A Case Study of Cooking Practices in Paraguay

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Submitted in partial fulfillment of the requirements for the degree of

MASTER OF FOREST RESOURCES

University of Washington

June 2014

Program Authorized to Offer Degree:

School of Environmental and Forest Sciences

College of the Environment

Abstract

Inefficient cookstoves have an adverse effect on health, the environment, and general living conditions. Women and children are especially vulnerable. Improved technologies and options exist; however, uptake and use have lagged behind expectations. Previous work has failed to fully address factors involved in the adoption and diffusion of improved cookstoves. Serving as a Peace Corps Volunteer in Paraguay, I performed a case study, interviewing 45 households in city, town, and rural settings. The findings indicate that cultural and traditional barriers have prevented effective use and uptake of better options, but that strategies for future improvement do exist.

Chap. 1: Introduction

This report describes the domestic cooking processes of people from the lower middle-income country of Paraguay (WDI 2014), and subdivided into rural, town, and city settings (delineation defined by Peace Corps Paraguay criteria). I worked with local committees and families on the construction and design of biomass burning cookstoves and ovens serving as an Environmental Conservation Peace Corps Volunteer in rural central Paraguay from 2011-2013. Throughout my service, I noted that in all settings, rich or poor, city or rural, families with improved technologies such as electric and/or gas ovens/stoves still chose to cook using biomass – many habitually cooking with open fireplaces, as revealed by their soot covered ceilings. The global negative consequences of inefficient cooking using solid fuels include the deaths of millions of women and children annually, environmental degradation, and low fuel efficiency (Rehfuess *et al.* 2006, Smith 2012). Informal reasons for not fully adopting modern current types of cookstoves notably included, among others: price, comfort, heat source, ease of use, and time constraints.

This project was designed to assess what types of cooking practices families used; what factors influenced this use; what the cost was; and what variation existed across socioeconomic settings. To help answer these questions, a case study of 45 families in nine different locations was performed in: three cities, three towns, and three rural areas. Additionally, by means of questioning and evaluation of these patterns, this study helps provide insights to help promote the more effective adoption of efficient cookstoves in the future.

Literature Review

Health Problems

The use of inefficient cookstoves or cooking over open fires causes a range of serious health impacts, including death from household air pollution (HAP) and increased incidence of respiratory illnesses (e.g., asthma) among women and children. Currently, 40% of the world, nearly three billion people or 500 million households, rely on traditional solid fuels for cooking and heating (WHO 2014a). These traditional solid fuels include wood, animal dung, agriculture waste, peat and coal. Burning solid fuels reduces air quality by increasing the concentration of particulate matter (PM) in smoke emissions. This increases the exposure of women and children to particulate matter and leads to an increase in adverse health risks. Particulate matter refers to larger particles in smoke that can be measured in microns. Inhalation of particles that are 10 microns or less ($\leq PM_{10}$) can cause cardiovascular and respiratory disease, and cancer. For reference, in comparison to second-hand smoke, cooking over an open wood fire is the emission equivalent of burning 400 cigarettes in one hour (Smith 2012). Generally, the smaller the particle size, the deeper it can penetrate into the lungs and therefore, the more damaging it is to a person's health (WHO 2014a). Indoor smoke pollution resulted in 4.3 million deaths in 2012. In combination with outdoor smoke exposure, one in eight total global deaths – around seven million - were attributed to total air pollution exposure in 2012 (WHO 2014a). Women and children are especially vulnerable to these harmful effects because they are most likely to be in cooking areas for extended periods of time (WHO 2006). They are also vulnerable to burns resulting from flame contact, cooking accidents, or from cookstove explosions. The majority of the 265,000 deaths each year from cooking accidents occurred in low- and middle-income countries (WHO 2014b). Women and children are also afflicted with physical discomfort from smoke inhalation and cooking that includes eye irritation, headache, and lower back pain (Diaz *et al.* 2007, Dherani *et al.* 2008). Physical discomfort for women is exacerbated during pregnancy, but more significantly the indoor air pollution is a major cause of adverse reproductive complications (Tielsch *et al*. 2009). Furthermore, the act of fuel collection exposes household members to additional pregnancy complications, head and spine injuries from carrying heavy loads; increased risk of insect and animal bites as well as physical attacks (GACC 2013).

The use of improved cooking practices minimizes the prevalence of soot that covers cooking receptacles, walls and ceilings, clothes and persons, thereby increasing overall health through improved hygiene. Soot, or black carbon, is also present outside; both locally and regionally, as second hand smoke (Smith 2012). The United Nations Environment Program estimated that controlling black carbon emissions could prevent 2.4 million deaths annually by reducing outdoor PM exposure ("Global Warming: The New Black" 2013). Fortunately, soot drops out of the atmosphere within weeks and is therefore mainly a local issue. In this regard, a global consensus is unnecessary for policy action on black carbon, and the problem can be quickly solved if carbon emissions to the environment are reduced.

A simple chimney stove can substantially reduce chronic exposures to harmful indoor air pollutants among women and infants (Smith *et al*. 2010). Additionally, placement of an improved vented stove (specifically, the ONIL rocket-stove) can reduce acute respiratory illness (Harris *et al*. 2011). The introduction of improved cookstoves alone, however, is not enough to ameliorate the adverse health impacts from traditional methods. Without continued stove maintenance in Peru, long-term reductions in CO exposure were not evident (Commodore 2013). In Guatemala, better stove maintenance was required to effectively reducing indoor air pollution and child exposure. In addition to stove and fuel type, kitchen volume and eaves have some effect on kitchen CO (Bruce *et al*. 2004). Similarly, in Honduras stove quality alone as a proxy for exposure was not sufficient. Household characteristics influencing ventilation provided a better evaluation (Clark *et al*. 2010). In Ghana and Ethiopia, improved cookstoves brought significant improvements, yet more changes in stove and/or fuel type or in household stacking patterns would be necessary to bring PM levels to safe levels (Pennise 2009). Valuing the benefits of improved cookstoves is not fully realized. Participants in peri-urban Uganda did not prioritize the potential health benefits of improved cookstoves. They cited financial considerations as the most important factor for cookstove acquisition and use (Martin *et al*. 2013). Women in Bangladesh did not perceive indoor air pollution as a significant health hazard. In addition, they prioritized other basic developmental needs over nontraditional cookstoves (Mobarek *et al*. 2012). In South Africa, strategies utilizing community-counseling intervention for health behavior change were found to be effective in reducing child indoor air pollution exposure.

Issues Related to Cooking with Solid Fuels

Collecting Fuel. Using inefficient cookstoves requires large amounts of time spent collecting fuel. Developing countries rely on forests for fuel, but continued access and availability to forests and woodlands is questionable in the face of continued deforestation. In fact, fuelwood accounts for about half of the global timber harvests (FAO 2010). As the average distance to the forest or woodland increases, households must spend more time collecting fuelwood. As this distance increases, households often switch to lower quality wood, which although decreasing collection time (Brouwer *et al.* 1997), also reduces cooking efficiency and increases the adverse health effects from smoke (Baldwin 1986). Labor plays a significant role in collection as well. A larger family with more adult females, rather than the distance to the forest or collection time is a more reliable indicator of fuelwood collection and use (Brouwer *et al.* 1997). In rural areas of India, domestic activities account for 10-12 hours of each day, with time spent gathering fuelwood and fodder accounting for 4-6 hours per day (Saksena *et al.* 1995). In other areas, fuelwood gathering takes far less time, often less than an hour per day (GACC 2013). The availability of alternate fuels and subsidization of electricity in the villages of South Africa, however, did not reduce fuelwood use by households. Many households even bought their fuelwood in times of local shortages, instead of using electricity. Overall, the households that collected their own fuelwood were poorer than both households that purchased fuelwood, and those that did not use fuelwood at all (Shackleton *et al.* 2006).

Cooking time. Many factors are involved in the amount of time that women spend cooking each day. The vast majority of time can be attributed to collecting fuel, but additional time is spent storing wood; splitting it into manageable pieces; starting the fire; and cleaning and clearing the cooking area. In rural villages in China, women can spend 2.5 times more hours per day cooking than women in urban areas (five hours versus two hours), with higher frequency and length of cooking events (Jiang and Bell 2008). These differences can be explained by more efficient and faster cooking methods using natural gas and/or electricity in urban areas. In addition to productivity losses from cooking with wood, the PM levels in the air were far higher in rural areas in comparison to urban areas, resulting in a greater incidence of negative health issues. In Tamil Nadu, India, women cooks spent over six hours per day in the kitchen area, whereas those not involved in cooking spent less than an hour (Balakrishnan *et al.* 2002). In other parts of India, those who reported their own cooking time far exceeded the actual time spent cooking (Saksena *et al.* 1995). Nevertheless a common theme in rural settings is that women spend significantly more time in the kitchen area than do men, thereby increasing their exposure to indoor pollution (Jiang and Bell 2008).

Income Expenditure. Household cooking expenditures vary. Factors include international, regional and socioeconomic differences, type of fuel used, and seasonal variations in fuel use, especially during the winter when cooking fires are often used as a supplemental heat source (Saksena *et al.* 1995). A study in India showed 7-10% of a household's income was spent on fuel and light, with almost 50% of this expense going for solid fuel in rural areas versus 6% in urban areas. Furthermore, 67% of all families used solid fuels as a primary fuel source, broken down into 87% in rural areas and 26% in urban areas (GACC 2013). In Ghana, 8-9% of income went to electricity and gas, distributed by 6.9% in rural areas and 11.3% in urban areas, suggesting that households in rural areas obtain more of their energy from other sources, such as biomass (GSS 2008). In rural households in Bangladesh, approximately 8% of household expenditures went to energy use (Miah *et al.* 2010). All of the aforementioned studies have a common theme: rural areas spend less on energy as a percentage of their income, but they rely more on solid fuel for energy relative to urban areas. As a result of declining supplies of solid fuel, and without a viable alternative, households in rural areas are susceptible to rapidly rising fuel prices, thereby increasing their average fuel expenditure.

Fuel expenditures in rural areas tend to be lower than in urban areas because rural households can more easily collect fuelwood and other types of solid biomass without additional monetary cost. Changes to access to or the price of fuel depends on many factors. In parts of Uganda, demand for both fuelwood and charcoal had negative elasticities; meaning an increase in price results in a drop in demand (Egeru 2014). However, in a study in Kenya, fuel wood, charcoal, liquefied petroleum gas (LPG) and electricity were both price and income inelastic, meaning that regardless of price, people will pay, but also suggesting that only a small proportion of income was spent on fuelwood. Regardless of the level of expenditure, the opportunity cost of inefficient cooking practices prohibits working in other peak income generating activities.

Environmental Concerns / Deforestation

The relationship between deforestation and fuelwood use has important implications for cooking practices in the developing world. Over one third of global consumption of renewable energy sources comes from household cooking and heating from fuelwood (FAO 2012). For example, in rural Guatemala, 88% of households used firewood for cooking (Taylor *et al*. 2011). Yet, to be renewable, the wood must be harvested in a sustainable manner and burned efficiently. This is not always the case. Globally, most deforestation takes place in tropical developing countries, whereas most developed countries with temperate and boreal forest ecosystems are experiencing stable or increasing forest areas (FAO 2010). As of 2011, Average annual global deforestation was 0.11%. In high-income countries the deforestation rate was -0.03% versus 0.31% in low-income countries (WDI 2014). In South America, deforestation rates have failed to decline in the past 20 years mainly due to forest conversion to agriculture (Ceddia *et al.* 2013).

The percentage of wood fuel production versus roundwood production is an indication of fuelwood use versus total wood production. In 2012, this percentage was 47% throughout the world. In industrialized countries the percentage was much lower – 16% in the European Union. Conversely, in least developed countries the percentage was higher at 91% (FAOSTAT 2012). Thus, in less developed countries, a greater percentage of wood production is used for wood fuel than in developed countries.

Higher population density and growth stresses local resources, such as fuelwood. Global population density is 54 people per square kilometer. However, in lower middle-income countries the number is 122. Global population growth from 2012 to 2025 is 1% in both global and lower middle income countries, but 0% in high income countries; meaning population growth is growing much more in lower income countries than in higher income countries. At the same time, global urban population rates are increasing while rural population rates are decreasing. Therefore, there will be more people and more cities. The rate of urban population increase is 2.0% globally, and 2.6% in lower middle-income countries. In high-income countries, the rate of increase in urban population is 0.7% (WDI 2014). Because the population growth and density is increasing, particularly in lower income countries, sustainable resource management will become increasingly difficult. No longer will household be able to harvest fuelwood from local sources without increased competition from their neighbors. As a result, resource extraction must come from other and less accessible locations.

Global Concern and Action

Goals of using improved cooking practices aspire to minimize air pollution, environmental degradation, and physical harm; empower women; reduce fuel use and cooking time; and improve the overall quality of life. The Global Alliance for Clean Cookstoves, a public-private partnership led by the United Nations Foundation, was launched to meet these goals. They represent a united front of efforts - partnered with hundreds of non-governmental and private sector organizations, and many governments, academic institutions, consultants, and foundations. The Alliance's '100 by 20' goal calls for 100 million homes to adopt clean and efficient stoves and fuels by the year 2020. To reach the goal, the Alliance aims to: (1) address the global needs to reach large-scale adoption; (2) target countries that emphasize market-based solutions; and (3) coordinate a global plan across all key sectors. In support of the Alliance's mission and goals, United States Senator Susan Collins introduced the "Clean Cookstoves Support Act," a bill that would reduce carbon pollution and improve public health by supporting a global market for clean and efficient cookstoves (Collins and Durbin 2014).

I facilitated the design and construction of 46 cookstoves in multiple locations in Paraguay serving as a Peace Corps Volunteer. The Peace Corps currently serves in 65 countries collaborating with governments, schools, communities, small businesses, and entrepreneurs to address many needs across all sectors of education, health, community economic development, agriculture, environment, and youth development. Promoting improved cooking options covers a variety of needs across all the sectors. Specifically, the Peace Corps Cookstove Criteria states that stoves should be desirable, accessible, effective, reliable, and maintainable in order to be promoted (USPC 2012). The recommended stove designs are variations on the widely promoted ‘rocket stove’. Why do the Peace Corps and other international organizations not fully promote the best cooking options, such as natural gas or electricity? Altogether, cooking sources ranked from lowest to highest in terms of cleanliness, efficiency, and convenience are: crop waste and dung, wood, charcoal and coal, kerosene, Liquefied Petroleum Gas (LPG) and natural gas, and electricity (WHO 2000). In most cases the cleaner fuels are the most cost effective, but in the developing world, gas and electric cookstoves are generally not affordable or the fuels are not available. Improving the traditional use of biomass, therefore, is the preferred option (Smith 2012). Evidence of the benefits of this strategy exists. Evaluations of the various improved stove designs demonstrate 20-50% reductions in exposure to particulate matter and carbon monoxide during use compared to conventional cookstoves (Masera *et al.* 2007). Indeed, a study of improved cookstoves in Guatemala found that they were effective in reducing indoor air pollution and children’s exposure to particulates, although both measures remained high by international standards. There were also problems with the acceptance, adoption and maintenance of improved cookstoves. On one hand, improved cookstoves are beneficial. On the other hand, can they be effectively disseminated and do they provide enough improvement?

Meeting the Peace Corps criteria and international goals of improved cookstoves has proven difficult in Paraguay. Rural families favor the inefficient traditional stove/oven combination. However, this type of dual-purpose cookstove reduces efficiency, longevity, reliability and maintenance while generating high levels of smoke and black carbon. Through a search of the literature on the subject, I have found that there are no improved cookstove designs that have a stove/oven combination. Instead, improved models for separate stoves and ovens exist. The question remains though, can this desire for a combination stove/oven be connected to the goal of improved, efficient, stoves? This specific Paraguayan problem is comparable to the international global cookstove approach. Internationally, several stove protocols and standards exist, however, there is no single agreed upon standard. Current laboratory protocols, furthermore, do not adequately cover all stove types (PCIA 2012). Aprovecho Research Center states that “from the perspective of the designer, four goals need to be met to design a stove: cooking effectiveness is the same or better than the traditional method; smoke is eliminated or reduced from the kitchen; less fuel is used; and is producible at an acceptable cost (Hatfield 2012). Therefore, it is apparent that many different effective solutions exist internationally. The issue then, is how to both provide a better product that meets the needs of the people.

Adoption and Diffusion of Improved Cookstove Technologies

Adoption. How is it that the technology for improvement exists, as well as the knowledge of the adverse health impacts from traditional cooking practices, and yet adoption still lags? The missing link lies in the overall community acceptability of a new stove design relative to the traditional method (Barnes *et al.* 1994). Adoption studies, in addition, are scarce relative to the global distribution of cookstove programs. As of 2011, more than 160 cookstove programs are running in the world. They have focused on developing new stove designs, improving large-scale manufacturing processes, and marketing techniques and financial incentives for stove dissemination. Regardless of the program objectives, however, understanding how cookstoves are actually adopted and their sustained long-term use has been inadequate (Ruiz-Mercado et al. 2011). A cross cultural study in Kenya, Nepal, and Peru illustrated that little was known about cultural and social barriers to improved cookstove adoption (Klasen *et al*. 2013). Yet, people want improvements. In Bangladesh, 83% of respondents would prefer an improved option (Miah *et al*. 2009). 98% of respondents in Kenya desired smoke reductions (Silk *et al*. 2012).

Historically, technology has clashed with user habits - the focus of the designer may not be congruent with the preferences of the user. Global Village Energy Partnership International suggests “that there are three principal dimensions affecting adoption of any radically new product or service by the poor: motivation, affordability, and the level of engagement required” (GVEPI 2009). In India, users prefer to use larger pieces and more wood, and to have a large flame when cooking, which conflict with more efficient cookstove use and designs (Werner 2009). I witnessed a similar situation in Paraguay. Global analysis of cookstove adoption confirms that each device is used for the cooking practices where it fits best - stacking. The relative advantage of each device must be analyzed in comparison with the cooking practices and available fuels (Ruiz-Mercado et al. 2011). Improved stoves based on traditional designs are more acceptable to people in the Western Himalayas of India (Aggarwal and Chandel 2004).

Correspondingly, transportation of non-local materials to rural areas can be difficult and costly. Wife's age (younger) and educational level of husband had negative significant impacts on cookstove adoption in Sudan (Muneer and Mohamed 2003). Education and household income were the most significant factors that determine willingness to adopt improved cookstoves in Pakistan (Jan 2012). Cultural compatibility and relative advantage were found to be crucial for adoption in central Nepal. Complexity was not a deterrent to successful adoption, but knowledge of an improved technology was not sufficient (Pandey and Yadama 1992). In a global study of adoption practices in developing countries, income, education, and urban location were positively associated with adoption. However, the influence of fuel availability and prices, household size and composition, and sex was unclear (Lewis and Pattanayak 2012).

Cookstove programs have a long unsuccessful history. Success has come, though, in areas where either biomass is purchased or where biomass is scarce (Vahlne and Ahlgren 2014). Perhaps another difficulty lies in the complexity of domestic energy use, which is largely dependent on household characteristics, such as income and location. In fact, adoption rates vary widely across regions, necessitating a specific, detailed analysis of local decisions (Beyene and Koch 2013). After more than a decade of electricity access in rural villages in South Africa, 90% of households continued to use fuelwood for cooking, and the proportion of households purchasing fuelwood has actually increased (Madubansi and Shackleton 2007). Similarly, in Mozambique, energy use was composed of a mix of sources, with the increased availability of electricity neither significantly reducing biomass use, nor increasing the use of electricity. The decision to use a specific type of energy was determined by the price and capability to invest in energy-consuming appliances (Arthur *et al.* 2010). Cookstove adoption rates, however, have increased over time in Ethiopia, although they are still short of targeted goals (Beyene and Koch 2013). Nonetheless, even with the adoption of new cookstoves, they do not necessarily replace traditional practices, but rather are often used as supplements. In a study in Guatemala, half of households reported continued use of open-fires in addition to improved cookstoves (Ruiz-Mercado et al. 2013). Similarly, in a study in Mexico, 55% of the sample used the stove after eight months (Pine et al. 2013). Reported uptake of improved cookstoves in Rwanda was 90%, although exclusive use was only 29% (Barstow *et al*. 2014). Because of this poor embracement, it is important to look at stove use over time, rather than the total number of stoves dispersed. Perhaps a lower adoption goal is more realistic for best case instead of the often-assumed 100%.

The United States Peace Corps found that poor use and lack of maintenance also undermined the adoption of improved cookstoves (USPC 2012). Improved cookstoves, even when used correctly, may not provide sufficient benefits. The cookstoves can reduce kitchen smoke by 10x, but exposure to children is only reduced by 2x because children do not spend a great deal of time in the kitchen. The smoke (exiting through the chimney) is still present in the outdoor environment, resulting in exposure (Smith 2012). Thus, problems with traditional cooking practices persist, albeit at a reduced incidence. Moreover, in Kenya, improved cookstoves were disproportionately acquired by households with higher socioeconomic status and by households headed by older women, suggesting that the goal of adoption by those most in need was not achieved (Silk *et al.* 2012). This was also found to be true in Mexico, where improved cookstoves did not reach the poorest sector (Tronosco et al. 2007).

Few studies have examined improved cookstoves from the adopters' point of view. Stoves have several uses of practical importance beyond cooking food. In rural Guatemala, for example, stoves were used as heat and light sources as well as social gathering points. Efficiency of improved cookstoves, as a result, can sacrifice functional, social, and cultural needs (Bielecki and Wingenbach 2014). Additionally, few studies have examined the problem of adoption from the perspective of the implementers. In Mexico, work was constrained by the need to meet the commitment with sponsors and a lack of shared vision among the work team toward the project (Troncoso et al. 2011).

Diffusion. Despite the fact the technology and resources for improved cookstoves exists, shortcomings occur through dispersion of materials and acceptance. For example in India, energy requirements for cooking account for 36% of total energy consumption, yet diffusion of renewable improved devices is observed to be far below their estimated potential (Pohekar 2005). To maximize the resources and take advantage of available technology, the diffusion process must be strengthened through questionnaires, pre-classifications, and interviews (Pine *et al*. 2013). Depending on the level of influence, men, women, and the government are important in the diffusion process. For example, how will the process for gender variations in firewood collection? In Honduras, men were more effective over longer distances whereas women over shorter distances. After hearing about improved stoves twice, active community members drove the process as well (Ramirez *et al*. 2013). Bridging the gap between extrinsic agencies and targeted village groups through local partners was imperative for acceptance of an improved stove project in Western India (Simon 2010). Training local vendors, having appropriate incentives and product integration effectively accelerated improved cookstove implementation in Kenya (Silk *et al*. 2012).

My experience as a volunteer in Paraguay provided several insights into the adoption and diffusion of improved cookstoves. I found that most households wanted an improved cookstove, however, they wanted cookstove materials to be gifted as well. Upon receiving materials, the male of the household or a town contractor would build a structure following his or her own design (if left unsupervised). This was often an inefficient product. Another negative outcome was inaction, where the materials would sit idly for extended periods of time to be used “later”, for a multitude of reasons, including for non-cooking purposes. The most significant factor in cookstove adoption that I found was the preference for an oven and stove combination structure. This dual-purpose cookstove severely reduces combustion efficiency. Throughout my two years in Paraguay, I had the opportunity to attend improved cookstove workshops, meet with Paraguayan cookstove business and technology leaders, community representatives and contractors, and development workers. All were highly motivated and well informed. Yet, transferring this wealth of information and action from mostly well-educated and urban individuals to less educated rural areas was a challenge. My experience suggests that intensive assessment and training, education, follow-up extension, and an appropriate design are needed for the adoption, diffusion, and correct use of improved cookstoves in Paraguay.

Paraguay in the Global Context

Paraguay has the opportunity and potential for adopting improved cooking options, yet overall adoption remains low. Throughout my two plus years in the country, I witnessed families cooking with wood, gas, electricity, and charcoal using cooking technologies ranging from open fires, cookstoves, electric ovens/stoves, gas ovens/stoves, wood fueled oven/stoves and both large and small braziers. I did not witness families use dung or crop waste, other than to burn as mosquito prevention or to start a wood fire, respectively. Interestingly, electricity, considered too costly an alternative in most developing countries, could be a viable option in Paraguay.

Paraguay is one of the world’s largest producers of hydropower; but plagued by government inefficiency and corruption it is ranked 150 out of 177 countries in the Transparency

International Corruption Index ranking. As a result, improvements to the poor infrastructure have been minimal ("How corrupt is your country?" 2013, “Paraguay’s Elections: Return of the Colorados” 2013). Perhaps problems associated with traditional cooking methods in Paraguay could be resolved through the adoption of an improved cookstove strategy that expands electricity use into rural areas.

Since the 1950s, more than 90% of the forestland has been cut down for agriculture conversion in Paraguay; first by settlers and later by private land owners (Hamilton and Bliss 1998, Huang *et al.* 2007). The commercial production of soybeans since the 1970s, has led to further deforestation of the ecologically diverse Atlantic forest in eastern Paraguay. Large-scale land conversion by commercial agribusinesses has caused great ecological damage, worsening landlessness and rural poverty. Indeed, in analyses of forest reserves intended to protect the Atlantic Forest, the inequality of land ownership in Paraguay was considered to be the most significant threat to conservation in forest reserves (Quintana and Morse 2005). Moreover, on-going deforestation from cattle companies threaten the northwestern Chaco region (Yanosky 2013). Continued deforestation in Paraguay has reduced the availability of fuelwood and increased its price. However, many households are involved in agroforestry projects for domestic and commercial purposes, such as eucalyptus plantations (Grossman 2012). Nonetheless, the increase in land procurement by commercial agribusinesses minimizes individual family property size and public forested areas, which significantly reduces access. To cope with these changes, many families are converting their forested land to agriculture in order to supplement their income, Figure. 1 (Hamilton and Bliss 1998). This land conversion increases the use of lower quality fuels, the time spent on fuel collection, expense for fuel purchase, and environmental and soil degradation.

The Global Alliance for Clean Cookstoves Country Profile of Paraguay characterizes relevant information as it pertains to cooking. The use of biomass as fuel in Paraguay is approximately 53% (81% rural, 33% urban) of the population. Overall fuel use is: wood 34%; coal 14%; gas 5%; electricity 1%; and other fuel 2%. Paraguay ranks 103 out of 183 countries on annual PM10 emissions [mg/m3], with only one half of one percent of the population using improved cookstoves, and over three million people affected by HAP (GACC 2014).

Fig. 1. Sugar cane field in central rural Paraguay

In Paraguay, certain customs dictate cooking practices. For example, during holidays and large gatherings, households bake corn bread products, which requires ovens and lengthy cooking times. Other practices have significant impacts on a daily basis. For example, families with pigs and other animals must allocate significant time each day to cook and prepare large quantities of animal feed (Fig. 2). To prepare the animals feed is equivalent to cooking an additional meal every day. A noteworthy custom, the drinking of yerba mate in the mornings, evenings, and when temperatures are cold, requires the heating of water and/or milk. A rapid and easy heating process is preferred for this custom.

Fig. 2. Large pot cooking animal feed

All the above factors influence the cooking choices of Paraguayans. Some are unique to them, and some can be related to other cultures. Access to fuel source is also important in Paraguay. Proximity and availability of fuel source and time usage are examples of external factors determining how one cooks. Cooking yucca, a staple of the Paraguayan diet consumed at nearly every meal, can take several hours in preparation and cooking time (Fig. 3). Households living in the city and who do not own any land may eat bread instead of yucca, because they neither have the vegetable to harvest or the wood to cook it with. They may not have the time for cooking or they may not be able to pay the electric or gas expense required to cook yucca for a long period of time. They therefore, change what they eat and how they cook to adjust to their specific circumstances. Paraguayan customs and practices, as a result, can be compared and contrasted with the global issues involved in promoting clean cookstove policies.


Fig. 3. Yucca, peeled and cooked.

Research Objectives

This research was designed to assess the cooking practices of Paraguayans. The objectives of this research were to:

1) determine what types of cooking devices Paraguayans use to cook, and frequency of use. Most, if not all, families use some combination of the four options: gas, electric, wood, and charcoal. Their choices and reasoning varied widely – with ambiguous or conflicting explanations. I wish to compare my findings with that of historical data on the subject.

2) assess the relative importance of the main attributes for efficient cookstoves. For example, how does price compare to ease of use? I also want to determine the price of use of each option (one time cost and monthly expenditure), and assess the relationship between perceived prices and actual prices. For example, many people claimed price as a deterrent of use of one device, but then used an option that actually costs more.

3) compare the perceived importance of product attributes between city, semi-urban, and rural settings. I notice a marked difference between these three settings, and will evaluate and compare them.

4) provide strategic recommendations that will help to promote the adoption of more efficient cookstoves in Paraguay. I will evaluate how the unique factors of the Paraguayan culture should be considered in the context of successfully introducing an improved cookstove. I will also provide analysis and comparisons of differences between location, socioeconomic status, and other determining factors for improved cooking implementation.

Chap. 2: Methods

Study Design

To address my research objectives, a case study of cooking practices in Paraguay was performed. The research followed Yin's (2003) definition of a case study – an investigation of contemporary cultural practices within its real-life context where the boundaries are not clearly evident. Furthermore, the research applied a mixed-method approach as defined by Creswell (2003), comprised of qualitative and quantitative analysis in the collection and assessment of data. This approach included interviews, site visits, coding of responses, and organization and analysis of data.

The study provides information of cooking practices applicable to Paraguay and the world. The study population of 45 households serves as multiple natural units to give an understanding of the local context of the issue (Yin 2003). Data collection was achieved through interviews conducted within the participant's home, ensuring a comfortable setting.

Considerations of Study Quality

To meet the criteria as defined by Yin (2003) for empirical data in social research, I ensured my case study contained construct validity, internal validity, external validity, and reliability. Construct validity is defined as the parameters being measured corresponding to the phenomena being tested. I did this by creating questions to fully encompass cooking practices in Paraguay. Internal validity is defined as accurate responses to questions. Internal validity could be problematic because participant responses were estimations and cannot be confirmed with direct measurements or verification. Although, the case studies were designed to determine perceptions, negating the need for accurate observations, it simply documents stated responses.

External validity is defined as applying findings to be generalized to the outside population. The multiple cases, 45 households, represented participants from cities, towns, and rural areas to provide a balanced sample size applicable to other situations. Reliability is defined as the study generating the same results if done again by a later investigator using the same methods. The methods of this study are documented below and a spreadsheet of all data derived from interviews is included.

Data Collection

Study Population

The study took place in nine different locations in three settings - cities, towns and rural locations. Three locations were selected within each of the three settings. In each location, five interviews were completed for a total of 45 interviews. Each study location was hosting a Peace Corps Volunteer (Fig. 4). Each location was assigned a code name signifying setting and location (C-City, T-Town, R-Rural to designate setting; and A, B, and C for location) to ensure confidentiality.

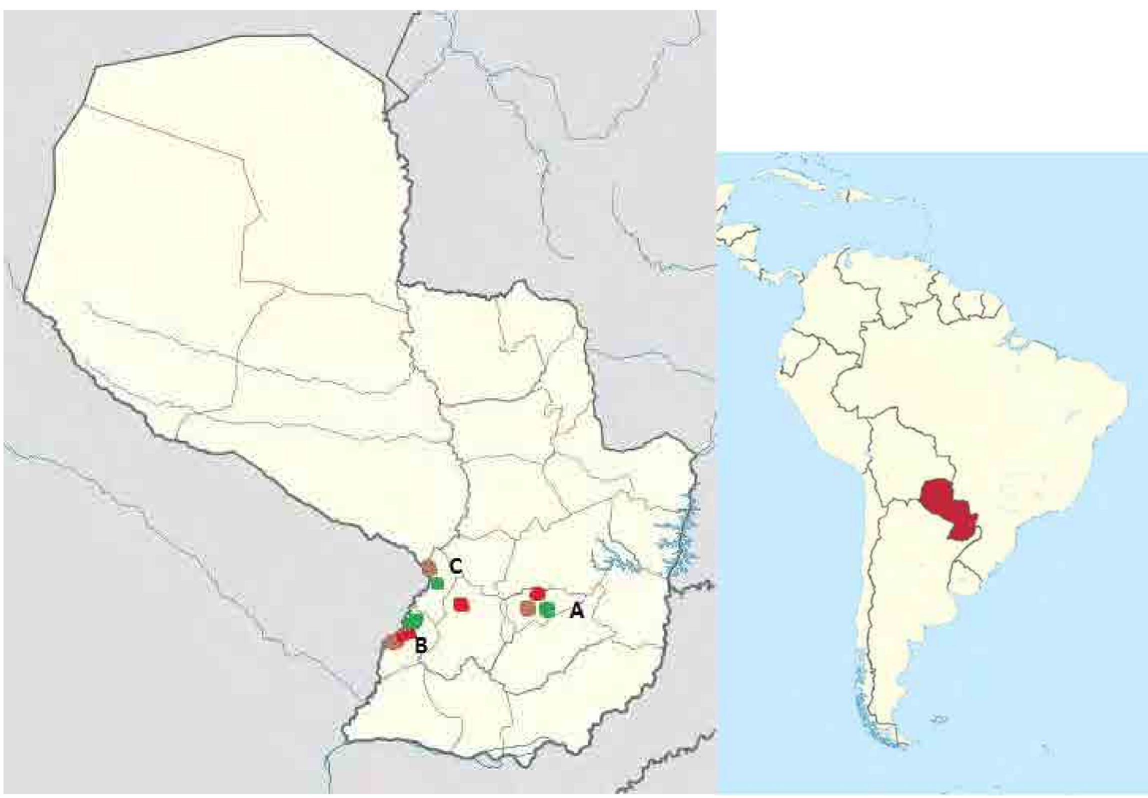


Fig. 4. The Nine survey locations in Paraguay. Brown: City, Green: Town, Red: Rural. Map adapted from http://newspaper.li/paraguay/.

In general, city locations had high population densities, paved roads, running water, little access to fuelwood, and small property sizes (Fig. 5). Towns had some paved roads, running water, some access to fuelwood, and a range of property sizes (Fig. 6). Rural locations had unpaved roads, large property sizes, some access to running water, and ready access to fuelwood (Fig. 7). All locations in the case study had access to electricity. In some locations in Paraguay, however, access to both running water and electricity is limited.

Fig. 5. Asuncion, Paraguay. Example of a city setting.

Fig. 6. Cobble stone road. Example of a town setting.

Fig. 7. Paraguayan farmland. Example of a rural setting

The location sites were determined by the presence of a fellow Peace Corps Volunteer living in the community. Each interview was performed in the presence of the PC volunteer living in the community (I conducted the interviews alone in my own community) to assist with translation, explanation, but more importantly to bring comfort to the interview process. By knowing the people of the participant household, the PC volunteer helped minimize any awkwardness or reticence on the part of the participant. When selecting the five households in each location, households were chosen to provide a representative socioeconomic sample of the community: one poor household, one relatively wealthy household, and three households from the middle class. The interviews took place from April to November 2013. I was not able to travel great distances north or south due to a combination of travel restrictions by Peace Corps, and the lack of transportation options.

Of importance, is that the three locations in the southwestern area on Fig 3 were geographically unique. All three locations were along one unpaved highway ending in city B. The city was directly across the river (Rio Paraguay) from Argentina. As a result, much of the work, commerce, and goods, in all three locations were tied to Argentina’s economy. Additionally, the terrain was sparse and soil unsuited for farming. For both reasons, gas use for cooking was more prevalent in this sample area.

Interview Methodology

Before each interview I explained to each participant that: (1) the survey was part of my education requirements, (2) answers would be anonymous, (3) questions could be skipped, and (4) that the results would provide information on Paraguayan cooking practices and help identify ways to improve the adoption of more efficient cookstoves. The interviews took place in participant households with one or two family members of each household (usually including the woman responsible for cooking meals. The interview script was read in Spanish and/or Guarani depending on participant preference. Questions were reworded in more understandable terms if the participant did not understand the original script. The local PC volunteer also assisted in this process. I did not administer all questions to all participants if the questions did not apply to the household. Each response was documented with notes of phrases, comments, or reasoning that I deemed relevant. Each interview took approximately 15-30 minutes depending on the number of cooking sources in the household and question comprehension.

Some comprehension problems did occur with various questions during the survey. If there were moments of confusion or misunderstanding, participants had a tendency to ‘shut down’. However, with added explanation and assistance from helpful youths within the households, valid responses were obtained. No data was entered in the rare case where the respondent did not comprehend the question.

Data Analysis

The interviews were initially formatted in a field notebook and then transcribed into Microsoft Word documents and Excel spreadsheets. The spreadsheets were created to organize the data into numerical (e.g., uses/month), categorical (e.g., yes or no), ordinal (e.g., more, less, same), and ratio (e.g., households that cook over an open fire versus total households) categories. The small sample size limits the statistical analysis of the data, however, and a qualitative analysis of the data was performed. The qualitative analysis of the quotes and statements were organized based on common themes using Microsoft Word charts.

Minimization of Bias

Awareness of potential for bias in interviews is essential. Sources of potential bias can occur from willful participant misrepresentation, accidental participant misrepresentation, and researcher misrepresentation. Willful participant misrepresentation was minimized because participants were not subject to incriminating or uncomfortable questions and they always had the option of not answering a question. The questions focused on everyday cooking practices. Additionally, the participants viewed Peace Corps volunteers in a friendly and not threatening manner. Volunteers were not politically involved or associated with any groups that could have adverse effects on the participant. Accidental participant misrepresentation was minimized through clarification of questions, skipping the question, or omitting questionable data. Researcher misrepresentation deriving from cultural and/or language misunderstanding was minimized by having two people help with survey administration and by consulting with youths in the household when necessary. Since most of the questions only required short answers, misunderstanding occurred very infrequently.

Chap. 3: Results

Cooking

Household Definition

The following results are household statistics from Paraguay significant to cooking practices. They include household size, gender of the cook, and hectares of land owned (1 hectare equals ~2.47 acres).

Household Members. The "standard adult" equivalence factors were used (Guidelines for Woodfuel Surveys, for FAO by Keith Openshaw) to determine the number of members in a household. This criteria allows for a proper adjustment of proportional energy demand depending upon the age and sex of all household members.

Comparison Criteria	
Child: 0-14 years	0.5
Female: over 14 years	0.8
Male: 15-59 years	1.0
Male: over 59 years	0.8

The average household size of all 45 Paraguayan families in the study was 4.6 people. Adjusting for the "standard person" equivalence factors results in a downward adjustment to 3.67 people. The tested population was relatively similar between city, suburban, and rural settings, averaging 3.46, 3.99, and 3.55 people, respectively (Fig. 8). My own observations varied slightly with the findings. In rural settings, extended families were much more likely to live together with multiple rooms and houses on one property. In city settings, Paraguayans were more likely to live in apartments or smaller settings with less people. Town settings comprised both elements of large families and apartment settings.

Gender of Cook. As is common throughout the developing world, women in Paraguay were found to be the predominant cooks. Overall, they made up 75.6% of cooks. However, this statistic is not an accurate depiction because women cooked at a much higher frequency. When men did cook, it was once or twice per week to barbeque for large family gatherings. To clarify, of the 21 meals per week, women cooked 19 or 20 of them.

Cooking Time. Daily time spent cooking can vary substantially depending on numerous factors. Self-reported cooking times can also be overstated. Despite this, the overall average cooking time per day was estimated to be 2.85 hours. As is common globally, cooking time increases in more rural areas. In rural locations the average was 3.43 hours/day, in towns it was 2.84 hours/day, and in the city it was 2.28 hours/day (Fig. 11). Cooking lunch constituted the bulk of cooking time and cooking breakfast and dinner often consisted of simply reheating food or involved only quick meal preparation. I noticed it was much more common for women to work in jobs outside the home throughout the day in town and city settings. In rural settings women often worked in the fields in the afternoons. As a result, cooking time for each meal was often short for each meal if women worked outside the home, whereas for those that worked at home, the lunch cooking time was much longer.

> *"The fire stays lit from breakfast to lunch. I don't use it for dinner."*[1]
>
> *"Breakfast and dinner take only half an hour [each]."*

Hectares of Land. For simplification, each lot the family owned was counted as 0.1 hectares, (approximately 10,000 sq. ft.). In addition, I used the median land area from the three rural, suburban, and city settings rather than an overall average, because of an outlier property size in one rural area of 240 hectares that skewed the land area data. Rural households were found to have more land (5.60 hectares) relative to suburban (.84 hectares) and city households (.18 hectares) (Fig. 8). Data from participants concerning forested land, and forested land used for firewood was not included because of minimal responses. Study participants either had none or had no idea of the area they did have. Based on my observations, families with sufficient property sizes used about a third to a half of their land for agriculture, a third to a half lay fallow or untouched, and the rest was left as wild woodland. When wood was needed households gathered mostly downed fuelwood around the property. Although, I generally did not recognize a sense of consciousness acknowledging tracts of land set aside for forest or future firewood use (even if they actually had). With larger property sizes, households in rural communities were more likely to have available forested land for firewood collection located nearby. With an adequate free supply, amount of used wood was not of great concern in comparison to the nominal monetary costs of electricity, gas, or charcoal.

[1] Relevant quotes have been interspersed throughout text

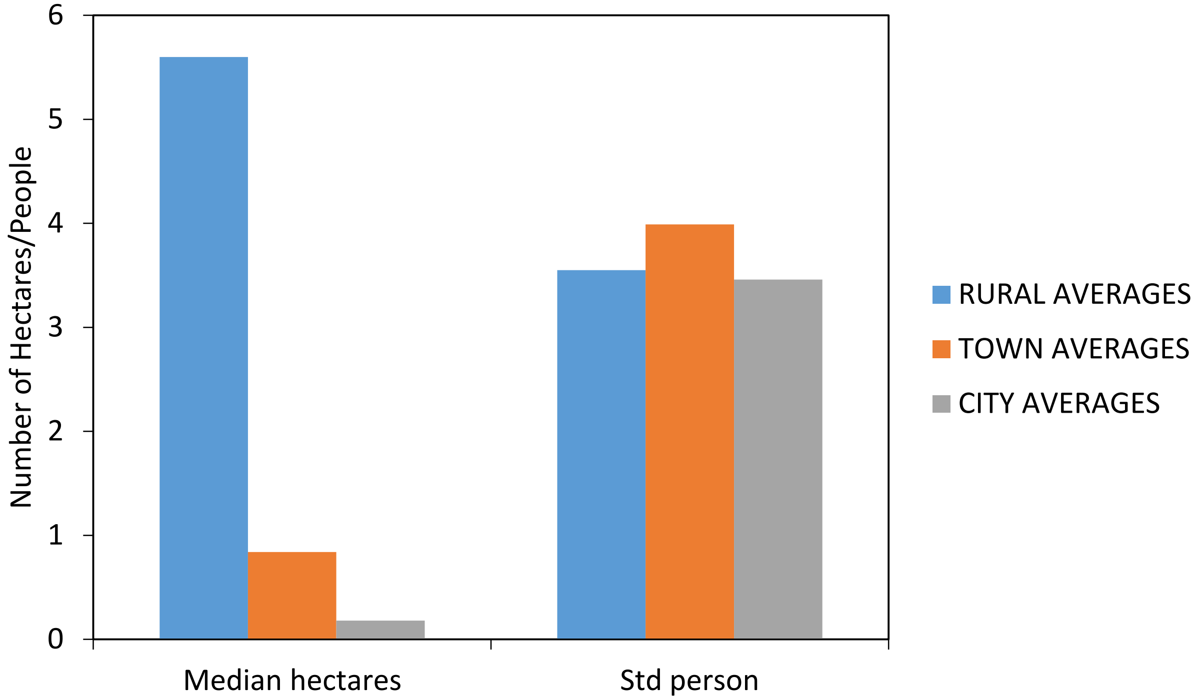


Fig. 8. Average Number of Hectares and People

Firewood. To better understand the cooking practices in Paraguay and evaluate the potential to introduce improved cooking practices in Paraguay, I wanted to discern the significance of firewood in respondents cooking practices: to determine who collected it, frequency and duration of collection, how it was used, how long the cooking fire was burning, and how the fire was started. Furthermore, I noticed that many households used a variety of cooking practices, and many continued to cook over open fires even when other, more efficient cooking technologies were being used. Many families, especially in rural settings, used large brick ovens in order to cook larger quantities of food relative to electric or gas stoves. Firewood, either burned in open fires or in some type of cooking structure, was used for all types of cooking purposes, ranging from cooking multiple items at the same time to cooking large items requiring a lengthy cook time to heating or reheating food or liquids and to baking items. Though still popular, fuelwood and charcoal consumption by households and other consumers, measured in cubic meters has dropped slightly from 5,978 in 2000 to 5,378 in 2010. This can likely be attributed to increased access to electricity and gas ("Factfish Catalog Energy and Environment," Fuelwood Paraguay). In town and rural locations in area B (scarce woodland and close to Argentina), the scarcity of fuelwood was more recognized than in town and rural locations in areas A and C. Households were more likely to stack their devices in area B for designated cooking practices in response to this scarcity. If they had to pay for gas, electricity, wood, and charcoal, they chose the fuel to meet their own needs. They did not have a readily available free source to rely on. My own observations and the study verify that households that used wood predominantly utilized free collection without acknowledgement of added labor, health, and time costs.

General Firewood Use. The collection of firewood is performed 70% of the time by men in Paraguay. In city and town settings, the percentage is closer to 55%. In rural areas, men obtained large quantities of wood from their fields using oxen and a wagon for transport (Fig. 9). In more suburban areas, men are less likely to be available and large quantities of firewood harder to obtain. This results in more frequent collection by women. I did witness women from poorer households in rural areas collecting wood day-to-day. This occurred if they neither had money, available men, woodland, or oxen and oxcarts. For the most part though, the men of rural areas collected large quantities rather infrequently.

> *"I don't want to chop down more trees. They give shade to my animals."*
>
> *"The wood is hard to collect"*

Fig. 9. Oxcart used for collection and transport of firewood

Frequency of firewood collection or use, and time spent collecting were lower in Paraguay than in other locations in the literature. Variations between city, town, and rural averages were not significant. Differences did exist in number of households that used firewood in each location: two, six, and 14 respectively. Overall averages for collection frequency were once per two months and about three hours per collection period (Fig. 10). However, differences between each household frequency and duration varied greatly. One household collected once per year and spent eight hours and another spent an hour collecting every day. Many purchased firewood due to lack of time, oxen and an oxcart, and/or available woodland. Those that purchased fuelwood, unfortunately, spent more for their fuel than if they used other fuel types. But the prohibitive initial cost of other devices prevented this option. Generally, I noticed that those that used firewood had free access to a source. Increasingly, many expressed concern about the longevity of this source, but only in an abstract far off concern. They were more concerned in the short-term advantages of increased agricultural land and subsequent profit, than in a long-term supply of firewood. In fact, a major Peace Corps project entailed planting trees. Any reason was adequate: firewood use; agroforestry benefits; or merely for profit. Yet, many volunteers and I, found this more difficult than expected. In comparison, convincing young individuals to save money and take advantage of compound interest because of the later payoff, is difficult when in competition with the many instant gratification options.

"I burned down my forest to plant more sugar cane. I have enough wood now."

Storage usually entailed a seasoned, large pile left uncovered outside (Fig. 11), and brought inside after cut into the desired size. For optimal efficiency and minimal smoke, small wood pieces are best (Baldwin 1986). Using small pieces, however, requires additional work and continual fire monitoring. Therefore, in the opinion of the cook, the benefits may not outweigh the costs. In fact, the results show that using small pieces is only desirable to start the fire, with preferences for larger pieces after initial lighting. When most women cook, they prefer to do other activities, without continued surveillance of the meal. Using larger pieces also prevents the fire from going out, because it can be left smoldering for many hours.

"I like to start the fire with small pieces, and then add large pieces. I need time to wash clothes. I need time to prepare lunch."

"I want the fire to stay lit all morning."

"Bigger pieces are better."

The desire for a fire burning for multiple hours was evident because burning time was greater than cooking time - 3.96 hours burning versus the cooking time of 2.85 hours (Fig. 12). When I visited families for the customary tereré (cold water tea) session and lunch, women could not participate. The men had returned from the fields and were resting/hydrating before eating. Women were busy doing any number of activities: laundry, preparing lunch, helping children get ready for school, or cleaning the house. Women could not afford constant monitoring of the fire (or a relaxing tereré session) because they were required to complete so many other tasks.

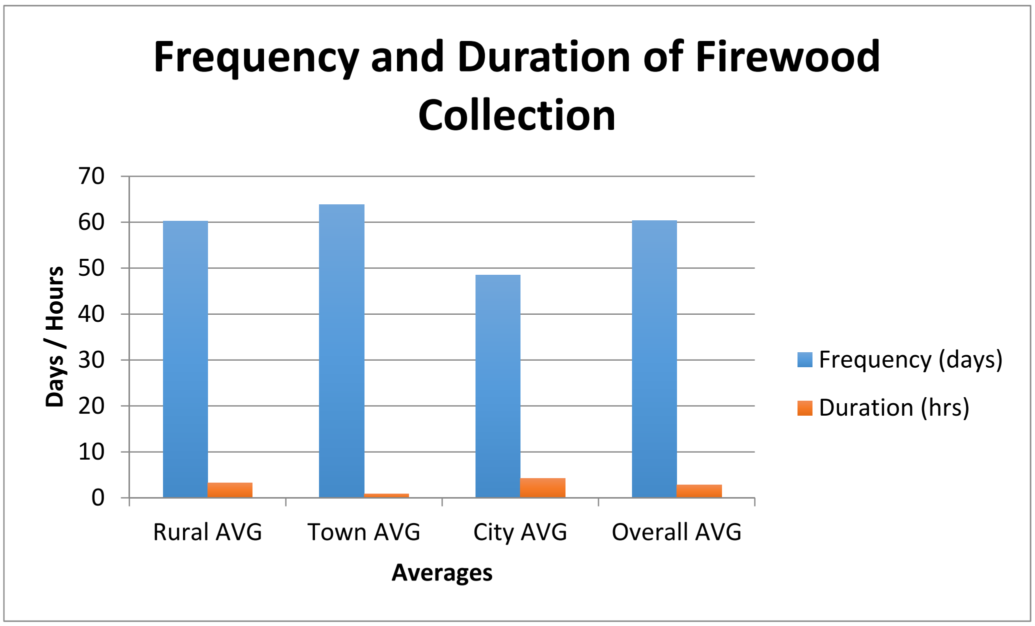


Fig. 10. Frequency and Duration of Firewood Collection

Fig. 11. Firewood Storage in rural household.

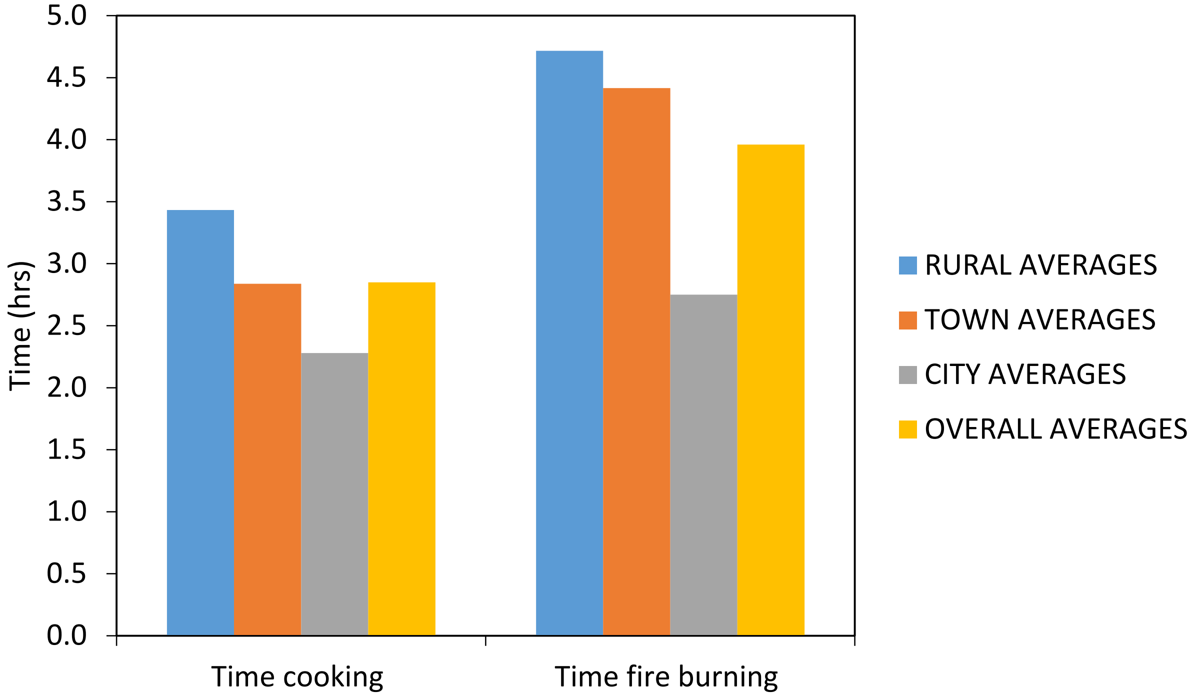


Fig. 12. Average Fire Burning and Cooking Times

Serving as an Environmental Conservation Volunteer in Paraguay required a wide variety of activities. A major element of the program was the topic of garbage and recycling management. Without adequate infrastructure, practiced 'management' of waste signified burning. One exercise I taught in Paraguayan high school, and middle school, attempted to alter this practice by bringing a bag full of materials such as batteries, aluminum cans, bottles, cardboard, Styrofoam, plastic bags, leaves, and grass. The task for the students was to separate the items into the categories: metals, plastics, glass, paper, organic material, and other. In both high school and elementary classes, many items were incorrectly placed. For example, Styrofoam was often placed in the organic material category. Waste, therefore, was waste, without differentiation. My task was to explain the differences and about possible other disposable methods. Additionally, I explained the danger from the inhalation of smoke caused by burning various materials. The unknown or disregard of this danger ignores concern of the carcinogens while simply focusing on disposal of the plastic. Moreover, if the danger from smoke from burning garbage is unrecognized, perhaps the same is true for the smoke from cooking. To apply this theme to cooking, I asked households how they started their fires. Most used a variety of sources depending on what was easily available. Paper was the most common fire starter (15), followed by biomass and plastic (7 each), and some using a form of lighter fluid (4).

> *"I don't care what I use. I want an easy fire."*

Brick Structure (*Fogon*). A brick cooking structure is a common presence in numerous households throughout Paraguay, and more so in rural communities (Fig. 13 and 14). From the study, eight were in rural communities, three in suburban communities, and two in cities. They range in design, materials, function, use, and overall productivity. The word "fogon" is a catchall term for a brick structure that is used for cooking. Some, for example had short, tall or no chimneys at all (Fig. 15 and 16). Without a sufficient height to maximize airflow, the "chimney effect" will not work (Agenbroad *et al.* 2011). Of the 10 respondents with structures, only three reached a height above the roof of the kitchen. The most popular design is one containing both a four burner stove plate "*plancha*", and a metal box to serve as an oven. Rebar, bricks, cement, and a red clay mixture are included in the materials. Though desirable in households, the structures are not effective for a number of reasons. (1) Bricks and clay absorb heat (not conductive), thus lowering the efficiency and necessitating more energy to cook the food. This also increases the temperature of the cooking area, which increases discomfort during warm summer weather. (2) The stove and oven combination structure minimizes the "chimney effect" due to distance from the flames to the exit. Also, whenever the stove is used the oven is heated too. Because families only use the oven sporadically (Fig. 32), this contributes to additional wasted energy. (3) The structure is difficult to clean and maintain. To ensure smoke and heat exit the chimney, ash build up inside the structure necessitates removal. The structure only functions properly if the heat from the fire at one end can flow from the stove area, past the oven, and out through the chimney. Any buildup of ash along the path prohibits maximum efficiency. In many cases, the ash buildup prevented any heating of the oven.

> *"My oven doesn't work."*

Cleaning can only be accomplished through brick dismantling to remove the soot in hard to reach areas, followed by brick replacement with added clay mixture. This is a cumbersome process, and often not done. I asked if *fogon* users cleaned their structure. Of the nine respondents, eight said they did. Their version of cleaning however, varied greatly in thoroughness. Additionally, because of the intensive labor required, and a cultural desire to appease uncomfortable situations through politeness, I believe many actually did not thoroughly clean their cookstoves, but chose instead to tell me they did. Thus, I do not believe the question was thorough enough to make a reliable conclusion. Maintenance is difficult because the high heat from cooking can crack the *plancha*, and over time the materials simply breakdown. (4) The large structure promotes the use of large pieces of wood, minimizing efficiency. Jamming large pieces of wood into the structure also increases the likelihood of damage (Fig. 17). (5) The structure is not built for effective heat transfer because it is devoid of even cross-sectional areas (Baldwin 1987). And finally (6), depending on use, the brick structure can use more wood per item cooked in comparison to cooking on the ground (structures generally do minimize HAP, however).

Fig. 13. Newly built fogon

Fig. 14. Fogon cooking numerous items.

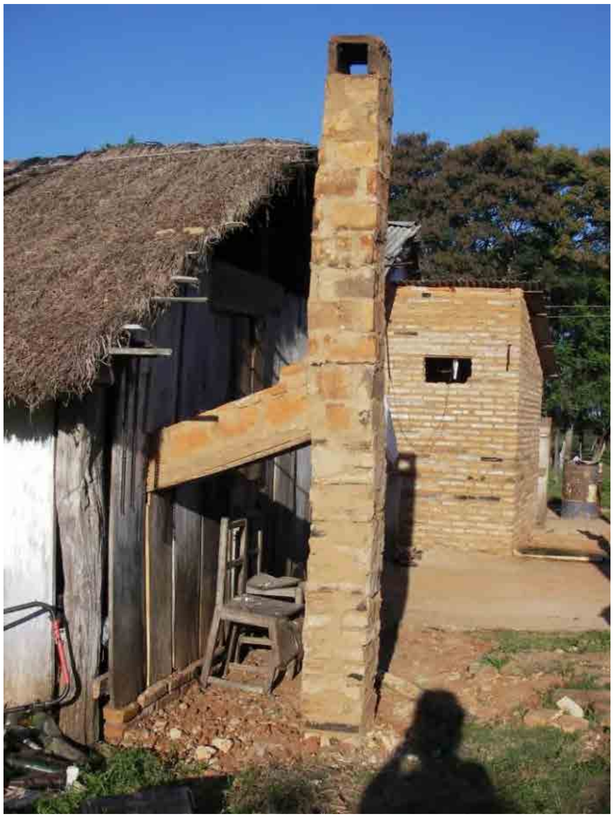


Fig 15. Sufficient chimney height.

Fig. 16. Low chimney height

Fig. 17. *Fogon* with large piece of wood. Note the damage of missing bricks under the *plancha*.

Comments about the *fogon* varied widely. People from rural areas claimed it was more comfortable, some complained the oven was too slow (likely from lack of air flow from soot build up), and that it was dirty from the smoke. In cities, those that had *fogons*, rarely or no longer used them.

> "*The fogon is very beautiful. I love it.*"
>
> "*I cook big lunches with my fogon.*"
>
> "*The oven is too slow.*"
>
> "*Wood is dirty and expensive.*"
>
> "*Too much smoke.*"
>
> "*We have a fogon, but don't use it.*"

Large Brick Oven (*Tatakuaa*). Large brick ovens are used to mainly cook the traditional cornbread product *chipa*. Their use is largely cultural and ceremonial, usually used during large festivities, especially throughout the week preceding the Easter holiday. But mostly, the brick and red clay ovens sit unused. The cooking process is time consuming and requires a large amount of wood relative to the amount of *chipa* cooked. For use, wood is inserted and lit (Fig. 18). Wood is continually added as needed for 30-45 minutes until the *tatakuaa* is sufficiently pre-heated. All excess wood and ash is removed and the *chipa* is inserted. Cooking time is only 10-15 minutes, but the structure stays hot for an additional 30-45 minutes for continual cooking (Fig. 19). However, the extra time is rarely utilized due to no further desire for more *chipa*. These structures are used much more in rural and suburban settings, where wood use is more prevalent and property sizes larger. Similar to large property size variations, *tatakuaa* use had a large value skewing the data of rural areas (300 uses per year). For that reason, I again chose to use the median of the three averages from each setting to obtain a more reliable value. The uses per year of the *tatakuaa* were 11.8 in rural areas, 11.5 in towns, and 2.67 in cities.

Fig. 18. Preheating *tatakuaa* for use.

Fig 19. Remove wood and ash, and then insert items (*chipa*) to be baked.

Open Fire Cooking. It was common for households to cook over an open fire using a metal stand or large logs for pot placement (Fig. 20, 21, and 22). Though this was most common for households without other options - rural settings with lower economic means - many families with electric, gas, charcoal, or brick structure options still chose to cook over an open fire. Of the total respondents, 20% cooked over an open fire; 40% in rural areas, 13.33% in towns, and 6.67% in cites (Fig. 23). Why is this so? In addition, many used various combinations of materials to make a cooking structure. However, they were often poorly built (Fig. 24). In actuality, they are elevated open fires. On the other hand, the elevated structure provided some relief.

"My back gets sore bending over."

Perception of taste impacted fuel type. Another woman claimed using wood tasted better and that it reminded her of the customs of the past.

"I cook on the ground because I'm accustomed to it. It's comfortable. My mom cooked like this. The food tastes better too."

On the other hand, many women had complaints about the overall use of wood use.

"Smoke makes me feel bad."

"My grandma cannot cook with wood. It is too hard for her."

"Smoke is dirty."

Many still thought open fires necessary to cook large pots (i.e. yucca and pig food) for extended periods of time. Other modes either could not support such a large pot, or households were not willing accept the cost.

"I cook the pig food every day [with wood]. The pot is too big to put on gas [stove]."

Moreover, of the 10 respondents, six believed *fogons* used more wood than cooking over an open fire. Perhaps, the poorly built traditional *fogons* contribute to this likely true belief. A study in Nepal showed that households with improved cookstoves actually used more firewood than those with traditional mud stoves (Nepal *et al*. 2011).

Fig. 20. Cooking on the ground. Note the large pieces of wood.

Fig. 21. Use of firewood.

Fig. 22. Cooking empanadas

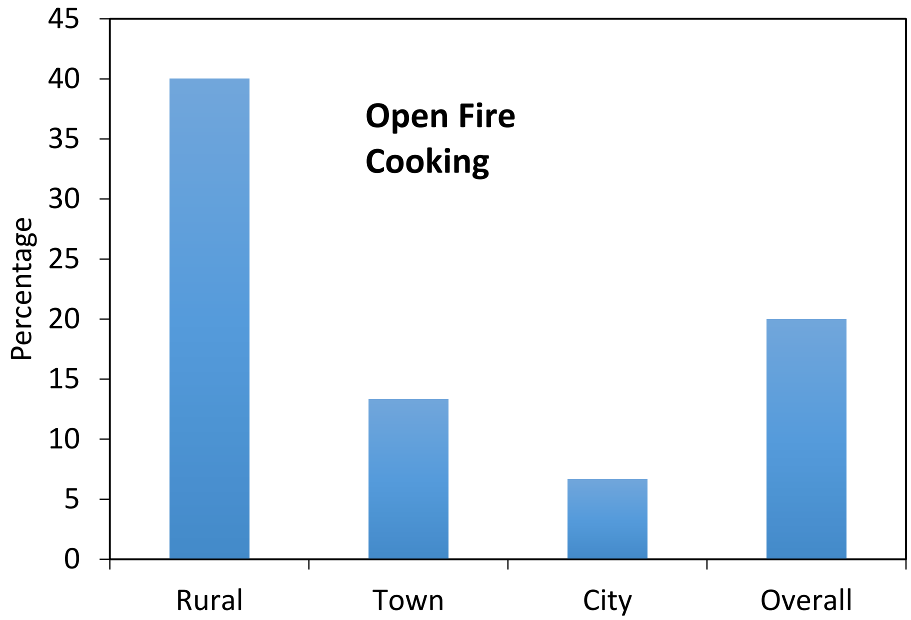


Fig. 23. Percentages of respondents cooking over an open fire versus those that exclusively use other devices.

Fig 24. An example of the improper use of fogon materials - the equivalent of open fire cooking.

Charcoal / Brazier. Charcoal use had a wide variety of functions in Paraguay. On weekends and holidays it was used to cook great quantities of food on large braziers (Fig. 25). On occasions with numerous people it was also positioned in numerous ways on the ground (Fig. 26 and 27). Evident in Figure 25-27 are the large quantities of meat cooked using charcoal.

"I use charcoal for yucca."

"I use charcoal for lunch and yucca."

"Charcoal is fast and economical."

"I use charcoal to barbeque."

"I use charcoal every weekend to barbeque."

"I use charcoal when the electricity goes out."

In fact, any significant meal had meat. The concept of not eating meat was not understood. If I visited a family for lunch and they were eating beans, they apologized profusely, feeling very ashamed. A meal with meat was associated with wealth and class, whereas beans signified a poorer socioeconomic standing. Therefore, any festivities were associated with grilling large amount of meat using charcoal.

When used for cooking large amounts of meat on the weekend or for festivities, men usually cooked.

"My husband knows how to light the charcoal. We use it for weekend barbequing and yucca."

"It [charcoal] is hard to light."

On a daily basis, households used charcoal in a one-pot brazier for cooking or a general source of warmth (Fig. 28). It was used for lunch and/or to cook yucca and weekend family barbeques. Often, in cold temperatures, the one-pot brazier was brought inside to provide a central heating unit.

"I like charcoal when it is cold."

"I use charcoal inside when it is cold."

The temperature outside was very similar to the temperature inside houses because they were generally open to the outside elements without insulation. This was more evident in rural settings. The exposure to carbon dioxide, however, is still present. (I remember feeling light-headed after prolonged periods sitting around the brazier when inside). For the most part, though, they are used outside or in the kitchen area for cooking purposes.

Fig. 25. Large brazier for charcoal use

Fig. 26. Charcoal used for large barbeque in open pit

Fig. 27. Charcoal cooking for large celebration

Fig. 28. Small brazier for charcoal use

Electricity. Electricity was used for cooking in households for oven use and/or to heat items on the stove. Generally electric stoves were not used for lengthy cooking. Subjects used small portable electric ovens with or without a stovetop (Fig. 29 and 30, respectively), or single burner stove for cooking purposes.

Ovens were often used when wood was unavailable, or to cook specific food items.

> "*I make cakes in my oven.*"
> "*I only use my oven [electric] to cook chicken.*"
> "*I use the oven when it rains [instead of wood].*"

Electric stoves were widely used, however, their comments varied greatly.

> "*Easy to heat water.*"
> "*I use it in the morning for milk [heating].*"
> "*I use the stove when the gas runs out, but is slow.*"
> "*My [electric] stove is cheaper than gas.*"
> "*I can't cook big pots. It's only good for one pot.*"
> "*The stove is slow and expensive.*"
> "*I only use when there is not time to gather wood.*"
> "*The stove is clean.*"

Using electricity was often claimed to be problematic for a number of reasons.

> "*When I use my electric oven, I can see the gauge spin around and around. It is too expensive*".
> "*Sometimes the power goes out. How can I cook?*"
> "*It burns my food often.*"

The Paraguayan electricity market, including generation, transmission, and distribution is controlled by the state-owned utility National Electricity Administration (*Administración Nacional de Electricidad*, ANDE) ("EIA," Paraguay). Almost all of their electric energy comes from the operation of two binational hydroelectric dams: Yacyretá with Argentina and Itaipu with Brazil. Itaipu is the world's largest hydroelectric plant in power generation, and provides roughly 75% of energy consumption in Paraguay ("The world's largest generator of renewable clean energy," Itaipu Binacional). However, Paraguay consumes much less than their 50% share in both projects (16% with Itaipu and less than 1% with Yacyretá), exporting the rest back to Brazil and Argentina, respectively ("EIA," Paraguay). Their low domestic demand, as a result, makes Paraguay one of the world's largest exporters of electricity, exporting 80% of total electricity production in 2011 ("Factfish Catalog Energy and Environment," Electricity Paraguay; "Paraguay," CIA).

"I like electricity. My country produces it. I've seen areas that were forest. All gone now."

Electricity consumption, nonetheless, has increased over time: doubling from 1990-2000, and almost doubling again from 2001-2011 to 8.073 billion kWh (97^{th} in the world). Per capita use has increased as well, from 501,000 kWh in 1990, to 879,000 in 2000, and to 1,228,000 in 2011 (93^{rd} in the world). As of 2010, almost 97% of the population had access to electricity growing from 90% access in 2005 ("Factfish Catalog Energy and Environment," Electricity Paraguay). Though according to a study of Latin American countries, electricity was not an access problem, but rather an affordability problem in about 50% of households in Paraguay (Byer *et al.*, 2009). Further problems arise from lack of national investment in transmission and distribution networks, resulting in black outs, and a high frequency of interruptions. Paraguay, however, does charge very low tariffs on electricity relative to other countries in South America ("Benchmarking Analysis of the Electricity Distribution Sector in the Latin American and Caribbean Region," 2006). This access to electricity has significant implications in the policies of improved cooking practices in Paraguay. Furthermore, it is unclear if actual electricity costs are prohibitive or economic perceptions of potential costs are the true factor limiting use. Delineating between electric use for cooking and from other appliances also proved difficult.

"I have no idea how much it costs."

These appliances included fans, refrigerators, freezers, air conditioning units, televisions, and washing machines. I believe general monthly cost estimations are high when compared with my own electric utility cost - daily oven and stove use, a refrigerator, daily fan use, and a heated shower. All participant households were larger than my own (I lived alone), however, I used my electric stove and oven at least as much if not more than most households, and I did not supplement my cooking with any other fuel type.

Fig. 29. Electric oven with stovetop.

Fig. 30. Electric oven without stovetop.

Liquefied Petroleum Gas (LPG). Gas was utilized for quick cooking or to reheat items. Ovens were rarely used. The general structure was a four burner stove with an oven, connected to a refillable tank of propane gas (Fig. 30). Gas was appreciated for its cleanliness, but considered expensive as well as problematic regarding uncertain capacity tank levels.

> "*I use gas to heat milk and water in the mornings.*"
>
> "*I like gas because it is fast and easy.*"
>
> "*I do not use the oven.*"
>
> "*I never use the oven. Very expensive.*"
>
> "*If I used gas everyday [for all meals], it would be gone in three weeks.*"
>
> "*Gas is annoying when it runs out. I never know when it will happen.*"

LPG use in Paraguay has been relatively stable in the last ten years, with a slight increase in the preceding ten years. Measured data by total consumption of households and other consumers in thousands of metric tons are: 45 in 1992, 61 in 2001, and 65 in 2010. ("Factfish Catalog Energy and Environment," Liquefied Petroleum Gas Paraguay).

Fig 31. Four burner gas stove and oven.

Other Potential Fuel Sources. In addition to the fuel types electricity, gas and biomass, future projects are in the process of supplementing current energy sources. Currently, Paraguay has no gas reserves and no gas production. They are, however, in talks with Bolivia to construct a pipeline to bring gas from Bolivia to Asuncion, Paraguay ("EIA" Paraguay, Byer *et al.* 2009). Also, there is a project underway for oil extraction in the Chaco region. President Energy, a British oil company, opened an oil province targeting 1 billion barrels before the end 2014. ("President Energy Targets 1 Billion Barrels to Open Up Paraguay" Bloomberg). Access to natural gas and the withdrawal of oil could have large impacts on the future use and availability of energy in Paraguay. No one interviewed used any fuel sources not previously discussed.

Oven and Stove Use. Cultural traditional preferences continue to dictate a combination stove and oven brick structure. This widely used structure heats the oven every time the stove is used. When the oven is not used, this is wasteful. The same is true if only the oven is used and not the stove. For efficiency reasons, the preference only makes sense if both the oven and stove are used at the same time. For that reason, this study determined the actual frequency of use of the oven. If the oven part is rarely used, for example, could an improved design be introduced to replace the traditional model? Could another mode be used for baking purposes? Based on my experiences, families that used biomass used it daily with a stove. Since daily stove use was a given, and oven use was much less prevalent, frequency of stove use was not relevant for this study. The study results indicate that oven use was greater with fuelwood in rural settings, in comparison to towns and cities (Fig. 32).

Electric ovens were used more in towns and cities in comparison to rural settings. Specifying between electric devices and their uses was very difficult because of the wide array of available options and levels of quality. Examples include a one burner electric stove, a two burner electric stove, an electric oven, an electric oven and stove top, and a built-in multiple electric stove. Gas oven use was low and similar in all settings. Also the structures tended to be similar throughout all locations: a four-burner stove and oven connected to a LPG tank (Fig. 31). Nonetheless, if gas was used, it was used primarily for the stove.

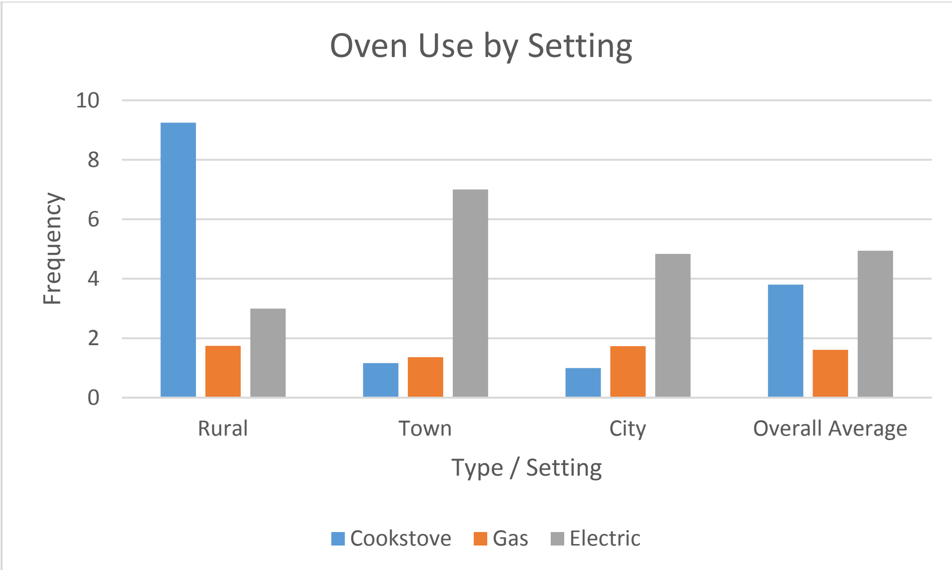


Fig. 32. Oven use per month by type and setting

Cost Comparison

It was necessary to find the initial cost of the structure to have an idea of the total cost of cooking. I used the conversion rate of 4,500 Guaraní's to US $1. The exchange rate fluctuated around this rate during the time of the interviews. The prices were estimations made by participants, and some were purchased many years in the past. Labor and materials were included in costs of structures for a valid comparison to purchased devices. In addition, types within each form varied widely. For example, the charcoal brazier ranged greatly in price between the one-pot and large barbeque style models. For the purposes of this study, fuel expenditure was the concern, and therefore, pricing each model of each fuel type was unnecessary. Respondents were not subdivided into socioeconomic classes because purchased items were similar. Open fire cooking was not included because it had little to no initial cost. The average cost of each item was approximately (Fig. 33):

US $100 for cookstoves
US $28 for braziers
US $152 for electric models
US $126 for gas models

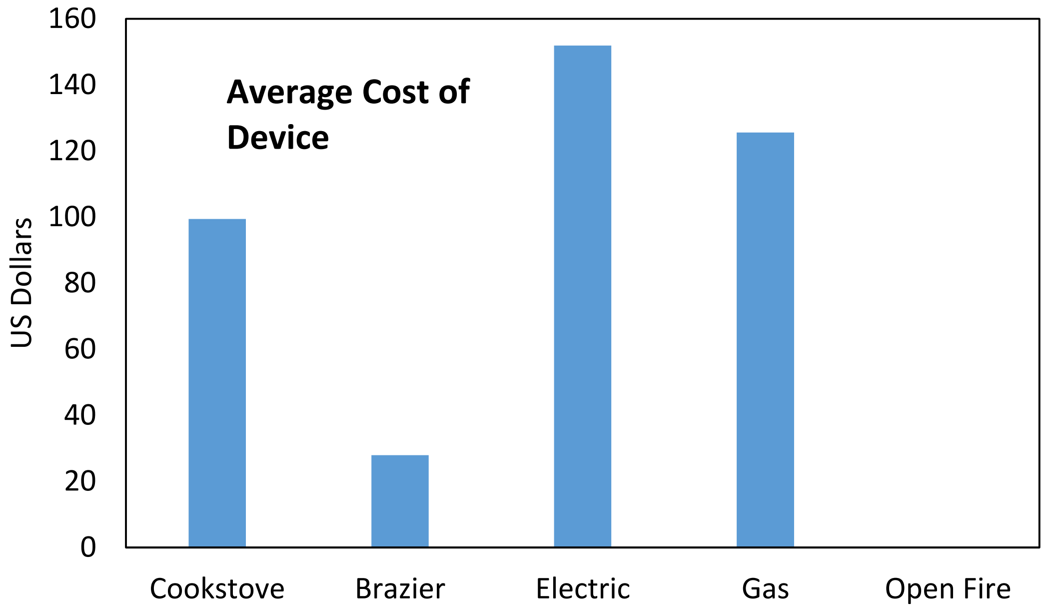


Fig. 33. Average initial price of cooking structures.

Average fuel cost per month when divided into structure and socioeconomic class reveals further components of cooking practices (Fig. 34). Rural areas spent less on fuel, except wood, than town and city respondents.

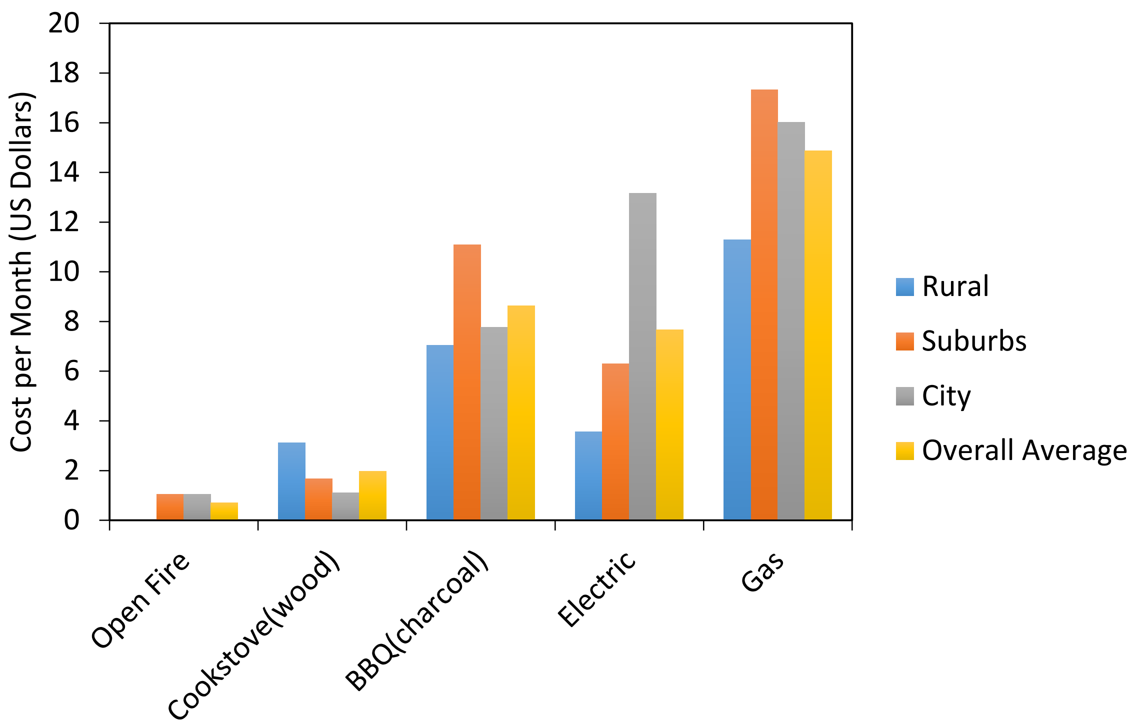


Fig. 34. Average fuel cost per month by setting and type.

Combining the fuel cost per month to the initial cost provides a reasonable estimate of the overall cost of cooking for each fuel type (Fig. 35). The costs strictly entail monetary expenditures and do not include labor or future adverse costs, especially evident with wood and charcoal. Oddly, while claiming electricity was more expensive, in reality, charcoal was more expensive (except for in city areas). In rural areas, the price for electricity is comparable to that of purchased fuelwood.

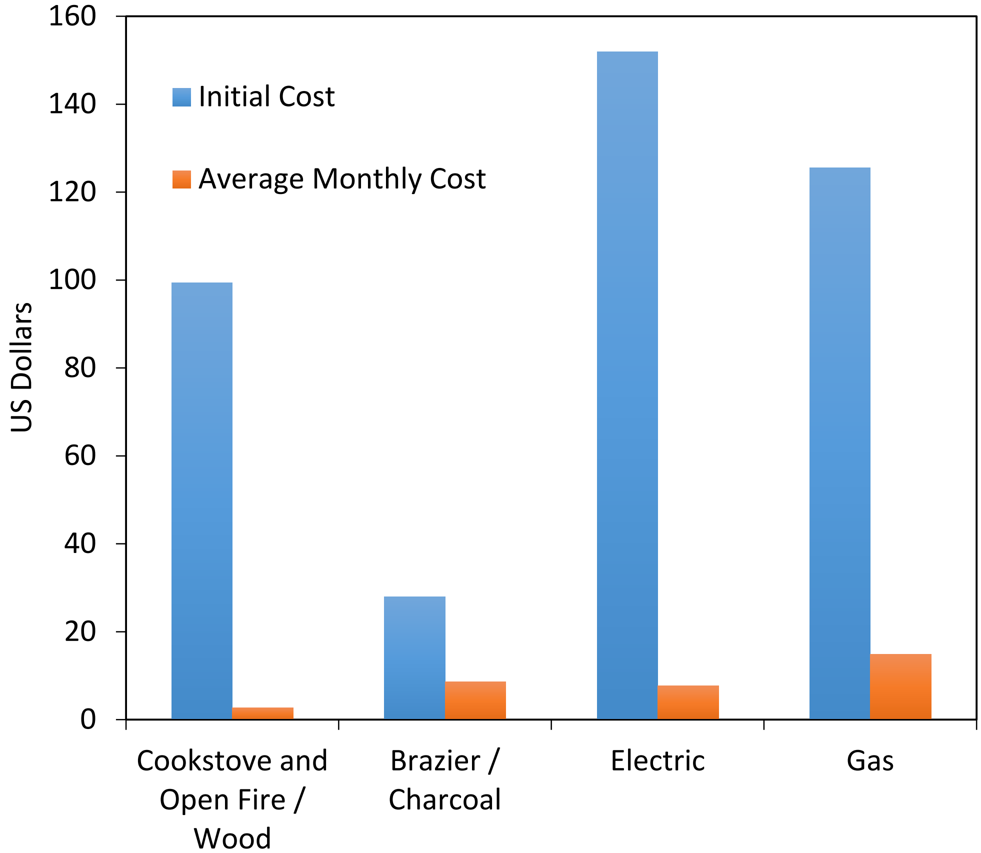


Fig. 35. Average Initial Cost and Average Monthly Cost by Structure and Fuel Type

Cooking as a heating source

During cold temperatures, people congregated around the cooking structure to keep warm. Additionally, they consumed higher quantities of hot foods and beverages. Based on responses, I tabulated seasonal fuel use as: no change, increases, or decreases. Overall, there were 23 claims of more fuel use in winter versus 12 claiming no change (Fig. 36). Charcoal use increased dramatically during winter for heating purposes. This practice is extremely dangerous because of increased exposure to particulate matter, carbon monoxide, sulfur dioxide, and/or nitrogen dioxide, and benzene (Olsson and Petersson 2003). Similar practices kill many throughout the world (Eckardt 2011, Lyness 2011). Traditional charcoal stoves use about the same amount as energy as an open fire stove to complete a task (not counting the energy lost in making charcoal, which can reach 70%), but produce up to two times more carbon monoxide and 80% less PM (MacCarty *et al*. 2010). Using these devices, therefore, not only risks death or adverse health effects, but also reinforces bad habits. If and when households in Paraguay become better insulated and less ventilated, the continued indoor charcoal use will have serious consequences.

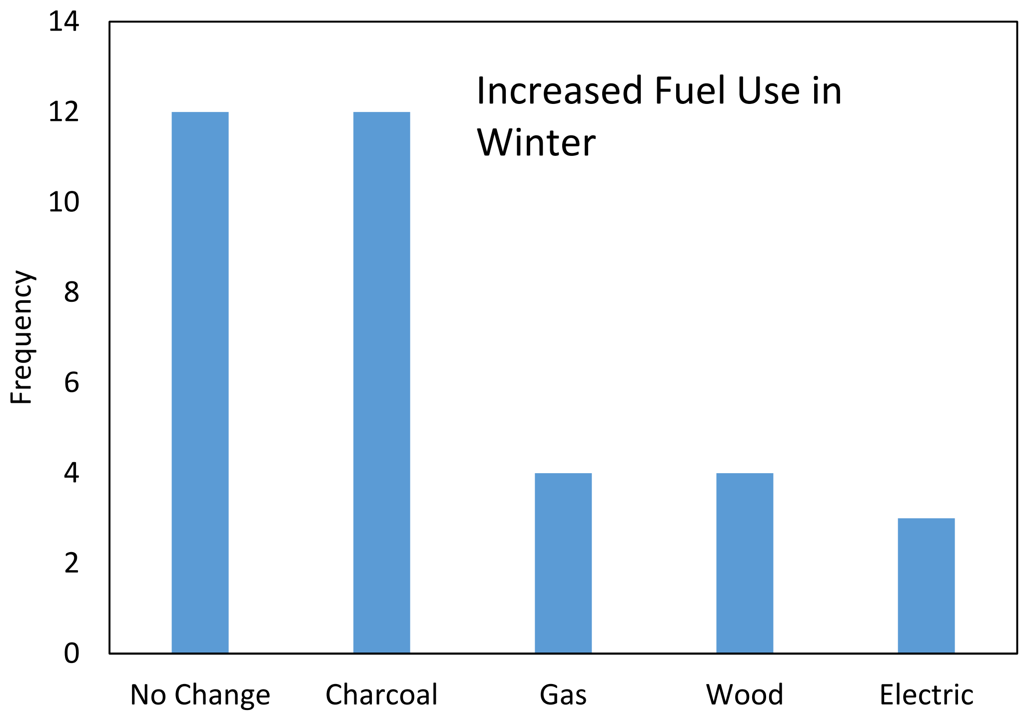


Fig. 36. Increased Fuel Use in winter by fuel type

Fuel perceptions

In order to find out respondents' perceptions of fuel, participants were asked three questions (Fig 37):

Is there was a fuel shortage (for any and/or all resources)?
Are resources diminishing, increasing, or relatively the same?
Are prices increasing, decreasing, or relatively the same?

Many respondents mixed answers to this question, claiming different perceptions for different fuel types. For example, if a respondent claimed that the price of wood and gas were increasing, but electricity was not, the data was entered as an increase in frequency for wood and gas, and no entry for electricity. No respondents claimed prices of fuel were decreasing for all fuel types. Also, no respondents claimed fuel resources were increasing.

When asked about a fuel shortage the most common answers were none and gas, followed by wood. One third of the respondents lived in close proximity to Argentina relying on the import of gas (B locations). This skewed the results slightly. A perceived diminishing of fuel was seen highest in wood, followed by none and charcoal. A price increase was mentioned with all fuels, followed specifically by gas. The overall results indicate that an immediate fuel shortage does not exist, but that there is an acknowledgement of diminishing fuels and an increase in price.

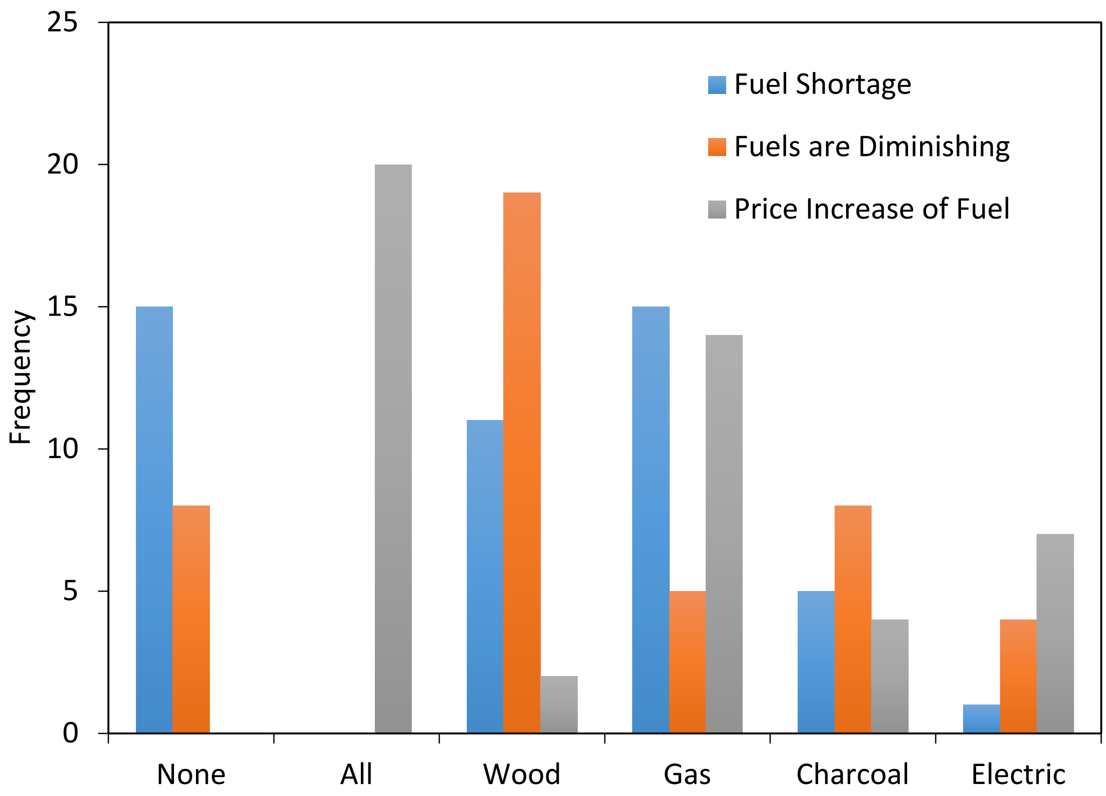


Fig. 37. Fuel perceptions by fuel type

Based on my experience, fuel perceptions were very difficult to generalize in Paraguay. Some responded regarding their household situation, others to the community, and others to the nation of Paraguay. For example, households with ample woodland had contrary opinions to wood availability and price than did their neighbors with little woodland. In my two plus years in country, I did see a noticeable decrease is woodland in and around my community. This was mostly due to brick and charcoal making. Households without available land had to travel farther and farther (or hire someone) to collect fuelwood as a result. On the other hand, some households planted trees for future use. Nonetheless, historic availability of land relative to population may have inhibited the idea of limitations of resources. I did get a sense of woodland viewed as an inexhaustible resource. And no matter the thoughts about charcoal, households will continue to use it on a weekly basis as cultural practices dictate.

In the last ten years, electricity access has reached far and wide in Paraguay. Yet this actual inexhaustible resource has faced difficulty in widespread adoption, because of a perceived high monthly cost (anything is more than not paying for wood), and an initial device cost. Rolling blackouts are also a point of contention with many households. Though high in frequency, duration is usually short (a few hours or less). Therefore, outages were more of an annoyance than a major risk when cooking using electricity.

LPG availability and price were dependent on import issues from Argentina, and local tank availability. Gas was not viewed as hard to get, but viewed as an annoyance when the tank ran low.

Preferences

Participants were asked questions about each device they used:

> Does your cooking method work well?
> Do you like it?
> What problems have you or do you have with it?

Overwhelmingly, these questions were not effective in gathering accurate responses. Participants tended to respond "yes, yes, and no". When they spoke openly about their cooking practices or about other issues did possible problems or cooking practices present themselves. For example, one participant claimed she cooked well with an open fire, that she liked it, and that there were no problems. She then remarked about problems with smoke in her eyes, the discomfort of bending over to cook, and the annoyance of finding good pieces of wood.

I believe the disconnect between responses and actual beliefs stem from the desire to answer the questions in the simplest and quickest way. They did not want to directly analyze or interpret their lifelong cooking practices. Because of this problem I did not include this data for each device, but did take note of relevant responses and have included them accordingly throughout the text.

The case study determined what fuel type households preferred to use, subdivided by socioeconomic area (Fig. 38), by asking the following question:

> Would you prefer to use a different cooking method?
> If so, what and why?

The question was asked for each device; however, respondents chose their overall favorite cooking method for simplification. A subdivision for each device was complicated because 'cooking' comprised too many forms of cooking. For example favorites differed: cooking meat with charcoal, heating milk with gas, baking with electricity, or cooking yucca with wood. Therefore, participants chose a universal favorite. Overall, gas was most liked, followed by wood, electricity, and charcoal. However, not a single respondent preferred wood in city settings. Electricity was preferred much more in city settings than in rural and town settings. Charcoal was not highly preferred in any of the three settings, perhaps because women were the predominant respondents, which may discount the apparent male preference for outdoor charcoal grilling.

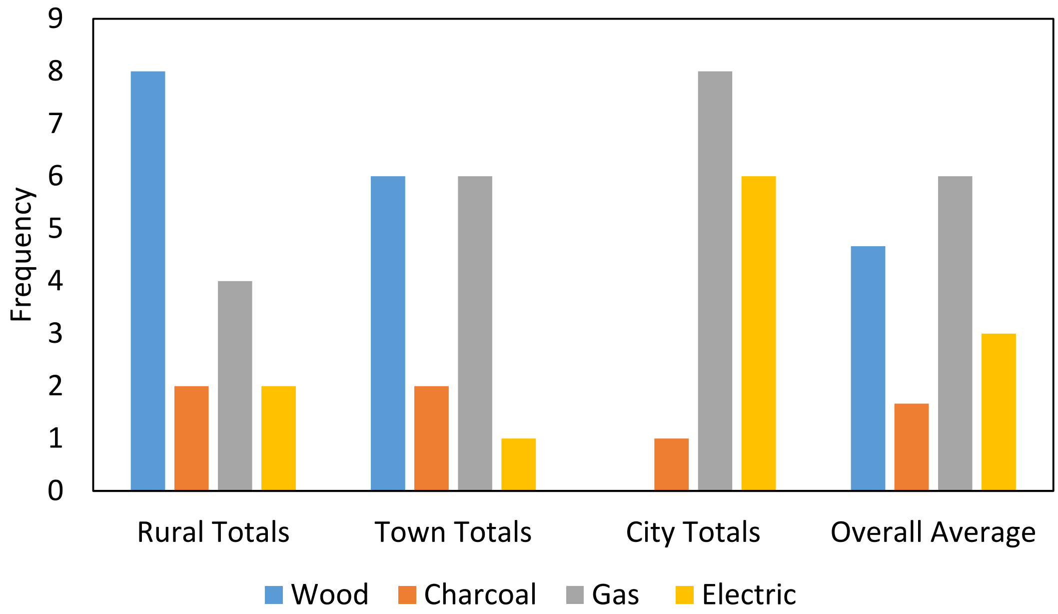


Fig. 38. Fuel Use Preferences

Analysis of 10 Criteria

To discover which criteria of cooking were more important than others, a ranking system of 10 attributes was created, and each participant was asked to rank them in importance: 1 – 10, most to least important. The rankings follow: fuel efficiency; taste of food; length of cooking time, minimal air contamination, minimal fire risk (house); ease of use; minimal burn risk; price; durability/longevity of structure; and household heating (Fig. 39).

No clear differentiation exists among the 10 criteria except for a stronger preference for fuel efficiency and a lesser preference for household heating. The lesser preference for 'household heating' is understandable because a Paraguayan winter is less than one month. For most of the year, no central heating is needed (none exists). No obvious preferences can be established of the other eight factors. Also, participants offered additional criteria of cleanliness and hygiene as a factor.

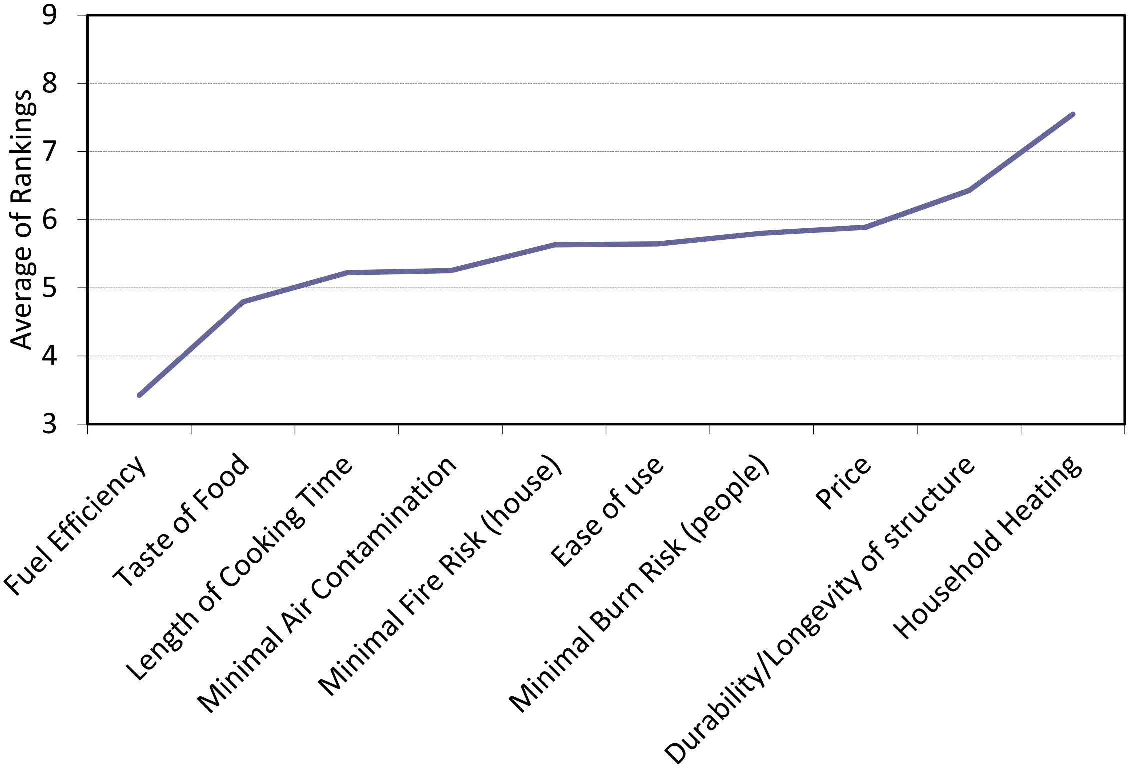


Fig 39. Overall Ranking of Cooking Attributes. 1-10, most to least important.

"Gas is dirty. I cook milk and it boils over on the stove. Hard to clean."

"When I cook with fire, my pots get dirty."

"My clothes smell like smoke. I don't like it."

The inclusion in future assessment of cooking criteria, therefore, should include a category of cleanliness and hygiene. On the other hand, with the numerous cooking criteria categories, ranking them may have been cumbersome or too difficult.

When socioeconomic settings are subdivided, variation is evident within the ranking of cooking criteria (Fig. 40 and 41). In rural area responses, taste of food, durability/longevity of structure, and household heating was thought to be more important than in town and city settings.

"Barbeque [with meat] is only good with charcoal."

"Food doesn't taste good if I cook with gas."

"I don't like the taste of food. Firewood is no good."

Rural houses tended to have less insulation (often plywood boards open to the outside), compelling the use of an inside heat source. The structure they cooked on, tended to breakdown or work improperly after a short time.

> "*The chimney doesn't work right. It's been two years [since construction].*"

> "*The stove top [plancha] broke. Too hot.*"

Rural areas clearly used devices with higher fire and burn risk, and difficulty of use. Ironically, their responses indicated less importance of these categories.

Town and city responses were similar except for length of cooking time, and minimal air contamination and minimal fire risk. In cities, minimal air contamination was more important and fire risk less important. Perhaps in cities, where respondents rarely used biomass, they were better informed on the dangers of air contamination. Or, maybe they were commending their own cooking choices preventing air contamination. Fire risk was acknowledged as a factor more so in town perhaps due to the higher density of people and material and continued use of riskier cooking devices. Unusually, participants from town and city settings often worked jobs outside the house and proclaimed insufficient time to cook. The ranking, however, shows no indication.

> "*I have no time to cook.*"

> "*I work all day. No cooking.*"

Other criteria subdivided between rural, town, and city settings were similar.

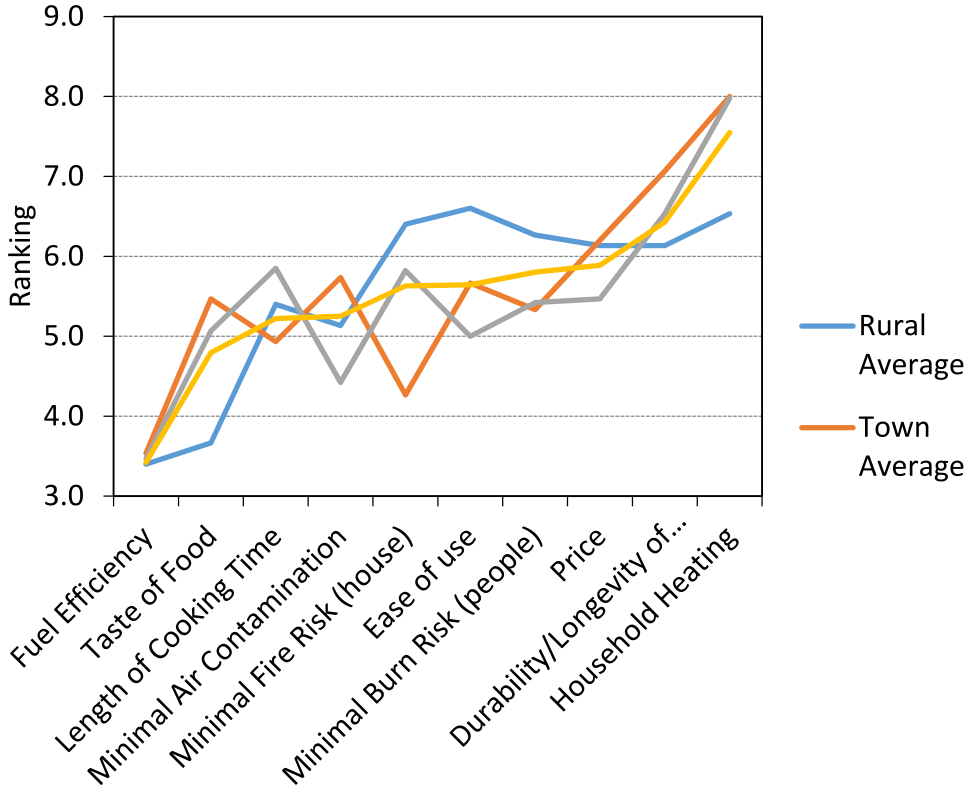


Fig. 40. Ranking subdivided by socioeconomic area. 1-10, most to least important.

	Rural Average	Town Average	City Average	Overall Average
Fuel Efficiency	3.4	3.5	3.5	3.5
Minimal Air Contamination	5.1	5.7	4.4	5.1
Minimal Burn Risk (people)	6.3	5.3	5.4	5.7
Minimal Fire Risk (house)	6.4	4.3	5.8	5.5
Household Heating	6.5	8.0	8.0	7.5
Taste of Food	3.7	5.5	5.1	4.7
Price	6.1	6.2	5.5	5.9
Durability/Longevity of structure	6.1	7.1	6.5	6.6
Ease of use	6.6	5.7	5.0	5.8
Length of Cooking Time	5.4	4.9	5.9	5.4

Fig. 41. Subdivided Ranking by socioeconomic area. 1 to 10, most to least important

Determining the weighted preference for each cooking attribute as opposed to a ranking provides a more accurate analysis of the data. Simply ranking the values gives relative importance but does not give the absolute importance of each attribute to another. For example, the difference between the second and third attribute can be great in weighted analysis, but not evident when simply ranked. To find relative importance, I assigned a value of three, two, and one to each attribute chosen to be first, second, or third in importance, respectively. If, for example every (45 households) participant chose the same attribute to be first, it would be valued at a maximum of (45*3) 135. Fuel efficiency was by far the most important; followed by minimal air contamination, taste of food, and length of cooking (Fig. 42). The other attributes were viewed similarly at low levels of importance. Therefore, after weighing the preferences, the differences between the lowest six attributes are relatively small. Ranking them in order, as a result, does not convey a sense of importance.

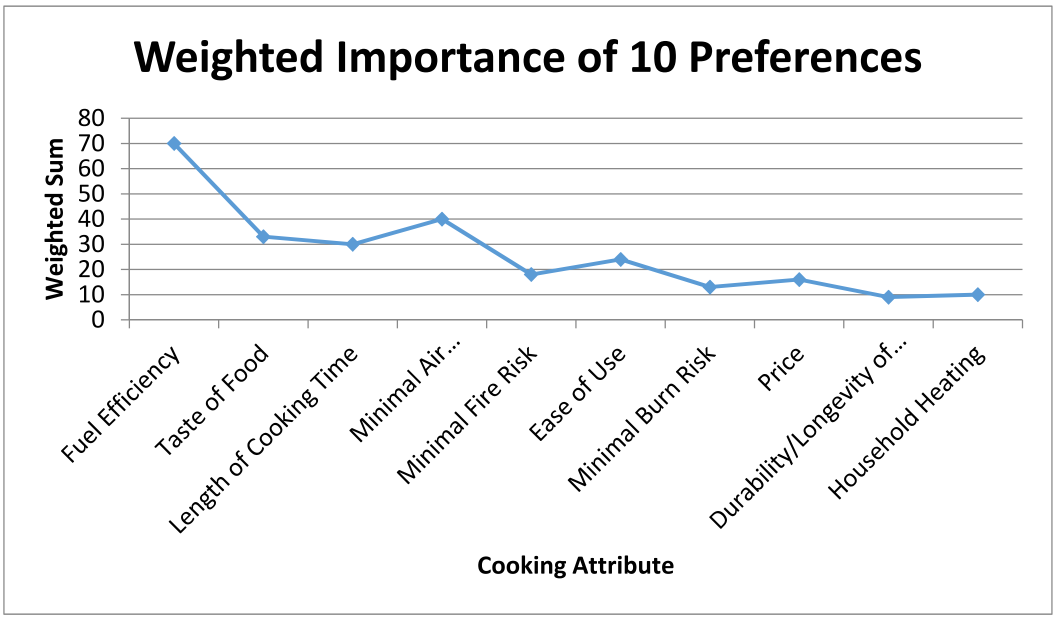


Fig. 42. Weighted Importance of 10 Attributes.

Important differences exist when comparing weighted values to ranking values (Fig. 43). First, fuel efficiency is viewed as far more important in weighted values than in ranked values. Second, minimal air contamination was seen as second most important in weighted analysis, but fourth in when ranked. This means that some highly valued minimizing air contamination, and others did not. The average values for ranking do not show the high level of differences between households. Finally, the categories of fuel efficiency, minimal air contamination, length of cooking time, and taste of food were valued relatively higher than the other six categories when given weighted values. Therefore, to help maximize adoption and diffusion of improved cookstoves, cookstove design and promotion should focus on the elements of fuel efficiency (especially), minimal air contamination, taste of food, and length of cooking time. While other values are important and should not be ignored, their relative promotion may not deserve equal observation. Conversely, fuel efficiency was viewed as the most important cooking attribute, but many respondents acted in direct opposition of their views. For example, many desired a traditional *fogon* instead of improved options. Based on my experience, this was due to traditional customs and cultural expectations. Perhaps a wood burning highly efficient cookstove is not desired if the model is perceived as ‘odd’. Many simply liked the traditional model because it met expectations, it is what contractors knew, and other models were seen as ‘weird’. Determining respondents’ views surrounding aesthetics may have provided further insights into cooking practices.

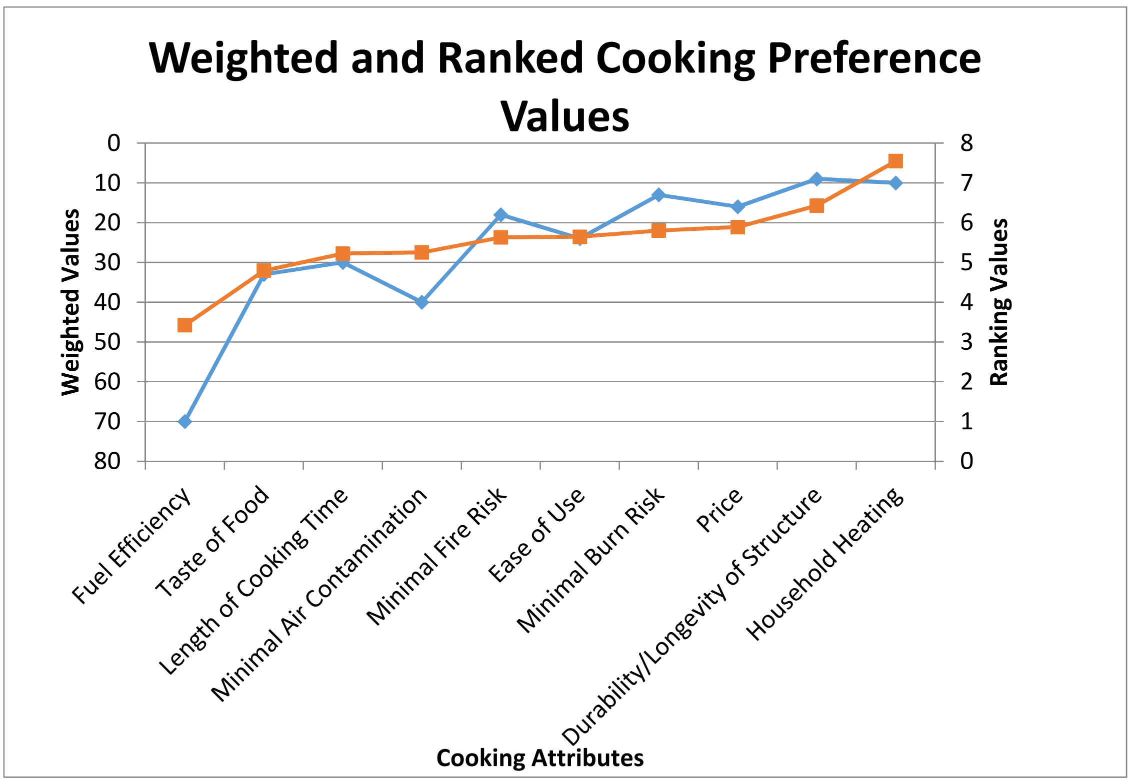


Fig. 43. Weighted and Ranked Cooking Preference Values.

Chap. 4: Recommendations and Conclusions

Promotion Strategies

Clearly, improving existing cooking practices in Paraguay is a worthwhile goal. Such improvement requires education, assessment, training, follow-up extension, an appropriate (culturally and technically) stove design, and contribution to the project. Cultural sensitivity dictates a respect for traditions; hence, pace of change may be slow.

Education. Awareness of poor cooking practices must be early and widespread. When using biomass, knowing why smoke makes women feel bad or why children suffer from respiratory illness is essential. Having an abstract idea about smoke being “bad” is not enough. There must be direct acknowledgement that soot buildup, hanging from the ceiling after years of cooking, can also buildup within womens’ lungs. That smoke from plastic is cancer causing. That using charcoal inside houses is poisonous.

A simple explanation clarifying efficient stove principles in conjunction with health hazard information must be widely emphasized. Long-term hazards must also be recognized. Trees may be abundant and seemingly cost free in the short term, yet long term costs are significant. How does the cost to health of daily smoke exposure compare to the monetary cost of using an improved cooking device? Perhaps addressing factors beyond the next day, month, or crop season will influence short-term choices.

Assessment. Cooking practices can vary widely across settings and even between neighbors. Though difficult, regional differences (ideally familial) should be evaluated. One household, for example, desired and received materials for a new cookstove. However, they had no ‘room’ to build it in. They could not construct the structure until there was cover because rain would cause destruction. Months passed without construction of a kitchen room, and therefore no improved cookstove was built. In retrospect, without an area for the stove, no materials should have been given.

If a family prefers wood, do they have access to it? Do they have land for sustainable firewood production? If so, will they plant trees? Do they have animals, such as pigs, requiring the additional cooking of large quantities of food? How often do they use the oven and with what device? Assessing overall cooking practices must be determined prior to implementing a project.

Training. When teaching participants, I often found most, if not all, would nod and smile in agreement and understanding. They were not entirely truthful in the literal sense. Therefore, training must accompany education and observation of developing cooking practices. The importance of proper maintenance as well as efficiency of multi-pot cooking would be part of this education. Any cookstove construction should be built with local contractors who have been guided and respected through the process.

A Paraguayan counterpart should complete technical training. Guidance from and teaching by a country national dispels the idea that the improved technology is external and non-Paraguayan. A counterpart helps not only improve culture or language barriers, but more importantly puts power in the hands of the people of Paraguay.

Follow-up Extension. Initial enthusiasm can wane into a reversion to traditional habits. Hence, follow-up visits are recommended to better assess effective long-term use, and respond to questions and concerns. Required maintenance can be reviewed and performed. Again, a Paraguayan counterpart would be most effective in a follow-up visit.

Appropriate Design. The current preference of the traditional brick stove and oven combination requires replacement with a better alternative. The traditional model is costly, large, and ineffective and unhealthy after a short time - without proper maintenance. However, cultural preferences currently have an aversion to more efficient options such as the 'rocket stove' (Fig. 44). However, a multiple pot variation of the 'rocket stove' design could be a viable option (Fig. 45). The oven should not be included in the same structure as the stove. For better adoption, some design changes would be necessary. For example, the stove would have to be raised from the ground to prevent dangers from the fire to children, and from marauding animals. Additionally, the design should be augmented to include a variation in pot sizes to account for the cooking of yucca and animal food.

Many of these changes may not be directly related to improvements in health, environmental, and living conditions; however, they are recommended because they will increase rates of adoption and diffusion. If, for example, respondents desire a large brick structure; design an efficient model that has big large aesthetic features, that are separate from the cooking process. The nominal increase in initial monetary price is well worth the benefits from regular cookstove use.

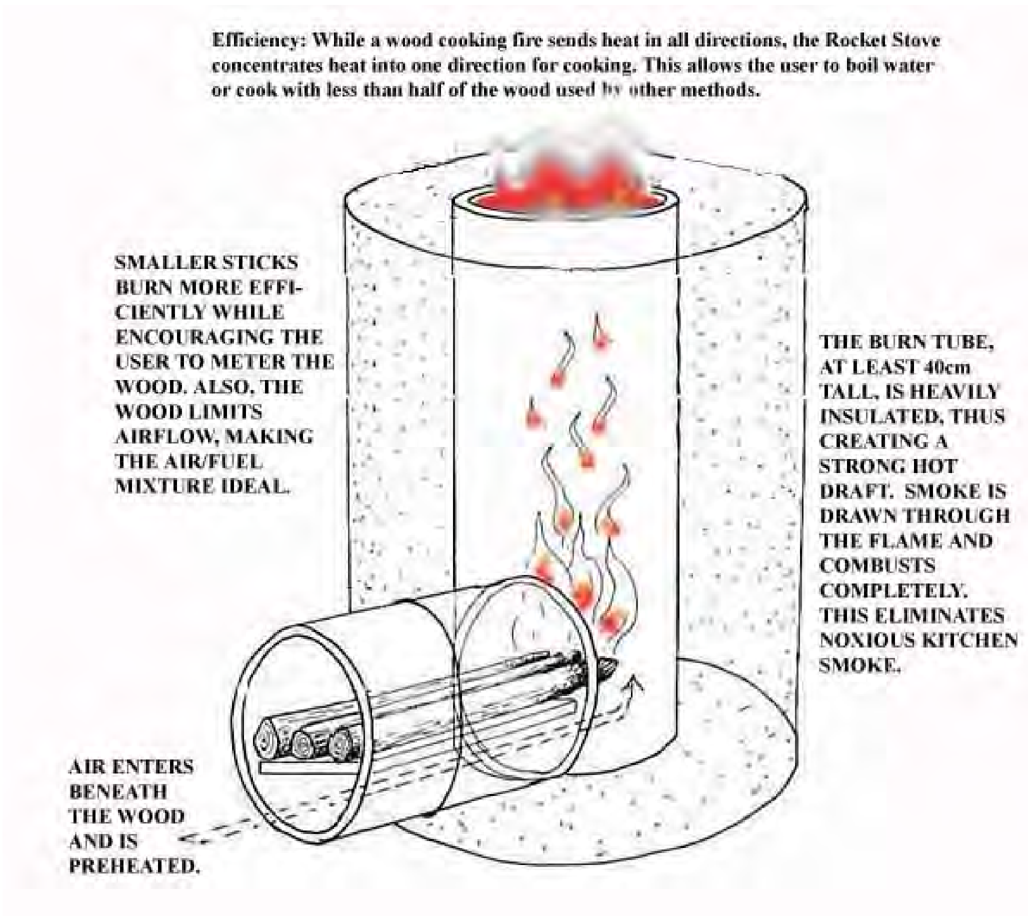


Fig. 44. ‘Rocket Stove’ design. http://www.emeraldmine.com/rocketstove.htm

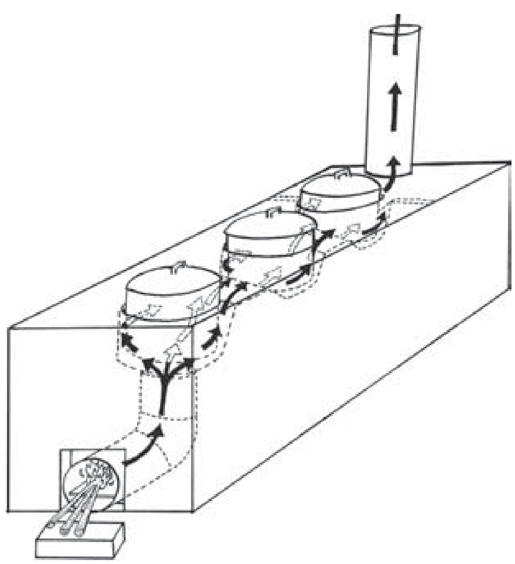


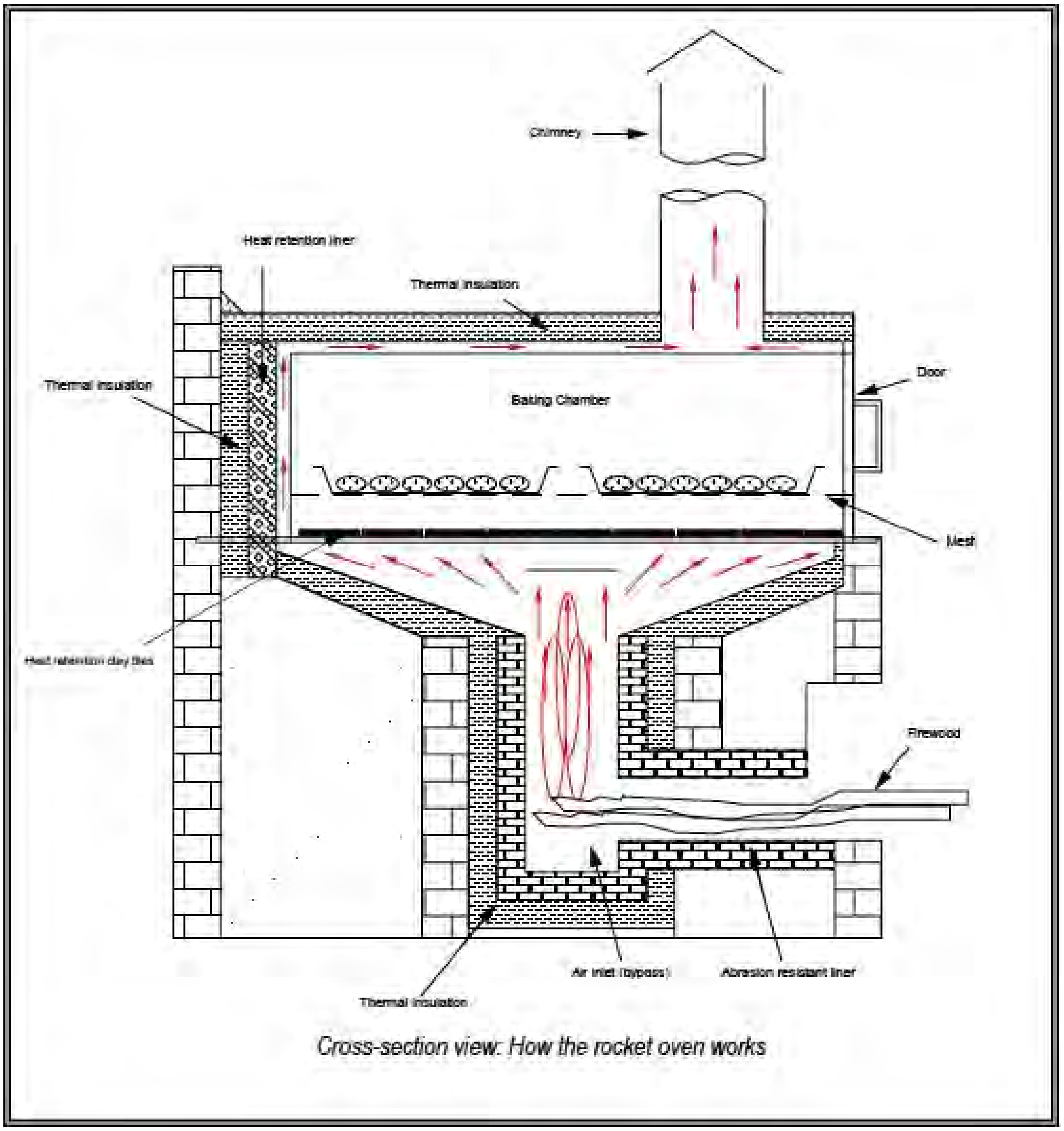
Fig. 45. Multi-pot ‘rocket stove’. http://www.aprovecho.org/lab/rad/rl/stove-design/category/1

Community / Household Contribution. To guarantee a sense of ownership in an improved cookstove project, the household or community must be invested. 100% gifting of project parts should never be done. I was often asked “Johnny, what will you give us?” Many expected me, the foreigner, to provide them with objects or money without their own contribution. I had to explain that I was not in the community bearing gifts, but to help facilitate improvements. Often, this conversation and subsequent understanding was a difficult process.

Contributions may be monetary, through labor, material contributions, or community and/or household projects. Peace Corps Paraguay and other developmental organizations required a 10% contribution. I believe this contribution percentage can be increased due to the flexibility of the contribution process. Examples are numerous. The local contractor can be paid by households to build improved cookstoves (after training), thereby providing labor and a new technology as well as placing a monetary value of the product. Households or communities could create nurseries and plant trees for sustainable fuelwood. Community groups could organize fundraisers to raise money for materials.

Tatakuaa and Oven Improvements

The large brick oven structure (*tatakuaa*) should be replaced with an improved design (Fig. 46). The *tatakuaa* is largely ceremonial and directly associated with family gatherings and holiday seasons. Because of this, adoption may be slow moving. However, the improved structure should be promoted for use as both a replacement for the traditional oven and the *tatakuaa*. The size of this new structure should be larger than the original oven metal box but smaller than the *tatakuaa*. This would be acceptable because the traditional oven is generally used with greater frequency than the *tatakuaa*. Thus, cooking more frequently with a more efficient alternative would offset the added time from infrequent cooking of large amounts of baked cornbread items.



Cross-section view: How the rocket oven works

Fig. 46. 'Rocket Stove' Oven. http://farmhack.net/node/253/revisions/455/view

An efficient charcoal structure can be utilized with augmentation to the 'rocket stove' design for fuelwood (Fig. 47). This would be especially beneficial when charcoal is used indoors with the one-pot option, because of reduced levels of carbon monoxide (However, in a best-case scenario, charcoal would never be used in areas with poor ventilation). Additionally, the improved structure would increase efficiency for both the one-pot option and large grilling structures (Still 2006). A rocket-type charcoal stove can reduce energy consumption by one-third and CO emissions by at least one half (MacCarty *et al*. 2010).

Fig. 47. Redesigned ‘rocket stove’ for charcoal. Close fuel entrance. Add charcoal underneath grate and chimney. http://www.aprovecho.org/lab/rad/rl/charcoal-stoves/category/34

Because of their perceived cleanliness and speed, gas stove designs without ovens should be promoted. A cheaper reduced initial price would be the result. Average monthly costs would still be greater than other fuel devices, but perhaps newer models would have higher efficiency and ease of use than the gas oven and stove combination. A gas gauge should also be introduced for tank level awareness.

Actual electricity use and cost should be determined for comparison with perceived use and cost. Is it slower than gas and fuelwood? What are the relative costs of oven and stove use? More importantly, the findings must be conveyed to users in an understandable way. If they continue to view electricity as prohibitively expensive, when in fact it is not, users will not adopt the electricity. In Paraguay, electricity access is widespread, and the resource is sustainable. Future use is the best long-term option, if both device cost and monthly price can be attained, and service reliable.

Challenges

The challenges of improving cooking practices are numerous, namely: cost, availability of outside materials, maintenance, and cultural barriers.

Cost. Three factors influence cost: the initial device cost, monthly expenditures, and the additional external costs of the fuel type. Household must believe in benefits if they are to convert from open fire cooking with no initial monetary cost to an improved option. Households are concerned with perceived monthly costs. For example, they may think electricity is expensive because the bill is infrequent and bundled with other appliances. Charcoal is perceived as less expensive because it is purchased more frequently in small quantities. In reality, the monthly cost of charcoal can exceed the price of electricity without recognition. Perceptions also dictate current fuel use. The present-day 'free' wood does not account for future availability, time lost in collection, or adverse effects from deforestation. Though monetarily free in the short term, the outlook is not sustainable. The challenges of cost are all associated with sacrificing a short-term monetary loss for an overall long-term gain.

Availability of Outside Materials. The initial traditional cookstove price is high (~US$100) relative to the price of potential improved alternatives. Yet, the availability of materials inhibits this potential. Distribution of improved cookstoves must be tied to local availability of materials. Without the availability, local contractors cannot be involved, and the adoption will be associated with an outside reliance on improvement. This is not sustainable.

Maintenance. Maximizing longevity of the structure is crucial to improving cooking practices. Therefore, structure maintenance should be simple. Participants should be educated, trained, and be able to obtain materials to perform any necessary repairs. Fuel savings in Peru study were found to be highly dependent on the level of stove maintenance and user training (Johnson *et al*. 2013). Perhaps a less efficient cookstove with easier maintenance is preferable to a more efficient more complicated option.

Cultural Barriers. The improved option must be accepted. Availability of a cheap and efficient cookstove is meaningless if households neither want nor use it. Therefore, cultural practices must be assessed prior to implementation. This could prove difficult if traditional practices are in direct conflict with improved options. In the case of Paraguay, the *tatakuaa* (large brick oven) and the *fogon* (brick stove) are both desired for traditional reasons. The adoption, as a result, will prove arduous.

Stove Design Criteria

The stove design must improve cooking efficiency, reduce emissions, and meet cultural preferences. Because efficiency and emissions are very sensitive to combustion chamber shape, material, chimney height, chimney diameter, and cook piece placements the design construction must adhere to strict guidelines (Agendroad *et al* 2011). Stoves that use small mass components take less time to boil, have better fuel efficiency, and lower pollutant emissions (Jetter and Kariher 2009). Yet, stoves that use small-mass components must be durable, affordable and meet user needs. Aprovecho Research Center states the Ten Design Principles for Wood Burning Stoves are:

1) Insulate around the fire using lightweight, heat-resistant materials.
2) Place an insulated short chimney right above the fire to burn up the smoke and speed up the draft.
3) Heat and burn the tips of the sticks as they enter the fire to make flame, not smoke.
4) High and low heat are created by how many sticks are pushed into the fire.
5) Maintain a good fast draft from under the fire, up through the coals. Avoid allowing too much extra air in above the fire to cool it.
6) Too little draft being pulled into the fire will result in smoke and excess charcoal.
7) Keep unrestricted airflow by maintaining constant cross sectional area through the stove. The opening into the fire, the size of the spaces within the stove through which hot air flows, and the chimney should all be about the same size.
8) Use a grate under the fire.
9) Insulate the heat flow path, from the fire, to and around the pot(s) or griddle
10) Minimize heat transfer to the pot with properly sized gaps.

Obviously, meeting all ten principles may not be possible for a widely adopted cookstove design. Meeting at least some principles will be an improvement to cooking over an open fire. Perhaps after assessing certain cultural and price limitations, a design can be augmented to meet as many principles as possible and be adopted.

Paraguay and Global Context

Cooking practices in Paraguay illustrate how differences within a country are influenced by factors such as geography, socioeconomic area, and cultural traditions. When designing improved cookstoves, it is important to note that these factors must be addressed. For example, some claimed to dislike the 'rocket stove' design because it was low to the ground - bringing about back pain, and a potential source of danger to children - necessitating design improvements. A desire for the traditional model stemmed from more than cookstove function. The model was historically viewed as 'normal'. The model represented a status symbol that expressed a step-up socially, and amongst neighbors. Other wood burning models were difficult to introduce because they did not have this same sense of normalcy or social respectability.

Proximity to Argentina and lack of available fuelwood were factors increasing gas usage in the B region of the study. Households were heavily influenced by the Argentine economy and poor road conditions linking communities to outside resources. The households were different in their cooking practices compared with other Paraguayan communities because of these factors.

The rapid population and urban growth will require more, as well as alter resource use. Continued wood scarcity could mean a promotion of electricity usage instead of an improved fuelwood cookstove if fuelwood access is minimized, and prices continue to increase. The aforementioned variation in fuel type use in Paraguay should be recognized when determining policies of improved cooking practices.

Future Questions and Research

This study was limited because of the low number of participants. With additional subjects, more detailed quantitative analysis through inferential statistics could be obtained. Additionally, to better understand total cooking costs, the initial cost and duration of ownership of each type of device should be subdivided further. Within each device type, the device lifetime and price varied widely. By knowing the combination of the initial price, length of ownership, and the monthly cost, a true idea of monetary cost can be obtained.

To better assess cooking criteria preferences, the categories could be reduced to fewer options to decrease confusion and difficulties in ranking too many choices. To reduce number of attributes, respondents could be asked to choose their top five or three choices. After determining these top choices, the question could be reduced to those fewer options, and taken to a higher frequency of respondents to achieve a reliable, statistically relevant result. Additionally, instead of ranking the values between each other, attributes could either be ranked as important or not important, or more thoroughly on a scale of importance from one through seven. By valuing attributes in this way, independent importance can be seen instead of relative importance.

Future questions on cooking practices are numerous: can cultural preferences such as the use of large wood pieces; traditional *fogons* and *tatakuaas*; and open fire cooking be altered? What design model can be created and adopted in Paraguay? What is the future of electricity acceptability and cost? What is the future of smallholder access to fuelwood? Will the knowledge of the many risks bring significant change? Addressing these questions is critical to determining a more in depth understanding of cooking practices in Paraguay.

My time in Paraguay conveyed a deep sense of cultural understanding. The people sincerely desired living improvements. My hope is that the desire for improvements will incorporate healthy cooking practices. To achieve any improvements requires capacity building on the local level, minimizing the expectation for outside rescuing. True improvement requires a delicate balance – openness and receptivity of the local communities combined with a sensitivity and cultural awareness of well intentioned outside agencies.

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Appendix

Cooking Practices Survey
English, Spanish, and Guarani

Survey
Peace Corps – Paraguay
Johnny Bruce, Environmental Conservation Volunteer 2011-2013
University of Washington, Master's International in Forest Resources

Survey
Encuesta
Analysis of Cooking Practices and Subsequent Reasoning
Análisis de las Prácticas de Cocina y Razonamiento Posterior

Date and Time:
Fecha y Hora:

Name of City/town and Department:
Nombre de la Ciudad/Pueblo y Departamento:

<u>FAMILY / HOUSEHOLD</u>
<u>FAMILIA/HOGAR</u>

How many members live in household?
¿Cuántos miembros viven en la casa?
Mboy pa peiko pende rogape?

What are their age and gender?
¿Cuáles son sus edades y géneros?
Mba´e aveguapa? Mbovy kuña ha kuimba´e?
How many hectares of land do you own?
¿Cuántas hectáreas de tierra poseen?
Mboy hectarea oreko nde yvy?

Approximately how much is forested?
¿Aproximadamente cuanto es bosque?
Mboy pa orekogueteri kaaguy?

How much is used for firewood collection?
¿Cuánto es utilizado para la recolección de leña?
Mboypa ojepura jepe´ara?

COOKING
COCINA

Who usually cooks?
¿Quién cocina normalmente?
Mavapa o Kocina jepi?

Who else cooks? How often?
¿Quién más cocina? Cada cuánto?
Avapa o kocina avei? hetaveces?

How much time do you spend cooking per day?
¿Cuánto tiempo gastas cocinando por día?
Mbovy tiempo eipuru e kocina hagua?

Do they you usually cook inside or outside? Or both?
¿Ellos y vos normalmente cocinan afuera o adentro de la casa? O ambos?
Ekocinapa okapi tera kotype?

> If inside, is the cooking area separate from sleeping the sleeping area by a wall or door?
> Si es adentro, esta la cocina separada del dormitorio por una pared o una puerta?
> Kotyperamo pa ojesepara nde koty kehagui pared tera okere rehe?

Does the family eat where the food was prepared?
¿La familia come dónde se preparó la comida?
Pe karupa pe tembi´u ojejapohape?

Always, frequently, sometimes, never
Siempre, frecuentemente, algunas veces, nunca
Akoi / Py´yi/ sapy´ante/ Nahaniri

How does your family cook? Check all that apply
¿Cómo cocina tu familia? Marque todas las que apliquen
Mba´eichapa oñe kocina nderogape?
Ground - w/ nothing, three rock, or elevated metal grate (specify):
Suelo, sobre tres rocas o alguna parrilla de metal (especificar):
Yvype, mbohapy ita ari / tera metal ari
Brick stove/oven
Fogones
Fogon

Electricity
Electricidad (cocina, hornos electricos)
Electricidape

Charcoal brazier

Brasero con carbon vegetal
Brasero carbondive

Gas stove
Cocina a gas
Kocina a gas

Biogas
Biogás
Biogas

Other (specify):
Otro: (Especifique):
Otro:

FIREWOOD
LENA
JEPE'A

If you use firewood to cook, how often do you use it?
Si usted utiliza leña para cocinar. ¿Cada cuanto lo utiliza?
Eipururamo jepe´a mbovypa eipuru?

How is the firewood acquired?
¿Cómo obtienen la leña?
Mba´eichapa etopa jepe´a?

Does your family buy it?
¿Tu familia compra la leña?
Ejeguapa jepe´a?

If so, how often do you buy it?
Si es así. ¿Cada cuanto suelen comprar?
Ejoguaramo, mbovy vece pa ejogua?

If so, how much does it cost?
Si es así. ¿Cuánto cuesta?
Mbovyre ejogua jepe´a?

Does your family collect it?
¿Tu familia colecta leña?
Embyaty pa jepe´a?

If so, how much time is spent gathering it?
Si es así. ¿Cuánto tiempo se dedica a recogerlo?
Mboy tiempo pe embyatypa?

If so, how often do you gather it?
Si es así. ¿Con qué frecuencia recogen?
Mavapa ombyaty jepe´a?

If so, who gathers it?
Si es así. ¿Quién recoge la leña?
Kada mbovy vece embyaty?

What do you use to start your fire?
¿Qué utilizas para iniciar el fuego?
Mba´eicha pa ejatapy?

When making a fire do you prefer to use large, medium or small pieces of firewood?
Al hacer un fuego se prefiere utilizar piezas grandes, medianas o pequeñas de leña?
Ejatapyta ramo ndepa eipuru jepe´a michiva, tuichamieva tera jepe´a paguasu?

Why?
¿Porqué?
Mba´ere?

How many hours per day is the stove/oven kept burning?
¿Cuántas horas por día mantiene encendido el horno?
Mboy hora al día pa nde horno (tatakua) omba´apo?

FOR STRUCTURES
PARA LES ESTRUCTURAS

How much was the initial cost of materials?
¿Cuánto fue el costo inicial de los materiales?
Mboypa e gasta ejoguahagua material kuera?

How much was the labor cost?
¿Cuánto cuesta la mano de obra?
Mboy e gasta ejapohagua? Nde mano de obra?

How often do you use the stove?
¿Con qué frecuencia usa la hornalla?
Mboy vece pa eipuru nde kocina?

How often do you use the oven?
¿Con qué frecuencia usa el horno?
Mboy vece eipuru nde tatakua?

Do you clean the stove?
¿Se limpia la hornalla?
Emopotipa nde cocina?

If so, how often?
Si así es. ¿Con qué frecuencia?
Kada mbovy pa emopoti?

Do you have a chimney?
¿Tiene una chimenea?
Erekopa chimenea?

How high is it relative to the roof?
¿Qué tan alto es el techo?
Mba´eichapa oi nde rogatechogui?

Do you clean it?
¿Vos limpias la chimenea?
Emotipa nde chimenea?

If so, how do you clean it?
Si es así. ¿Cómo se limpia?
Mba´eichapa emopoti?

If so, how often?
Si es así. ¿Con qué frecuencia?
Mboy vece?

Do you have a large wood oven (tatakuaa)
¿Tiene un tatakua?
Erekopa tatakua?

If so, how often do you use?
Si es así. ¿Con qué frecuencia lo usas?
Kada Mboy pa eipuru?

Does your cooking method work well?
¿Su método de cocción funciona bien?
Oikoporapa nde tatakua se cocina bien la tembiu?

Do you like it?
¿Te gusta?
Nde gustapa?
What problems have you or do you have with it?
¿Qué problemas tenes usándolo?
Mba´e problema pa ereko pende método de kocina?

Would you prefer to use a different cooking method?
¿Preferiría utilizar un método de cocción diferente?
Ndepa eipurune otro método ekocina hagua?

If so, what and why?
Si es así. ¿Qué y porqué?
Mba´erepa?

ELECTRICITY
ELECTRICIDAD

How much was the stove/oven?
¿Cuánto le costó su cocina/horno?
Mboypa e gasta nde cocina rehe?

If you use electricity, how often do you use it?
Si utiliza electricidad, con qué frecuencia lo utiliza?
Eipururamo electricidape. Mbovy vece eipuru?

How often do you use the stove?
¿Cómo utiliza la cocina?
Mba´eicha eipuru la nde cocina?

How often do you use the oven?
¿Con qué frecuencia usa el horno?
Mboy vece eipuru la nde tatakua?

How much do you think it costs per month with regular use?
¿Cuánto crees que cuesta por mes con un uso regular?
Mboy e paga cada mes ipururamo?

Does it work well?
¿Funciona bien?
Oikopora la nde cocina eléctrica?
Do you like it?
¿Te gusta?
Nde gustapa?

What problems have you or do you have with it?
¿Qué problemas tenes usándolo?
Mba´e problema pa ereko pende método de kocina?

Would you prefer to use a different cooking method?
¿Prefiere utilizar un método de cocción diferente?
Ndepa eipurune otro método ekocina hagua?

If so, what and why?
Si es así. ¿Qué y porqué?
Mba´erepa?

CHARCOAL/BRAZIER
CARBON/BRASERO

If you use a brazier, how much was it?
Si utiliza un brasero. ¿Cuánto costó?
Eipururamo nde brasero. Mbovypa e gasta?

How often do you use it?
¿Con qué frecuencia se utiliza?
Mboy vece eipuru la nde brasero?

How is it acquired?
¿Dónde se puede comprar?
Moopa ejogua?

How much does a package cost?
¿Cuánto cuesta un paquete de carbón?
Mboy o vale petei paquete de carbón?

How often do you buy it?
¿Con qué frecuencia se compra?
Mboy vece ejogua la carbón?

Does it work well?
¿Funciona bien?
Oikopora la nde brasero?

Do you like it?
¿Te gusta?
Nde gustapa?

What problems have you or do you have with it?
¿Qué problemas tenes usándolo?
Mba´e problema pa ereko pende método de kocina?

Would you prefer to use a different cooking method?
¿Prefiere utilizar un método de cocción diferente?
Ndepa eipurune otro método ekocina hagua?

If so, what and why?
Si es así. ¿Qué y porqué?
Mba´erepa?

GAS
Cocina a GAS

What was the initial cost of the stove/oven?
¿Cuál fue el precio inicial de la cocina?
Mboypa e gasta ejoguahagua nde cocina?

If you use gas, how often do you use it?
Si utilizes gas, con qué frecuencia lo usas?
Eiporuramo, Mbovy vece eipuru nde gas?

How often do you use the stove?
¿Con qué frecuencia se utiliza la hornalla?
Mboy vece pa eipuru nde kocina?

How often do you use the oven?
¿Con qué frecuencia se usa el horno?
Mboy vece eipuru nde horno de cocina ?

How much is it to fill up a tank?
¿Cuánto cuesta llenar una garrafa?
Mboy e gasta nde garrafare?

How often do you fill it?
¿Con qué frecuencia lo llena?
Mbovy vece e carga la nde gas?

Does it work well?
¿Funciona bien?
Oikopora la nde kocina?

Do you like it?
¿Te gusta?
Nde gustapa?

What problems have you or do you have with it?
¿Qué problemas tienes o tienes usándolo?
Mba´e problema pa ereko pende método de kocina?

Would you prefer to use a different cooking option?
¿Prefiere utilizar un método de cocción diferente?
Ndepa eipurune otro método ekocina hagua?

> If so, what and why?
> Si es así. ¿Qué y porqué?

Mba´erepa?

OTHER
OTROS

How much for initial materials?
¿Cuánto cuesta los materiales para iniciar?
Mboypa e gasta ejoguahagua material kuera?

How often do you use it?
¿Con qué frecuencia lo usa?
Mboy vece eipuru?

Does it work well?
¿Funciona bien?
Oikopora?

Do you like it?
¿Te gusta?
Nde gustapa?

What problems have you or do you have with it?
¿Qué problemas tienes usándolo?
Mba´e problema pa ereko pende método de kocina?

Would you prefer to use a different cooking option?
¿Prefiere utilizar un método de cocción diferente?
Ndepa eipurune otro método ekocina hagua?

If so, what and why?
Si es así. ¿Qué y porqué?
Mba´erepa?

Do your cooking habits change depending on the season (summer versus winter)?
¿Sus hábitos de cocina cambian dependiendo de las estaciones (verano versus invierno)
Ndepa ekocina petei laja hakupe ha otro laja ro´ype?

If so, how?
Si es así. ¿Cómo?
Mba´eicha?

FUEL PERCEPTIONS
PERCEPCIONES DE COMBUSTIBLE (LENA, GAS, ELECTRICIDAD O CARBON)
COMBUSTIBLE MBYATY

Do you believe there is a fuel shortage?
¿Cree usted que hay una escasez de leña, gas, electricidad o carbón?
Nde pa ere o faltamaha pe jepe´a, gas, electricidad o carbón?

Do you believe fuel resources are diminishing?
¿Cree usted que los recursos de leña, gas, electricidad o carbón están disminuyendo?
Ndepa ere umi jepe´a, gas, electricidad o carbón renda opamahina?

Do you believe the cost of fuel is increasing, decreasing, or relatively the same?
¿Cree usted que el costo de leña, gas, electricidad o carbón está aumentando, disminuyendo o es relativamente lo mismo?
Nde pa ere pe jepe´a, gas, electricidad o carbón repy ojupi tera oguejy tera pa ojolayande?

PLEASE RANK in importance the cooking attributes that are most desirable; from 1 being most important to 11 being least important
POR FAVOR ORDENE de acuerdo a la importancia de los atributos de la cocina cuales son mas deseables, desde el 1 siendo el más importante al menos importante el numero 11.
Emohenda:

Fuel efficiency
Eficiencia de la leña, gas, electricidad o carbón
Eipora jepe´a, gas, electricidad o carbón

Minimal air contamination
Contaminación mínima del aire
Sa´ive oñekontamina pe aire?

Minimal burn risk (people)
Riesgo de quemadura mínima (personas)
Sa´ive peligro oga ekaivo

Minimal fire risk (house)
Riesgo mínimo de incendio (casa)
Sa´ive peligro okaivo?

Household heating
Calefacción doméstica
Jepe´e hagua

Taste of Food
Sabor de la comida
Tembiu hekue

Price of fuel
Precio del combustible - Gasto

Combustible hepy?

Durability/Longevity of structure
Durabilidad/longevidad de la estructura
Mbovy tiempo pa oiko ko estructura?

Ease of use
Facilidad de uso
Ndahasyi ipuru

Length of cooking time
Duración del tiempo de cocción
Mbovy tiempo e kocinapa?

Other (please write-in):
Otros (por favor especifique):
Otro