deforestation rate of 3.4% (Andrews and Borgerhoff Mulder, 2022). To combat deforestation and potentially allow for regrowth, the local government has put community forest management programs and cutting restrictions on clove and mangrove tree species (Collins, 2020).



Figure 2: Zooming map of Pemba in relation to Tanzania, Pemba Island as a whole, and the focus area of Wete District with markers of interview locations with number of interviews conducted (Gaia GPS, 2025).

This study focuses specifically on the Wete district; one of four districts and is on the northern half of Pemba. The population has grown from 107,916 in 2012 to 148,712 in 2022, with an average of 6.2 persons per household and an average growth rate of 2.1% annually (Wete District Profile, 2017, 22) (Clark et al., 2023, p. 4). Wete district has one of the lowest electricity connectivity rates in the Zanzibar Archipelago, with 74% of the households relying on other energy sources for daily activities. The most common fuel sources in the area for cooking are firewood, charcoal, and gas (Wete District Profile, 2017, 62). Based on a census from 2012, 80% of residents in the Wete district primarily rely on firewood as a fuel source when cooking, which contributes to deforestation in the area (Wete District Profile, 2017, 76). The most common methods for cooking in the Wete district are three-stone fires, charcoal stoves, gas stoves, and electric cookers according to a 2017 census (Wete District Profile, 2017, 76).

A health survey conducted in the Wete district in 2015 reported pneumonia and upper respiratory tract infections as the main causes of mortality and morbidity in people (Wete District Profile, 2017). Pneumonia accounted for 40% of mortality in people of all ages and 45% of deaths in children under the age of five – the leading cause of death. The top cause for morbidity was upper respiratory tract infections, with 47,586 reported cases that year, making up 42% of total reported morbidity. Though these respiratory illnesses could be caused by many different factors stove usage could potentially be a significant contributor as it has been linked to indoor air pollution (Kaputo et al., 2023, 10).

Community Forest Pemba cookstoves

Community Forest Pemba (CFP) is a non-governmental organization (NGO) located in Pemba, Tanzania. The organization strives to provide local communities with the resources needed to adapt to and prevent environmental changes specifically deforestation. One of these efforts was the training of local community members, mainly women, on how to produce efficient cookstoves. The clay efficient cookstove is a simple design where a clay cylinder is created with an open top and nodules going inward that hold pots with a wide opening at the base where wood can be placed inside to burn. This restricts airflow is meant to allow for slow and clean burning of biomass fuels resulting in a reduction of the amount of firewood used and lowering the amount of smoke emitted from the stove. The design can vary from being made from only locally sourced clay or using a metal casing to improve durability and longevity as well as increasing insulation (seen in Figure 3). Community Forest Pemba used a “training of trainers” strategy to ensure that the practice of building clay stoves was taught throughout

different areas. The course was broken up into two sections, one theoretical and one practical. The theory section outlined the impacts of efficient cookstoves. Specifically describing the environmental and health benefits that the stoves facilitate. The practical section of training included where to collect materials, and then taught the community members how to build the stoves (Omar Msellem, personal communication, 2025).

With a reduction in fuel use through adopting fuel efficient cookstoves, the goal is that there will be a reduction in deforestation which is currently occurring at a rate of 3.4% annually (Andrews and Borgerhoff Mulder, 2022). This goal is supported by a study done in Zanzibar which found that the main cause for deforestation in rural Zanzibar is fuel usage. However, this study stated that the impact of widespread use of efficient cookstoves cannot be analyzed until they have been adopted for a long period of time (Makame, 2007). An inability to access wood would affect the ability of local communities to continue critical subsistence practices.



Figure 3. Image 1. Clay Efficient Cookstove (CES) with a metal casing. Image 2. CES being built from just clay before drying (DeGrandpre 2025).

Methods

In this section, the mixed method approach used in the study will be described and the reason it was chosen will be explained. The first method used was the semi structured interviews which were selected as this interview method allows for a guided discussion but leaves room for follow up questions. The second method used was biographical sketches which were chosen to gain insight into the life histories and personal experiences of the interviewees.

Initial Interviews

For this project the methods were selected to allow for a better understanding as to why certain stove types are used within households. The two different interview types were selected to allow for discussions that not only answered the questions provided but gave the interviewees room to share additional information they believed to be important. To collect information on stove usage semi-structured interviews were conducted, which consisted of a series of 24 scripted questions (see Appendix) with additional follow-up questions depending on responses to the initial questions (Bernard, 2013, 181). The interviews took place in the district of Wete with both rural community members and urban community members. Each Interview lasted around 20-30 minutes depending on the detail of the responses and the number of follow up questions asked. A local resident not affiliated with Community Forest Pemba (Mohammed Nassor Ali) was hired as a translator who provided translations for responses and explained difficult questions. He also set up the majority meetings with the interviewees using his knowledge of who would be willing to be interviewed in the area. These interviews were conducted in the homes of the interviewees. During the interviews notes were taken by hand based on the translations provided. A total of 26 people were interviewed during the first round of interviews: 20 were residents found by Ali who were the primary household cooks seven of which were not

included in the results due to inconsistencies in methodology and six interviews were organized by Community Forest Pemba four of which were coop operatives who built and sold Clay efficient cookstoves (CES) these were the only interviews arranged and translated by members of the NGO Community Forest Pemba. The interviews with coop operatives provided insight into the entrepreneurial side of CFP's stove initiative. To ensure ethical considerations, the participants were informed that they would remain anonymous and were told about the specifics of the study.

Initially, Community Forest Pemba helped to arrange six meetings with CES coop participants and people who owned a CES. The NGO also provided translations and transportation. However, after these 6 interviews our collaboration ended to prevent a conflict of interest in the rest of the interviews.

Once the interviews were complete the results were analyzed by placing all detailed responses into an excel sheet to better compare responses. This information was then organized into different sheets based on the questions asked. The responses to the questions discussing stoves impacts on health were grouped in one sheet and each other category had its own separate sheet to make it easier to analyze. These excel sheets were then distilled down by assigning general categories to the responses that were similar. For example, the phrases cough, chest pain, trouble breathing, were grouped into respiratory issues. This allowed for easier analysis for general results and when analyzing more specific working or quotes the comprehensive excel sheet was referred to.

Type of Interview	Grouped or Individual	Number Separate Interviews	Number of participants	Rural or Urban	Notes
CFP Interviews	Grouped	1	3	Rural	

CFP Interviews	Individual	3	1	Rural	
Randomized Interviews	Grouped	1	7	Rural	Not Included in results
Randomized Interviews	Individual	4	1	Rural	
Randomized Interviews	Grouped	1	2	Rural	
Randomized Interviews	Grouped	1	3	Para urban	
Randomized Interviews	Grouped	1	4	Urban	

Table 1: This table depicts the different interviews conducted during the study and organizes them based on who organized the interviews CFP or Ali.

Biographical Sketches

In this research project, biographical sketch methodology was used to convey the personal histories or life stories of community members in relation to cookstoves. Biographical sketches provide insight into the progression of a behavior or trait throughout a lifetime or across generations. This social science methodology was used to develop a comprehensive understanding of the personal components of a subject as well as observe if there has been a change in stove usage determinants over generations (Kridel, n.d., p. 1). The goal of using this methodology was to see if stove use type has changed over generations and if there were any long-term health impacts observed across generations. Once the initial interviews were complete, three participants were selected to be interviewed for a biographical sketch based on the detail of their responses as well as their willingness to complete an additional interview. These women

remain anonymous in the write up however they were assigned random Swahili names to easily reference them throughout the paper. One of the three selected was a woman who used a clay efficient stove (CES), and two who used a combination of a charcoal cookstove and a TSF. These women participated in a second more in-depth semi-structured interview that dove into their life histories regarding the use of cookstoves. During these interviews, there were 39 questions and ten sub-questions (see Appendix). The interviews helped to establish individual histories of the role that cookstoves have played in the lives of the participants. Like the initial interviews these were conducted in the homes of the interviewees who were asked if they would allow for a photograph of their kitchen was allowed to be included in the paper. These interviews were converted into narrative paragraphs that included important points and quotes so that they could be analyzed alongside the initial interviews.

Limitations

Throughout the span of the project there were several significant limitations that must be addressed as they potentially impacted the results of the project. First being that initially, Community Forest Pemba helped to arrange meetings with CES coop participants and people who owned an CES. It is important to note the there is potential bias from CFP both organizing and translating the interviews with the owners of the CES because they created the stove initiative that the women are part of. To avoid further bias a new translator was found who was not affiliated with CFP. The second limitation which was the challenge of documenting the interview responses accurately. The language spoken in Pemba is Swahili which had to be translated to English by Ali who was not fluent in English. On several occasions, he had difficulty translating the interview questions as they were intended which sometimes resulted in

confusion from the interviewee. The issue arose with the question about health impacts where the translator used the word smoke when posing the question which could have skewed the results for future interviews as it encouraged the interviewees to think of health impacts caused by smoke specifically. This issue was addressed by altering the questions early on in project so that they were more easily translated directly without using words that encourage a specific response. The issue of direct translations was also present with the interviewee responses. Ali aimed to translate each response word for word however the exact wording used by the interview was not guaranteed as he was unable to translate some words to English. To help with this issue Google Translate was used to aid with translations however even with the use of Google Translate there were terms that could not be directly translated into English.

Lastly, there were miscommunications with Ali about the interview format, the first interview organized by him was with seven women instead of seven individual interviews. This interview was difficult to document as there were many people responding at once and the participants concurred with each other's responses which would have skewed the results. To ensure that this seven-person interview did not skew the results the responses were not considered during analysis.

Results

The results presented in this section reflect the responses to the questions asked throughout the interviews. Each subsection corresponds to a specific question and outlines participants' responses. First, the commonality of each cookstove type was quantified by identifying the primary and secondary stove types used by participants. Determinants of stove use were drawn from the follow-up question asking participants why they use their primary stove type. Advantages and disadvantages were summarized from responses to a question prompting

interviewees to share the advantages and disadvantages of the stove types they use. Fuel use was explained based on a number of questions directed towards the reasons that certain fuel types were used as well as the time and cost required to obtain each fuel type. Lastly, perceived health risks were determined from responses to the question about the health risks associated with each stove type.

Household Cooking Technologies

There are five common cookstoves in Pemba which include the a) three stone fire (TSF) or *mafiga* in Swahili, and four **alternative** stove types b) charcoal cookstove, c) clay efficient stove (CES), d) gas cookstove, and e) electric cooker (as seen in Figure 4). In the Wete area, multiple stoves are often used in one home. Out of the nineteen interviewees that were included in the results, eleven people used multiple stoves in their homes, and eight people used one. The total number of cookstoves used by the nineteen people was 34 cookstoves, averaging 1.7 cookstoves per home.



a) Three Stone Fire (TSF)



b) Charcoal Stove



c) Clay Efficient Stove (CES)



d) Gas Stove



e) Electric Pressure Cooker

Figure 4: Images of the five types of cookstoves observed during the project a) three stone fire (TSF), b) charcoal stove, c) clay efficient cookstove, d) gas stove, e) electric cooker (DeGrandpre, 2025).

Commonality and cost of cookstoves

The most common stove used is the TSF, which consists of three stones positioned around a wood fire used to hold up a single pot, making it a low-cost option for cooking. This method was used by 74% of people interviewed, and 58% of people used it as their primary cooking method. Out of the 14 households that used a TSF, 79% of them used it as their primary stove type, whereas out of the 20 total alternative cookstoves, 40% of people used them as their primary cooking method. The second most common cookstove was the charcoal cookstove, which is made from clay and metal. These cookstoves are bowl-shaped and have metal legs to keep them balanced. The charcoal is placed in the bowl of the stove, and a pot is placed above on

metal arms. The clay and metal trap the heat of the charcoal and allow the stove to continue cooking for long periods. These cookstoves typically cost from 15,000 TSH for a small stove (6 USD) to 18,000 TSH (7.20 USD). From the study group, eight people used one in their home. Charcoal cookstoves were also the second most common primary stove, with four interviewees using them primarily, accounting for half of the alternative cookstoves used primarily. The clay efficient stove (CES) was used by 26% of the people interviewed, with 16% of people using it as their primary cooking method. The stove has a simple design and was introduced by Community Forest Pemba to the Wete area. This cookstove is produced by local community members and is made up of clay and sometimes metal. The clay is locally sourced and is used as the base for the stove. Metal is often attached to the clay stove to increase the stove's efficiency and durability. This stove relies on firewood as fuel. The stove can hold one pot, which is placed on inward tilting knobs. The basic process of building a CES can be found in the Appendix. The price of these stoves' ranges from 5,000-15,000 TSH or roughly 2-6 USD. The gas cookstoves used in Pemba consist of a gas canister with a gas valve connected to a burner. Out of the 19 interviewees, four of them (21%) used a gas stove, with only one using it primarily. These cookstoves cost around 56,000 TSH or 22.4 USD for the initial set up with a 6 kg gas canister. The least common stove type was the electric cookstoves, which consist of electric pressure cookers and ovens. Out of the nineteen interview subjects, two used electric cookstoves. These are mainly used for specific types of food such as rice, beans, or baked goods. These are the biggest investments with standard options costing around 200,000 TSH or 80 USD.

Determinants of Cookstove Use

One of the main determinants for the use of the TSF was the amount of food cooked in the home. In the interviews, women shared that they use the TSF in combination with charcoal or CES because the other stoves can only hold one small pot, whereas the TSF can hold a larger pot. Using both the TSF and an alternative stove allowed for multiple foods to be cooked at a time. Another factor that was mentioned was the affordability of the TSF. One woman shared that she continues to use the TSF because it is fast, but mainly because charcoal is expensive. An additional determinant repeated by interviewees was that the rainy season made it more difficult to burn wood. They shared that when there is heavy rain, finding dry wood is impossible, which results in them having to wait for the wood to dry. This is inconvenient, and often wet wood is used for the fire, resulting in more smoke. Because of these problems, four women shared that they switched to alternative stove types in the rainy season. Three of them switch to charcoal, and one transitions to an electric oven. However, one woman shared that she would prefer to use charcoal in the rainy season but is unable to because there is less access to charcoal during this season. She blamed the lack of availability of charcoal on the demand and said that people produce less charcoal in the rainy seasons because people do not want to monitor the charcoal heaps while it is raining. She then said that this makes it so that she must use firewood inside, which she does not typically do (image of Lulu's kitchen Figure 5). This was a unique experience shared by Lulu in one of the biographical sketch interviews (full biographical sketch interviews in the Appendix). In the biographical sketch interviews, it was mentioned by all the interviewees that they were taught by their mothers to cook using the TSF with one woman saying it is a "rite to passage into womanhood". This was also mentioned by multiple interviewees who shared that they continued to use the TSF as it is what they have always used.



Figure 5: Image of Lulu's kitchen both inside (1) and outside (2) with labeled stove types (DeGrandpre, 2025).

The main determinants that incentivized the use of charcoal in households were the rainy season, smoke damage, convenience, and cost. As stated above, the rainy season was found to be a determinant of charcoal stove use, with three people switching to charcoal during the rainy season. Smoke damage was also mentioned as a determinant for charcoal cookstove use. Four women who were interviewed said that they transitioned to a charcoal cookstove because the TSF method results in damage to the walls and ceiling of their homes from the amount of smoke. According to the interviewees, the smoke often contributes to the discoloration of walls and can cause breaks in the roof. Three of the women who referenced these issues transitioned to charcoal to help prevent the impacts that smoke has on the home, as seen in Figure 6. One of the women shared that she rents her home and is not allowed to use a TSF because of smoke damage. She also shared that she misses using the TSF as it was very fast at cooking and allowed

her to cook lots of food at once, which is helpful for her business, where she sells food.

According to several interviewees, the stove they used each night often depended on factors such as how late they got home from the farm and how they were feeling health-wise. One woman shared that when she is running late, she uses charcoal because she can do so inside and does not have to collect firewood before cooking. Another determinant identified from the interviews was the price of charcoal. When asked what type of stove they would choose if they could use any stove, two people stated they would like to use charcoal, but it is too expensive. One user of charcoal shared that she uses it as a secondary stove type because it is too expensive to use exclusively.



Figure 6: Image of the smoke damage from a TSF on a kitchen wall (DeGrandpre, 2025).

The 6 people who used the CES all shared that they used them because they use less wood and produce less smoke than the TSF. Though four of them used other methods as well. The explanation for this was that the CESs are too small and are unable to cook the amount of food necessary for the family's needs. Two women shared that larger versions of the CES are available, but they are more expensive which prevents them from investing. They are also only able to hold one pot at a time, which was brought up as an issue during the interviews. Three people shared that they used the TSF in addition to the CES so that they could cook two things at once.

Three women who participated in the CFP clean cookstove initiative were also interviewed in relation to the use of CES. These women shared their experience in building and selling the CES as well as their participation in the training of trainers method that was used. Two of the three women shared that they can make supplemental income from the selling of the CES which they use to pay for their children's education. In one of the biographical sketch interviews Eshe said, "all work is hard, but the money is important". The women shared that during Ramadan sales increase as people cook larger meals and require additional cookstoves. The two main limitations that were brought up about the continued production of the cookstoves was that it has become more difficult to harvest clay from the nearby clay fields and the price of the metal casing has increased in recent years making it less affordable to continue seeing the stoves. One woman shared that she had organized an additional training for women in a nearby village continuing the training of trainers method.

During the interviews with gas cookstove users it was repeated that gas cookstoves are often used for quick foods or for emergencies as they require minimal effort to produce a flame. Three out of the four users said they used gas sparingly. They said they use it for quick foods

such as eggs, or heating milk. Eshe from the biographical sketch interviews said, “sometimes if you want to make milk but it is nighttime, getting the wood and starting the fire is very hard”. One of the interview questions asked about what type of stove the interviewee would choose if they could use any stove. Gas was stated the most frequently with 38% of people saying they would prefer to use it as their primary cooking method. The follow up question to this asked why they do not use the stove they would prefer to use. The response to this question was the same for every respondent with 100% of them saying switching to gas was too expensive. During a biographical sketch interview with Mgeni she shared that she hopes her children will use gas or electric as their primary cookstove saying “the time has come for easy cooking”. She then talked about how her children are students right now and once they get employed, they will have no time for collecting firewood.

The electric cookstove was used by two people which makes the information limited. However, the two people who used an electric stove shared that it was useful for specific items which cooked for longer periods. The electric cookstove was brought up one time when recipients were asked what kind of cookstove they would use if they could use any. The reason this cookstove was not used by this interviewee was the high expense and lack of connectivity associated with using an electric cookstove.

Advantages and Disadvantages of Cookstoves

The three main terms used to describe the advantages of the TSF were “fast”, “easy”, and “traditional”. The TSF was described as fast by 50% respondents, easy by 71% respondents, and 2 people said that the TSF being traditional was an advantage. When referring to the speed of the TSF, in comparison to the alternative cooking methods described above, the respondents were specifically talking about the cooking time. One woman shared that when using the TSF, she is

able to finish cooking early, providing her with more time to do other things. Generally, when interviewees responded with “easy” as an advantage of the TSF, they were referencing the physical setup of the cooking method. They shared that the stones are easy to find, and the wood is close by, which makes it easy to start the fire and get a flame hot enough to cook. The two interviewees who used the term “traditional” were referring to the TSF as a common practice they have always used.

When asked about disadvantages, there were a total of thirteen distinct issues mentioned. The ones that were repeated multiple times were smoke (9), lots of firewood (4), eye pain (4), respiratory issues (3), and large fire (3). Smoke was frequently stated as a fundamental cause for the other disadvantages shared. For example, every time eye pain or respiratory issues were referenced as a disadvantage, so was smoke. Smoke was also mentioned as a disadvantage because it leaves dark residue on the walls of homes. The TSF was the only stove type that had health issues mentioned when discussing disadvantages, except for one respondent listing burns as a disadvantage of charcoal stoves. Five different health issues were listed among the thirteen disadvantages. These included respiratory issues, eye pain, burns, stomach aches, and the flu.

For charcoal cookstoves there were four distinct advantages mentioned. These were easy (2), burns longer (2), less smoke (1), and better for the rainy season (1). When respondents described the use of charcoal cookstoves as easy they referred to not having to gather wood for the fire and being able to cook in their home instead of outdoors.

When asked about disadvantages, two main points came up. These were cost (3), and burns (1). The issue of cost came up for three out of the four people who shared disadvantages of charcoal stoves.

The CES cookstove method had the biggest number of unique advantages with six different advantages mentioned. These advantages were less firewood (4), less smoke (4), clean (2), good food (2), controlled flame (2), and better than TSF (2). These responses were given in the context of comparing the CES to the use of a TSF meaning the CES uses less firewood and has less smoke than the TSF. This was interesting as the question did not include mention of the TSF however it could have been an issue with the translation of the question. The disadvantages shared were that the CES is too small (2), slow (1), and not good in the rainy season (1).

The advantages for gas cookstoves were that they are fast (2), easy (1), and good for emergencies (1). The two respondents that said that gas was fast shared that they are good for foods that take a small amount of time to cook. Eggs and milk were referenced as things that were often cooked using the gas stove as they cook quickly and take a small amount of gas. When asked about disadvantages they stated they were dangerous (2), and expensive (2). Both interviewees who stated that gas stoves are dangerous shared that sometimes when the gas stove first ignites a big plume of fire sometimes occurs which can result in burns.

The electric cookstoves had four different advantages listed by the two participants who used them. These included easy (1), fast (1), useful in the rainy season (1), and best for baking (1). This was the only stove type that had only one disadvantage which was expense (1).

Fuel Type Used

Both the TSF and CES rely on firewood as fuel, which is the most commonly used fuel type in this study, with 79% of households using wood to some degree and 74% of people using it primarily. Firewood is a free but labor-intensive fuel source and is mainly cut or collected by the women in the family. Seven out of the fifteen firewood users stated that they go to their farm for wood, or if they do not own a farm, they use someone else's farmland. One woman shared

that often when farmers are clearing the trees on their plots, people come to collect the wood from the trees cut. The mention of farms was unprompted, signifying that there are likely more firewood users that rely on farms as their source of firewood. The practice of collecting this fuel source is a time-consuming activity with subjects averaging 6-8 hours a week spent collecting wood for the TSF. Three interviewees shared that the practice of collecting wood was time consuming and dangerous as they used machetes to cut the wood with one woman saying, “we are tired all the time”. The CES users spend an average of 2.6-2.8 hours per week. The interviewees who made the transition to a CES stove shared that because they spend less time collecting firewood, they are able to spend more time doing other tasks. With the time saved the women shared that they have additional time to do housework, and farming. One woman shared that she owns a sewing business, and she is now able to take on additional clients which provides her with supplemental income.

The most common trees collected for fuel are clove, mangrove, mango, cashew, coconut, lemon, and bongo. When asking about wood type, clove was mentioned multiple times as the best type of wood for fires as it produces a nice smell and contains natural oils that allow it to burn for longer periods. During the interviews, the participants were asked if they had experienced a change in accessibility for collecting wood. All eleven people who answered the question responded that they have noticed a change in accessibility. Five women shared that they now must use public transportation to get to a location where they can collect wood, which has increased the time it takes to get wood. Another woman shared that she used to be able to access wood near her home but now must walk 2 hours to begin collecting. The main explanations for the change in accessibility provided were population growth leading to a high demand, urbanization, and restrictions on the type of trees that can be cut. Many women said that as the

population of Wete district continues to grow the amount of wood is reduced as new homes are built in areas that once had forests. The interviewees also shared that the use of clove and mangrove has been reduced in recent years because it has become illegal to cut these tree types. These conservation efforts were referenced in an interview, with one woman citing the restrictions as one of the reasons it has become more difficult to collect wood.

Charcoal was observed as the second most common fuel source in the study group with 42% of participants using it. Many families purchase a bag of charcoal once every two weeks, but it depends on the size of the family. These bags cost 10,000-12,000 TSH or around 4-4.8 USD. This cost is too high for many families to be able to primarily rely on charcoal.

Gas can be found in some homes, but it is not frequently the main source of fuel used in the home. Often gas is used as an emergency fuel source for situations when other fuel sources are not available or there is not enough time to start a wood or charcoal fire. Gas is also used when preparing things that cook fast such as eggs, heating milk, and making tea. These tasks use very little gas which is expensive. Using gas requires purchasing a gas tank which comes in multiple sizes depending on the household needs. A 6kg gas tank costs around 26,000 TSH or 10 USD. A larger 30 kg tank costs around 120,000 TSH or 48 USD on top of the previously stated gas stove set up. These tanks last between 3-6 months depending on frequency and length of use according to the four interviewees who used this fuel source. The cost of the gas tanks is often out of the price range for families which is why many do not use gas at all and why those who do have access preserve their supply.

Electricity was the least common fuel type used. Like gas, the use of electricity is specialized for certain items. Electricity is primarily used to cook rice, beans, and baked goods. These items take longer amounts of time to cook and would require high amounts of fuel to

cook. The use of electricity is limited because of a lack of accessibility in many areas of Wete district as well as because of the cost per unit. Single units of electricity typically cost from 260-330 TSH or 10 cents USD and are subject to additional service fees. According to a local woman who used an electric oven, baking a cake takes around 30 Units of electricity, costing her around 7,800 TSH or 3.12 USD in electricity alone.

Health

When asked about health issues the TSF was discussed the most. In total nine different health issues were brought up in association with the TSF whereas the alternative stoves had a total of six health issues mentioned. The four most common health categories that were discussed for the TSF were smoke (9), eye irritation (8), respiratory issues (6), and burns (4). The category of respiratory issues included any mentions of coughing (3), chest pain (2), and breathing problems (1). The differences between the health issues for the TSF and alternative cookstoves can be seen in Figure 7. Smoke was brought up for both the TSF and the alternative cookstoves but in very different contexts. For the TSF smoke was stated nine times as an explanation for the health issues stated. Whereas for the alternative stove types of the phrases less smoke (5), no smoke (2), and very little smoke (1) were used. One of the follow up questions asked when people referenced respiratory issues in association with the TSF was how they knew the issue was caused by the stove. A few women shared that they felt sick only when cooking and directly after. However, Mgeni (from the biographical sketch) stated that she knew her illness was from the cookstove because "the doctor asks about the type of stove you use to decide what disease you have". The most common health issue out of all the alternative stove types was burns (2).

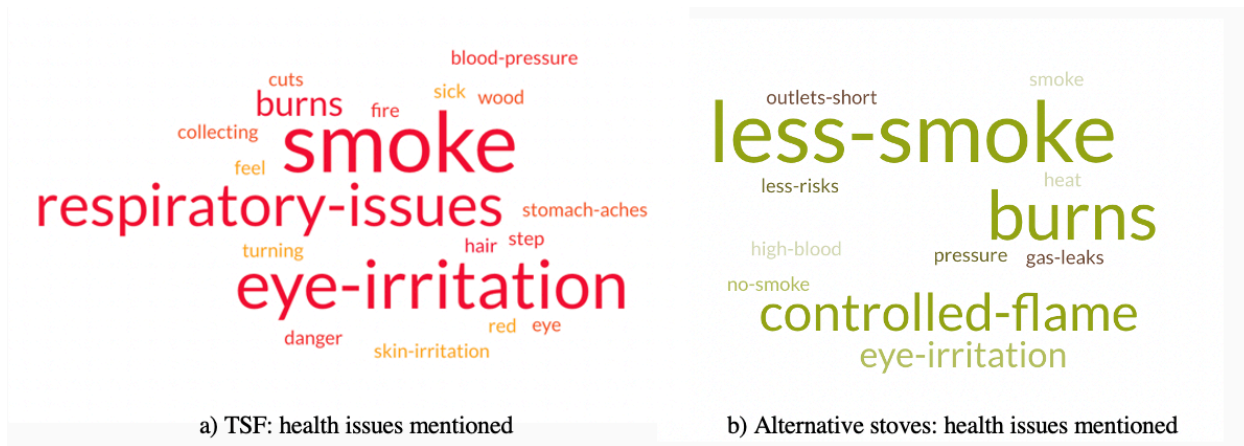


Figure 7: Word map of the terms used to answer the question of health risks a) TSF b) alternative stoves.

Discussion

Prevalence of TSF

Throughout the analysis of TSF use it became clear that one of the most significant reasons for the use of the TSF connects to its ability to cook large amounts of food. This method caters to the common practice of cooking large meals. As stated in the background the average household size in Pemba is 6.2 people, which means large meals are necessary to feed everyone in the home (Wete District Profile, 2017, 7). The TSF can accommodate these larger family sizes as it is easily adjustable to fit larger pots. This is also one of the main reasons that even when a family uses an alternative stove type, they continue to use the TSF in combination with this stove, so they can cook multiple things at once. One of the women who produces CES shared that during Ramadan her sales increased dramatically as people were cooking many different food types. Though this means that some families invest in multiple alternative stove types to cook large meals, it can be assumed that many do not, and likely continue to rely on the more financially accessible method of using a TSF.

In addition to this the TSF is the oldest method of cooking in Sub-Saharan Africa and has been the most commonly used stove type up to the present day (Kaputo et al., 2023, 11). In the study area the TSF not only was the most common stove type used but was the stove type that people were taught to cook with. This personal tie to the stove makes it the standard method for cooking. Many of the interviewees saw little reason to switch to alternative stove types as they have been using the TSF all their lives and their mothers and grandmothers used it too. When describing learning to cook in the biographical sketch interviews, the women recounted their experience pleasantly as a rite of passage into womanhood. In addition to this, when discussing advantages of the TSF method two women said the TSF was “traditional”. The fact that the women considered “tradition” an advantage displays the importance of family customs on the women’s stove choice. This cultural and personal attachment to the use of the TSF likely acts as a barrier when adopting alternative stove types particularly as users do not want to diverge from their historical practice.

Fuel collection accessibility and environmental impact

The use of firewood was the most common type of fuel used with 74% of household using it to some degree when cooking. This fuel type has several implications for use, the most mentioned implications being accessibility and environmental impact. These implications are interconnected as they are both impacted by deforestation and forest management strategies. Women who are typically the main collectors of wood in the home are the most impacted by the changes in the demand and accessibility of firewood. The people who used the TSF stove method spent an average of 6-8 hours a week collecting wood whereas women who used the clay CES averaged 2.6-2.8 hours each week. This difference displays a dramatic change in fuel labor demand which could have impacts on how realistic wood burning stoves are in the future. The

change in accessibility of firewood was asked about in the initial interviews with 100% of respondents saying there has been a significant change. This change in accessibility was blamed on high demand, urbanization, and restrictions. During the interviews women shared that as the population of Wete grows additional homes are built in areas that once had forests which reduces their accessibility to firewood. In addition to this, the increase in population from 107,916 in 2012 to 148,712 in 2022 puts additional stress on the remaining areas because of the reliance on wood for cooking and charcoal production. The reduction in accessibility of firewood might put many families at risk of fuel scarcity. This would have a more prevalent impact on families that depend mainly on a TSF as it requires more wood. Additional changes in accessibility are caused by the forest management strategies that have been put in place to combat deforestation. These strategies include protections placed on specific wood types such as clove and mangrove trees. Though these restrictions are important to protect natural areas in Pemba they also reduce the areas and types of wood that can be collected by families. As the availability of wood decreases the use of the TSF likely will stop being a realistic option for families. The use of the CES could potentially act as a good alternative as it requires less wood to function with users sharing it has reduced the amount of wood they have to collect on a weekly basis. This method also does not use costly fuel sources such as charcoal or gas.

Seasonal changes in stove type and fuel access

When discussing the determinants of stove type, the rainy season was brought up by five participants. These women shared that when the rainy season comes, they struggle to collect wood as the conditions are less tolerable. In addition, they shared that the wood is wet when they collect it which means that they must wait for the wood to dry before using. When damp wood is burned it produces high amounts of smoke which increases the dangers of wood burning.

Because of these difficulties, four women said they would change from the TSF to an alternative stove type. Three of these women switched from a TSF to charcoal cookstoves as their main cooking method in the rainy season. This switch creates financial strain for the families who make the change as charcoal is a costly fuel source. One woman shared that in the rainy season she switches to using electricity as it is easier.

The last woman who brought up the rainy season had a different perspective on the issue. She shared that she would prefer to use charcoal in the rainy season because of the difficulty using wood in the rainy season but she is unable to use charcoal because there is less access to it due to a higher demand, and that often rain prevents charcoal production, resulting in a lower supply. This change in accessibility is troubling as it has forced this woman to use the TSF in her home instead of outside which puts her at higher risk of smoke inhalation. These examples display a pragmatic approach by households, where they are forced to choose the stove not based on preference or safety but on availability.

Smoke and health

The impact of indoor air pollution has been linked to respiratory illness throughout countries that rely mainly on biomass fuel (Kaputo et al., 2023, 10). Based on the results of the interviews, Pemba faces the same issue which is displayed by the frequent references to smoke in the responses to the health interview question. Out of the fourteen TSF users, smoke was used by nine people to explain the health issues experienced by the interviewees. The most frequently referenced issues were eye pain, respiratory issues, and burns. Both respiratory and eye irritation were blamed on the smoke. The most referenced respiratory issues were coughing, chest pain, and breathing problems. These are all signs of serious respiratory problems, which are additionally concerning because none of the interviewees displayed any plan to reduce their

exposure to smoke. The most common causes of death and morbidity in Wete District are respiratory issues, which are likely related to the consistent exposure to smoke from the TSF (Wete District Profile, 2017). Though most alternative methods of cooking still produce air pollutants, they are in lower quantities and were not brought up when discussing health, with the exception of one-woman saying charcoal releases less smoke but takes longer to cook, resulting in prolonged smoke exposure.

Awareness of Health Impacts

When asking about health issues, 11 out of the 14 people who used the TSF explained the different health issues they experienced, displaying an awareness of the dangers that TSFs pose. Seven people specifically referenced health issues caused by the smoke from the TSF. These people shared that it makes them feel sick during and directly after cooking. This feeling of discomfort is something that these women have become accustomed to living with. However, that should not be mistaken for a lack of knowledge about the risks. During the biographical sketch interview, Mgeni shared that when she goes to the doctor with a problem, they ask her what stove she uses to determine the illness. This shows that the common narrative displayed in the background that people have a lack of understanding of the health risks is not the case in this sample of Wete District residents. The TSF cooking method has been deeply ingrained in historic cooking practices, as it provides the means to supply enough food for the family in a timely manner. Despite this, many women expressed a desire to switch to cleaner-burning cooking methods such as charcoal, gas, and electric. However, despite this wish to switch to an alternative cooking method, many have a financial barrier that prevents the transition. This barrier was clearly displayed in the interviews when 38% of participants stated that they want to switch to a gas stove but are unable to because it is too expensive. Not only are the alternative

stoves themselves costly, but being able to routinely purchase fuel is an impossibility for many households.

The awareness of health impacts of biomass burning cookstoves can also be observed in the government of Tanzania with a 2025 initiative being put in place to distribute electric cookstoves to rural areas in Tanzania. Because this initiative has only just begun it is impossible to directly analyze its effectiveness at reducing the health issues linked to stove type. This initiative aims to facilitate a transition from biomass burning cookstoves to alternative cookstoves in 4 out of 5 Tanzanian citizens (*Tanesco Champions Clean Cooking with Subsidised Electric Stoves*, 2025, p. 1). Despite the good intentions of the initiative, it would likely need additional measures to function effectively. This would have to include the expansion of electrical connectivity to rural areas in Tanzania because based on a 2016 statistic only 42.8% of Tanzanian households have access to electricity (Pelizan et al., 2019, p. 3).

Based on the results of this study the potentially more realistic alternative for this initiative could be distributing gas cookstoves and providing subsidies for gas tanks. As previously stated this method was the most highly desired cooking method with 38% of respondents saying if they could afford to, they would use gas instead of their current method of cooking. Gas appears to be a more accessible fuel source on Pemba Island with accessibility never coming up as an issue.

Community Forest Pemba Stove Initiative

The Community Forest Pemba initiative, which teaches local women to build their own stoves, has shown potential to enhance income opportunities, and reduce fuel burdens. The price of these stoves' ranges from 5,000-15,000 TSH or roughly 2-6 USD, which is even less than the

previously mentioned average price of low consumption cookstoves which was 5-20 USD (Andrews & Borgerhoff Mulder, 2022). The three coop participants displayed a continued dedication to the creation of the stoves and the education of other community members. One of the women interviewed shared that just the day prior, she had gone to a nearby village to teach a group of women how to build the stoves, demonstrating the initiative's continued community engagement. One of the primary reasons the initiative has continued is that it provided autonomy to the participants to run their own business and supplement their income on their terms. This method allowed for the initiative to align with the individual practices of the participants. The additional income from the sale of the stoves provided the means for two women to support their children's education. In addition to the financial impact of the initiative, the use of the CES displayed a decrease in firewood use, with 4 out of 6 users saying they noticed a reduction in fuel use. This reduction in fuel was also displayed through the amount of time spent collecting wood with the CES vs the TSF, which was 2.6-2.8 hours weekly for the CES and 6-8 hours weekly for the TSF. The difference in time spent collecting wood shows the efficiency of the CES, which is important in an area that is losing accessibility to firewood. The main limitation to the widespread adoption of the cookstove production initiative is that the clay used for the cookstoves is only found in specific areas in Pemba. This makes it difficult for people who do not live near the clay to participate in this practice. Though it is important to note that this sample size is very small meaning that these results might not be the same for a larger sample size. However, this does display promise and should be explored on a larger scale.

Conclusion

This study aimed to answer the question: What are the determinants for use and health impacts of the most commonly used cookstoves among community members in Pemba? With a

secondary question of how these factors impact the adoption of “clean” cookstoves? The main findings from the study reveal that the TSF continues to be the most used cooking method, due to large family size, and affordability. The results also aligned with outside sources analysis of the health risks of cookstoves with many interviewees referencing smoke as a contributor to respiratory issues and other health issues. However, despite this awareness the interviewees did not display a transition to alternative stove types due to the practicality and affordability of the TSF. In addition to this the study displayed that the newly introduced clay efficient cookstove initiative has potential community benefits, including a reduction in fuel usage and alternative sources of income for cooperative members. However, it is important to note the limitation of clay availability as a barrier to widespread adoption of the cookstoves. The findings from this study are limited as it was conducted with a relatively small sample size and should be explored further in future studies.

The significance of this study is that it provides information on what drives the use of different stove types within households which will help to provide information how to implement alternative cookstove initiatives. Future research should be conducted to further explore the cultural significance and health impacts that stoves have on this area or see if there is a difference in stove use on the South side of Pemba Island. In addition, there should be emphasis on providing community members with alternative stove types that are financially accessible. These suggestions will become increasingly important to implement as the accessibility of fuel continues to decrease and the awareness of health impacts increase the demand for alternative stove types. It is important to provide accessible alternative stove types to fill this demand. The Community Forest Pemba initiative could be used as a model for other areas or organizations that have identified similar challenges. Ultimately, this study dove into the

complexities of stove usage in Pemba while also providing a foundation for future initiatives that aim to target health, sustainability, and cultural relevance in the context of stoves.

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Appendix

Interview Questions

In this subsection the questions asked during both the initial interviews and biographical sketch interviews are listed.

Initial Interviews (with Swahili translations):

1. Name: Jina lako nani?
2. Age: Una miaka mingapi?
3. Livelihood or job Ni ipi shughuli yako ya kiuchumi (Kazi)
4. Who does most of the cooking in your household? Ni nani anayepika zaidi katika kaya yako?
5. How many people are being cooked for in your house? Ni watu wangapi wanaopikwa nyumbani kwako?
6. What are the different types of cookstove used in house to prepare food? Ni aina gani za majiko hutumika nyumbani kwako kuandaa chakula?
7. What are the advantages of using these cookstoves? Je ni faida gani za kutumia majiko haya?
8. What are the disadvantages of using these cookstoves? Kuna hasara gani za kutumia majiko haya?
9. Were there any other cookstoves used before the cookstove you use now? Kulikuwa na majiko mengine uliyotumia kabla ya jiko ulilonalo sasa?
10. What kind of cookstove would you most like to use? Jiko la aina gani zaidi ungependa kulitumia?
 - a. Charcoal stove? Jiko la mkaa
 - b. Clay efficient cookstove? Jiko sanifu la udongo
 - c. Three stone fire? Jiko la mawe matatu
 - d. Gas stove? Jiko la gesi
 - e. Iron grill? Jiko la chuma
 - f. Electric stove? Jiko la umeme
11. Why do you not use this type of cookstove? Kwa nini hutumii aina hii ya jiko?
12. Why do you not use a Clay fuel efficient wood burning cookstove? Kwanini hutumii jiko sanifu la udongo?
13. What kinds of fuel do you use? Unatumia nishati ya aina gani?
14. Most commonly used to least commonly used How often do you collect or buy fuel each week? Ni mara ngapi unakusanya au kununua nishati kila wiki? Ni mara ngapi unakusanya au Kununua kuni kwa wiki?
15. How much time does it take you to collect wood for cooking fuel? Je ni masaa mangapi unayatumia kukusanya kuni kwa wiki?
16. How much money is spent on cooking fuel? Ni kiasi gani cha fedha unatumia Kununua kuni/nishati ya kupikia?

17. Has this changed from the stove you used previously? Hii imebadilika kutoka kwa jiko uliotumia hapo awali?
18. How do you spend the extra time from having to collect less fuel? Unatumiaje muda wa ziada ulio nao kwa kukusanya mafuta kidogo? Unatumiaje muda wako wa ziada ambao uliotumia katika utafutaji wa kuni?
19. What types of wood do you prioritize collecting? Ni aina gani za kuni unazipa kipaumbele kukusanya?
20. Do you use other wood types to reduce the time spent collecting wood? Unatumia aina nyingine za mbao ili kupunguza muda unatumika kukusanya kuni?
21. Do you cut the wood you gather? Unakata kuni unazokusanya
22. Has there been a change in accessibility of wood in the last 5 years? Kumekuwa na mabadiliko katika upatikanji wa kuni katika miaka mitano iliyopita Kumekuwa na mabadiliko katika upatikanji wa kuni katika miaka mikumi iliyopita
23. Has this changed the distance you have to travel to collect wood?
24. Hii imebadilisha umbali unaopaswa kusafiri ili kukusanya kuni?
25. What are the health risks of past stoves you have used? Ni hatari gani za kiafya za majiko ya zamani ambayo umetumia?
26. Have these risks changed with the use of your current stove? Hatari hizi zimebadilika na matumizi ya jiko lako la sasa?
27. Do you have anything you would like to elaborate on regarding stove use or do you have any questions for me? Una lolote ungependa kuongeza kuhusu matumizi jiko au una maswali yoyote kwangu

Biographical Sketch Interviews:

1. Where did you grow up?
2. Have you moved since then?
3. Who typically cooked for you when you were a child?
4. What type of cookstove did they use?
5. Was your kitchen indoor or outdoor
6. Is it the same place as now
7. When did you start to cook?
8. Who taught you how to cook?
9. Did you enjoy learning and why?
10. What is your favorite memory of cooking with them?

11. What was your favorite dish?
12. Was there a lot of smoke in the kitchen?
13. Did your parents have any health issues that you observed when they were cooking in the kitchen?
14. a. Did you or your siblings experience any health issues yourself when you were young?
b. Do you think that any of their health issues were related to the smoke from the stove that they used to cook with? c. Do you think your health issues are caused by the stove you use?
15. Who collected the fuel for your stove when you were a child? a. How much time did this take them? b. How often? c. How far did they walk? d. If it was them: Did you go with other people or your siblings? e. Do you have any memories or stories from collecting firewood? Current:
16. Who collects firewood for your household now?
17. How long do they spend collecting firewood each week?
18. How far do they walk?
19. Is it more difficult to collect wood now compared to when you were a child?
20. Why is it more difficult?
21. Have the types of wood collected for fuel changed from when you were a child?
22. How have they changed?
23. What types did you use then and what do you use now?
24. Why has it changed?
25. Do you mix different types of wood now?

26. Did you always do this?
27. Maybe research how different types of wood burn. Are some cleaner etc. are health issues potentially caused by a change in resource accessibility with protections and deforestation.
28. Do you have to travel further for firewood now?
29. Why has it changed?
30. Have you taught your children to cook?
31. What type of stove do you use now? a. TSF: why do you prefer to use this b.
32. When did you change the stove, you used?
33. Why did you make this choice?
34. Do you still use the old stove?
35. Do you ever miss your old stove? a. Why?
36. The local knowledge as to why people like to use the TSF – cooking outside vs inside
37. How has this affected your cooking practice?
38. Have you noticed any health issues related to the use of your new stove?
39. Do you make different food now?
40. Has the amount of time collecting fuel been reduced with the cooking stove you use now?
41. Why did you want to start building stoves?
42. What are the difficulties of building and selling stoves?
43. Have other stoves become more popular throughout the years?
44. If you cannot get your typical fuel material what is your backup?
45. Do you prefer the efficient cookstove/Do you want a more efficient cookstove?

46. How have stoves impacted your life?

47. If you are feeling sick does someone else cook for the family?

48. What stove do you hope your children will use for cooking? a. Why?

Full Biographical Sketch Interviews

Eshe

Eshe is a CES producer who builds and sells stoves on top of working in her family farm. She is a forty-year-old mother of seven who lives in a rural area about thirty minutes outside of Wete city. She lives in the same home she grew up in with her ten other siblings which have since moved out. Now she lives in the home with her husband and kids. During the interview she recalls her mother teaching her to cook when she was seven years old using a TSF. She passionately shared that she enjoyed learning to cook when she was young as she saw it as fulfilling her responsibility as a woman. She said it makes her happy to cook her children their favorite food rice (*wali*) and sauce (*mchuzi*). She shared that now she uses a CES to do most of her cooking. Her explanation for the shift from the TSF was that the CES reduced the amount of wood used in turn, lowering the time she spends collecting wood. Despite the reduction in time spent collecting wood, she shared that when she goes, she often gets to spend time with her children who often accompany her. Though they are there to help her with the wood collection, Eshe said that they usually find a small object like an orange and play soccer while she collects the wood. After recounting her experience collecting wood, she shared that now it has become far more difficult to collect wood because of people building homes and cutting down the trees nearby. She now must walk for more than two hours before she can start collecting wood for her home. Even the wood types have changed in recent years “when I was a child, we always used

clove trees as they have a better smell. Now there are no clove trees to cut”. When asked about her business of selling CES, she shared that it started thirteen years ago as a hobby and it was nice to also make money. She said it has become difficult to access the clay necessary to build the stoves, which has made building the stoves hard. The availability of clay is dependent on the area as the naturally occurring clay soil can only be found in certain areas. This makes it difficult to access if the amounts dwindle or a person does not live in the right area. When asked why she continues if it has gotten harder, she said that “all work is hard, but the money is important”. She followed this by saying that she does not want her children to continue this business and instead hopes they continue their studies. To help them pursue academics, the money she makes from selling stoves is put towards school fees and uniforms. Despite her approval of the CES she currently uses she discussed wanting to one day own a gas stove. She shared that her sister in Dar es Salaam uses one and Eshe said it would change her life. She would then save so much of her time and energy spent collecting firewood. She also said, “sometimes if you want to make milk but it is nighttime, getting the wood and starting the fire is very hard”.



Figure 5: Image of Eshe’s kitchen with a clay CES and wood storage (DeGrandpre, 2025).

Lulu

Lulu is a 40-year-old housewife with seven children. She moved to Wete from a small town far from Wete when she was married. Like all the other women interviewed she grew up with a TSF as the only method of cooking. Her mother taught her to cook when she was nine years old which she said she enjoyed very much as it was “special work for the women”. She recalled a memory of a time when she was ten and cooking porridge. She apparently tried to grab the pot from the fire, but it was so hot that she let go of it and it spilled on her legs. She laughed as she recounted the story and told the translator to leave. She then snickered as she showed me the small scar that still marked her leg. While cooking with her mom she remembered there being lots of smoke which she blamed for her mother’s kidney issues, cough, and eye pain. When asked about why she thought the smoke caused these issues she shared that it got so bad

that they had to take her mother to Dar es Salaam for treatment. She was able to get treatment there, and the doctor said her illness was due to smoke. According to Lulu her mother did better after treatment but when she started cooking again, she didn't feel good anymore. She also shared her experience gathering wood with her mother. She stated that she hated collecting wood because she was a student and was very busy with her studies. She stated that when they went to collect wood "we started without eating and when we arrived, we were so tired we had to sit and rest before collecting wood". As she shared her experience collecting wood, she shook her head in disapproval. When asked about collecting wood now she smiled and said that her husband collects the wood for the family. Currently she uses a TSF and charcoal to cook. She said that she continues to use the TSF because it is easy and fast for her to cook with. She sometimes uses charcoal because she can use it inside. However, she shared that sometimes in the rainy season it is harder to get charcoal, so she must use firewood inside when it is too rainy to cook outdoors. When she uses the TSF she gets severe eye pain. She said "look in my eyes'... 'look they are all red now'.... 'It feels like there is black pepper in my eyes". During the interview she shared that she has taught her own children how to cook, however they did not experience the same love that Lulu felt when cooking. Despite Lulu enjoying teaching and spending time with her children they are not happy to cook as they are busy with their studies and do not want to spend time cooking.



Figure 6: Image of Lulu’s kitchen both inside and outside with labeled stove types (DeGrandpre, 2025).

Mgeni

Mgeni is a fifty-two-year-old farmer with seven kids. She first learned to cook food on the TSF when she was five years old. She started with simple things like tea and breakfast then moved on to more complex recipes. She said she enjoyed learning to cook from her mother as it was “special work for a woman”. She remembers when she cooked with her mom there was a lot of smoke in the kitchen which sometimes resulted in her mom kicking Mgeni out of the kitchen. When Mgeni was young she remembers her mother suffering from eye pain and a cough. She even shared that the color of her mother’s hair changed from black to reddish from the heat of the flame. According to Mgeni her mother’s health issues were a continuous problem and did not stop when she wasn’t cooking. When asked about the cause of these issues Mgeni shared that

they were caused by daily exposure to smoke. Shae said that her and her siblings also experienced similar health issues but to lower degrees. She shared that she had eye and chest pains, but they stopped once she left the kitchen. She currently uses TSF and charcoal for cooking though she typically uses a CES but it recently broke. She said that she continues to use the TSF because it is fast but mainly because charcoal is expensive. She hopes that in the future her children will use gas or electric stoves. She said “the time has come for easy cooking” then shared that her children are students right now and once they get employed, they will have no time for collecting firewood.

How to build an efficient clay cookstove:

The adoption of clay fuel efficient cookstoves was introduced by a series of community training programs that aimed to teach residents how to build their own fuel-efficient stoves. The training lasted eight days and included an introduction into the importance of using fuel efficient stoves. This outlined how the stoves would help the individual by reducing fuel usage and reducing indoor air pollution (IAP). It also outlined the importance for local conservation as with a reduction in fuel demand there is less pressure on surrounding forests which are where the community collects their firewood supply. This background section of the training was followed by in-depth instructions on how to build the stoves using local materials. These materials included clay, ash, and water. The clay can be found in large quantities in specific areas of the island which allows for community members in these areas to collect their own clay. The clay is then shaped and fired to create basic fuel-efficient stoves. The water and ash play a smaller role but are no less significant. The water is mixed with the clay to make it malleable which allows for

shaping and smoothing of the stove. The ash is used to prevent the stove from sticking to the ground or mold if used. These ingredients are generally easy to collect in large quantities though the collection of clay can require travel if the person does not live in an area where the clay soil naturally occurs.

The basic process of making a stove includes placing ash on a bed of banana leaves. Then a slab of clay water mixture is placed on top where it is shaped into a thick round base. Once the base is created a pot is dampened and covered in ash this is used to shape the stove. The pot is placed on the base slab where they then build up clay on either side of it to create a cylindrical shape. Once the walls around the pot are created the pot is pulled upward to continue to shape the stove as the walls are built up. Once the walls are at the desired height roughly 1/2m tall the pot is removed. After the pot is removed the clay cylinder is smoothed out to create a more uniform texture and ensure that the inside of the stove has no thinner areas of clay. When this process is complete the stove is left to dry for several hours. At the point of drying where the stove is firm, but still wet three half circle chunks are taken out of the top rim of the stove. The remaining areas are then shaped inward to act as a resting place for a pot. Once this is complete the stove is left to continue drying for a day. In a day's time the addition of the square opening for placing wood inside and nobs are added to the stove to make it practical for use. For aesthetic reasons coconut shells are used to smooth out any imperfections on the surface of the stove. When the stove has the correct shape, it is left to dry for 14-21 days depending on how rainy it is. The more rain the longer it takes to dry. After the drying period the stove is placed in a fire made from coconut stalks. The stoves are burned for 6 hours which makes them more durable, they are then ready to use.



a) spreading ash



b) clay base



c) coat pot



d) build up clay



e) basic stove shape



f) shape for cooking use



g) smooth edges



h) cut out hole for wood