More sustainable cooking technologies – A case study in rural kitchens in Michoacan, Mexico

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Abstract

Currently millions of people around the globe rely on wood as a source of fuel for cooking. Although this situation not only pertains to impoverished rural communities, it is within these communities and in industrializing countries like Mexico that this is occurring the most. The burning of wood in open fires is causing a number of health problems but is also deteriorating for the rural household economy as well as for the local and global environment. Women and children are the main groups exposed to the indoor smoke produced while cooking. Illnesses as a result of this exposure take millions of lives every year. Expenses on fuel for cooking represent a significant part of the rural household income. The emissions from the cooking fires and the resulting deforestation together add up to the threat of global warming.

Currently one-fourth of the Mexican population is framed within this context. This thesis looks into the adoption of more sustainable rural cooking technologies and its consequences. The overall aim of this case study is to examine the contribution to social, economical and environmental sustainability once a new cooking technology is adopted by Mexican rural families. The particular objectives concern the process of optimizing human health and the consumption of cooking fuels within the Mexican rural household.

Over a six-week period, twenty-four rural households in two rural communities from two different regions in the state of Michoacan, Mexico were visited, observed and interviewed. An improved wood-burning stove and a solar cooking device were studied. Through the adoption of these cooking technologies, reductions of indoor smoke exposure, wood fuel consumption and carbon dioxide equivalent emissions are significant. In order for a new cooking technology to be adopted it must meet certain requirements within the concept of an appropriate technology. Finally, consequences from the adoption are clearly reflected in improvements within the rural kitchen, the household and therefore the entire family.

Keywords

Mexican rural kitchens, appropriate cooking technologies, indoor smoke exposure, wood fuel, adoption process, sustainability

Table of Contents

List of Tables

List of Figures

Currency conversion rate used in this thesis

$1 USD (United States Dollar) = $10 MXN (Mexican Pesos)
For simplification all monetary values will be displayed in $USD

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Ignacio V.V.

List of Acronyms and Abbreviations

ALRI	Acute Lower Respiratory Infection
AT	Appropriate Technology
CIA	Central Intelligence Agency
CIECO	Centro de Investigaciones en Ecosistemas (Center for Ecosystems Research)
CLD	Casual Loop Diagram
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CONAE	Comision Nacional para el Ahorro de Energia (National Commission for Energy Savings)
COPD	Chronic Obstructive Pulmonary Disease
FAO	Food and Agriculture Organization
FMCN	Fondo Mexicano para la Conservacion de la Naturaleza (Mexican Fund for the Conservation of Nature)
GHGs	Green House Gases
GIRA	Grupo Interdisciplinario de Tecnologia Rural Apropiada (Interdisciplinary Group for Rural Appropriate Technology)
HECA	Healthy Environments for Children Alliance
IACATAS	Investigaciones Aplicadas en Ciencias Ambientales y Sociales (Applied Research in Environmental and Social Sciences)
IAP	Indoor Air Pollution
ICS	Improved Wood-burning Stove
INEGI	Instituto Nacional de Estadistica Geografía e Informatica (Nacional Institute of Geographical Calculated Statistics)
ITDG	Intermediate Technology Development Group
LPG	Liquid Petroleum Gas
NGO	Non-governmental Organization
PM	Particulate Matter
SAGARPA	Secretaria de Agricultura, Ganaderia, Desarrollo Rural, Pesca y Alimentacion (Secretary of Agriculture, Ranching, Rural Development, Fisheries, and Food Supply)
SCD	Solar Cooking Device
SD	Sustainable Development
SHE	Solar Household Energy
SUST	Sustainability Science Project
SSA	Secretaria de Salud Mexico (Mexican Secretary of Health)
UN	United Nations
UNDP	United Nations Development Programme
UNAM	Universidad Nacional Autonoma de Mexico (National Autonomous University of Mexico)
WCED	World Commission on Environment and Development
WEA	World Energy Assessment
WEO	World Energy Outlook
WHO	World Health Organization
WWF	World Wildlife Fund for Nature

1. Introduction

"Certainly, by half a million years ago the hearth was part of our ancestor's camp life"

Leakey & Lewin (1977)

1.1 A Burning World Issue

According to the World Energy Assessment (2004), currently more than two billion people in the world cannot access energy services that are based on efficient use of gaseous and liquid fuels, or electricity. Without this access they rely on the burning of solid fuels to generate energy for essential daily activities such as cooking. Although this situation not only pertains to impoverished rural communities, it is within these communities and in industrializing countries like Mexico that this is occurring the most. The lack of access to efficient energy sources for cooking is closely linked to a wide range of social problems (WEA 2004).

According to the World Health Organization (2008) the reliance on solid fuels for cooking purposes causes constant damage not only to the environment, but also to the economy and the health of the members of rural families. At times, households who already must subsist on a low budget are severely affected (Troncoso et al. 2007; WHO 2008). Low-income rural households most frequently used wood or charcoal as a source of fuel for cooking (WEA 2004). It is obtained from forests ecosystems, an action that contributes to forests degradation and deforestation which in turn affects the global forests' natural mechanism (i.e. carbon fixation) for balancing green house gases[1] (GHGs) in the atmosphere (Masera et al. 2005; Tucker 1999). On the other hand, the combustion of wood releases carbon dioxide (CO_2) and other GHGs (see Figure 4), which represent contributions to global warming (Johnson et al. 2008; Masera et al. 2005). Recent scientific research has shown that the '*atmospheric brown clouds*', partially created by cooking with wood, contribute to global and regional climate changes that significantly perturb the hydrological cycle (Ramanathan & Carmichael 2008). Various other gases are generated by the combustion of wood fuel (see Figure 11), they severely damage human health through the constant exposure to indoor air pollution (IAP) within the rural household while cooking is performed (Smith 2006; Smith et al. 2000). According to the WEA (2004) *"…the damaging pollutants from a typical wood-fired cooking stove create noxious fumes at anywhere between seven to five hundred times over the allowable limits*". The major causes of death and disease around the globe are exposed by the World Health

[1] Gases that reduce the loss of heat in the atmosphere thus could contribute to the raise of global temperatures through a greenhouse effect

Report (2002) in Figure 1, in which estimations of deaths and ill-health are showed in disability-adjusted life years (DALYs)[2] from the dominant risk factors in year 2000.

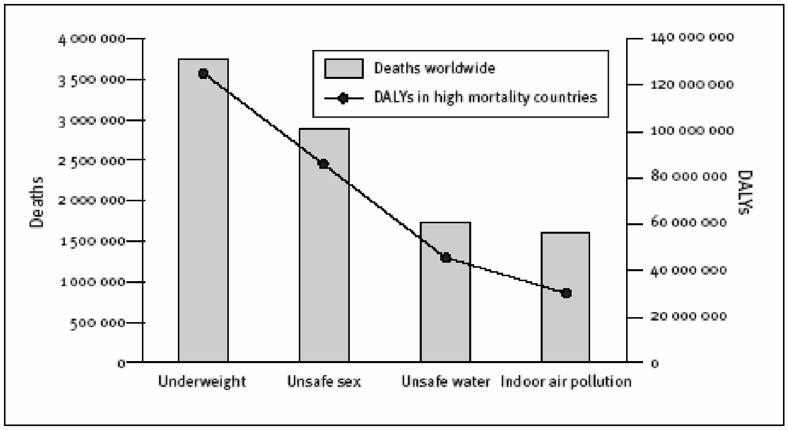


Figure 1: Deaths and DALYs from leading risk factors in year 2000

(Source: Warwick and Doig, 2004, adapted from WHO Report 2002)

Women and their youngest children are the most exposed group to IAP because of their household roles, thus they are the most directly affected and the main victims of illness and death due to the exposure (Desai et al. 2004). Acute lower respiratory infections (ALRI), in particular pneumonia in developing countries, are the largest killer by causing more than 2 million children deaths per year (WHO 2008). Figure 2 shows the deaths for children under-five by diverse causes according to the WHO (2002) framed by its programme: *'Healthy Environments for Children Alliance'*.

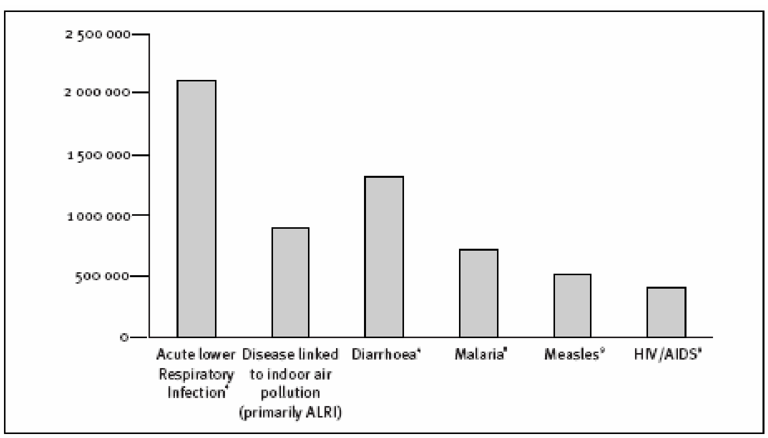


Figure 2: Deaths in children under-five by diverse causes

(Source: Warwick and Doig, 2004, adapted from WHO HECA 2002)

[2] DALYs is a formula to measure health risks used by the WHO and the World Bank, which estimate life years lost from injuries and disease as well as the subsequent disability over the lasting years

In their article *'Smoke: the Killer in the Kitchen'*, Warwick and Doig (2004) remark that this is a well known worldwide issue and that it should raise international outrage that this issue has been ignored for so long. This thesis proposes and discusses on ways to mitigate the consequences of this complex worldwide issue. This research shows that there are more sustainable cooking technologies available and that it is feasible to introduce them into rural communities. In this particular case study in two units of analysis within rural Mexico, but to a certain point, even in other rural communities around the world depending on the context of their settings. Through the adoption of appropriate rural cooking technologies, such as an improved wood-burning stove (ICS) or a solar cooking device (SCD), social and economic sustainability is locally enhanced in terms of fuel consumption and human health. An environmental sustainability is enhanced globally in terms of wood fuel consumption and emissions. The adoption of a new cooking technology depends on several factors, certain phases within the innovation-decision process must be accomplished in order to be able to measure its consequences (Rogers 2003). It is also presumed by this thesis that the new cooking technology should have certain characteristics according to the rural context, this is to say, it should be an appropriate rural cooking technology (ITDG 2007; Troncoso et al. 2007).

1.2 Analytical Framework

There are several quantitative and qualitative studies based on Mexican rural households in relation to their cooking technologies (Berrueta et al. 2007; Masera et al. 1997a, 2000b, 2005c; Troncoso et al. 2007). This thesis is a qualitative piece of research that analyses and discusses related phenomena in two case units (Bryman 2004; Ragin 1994) of rural Mexico within the state of Michoacan (La Lajita and Patamban). The ambition is to add a case that is representative for questions raised in similar preceding studies by a goal of enriching and deepening the understanding of the research subjects (Ragin 1994). To start framing the analytical questions of this study, the aim and the particular objectives, the methodology and the research questions are exposed below.

The overall aim of this thesis is to expose how social, economic and environmental sustainability is enhanced by the adoption of an appropriate rural cooking technology. The particular objectives concern the process of optimizing the human health and the consumption of fuels for cooking within the rural families. This study proposes possible solutions to protect the human capital and the incomes of rural households. It also remarks on the consequences and advantages from adopting a more sustainable cooking technology within the Mexican rural households. Through a research shaped by fieldwork, participatory observation, experimentation and interviewing, framed by purposive sampling (Bryman 2004; Ragin 1994), a qualitative research is formed to answer the following research questions:

How can the adoption of new cooking technologies enhance sustainability for rural families in the state of Michoacan, Mexico?

What cooking technology would be appropriate within the given context?

To what extent are these cooking technologies adopted by the members of the rural families?

These research questions are discussed throughout the study as a means of evaluating the problems that are caused by cooking on an open fire. Furthermore, they will weigh the local and global benefits and the feasibility of implementing and adopting more sustainable cooking technologies.

1.3 Relevance and Intended Contribution

The relevance of this study lies within the dealing of a worldwide issue that implies severe social, economic and environmental problems generated through rural cooking activities. Problems that are framed by three main aspects: the exposure to IAP, an uncertain rural household income touched and the constant damage to the environment. All of the above, as a consequence of the use of wood fuel for cooking on open fires. These current issues frame a suitable setting for inquiring into more sustainable solutions for a problem that is currently affecting millions of people in the world (WEA 2004). It is therefore addressed with an intended contribution of exposing and analyzing one more of several actions that could lead towards a more sustainable rural development concerning cooking technologies. Within this thesis all three pillars of sustainability are touched, by suggesting improvements in the rural families' welfare, wealth and environment. In a country where more than one-fourth (27.2 million people) of the total population use wood fuel for cooking (Masera et al. 2005), this study intend to target a particular group of families in rural Mexico, families for whom just a small change would have a substantial impact on their daily lives.

1.4 Personal Experience and Initial Exposure

While I was studying my bachelor's on Human Resources Management in Mexico (1996-2000), I started to visit a rural community named La Ticla, located on the Pacific coastline in the state of Michoacan, Mexico. During those years I met a rural family who I continue to visit to this day. I befriended this family and through my relationship with them and my active participation in daily family activities such as wood gathering and cooking

I experienced an ongoing first-hand exposure to *'The Burning World Issue'*. During my participation in wood fuel gathering, I witnessed how some of the young family members were going to *'la leña'* [3] instead of being in school. Through my experience and observations at *'la leña'* I witnessed that sometimes this activity went beyond wood gathering to actually cutting down trees though no one was eager to admit this. When I participated in cooking, I was exposed to the smoke that is continually produced by the open fire. My personal experiences have given me a better understanding and a solid foundation from which I can approach this issue from the points of view of both, a researcher and someone who has actually been exposed to the problem in advanced. My experiences at La Ticla sharpened my interest and motivated me to structure this issue within a transdisciplinary framework based on the LUMES' aim for sustainability.

2. Background

2.1 Mexico and Michoacan

Mexico is a North American country bordered by the United States to the north and Guatemala and Belize to the southeast. It has a land mass of 1,953,358 km² (Moreno 2005). The last census by the National Institute of Geographic and Calculated Statistics reported Mexico's population to be 105 million people (INEGI 2005) of which 40 million live in rural communities (Figueroa 2006). As an industrializing country or middle income country, with per capital income of $7,870 USD and a life expectancy of 75 years (World Bank 2007), Mexico's economy is the 12th largest in the world, and Mexico is the 8th largest exporter of goods and services worldwide (WEO 2002). In contrast, in Mexico, three percent of the population lives from less than one dollar a day and 11.6 percent with less than two dollars a day (UNDP 2007/2008). In Mexico income distribution remains highly unequal (CIA 2008). According to Meza (2004), the poor are getting poorer; in year 2000, the poorest 20 percent of Mexico's population shared three percent of the total income and consumption while the richest 20 percent shared more than 59 percent of the nation's wealth. The primary economic activities still practiced on a subsistence level in Mexico's rural communities (where almost one third of the total population lives) are agriculture, animal breeding and fisheries (Moreno 2005). Due to its diverse climates and ecosystems, Mexico is considered to be one of the most biological diverse countries in the world (Greenpeace & WWF 2008). In

[3] 'the wood' (in English) which means going to gather the wood. This expression is recognized all along the state of Michoacan or even along the entire country with the same meaning

Mexico, 28 percent of the landscape is covered with forests, of which 12 percent is comprised of tropical forest land (Moreno 2005).

The state of Michoacan represents three percent of the country's landmass. It has a total population of 4.5 million people of which 34 percent live in rural areas and are dispersed among 9,505 communities with populations of less than 500 in each (Moreno 2005). A 48 percent of the rural population in Michoacan lives without basic services such as health care and education (Figueroa 2006). Sixty-three percent of the Michoacan's landscape is covered with forests, whereas 34 percent of the state is comprised of tropical forest land (Moreno 2005). Stretching from highlands to the coastline, Michoacan has a diverse range of climates. As previously mentioned before, is within the state of Michoacan, where two rural communities were chosen to fulfill the aim of this study case. But, firstly, the fuel consumption for cooking, the health and environmental impacts and the cooking technologies within rural Mexico will be examined.

2.2 Fuel Consumption

In Mexico, wood remains the main source of fuel in rural households (Masera et al. 2005; Troncoso et al. 2007). According to Masera et al. (2005) 18.7 million people rely entirely on wood as a source of cooking fuel. Another 8.5 million use wood in combination with liquid petroleum gas (LPG). Figure 3 shows the evolution of wood fuel users in Mexico from 1960 to the year 2000 (Masera et al. 2005). Masera (2005) explains that LPG has been penetrating the rural market as a complementary source of fuel rather than a substitute fuel. Households in rural Mexico follow a *'multiple fuel'* strategy for cooking (Masera et al. 2000; Masera et al. 2005) which means a combination of technologies (i.e. wood and LPG) while performing their daily task. Masera also remarks that the wood-savings gained from switching to LPG from wood are not noticeable because rural households continue to use wood for the most energy-intensive tasks, such as making tortillas[4] and preparing traditional dishes such as beans, the two staples of the Mexican diet.

[4] Type of thin, unleavened flat bread made from finely ground maize (corn). Making tortillas demand the previous task of cooking the *'nixtamal'* (stewed corn) in order to prepare the dough

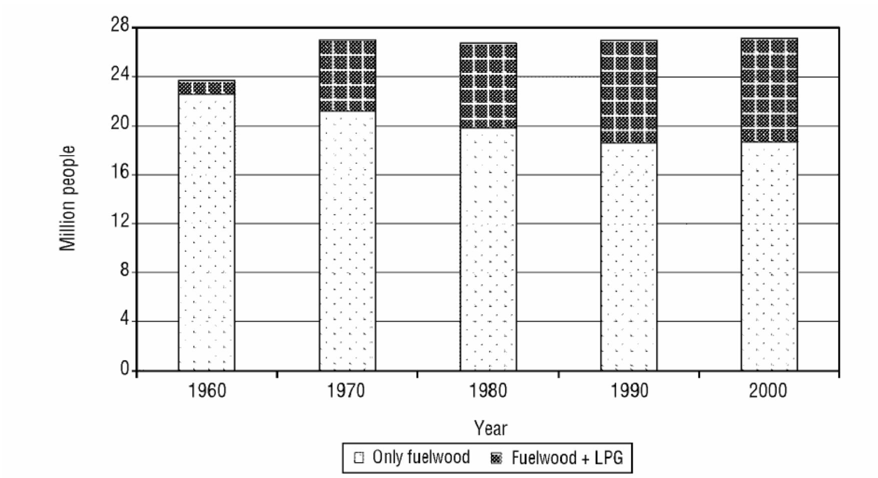


Figure 3: Evolution of wood fuel users in Mexico, 1960-2000

(Source: Masera et al. 2005)

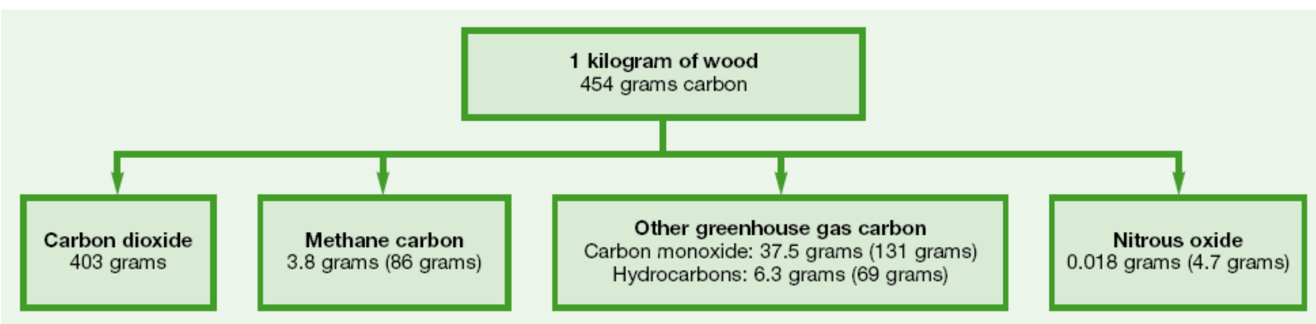
2.3 Health and Environmental Impacts

According to WHO (2002), indoor air pollution is responsible for 2.7 percent of the global burden of disease. Kirk R. Smith (2000), an expert on indoor air pollution (IAP) and professor of global environmental health at the University of California in Berkley, explains that the incidence of ALRI can be increased by the exposure to IAP by affecting the body's defense systems. Chronic obstructive pulmonary disease (COPD) in women and pneumonia in young children are the two main illnesses caused by exposure, but there is a growing body of scientific evidence linking lung cancer and other cancers, tuberculosis, low birth weight, cataracts and other eye diseases to indoor smoke exposure from the combustion of solid fuels (Smith 2006).

The Mexican Secretary of Health (SSA) (2002) considers IAP a serious public health issue in the country. ALRI in children under one years of age was the third highest cause of death in Mexico in 2005 (2,490 deaths) (SSA 2005). ALRI in children from one to four years of age was reported as the second highest cause of death in the same study (572 deaths). During the year 2004, ALRI was the highest cause of death among children from one to four years of age (677 deaths) and ALRI in women during 2005 was the sixth highest cause of death (7,068 deaths) (SSA 2005). During the same year, COPD was responsible for 9,082 deaths in women (SSA 2005). The illnesses as a result of the exposure to IAP generated from open fires for cooking in Mexico take thousands of lives every year (SSA 2005).

Concerning the forests ecosystems, Mexico's forests are threatened by unregulated deforestation. In fact, Mexico shows one of the highest rates of deforestation in the world (Huerta 2008). Forest cover decreases annually at a rate of 0.8-2 percent, in another words meaning that approximately between 370,000 to 720,000 hectares of forests are cut down every year (Klooster and Masera 2000). According to Greenpeace Mexico (2008) it is estimated that 70 percent of the national wood market has illegal provenance. In other words, there is not much legislation or control concerning the cutting of trees in the country. Omar Masera (1997), an expert on climate change mitigation within the forest sector and bioenergy, explains that during the mid-1980s, 668,000 hectares per year were deforested. In countries like Mexico consequences from deforestation trigger severe environmental deterioration such as soil erosion. In the state of Michoacan, 36 percent of the land was eroded by the early nineties (Landa et al. 1997). Although the main drivers for forest loss are in most of the cases cattle ranching and the conversion to agriculture (Munoz-Pina et al. 2008), the extensive use of wood fuel for cooking purposes adds to the issue, resulting even in scarcity of wood fuel in some rural communities (Troncoso et al. 2007). In communities where the wood is scare, the expenses on this fuel vary between $5 and 10 USD per family per week (Ibid). For certain families this could represent up to 15-20 percent of their total monthly income (Masera et al. 2005). This situation raises a very important question concerning malnutrition: fuel or food? This obviously shows a strong link between cooking fuel demands and a very serious health worldwide issue such as underweight (see Figure 1). Undernourishment in Mexico accounts for 5 percent of the total population (UNDP 2007/2008).

Moreover, as previously briefly explained before, the incomplete combustion of wood releases CO_2 and other GHGs that contribute to global warming (Johnson et al. 2008; Masera et al. 2005). Figure 4 shows the emissions generated when one kilogram of wood is combusted in a typical open fire stove (Smith et al. 2000 in WEA 2000).



Note: Numbers between parentheses are CO_2 equivalents of non-CO_2 gases

Figure 4: GHG emissions from burning 1 kg of wood

(Source: Adapted from Smith et al. 2000 in WEA 2000)

If numbers between parentheses (CO_2 equivalents) are added to the CO_2 grams emitted, the total GHGs emissions are 693.7 CO_2 equivalent grams. According to Masera et al. (2005) the use of wood fuel averages 2 kilograms per day per capita in Mexico (with great variations depending on the region), although it is problematic to asses the emissions of these GHGs coming from wood fuel burned in typical rural stoves in the country (Edwards et al. 2003) we should bear in mind that more than 27 million people burn wood for cooking purposes in Mexico (Masera et al. 2005). Therefore the implications from the burning of wood for cooking purposes in Mexico make a very serious and complex impact to the environment that should be treated as such.

2.4 Cooking Technologies

In rural Mexico, cooking is usually performed on a traditional open fire called a *fogon*[5] which functions as a base for the pot or the *comal*[6]. There are mainly two types of *fogon*; the Three-stone and the U-type (Figure 5). Although these types of stoves surround the fire, they have neither a combustion chamber nor a hood. Therefore combustion is incomplete and uncontrolled, generating harmful levels of particles, gases and dangerous compounds (Berrueta et al. 2007). Additionally the intense heat produced by the open fire exposes the women who are cooking tortillas to very high temperatures which harm their eyes as well as the skin on their arms and hands.

a b

Figure 5: a) Three-stone *fogon.* b) U-type *fogon*

(Source: Velasco, Patamban & La Lajita 2008)

A wood-burning stove that is able to complete the tasks of the traditional *fogon* without the drawbacks of smoke and heat exposure and high levels of wood consumption should be recognized as an ICS. The Patsari[7] Stove

[5] Name for any kind of open fire stove in Mexico
[6] A round large flat metal or ceramic surface on which tortillas are cooked
[7] In the indigenous language (Purepecha) means "the one that keeps"… the heat, the health, the environment and the economy of the rural households

addresses these drawbacks by integrating into its design a combustion chamber and an exhaust pipe. The combustion chamber encourages a complete combustion and the reduction on wood fuel consumption. The exhaust pipe funnels the smoke outside the kitchen reducing the health risks from the IAP exposure. The Patsari Stove's design comes from an improved Lorena[8] Stove. It is the result of several years of research and improvements based on field experience and laboratory testing. Which were performed by a local non-governmental organization (NGO) named the Interdisciplinary Group for Rural Appropriate Technology (GIRA), constantly advised by the Center for Ecosystems Research (CIECO) within the National Autonomous University of Mexico (UNAM). In 2006 the Patsari Stove was awarded the Ashden Health and Welfare prize for Sustainable Energy[9]. It is also recognized as *'la Chimenea'*[10] among members of rural communities in Mexico. It is made of cement and brick. The interior of the brick structure is covered and filled with a layer of sand which in turn is covered and shaped with a layer of clay to secure and seal the *comals* on the top of the stove. An interior combustion chamber delivers heat directly to the *comals,* creating an efficient heat distribution system that requires less wood consumption (see Figure 6b). Patsari Stoves consume a high percent less wood fuel than traditional *fogons.* These *comals* function as the cooking surfaces (see Figure 6a). The largest of the three *comals* is used as the primary cooking surface. It is ideal for preparing tortillas and other types of food. Most of the heat is directed from the combustion chamber to this *comal.* Two smaller *comals* which receive less heat from the combustion chamber are ideal for small pots that are used for tasks such as boiling water, heating food and keeping food hot for longer periods of time. The smoke that is created in the combustion chamber is funneled out of the kitchen via an exhaust pipe or *"flue"* leaving the kitchen smoke-free.

a

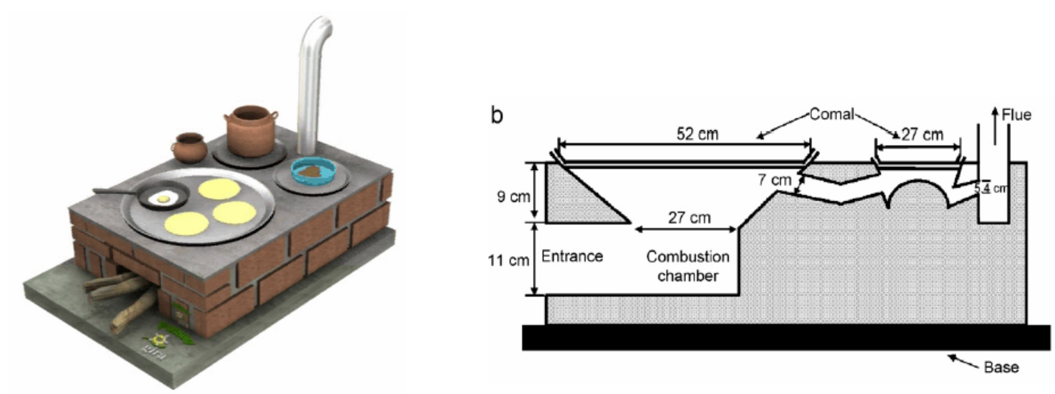


Figure 6: a) The Patsari Stove. b) Cross-sectional view of the Patsari Stove

(Source: Berrueta et al. 2007)

8 Improved wood-burning stove originally designed in Guatemala. Its name comes from the combination between *lodo* (clay) and *arena* (sand) in Spanish which are the materials used for its construction
9 http://www.ashdenawards.org/winners/gira
10 'the Chimney' in English

Over 1800 Patsari Stoves have been constructed by the GIRA during the last four years, mainly in Michoacan. In total over six thousand Patsari Stoves are currently in use throughout Mexico (Personal Communication, Interviewee 27, 2008). GIRA contracts technicians who are in charge of constructing the Stoves as well as transferring the 'know how' of the construction and maintenance. Therefore stonemasons in rural communities[11] where GIRA's technicians are constructing Patsari Stoves are always welcome to learn how to construct them. This transfer of technology is taking place in over ten Mexican states. The total cost to build a Patsari Stove is between $85 and $100 USD depending on if one or two people construct it. It takes around three hours for two persons to build one. A Patsari Stove can be used as soon as the exhaust pipe is connected, this is to say, right after it has been constructed.

A SCD cooks food using direct sunlight as its only source of energy, therefore no smoke is produced. Solar cookers have limitations within their operation. They must be placed in an outdoor area with direct sunlight exposure. Thus they cannot be used on cloudy days, in shady areas, in the early morning or at night. To merit consideration for solar cooking promotion, monthly insolation[12] should exceed four kilowatts per hour per square meter (kWh/m²) per day on average (Curtis, 2006). Mexico has an average global daily insolation of 5 [kWh/m²] per day during the entire year (CONAE, 2007). The average daily solar radiation in Michoacan ranges from 4.2 to 5.9 [kWh/m²] with the exception of December when it is 3.7 [kWh/m²] (CONAE, 2007).

A common currently type of SCD in Mexico is the HotPot (see Figure 7). It is a result of cooperation between a national NGO; the Mexican Fund for the Conservation of Nature (FMCN), an international NGO; the Solar Household Energy Inc. (SHE) and an international research center; the Florida Solar Energy Center (SHE 2006). It is only manufactured in Mexico, mass-produced by Integrated Logistic Solutions company in the north of the country (Personal Communication, Interviewee 2, 2008). Its design combines two traditional approaches to solar cooking, the solar oven and the focus cooker, into a strong, portable and highly efficient solar oven (SHE 2006). It is commonly recognized as *'la Olla'*[13] among members of rural communities in Mexico. The HotPot consists of a reflector and a glass container. Inside the glass container there is a black metal container with a cooking capacity of 2.5 liters. The metal container absorbs the heat and since it is not touching the glass pot, the effect of an oven is achieved. It reaches temperatures of up to 130ºC. All this heat is created by the reflection of the sunlight. The glass container, which is used with a glass lid to create a green house or oven effect, is placed in

[11] Stonemasons *"albañiles"* are found in almost every rural community in Mexico
[12] Insolation is a measure of solar radiation energy received on a given surface area in a given time. It is measured by [kWh/m²] per day
[13] 'the Pot' in English

the reflector that is made from aluminum or aluminum-coated cardboard. Its function is to reflect the sunlight, concentrating it onto one focus point where the pot is placed.

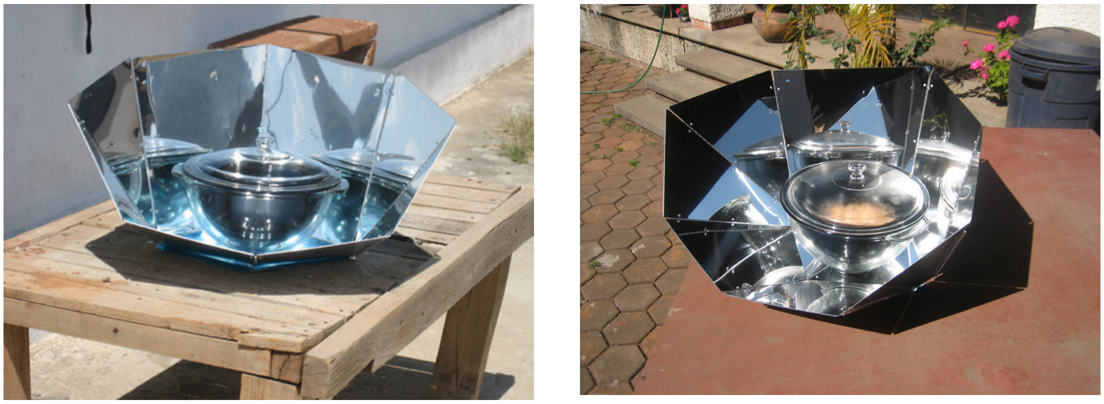


Figure 7: The HotPot

(Source: Velasco, Patzcuaro 2008)

The price of a HotPot is $50 USD for the aluminum-coated cardboard reflector and $80 USD for the aluminum reflector (Personal Communication, Interviewee 2, 2008). Almost any kind of food can be cooked and there is no fuel cost since sunlight is free. The use of this technology is not exclusive to rural communities; the HotPot is marketed and could be used in urban settings throughout the world (Xanic 2007).

The goal of the HotPot's designer is to use the proceeds of worldwide sales to subsidize the cost of HotPots for rural communities through FMCN. FMCN is a high level NGO that is recognized as the main client of Integrated Logistic Solutions in Mexico. FMCN sells, distributes and donates HotPots throughout Mexico through a diverse network of local and national NGOs. FMCN and these organizations work diligently on promoting, training and monitoring the distribution and usage of the HotPot. All of this is done through organized programs that are concerned with the reduction of wood fuel consumption, indoor smoke exposure and climate change. In some cases costs could be subsidized by different NGOs (including FMCN and SHE) but in other cases the HotPots are sold according to different payment plans or exchanged for varied activities such as garbage collection in the area (Personal Communication, Interviewee 2, 2008; Xanic 2007).

2.5 The Setting; Patamban and La Lajita

The community of Patamban is an indigenous rural community located in the highlands within the Purepecha[14] region in the northwest of Michoacan (see Figure 8). According to the rural development agency Melchor Ocampo Consulting (2007), 844 households[15] are comprised of 3,280 people who mainly subsist on construction work and pottery making (45 percent), agriculture and animal breeding[16] (34 percent), and commerce and services (19 percent). All of the households use wood as a source of fuel for cooking, 69 percent combines it with LPG (Melchor Ocampo 2007). Patamban has a cool stable climate with an average temperature ranging from 7ºC to 22ºC with a rainy season during the summer. The vegetation in this area is primarily represented by pine, cedar and evergreen trees (Ibid).

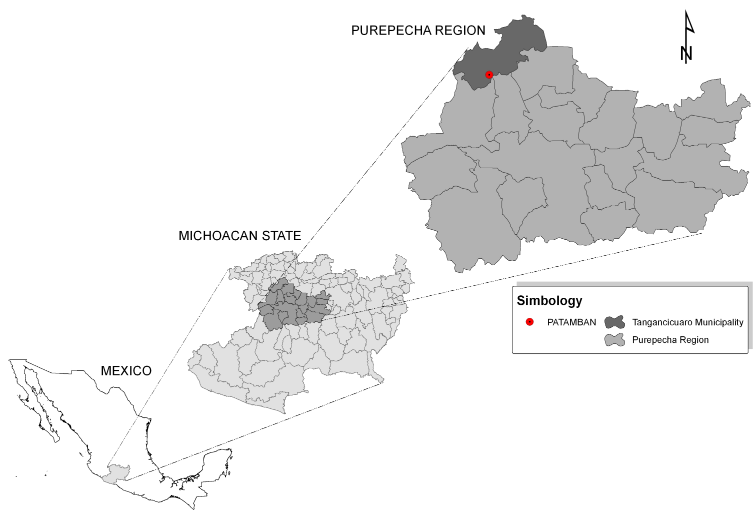


Figure 8: Location of Patamban

(Source: CIECO 2008)

In the rural community of Patamban Patsari Stoves were constructed in ten different households as part of an international project with a top-down approach from the Food and Agriculture Organization of the United Nations (FAO 2001). The Regional Special Programme for Food Security (RSPFS) in Mexico is coordinated by the Mexican Secretary of Agriculture, Ranching, Rural Development, Fisheries, and Food Supply (SAGARPA)

[14] Region with indigenous population centered in the northwestern region of the state of Michoacan

[15] According to INEGI a rural community has less than 2,500 inhabitants. Being qualified as a 'rural communities group' is determined solely by the population of the community. Other factors such as the access to water, electricity and sewage are not taken into account

[16] A few cows, pigs, chickens or goats

which delegates different projects to a diverse group of NGOs. With the aim of poverty reduction and improvement on food security for the next 15 years, RSPFS in Mexico has been a project narrowed to the most critical areas concerning this issue. One of these regions is situated in the state of Michoacan (FAO 2001). GIRA was contracted by one of these NGOs (i.e. Melchor Ocampo) to construct the Patsari Stoves as part of a rural development integrated programme that offers other rural technologies such as cisterns, dry toilets and the training for harvesting vegetables for household consumption (Melchor Ocampo 2007).

The rural community of La Lajita is located in the southeast of the state (see Figure 9). La Lajita has a population of 178 people of which almost one hundred percent are mestizos[17]. The primary economic activities of La Lajita's residents are agriculture and animal breeding. All of them use wood as a source of fuel for cooking and 80 percent combine it with LPG (IACATAS 2005). The climate is hot and humid all year long with a rainy season during the summer. It is located below the '*Tierra Caliente*' [18] region. The prevailing vegetation in this region is the low jungle forest.

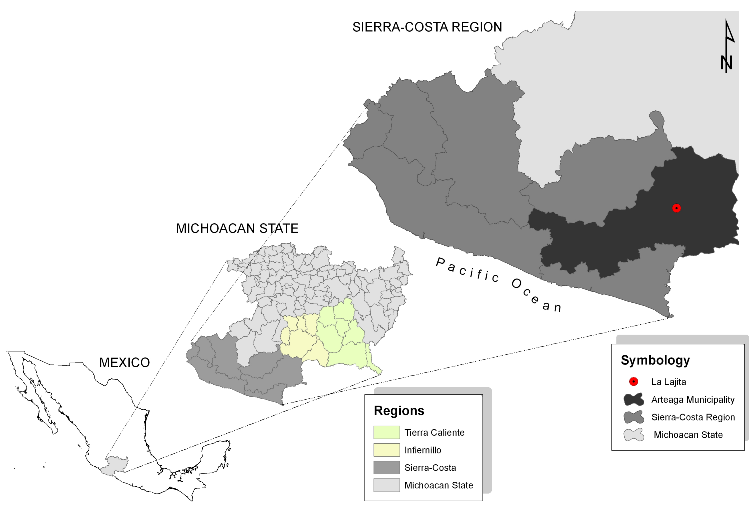


Figure 9: Location of La Lajita

(Source: CIECO 2008)

In the rural community of La Lajita Patsari Stoves and HotPots were constructed and distributed respectively as part of a project conformed by a group of Environmental Science Bachelor students from the UNAM. For this project, the group of students was technically and scientifically advised by GIRA and the CIECO respectively. They wanted to start an NGO and they decided on bringing the two cooking technologies into ten households

[17] People of mixed European (Spaniard) and native American lineage living in the region of Latin America
[18] 'Hot Land' in English

that confirmed interest in both technologies after the first visit to the community. Later on, an extra four families became interested on the Patsari Stove and four more new Stoves were constructed in four different rural households.

3. Theory and Methodology

3.1 Theoretical Ambition

The theory behind this research will be applied in the analysis and discussion; and will thereby be consumed. A possible output from the analysis will contribute to the theory by adding further concepts and thus inform back to theory (Bryman 2004). The theory that frames this thesis elaborates on three main concepts: an *appropriate technology*, its *adoption process* and its *contribution to sustainability*. All topics within this subchapter are the theories that frame this research. In Chapter 4, the findings and discussion will elaborate according to these concepts recognized as the theory behind this study.

During the early 1970's the concept of an *'appropriate'* technology (AT) emerged. This was done by Dr. Ernst Friedrich Schumacher, author of *'Small is Beautiful'* (1973), a groundbreaking work on suitable technologies framed by an approach that wanted to *"find out what people are doing and help them to do it better"* (ITDG 2007). Low cost, suitable and small-scale development ideas were the path to follow in order "*to help people to help themselves"* (Ibid). Troncoso et al. (2007) remarks that a technology can be labeled within this range when it is simple to operate, responds to user's needs, respects the local culture and tradition, employs local materials and labour as much as possible and uses the resources in a rational and possible renewable way. According to the Center of Rural Technology in Nepal (2008), an AT should be the one that is effective in meeting the basic needs of the rural communities and improves their life support system by creating better options and opportunities for sustaining the rural livelihood. The definition of an AT can be differently interpreted, but it is clear that it must be suitable in terms of simplicity, cost, improvements, culture, tradition and in general according to the rural context. Therefore an AT should be developed according to the context in which it is going to be used. Many different characteristics could be taken into consideration to classify a technology as appropriate or not, but it is easier than it sounds. In order to fulfill the aim of this study an AT is framed within a wider spectrum, which means that it could have only some of these characteristics and still be considered as an AT.

The theory behind this thesis regarding an adoption process fully relies on the diffusion of innovation theories developed by Everett M. Rogers since the early 1960s. Rogers (2003) defines diffusion as the process by which an innovation is communicated through certain channels over time among the members of a social system. He also explains that an innovation could be an idea, action or technology that is perceived as new by an individual or other unit of adoption like any social system (Ibid). The process or action of diffusing and adopting a new technology, and the consequences of this, is framed within what Rogers (2003) calls the Innovation-Development Process. Figure 10 exposes a simple adapted model from the Rogers' Process that will be used later in the analysis and discussion parts.

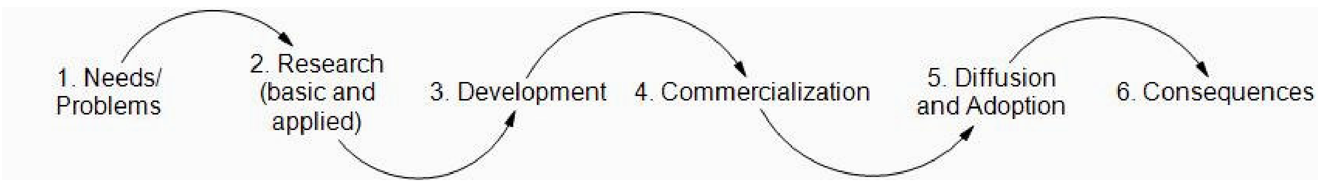


Figure 10: The Adapted Innovation-Development Process

(Source: Adapted from Rogers 2003)

According to Rogers (2003) there are six phases within this process: problems or needs, basic and applied research, development, commercialization, diffusion and adoption, and consequences. He explains that the recognition of a problem or need will stimulate research and development activities with the desire of creating a new technology, later on this basic and applied research will lead to the development of a technology that is expected to meet the needs or to solve the original problems that are driving this whole process. Through a process of commercialization which includes production, manufacturing, packing, marketing and distribution of the new technology, it will be embodied to be diffused and possibly adopted by the new users. As a final phase of this process; the consequences are defined as the changes that may occur to the new user or the entire social system even if the technology was not adopted.

Rogers (2003) explains that there is also a five phrase Innovation-Decision Process that includes the following stages: knowledge, persuasion, decision, implementation and confirmation. All those steps may or may be not part of the diffusion of new cooking technologies; this will be discussed within the analysis of this thesis. Rogers also remarks the importance of looking on how this new technology is compatible with the values, beliefs, and past experiences of the individuals in the social system, thus the diffusion of a new technology should not only be seen as a technical matter but also as a social process (Ibid).

The concept of sustainability framed by sustainable development (SD) was first expressed in the Brundtland Report (1987) with the title '*Our Common Future'*, as the result of the Brundtland Commission also known as World Commission on Environment and Development (WCED) convened by the UN in 1983, it was also the first publication to recognize within the international arena the concept of SD:

> Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. (WCED 1987).

According to Sneddon et al. (2005) this definition of SD *"…is the most widely accepted starting point for scholars and practitioners concerned with environment and development dilemmas"*. Therefore for purposes of this thesis, sustainability should be understand and framed within this concept, bearing in mind that any action that concerns the use of resources within a more efficient rate of consumption should be recognized within a sustainability framework.

During the UN Conference on Environment and Development (UNCED) in 1992 also know as '*The Earth Summit'*, Agenda 21[19] was formulated. Agenda 21 could be seen as the blueprint for sustainability until current times, it is a plan in how to make sustainable development by considering not only the environment but also the society and its economy. This is to say that all three aspects (i.e. environmental, economic and social) should be taken into consideration. This is however rather a much criticized approach framed by what some called the three-legged-stool model of SD (Neil & Kenneth 2003) which it could be subject to further and intense discussion. For purposes of this thesis, the importance relies in the fact that this case study touches the three pillars of sustainability or in all case the three-legged-stool of SD. But it recognizes its boundaries, it remarks that the approach of Neil and Kenneth (2003) in which the environment is placed at the top of the stool (instead of sustainability) is also valid.

Sustainability aims should be approached within transdiciplinarity. This concept defined by Max-Neef (2005) suggests that teams of researchers with more than one area of knowledge should not only cooperate with each other[20], but also coordinate between all hierarchical levels. For some institutions, the concept of sustainability has even developed as a type of science that is approached within this concept of transdiciplinarity, this is the

[19] http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=52
[20] According to Max-Neef (2005) this means pluridisciplinarity

case of the Sustainability Science Project (SUST)[21] which frames a useful example of SD for this thesis by recognizing that an:

> Appropriate mobilization of science and technology is essential if society's developmental goals are to be reconciled with the planet's environmental limits over the long term. (SUST 2000).

According to the WEA (2000) the relationship between SD and energy production and use involves two relevant characteristics: a) the importance of satisfactory energy services for meeting basic human needs, aiming for improvements in social welfare and economic growth, in more explicit words: *"energy as a source of prosperity"* and b) the production and use of energy should not risk the quality life[22] of present and future generations and should not exceed the carrying capacity of the ecosystems. Finally, according to Boyle (2004) a sustainable energy source meets these criteria: it is not substantially depleted by continued use, does not cause significant pollutant emissions or other environmental problems, and does not entail substantial health hazards or social injustices.

3.2 Methodological Considerations

The methodological framework of this research, conformed by its two units of analysis within a single case study (Yin 2003), embraces a qualitative research shaped by fieldwork, participatory observation, experimentation (Bryman 2004) and interviewing (Kvale 1996). Through an essentially strategic sampling (i.e. purposive sampling) data from 24 households within these two units was obtained to be analyzed and discussed for finding answers to the research questions (Bryman 2004). The analysis is based on the findings from a six-week period of fieldwork study. It also elaborates on and advances the findings of previous studies which have been carried out and are referenced in this thesis. Mikkelsen (2005) explains that the method of following multiple strategies in one single research is a method that will overcome the problems of relying upon one single methodology or set of data. This is what Mikkelsen calls 'triangulation' (which also evokes a transdisciplinary approach), with an aim of helping the validation of observations and data, something also performed along this study (Ibid).

The subject of study within this research is recognized by the adoption of new cooking technologies in rural communities in Mexico and its contribution to social, economic and environmental sustainability. It is encouraged by the worldwide problematique described in the introduction of this thesis. It is a case study, which

[21] http://www.hks.harvard.edu/sust/overview.htm
[22] A concept very complex to define. For purposes of this study should be recognized as well-being physical aspects (health, diet, shelter) and physiological state

inquires into the investigation of a contemporary phenomenon within its real-life context in two units of analysis (Yin 2003) and two different cooking technologies. The selection of the two units of analysis to fulfill the aim of this research was done according to a purposive sampling (Bryman 2004), which was framed by the different projects taking place in Mexico concerning the two cooking technologies (Personal Communication, Interviewee 2/27, 2008). These include access to the rural settings, NGOs' network, stage of the projects, technologies and the general feasibility of being introduced into the two rural communities and the 24 households. Within this strategy, participatory observation and interviewing for data collection was performed to elaborate on the study (Bryman 2004). The six-week field work was framed by my indirect collaboration with GIRA concerning practicalities, therefore I went back and forward from the desk (in GIRA's offices) to the field in several occasions. My participatory observation (Yin 2003) was supported through my temporary residence in both communities and by taking part in the construction and maintenance of some of the Patsari Stoves. Another important aspect was my recognition by the members of the rural communities as a staff member in an organizational setting (Ibid). During this research I have done experimentation (Bryman 2004) in my own HotPot recording relevant data that helps me understand and promote the cooking technology framed within my own experience.

Yin (2003) explains that one of the most important sources of information for case studies is the interview. In both communities my interviews were previously structured (see Appendix 2) but mainly of an open-ended nature, allowing me to ask key respondents about the facts of a matter as well as their opinions about events (Yin 2003). In certain cases, some of the questions asked to the respondents were framed within proposing their own insights into the technologies (e.g. 'Do you have any suggestions for a better performance of the Stove?'), which may be used as the basis for further inquiry (Ibid). These interviews were carried out in both communities during my stay. I visited both communities on two different occasions, in three of these visits I stayed days and nights among the rural families having an opportunity to develop my research according to the techniques previously mentioned. During my first visit to La Lajita I spent four days living in one of the rural households (i.e. Micaela and Jesus Franco). During this time I visited and interviewed 14 different households in total within the community. Ten of them had a Patsari Stove and a HotPot and four more had only a Patsari Stove. During my second visit to La Lajita I helped with the construction of two Patsari Stoves for an entire day. During my first visit to the community of Patamban I went to visit ten households in which a Patsari Stove was going to be constructed. I stayed two days and one night in the community together with some of the technicians from GIRA. After three weeks, I went back to the community to visit the same ten households to search for answers concerning the consequences of use or disuse of the Patsari Stoves. It was impossible to visit three out of the ten previously investigated households because in one case the whole family was selling its pottery in another town, in another case they were out of town for medical reasons (in both cases they were away for several days) and in the last case the Patsari Stove had not yet been used because the family was still to move in. All the interviews performed during this research were recorded for deeper analysis (Kvale 1996). The data collected through the interviews lead me on finding the evidence for addressing and answering my research questions (Yin 2003). Moreover, a group of informants were interviewed (Interviewees 1/2/13/27) conformed by the Head Coordinators of both NGOs (FMCN and GIRA) on each cooking technology and two staff members of GIRA.

The last of my methodological considerations concerns transferability of this case study, meaning that the analysis could represent more rural communities in Mexico or even worldwide. How can one tell if the local adoption of a new cooking technology, could lead to a similar development towards sustainability also in other rural communities in the country or even worldwide? According to Lincoln and Guba (1979 in Gomm et al. 2000) the answer to that question must be empirical and it is called *'fittingness'*. It is based on the degree of transferability as a direct function of the similarity between two contexts, so fittingness *"… is defined as the degree of congruence between sending and receiving contexts"* (Ibid). The two units of analysis selected for this case study are representative of two different rural settings in Mexico, they have different sizes, locations and therefore climate, but also have the same traditions and behaviors concerning cooking activities, they both use mainly wood fuel for cooking and therefore they must deal with the same consequences, so the essence of the two units of analysis is very similar. Bearing in mind that more than 27 million people in rural communities in Mexico are dealing with the same type of consequences (Masera et al. 2005), this case study have a certain degree of transferability for framing possible solutions for dealing with the same problematique in other rural communities in Mexico. Concerning rural communities in the rest of the world, the context of the settings should be carefully addressed in order to determinate the degree of congruence between the sending and receiving contexts (Lincoln and Guba 1979 in Gomm et al. 2000).

3.3 Limitations on the Analysis

The limitations of this thesis concern the diagnosis of three main aspects: a) the medical supported evaluation on the health of women and children related to IAP, b) the emissions of gases (GHGs and others) and c) an evaluation of each cooking technology in terms of energy flows. Concerning the health issue, the data accumulated is limited to the testimony of the women interviewed. Elaborating on their symptoms and experiences thereof possibly related to IAP exposure according to extensive scientific investigation (Smith et al. 2000a; 2000b; 2006). Concerning the emissions of gases generated by the combustion of cooking fires, it is limited to the information obtained by the previous studies performed by other researchers in this scope

(Berrueta et al. 2007; Johnson et al. 2008). The scientific evaluation in terms of energy flows within the technologies is neither analyzed nor discussed. Albeit since early stages of this investigation some of these problems were recognized as core issues of this whole worldwide problem it is impossible to perform such evaluations within the time frame of this research and my knowledge. At the same time, several interesting facts did derivate from each community during the research, for methodological and analytical reasons only relevant findings according to research questions will be the subject of analysis and discussion.

4. Findings and Discussion

4.1 Cooking fuel

Being around rural communities in Mexico during several years allows me to make the statement that cooking in Mexican rural households is practically exclusively performed by the women in the family. According to previous researchers' findings, fuel wood remains the main source of fuel for cooking (Masera et al. 2005; Troncoso et al. 2007) in both rural communities, although a multiple fuel strategy (Masera et al. 2000a, 2005b) also takes place. Out of the entire group of interviewed households, Table 1 shows the percentage of households that combine the use of fuel wood and LPG for cooking in the two rural settings (the percentage left out in both communities is because they only use wood fuel for cooking).

Rural Community	Fuel wood and LPG
La Lajita	90 percent
Patamban	80 percent

Table 1: Cooking fuel in La Lajita and Patamban

(Source: Personal Communication, All Interviewees in both communities, 2008)

This lead my analysis into finding the consumption of each cooking fuel, discovering that in both communities the LPG stoves were the secondary option for cooking. Cooking with LPG is only performed when the task must be done in a short period of time, early in the morning or late at night (Personal Communication, Interviewees 6/8/10/12/14/18/20). LPG is recognized in rural communities in Mexico as an expensive and sometimes luxurious technology for cooking, it comes in cylinders (exchangeable refillable tanks that contain 30 kg of

LPG) which cost $30 USD per unit in the state of Michoacan. For some of the households one cylinder could last only one month either because cooking is performed for a numerous family or because they also cook food for selling (Personal Communication, Interviewees 4/12). Expenses on fuel for cooking vary depending on the community. In La Lajita wood fuel is free and every household interviewed there remarked that they get their fuel by going out to the tropical forests to gather it. Going to *la leña* is an almost daily activity that does not necessarily represent a big effort even though everyone remarked that they need to go further for gathering it than some years ago. In contrast, in Patamban wood fuel must be purchased, an animal load could vary in price from $8 to $10 USD depending on diverse factors such as if the load is carried by a donkey or a horse. An animal load is delivered to the household and consists on 130 to 150 logs depending on the type of wood and the animal that carries it and this load could last up to 15 days (Personal Communication, Interviewees 4/6/8/11). Table 2 shows the findings concerning the monthly monetary expenses of wood fuel and LPG, before and after using the Patsari Stove in the Patamban community[23]. The last line of the table remarks the percentage of wood that is saved after the usage of the Patsari Stove. These data are also used for calculating the expenses on wood fuel. Only six households gave useful information because the other four were either not interviewed after three weeks (reasons already sited before) and in another case one of the women have not used her Patsari Stove sufficient times to remark any useful information. Remark that Interviewee 7 does not have any expenses on wood (she gets it for free) but she point out that she was saving up to 70 percent of wood fuel after using her Patsari Stove. The reason could be that she had two *fogons* before, now she cooks everything in one Patsari Stove (Personal Communication, Interviewee 7, 2008). (N/A = not applicable).

ASPECTS	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee12
1. LPG*	N/A	N/A***	$8 USD	$15 USD	$10 USD	$30 USD
2. LPG**	N/A	N/A	$0 USD	$10 USD	$0 USD	$25 USD
3. WOOD*	$10 USD	$24 USD	$10 USD	$20 USD	$0 USD	$15 USD
4. WOOD**	$4.5 USD	$14.4 USD	$5 USD	$10 USD	N/A	$12 USD
5. SAVING	$5.5 USD	$9.6 USD	$13 USD	$15 USD	$10 USD	$8 USD
6. WOOD SAVINGS	55 %	40 %	50 %	50 %	70 %	20 %

*Before using the Patsari Stove
** After using the Patsari Stove
***Expenses on LPG were up to 30 USD per month (now the LPG stove is out of order)

Table 2: Monthly expenses of wood fuel and LPG

(Source: Personal Communication, Interviewees 3/4/5/6/7/12, 2008)

[23] Both (LPG and wood fuel) were estimated according to the women's perceptions, exact measures were impossible to obtain considering the time (21 days) and the technology available

Almost every woman gets motivated when they hear about the reduction on the wood consumption from the early adopters (Rogers 2003) when cooking is performed in a Patsari Stove but even more when they start seeing this reduction reflected in their monthly budgets letting them buy in some cases other items, in several cases more food (Personal Communication, Interviewees 3/4/6/14, 2008).

> I was using 7 or 8 logs before every time I was making tortillas in my fogon, now I only need 2 or 3 to make them in my Patsari Stove. (Esther Hernandez, Patamban, 2008)
>
> Before having the Patsari the LPG lasted maximum one month… now it has been more than two months with the same LPG cylinder… (Ignacia Espino, La Lajita, 2008)

In some cases the LPG is completely abandoned:

> After having the chimney, I didn't buy any LPG no more, why should I buy it, for what? (Raquel Ayungua, Patamban, 2008)
>
> An LPG stove is expensive to maintain, LPG is very expensive, more than wood, even though the price of a Patsari Stove and a LPG stove could be the same we will be always more interested in the Patsari because it consumes wood and works according to our expectations and we can make tortillas on it. (Esther Hernandez, Patamban, 2008)

Since the HotPot only needs sunlight as fuel to perform, in La Lajita relevant findings were observed according to this feature as far as wood consumption concerns. Since the wood fuel is free, any savings in wood for cooking do not represent any economic savings but instead they represent less physical effort from the members of the rural household on gathering and cutting the wood, something that is done mostly by the women and the children. Table 3 shows how many times the HotPot is used in La Lajita community.

Interviewee	14	15	17	18	19	20	22	23	24	25
Times every 15 days	4	2	2	2	1	1	4	4	2	4

Table 3: HotPot usage frequency in La Lajita

(Source: Personal Communication Interviewees 14/15/17/18/19/20/22/23/24/25, 2008)

An average household usage of the HotPot in La Lajita is 2.6 times every 15 days. The two stapes of the Mexican diet are as mentioned before, tortillas and beans. Since tortillas can not be cooked in a HotPot (*nixtamal* could but people do not do it) for this analysis the cooking of beans can show wood fuel savings by cooking them in the HotPot instead of an open fire. Beans are the most common food to be cooked in the HotPot (Personal Communication, Interviewees 14/15/17/18/19/20/22/23/24/25) although they also use it for cooking several other meals like: *mojarra*[24], chicken, rice, vegetable soup, eggs and even *tamales*[25] (Personal Communication, Interviewees 14/15/17/18/22). According to Masera (1994), cooking 1 kilogram of beans in a three stone fire requires 6.19 kg of dry wood. However, if they are cooked with the HotPot no wood fuel is required. Presuming that the HotPot is used during 50 percent of the cooking sessions for cooking 0.5 kilograms of beans each time, the amount of saved wood would be as follows:

[(2.6 average time/2)*10 families] * [(6.19/2) kg of wood] = 39 kg of wood fuel is saved every 15 days

This means (39 kg)*(2 [15 days periods in one month]) = 78 kg every month, (78 kg)*(12 months) = 936 kg every year, almost 1 ton of fuel wood is saved each year if ten households use the HotPot for cooking 0.5 kg of beans every second week[26]. The reduced wood fuel consumption when both of the cooking technologies are in use contributes to more sustainable cooking practices within the rural households.

4.2 Health Implications

The smoke generated by open fires for cooking leads to two major impacts: within the rural household in terms of exposure to IAP (Smith et al. 2000) and globally in terms of gaseous emissions (Johnson et al. 2008; Masera et al. 2005). Along the following subchapter, the effects and health implications from the IAP exposure in both rural communities will be addressed. By directing the smoke out of the kitchen and out of the household an enormous positive impact in human health is tangible (Personal Communication, All Interviewees, 2008). Although it is complex to analyze each particular case for matters previously explained on the limitations of this analysis, framed by the testimonies collected from the women interviewed and by previous scientific knowledge already generated, the following findings and discussion are addressed. Another main acknowledged feature of the Patsari Stove and in all cases of the HotPot is the free-smoke ambiences when they are operating. After doing research in 24 households only two of the women told me that they were not affected in any sense by the smoke (Personal Communication, Interviewees 9 & 10, 2008).

[24] Kind of perch (in the order *Perciformes*), found in almost all aquatic environments, typical around this region
[25] Native American food that consist of steam-cooked corn dough
[26] The consumption of beans is higher on average therefore the amount cooked, but the calculation is conservative due to the fact that during the interviews I remarked some discontinuance (Rogers 2003) on the usage of the HotPot in several cases

Warwick & Doig (2004) explain that the composition of the smoke as a result of cooking fires varies according to factors such as the quality of the wood fuel (e.g. wet wood produces more smoke than dry wood) and the design of the cooking stove where it is burned. In addition to any IAP, the size of the kitchen and the air changes are very important factors to take into consideration, in the case of La Lajita the kitchens tend to be bigger than in Patamban and also more ventilated due to the climate conditions. Kitchens in Patamban are more isolated because of the same climate reason (see subchapter 2.5), keeping the place warm in many cases is more important than being exposed to IAP. An interesting discussion motivated by one of the GIRA technicians (Personal Communication, Interviewee 13, 2008) explains that the Patsari Stove has a two-directional benefit in the sense of heat (see subchapter 4.4 for further inquire). Figure 11 (Warwick & Doig 2004) shows the amount of noxious gases that are generated from the combustion of one kilogram of wood burning in an open fire in a 40 m³ kitchen (i.e. an accurate average size of a kitchen for both settings of this thesis) with 15 air changes per hour, it also shows the typical standards set to protect the health and the number of times in excess of the guidelines according to these concentrations of noxious gases from the combustion.

Pollutant	Typical concentrations*	Typical standards set to protect health	Number of times in excess of guidelines
Carbon monoxide (ppm†)	129	8.6	15
Particles (µg/m³)	3300	100	33
Benzene (µg/m³)	800	2	400
1-3 Butadiene (µg/m³)	150	3	50
Formaldehyde (µg/m³)	700	100	7

* From burning 1 kg of wood in a traditional stove in a 40 m³ kitchen with 15 air changes per hour.
† parts per million.

Figure 11: Pollutants generated from burning 1 kg of wood

(Source: Warwick & Doig 2004, adapted from Smith 2000)

Measurements on the particulate matter (PM) are PM_{10} and $PM_{2.5}$ (this refers to particles size) and the small size of these particles (i.e. less than 10 micrometers [µm] diameter and less than 2.5 µm respectively) enables them to be carried deep into the human lungs, with the smallest (i.e. $PM_{2.5}$) being the most penetrating and damaging to health (Warwick & Doig 2004). According to Armendariz et al. (2008) there has been poor systematic evaluation in Mexico concerning the reduction on IAP concentrations after installation of an ICS. After performing research in 60 rural kitchens in the state of Michoacan (2008), Armendariz et al. explain that average $PM_{2.5}$ 24-hour personal exposure was 0.29 µm/m³ and mean 48-hour kitchen concentration was 1.269 µm/m³ for women using *fogon*, and that the construction and usage of a Patsari Stove in these homes resulted in 35 percent reduction in median 24-hour $PM_{2.5}$ personal exposure and in 74 percent reduction in median 48-hour $PM_{2.5}$ concentration in kitchens. During the same study, carbon monoxide (CO) reductions after installation of a Patsari Stove were 77 percent for median 48-hour kitchen concentrations and 78 percent for median 24-hours personal exposures (Ibid). Figure 12 shows the most commonly stated health problems related to cooking on a *fogon*. The figure also shows the frequency of times it was mentioned in one way or another.[27]

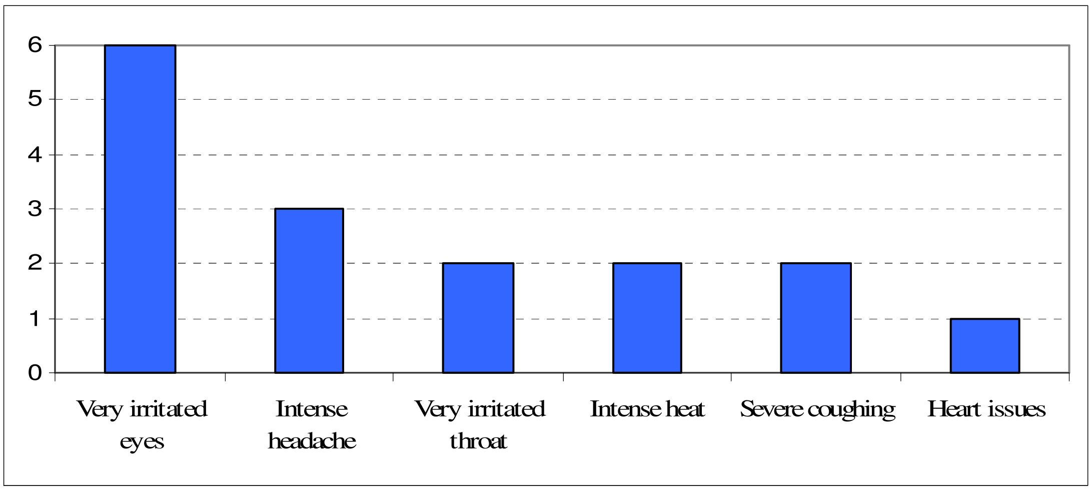


Figure 12: Experienced consequences from IAP exposure

(Source: Personal Communication, Interviewees 3/4/5/6/7/8/9/10/11/12, 2008)

COPD and ALRI are the two most common chronic diseases and killers from IAP exposure, but lung cancer, pulmonary tuberculosis, low birth weight and infant mortality, cataracts and asthma are other serious health effects related to IAP exposure (Warwick & Doig 2004). As a comment on the health effects from IAP, one interviewee made the following statement:

> …everyday I had a cold and very easily I catch infections, the doctor told me it was the constant exposure to the daily smoke. (Modesta Farias, La Lajita, 2008)

After Patsari Stoves were constructed and used in the rural kitchens the following comment was heard:

> My grandchildren use to say: *"grandma we are going to suffocate in this kitchen…"* then, when I started to use the Chimney everything changed… no more smoke. (Filiberta Vazquez, La Lajita, 2008)

[27] Figures 11 shows only the findings from the 10 households of the Patamban community

In agreement to the theory behind this thesis, the use of energy should not risk the quality life of present and future generations (WEA 2000). By not being exposed to IAP, the human health of all the family members within the rural household is improved in several ways and what more, thus the enhancement of sustainability is not only framed by social concerns but economic as well:

> … it is very expensive, when I go to the doctor for sore throat reasons due to the smoke… the other day I paid 1,300 pesos ($130 USD) including the ride to Zamora (close by city) to visit the doctor… (Esther's H. older son, Patamban, 2008)

Another relevant aspect discovered during the study is the issue of wood fuel gathering. In some cases the locals need to carry it for quite far distances, it is heavy and bulky to carry, the carrying could hurt the backbone and shoulders as well as the knees (Personal Communication, Interviewee 7, 2008). The consumption of less wood fuel for each cooking session also leads to avoid these types of issues. A clear example is illustrated in the following statement:

> …now I can make my own tortillas with two or three logs that I gather when I go for a walk… (Ignacia Espino, La Lajita, 2008)

4.3 Environmental Effects

We now know that the combustion of wood fuel not only represent a threat to human health but also to the environment in terms of emissions. Every time one kilogram of wood is combusted CO_2 emissions and other GHGs are released into the environment (Johnson et al. 2008; Masera et al. 2005). Emissions vary and are very complex to asses (Edwards et al. 2003), but as previously assessed (from Figure 4) the total GHGs emissions from burning 1 kilogram of wood in an open fire are 693 grams (or 0.693 kg) of CO_2 equivalent (Smith et al. 2000 in WEA 2000). According to Masera et al. (2005) the use of wood fuel averages 2 kilograms per day per person in Mexico and more than 27 million people are implicated in this case. Therefore the consequences from the wood burning for cooking purposes in Mexico frame a large and complex impact to the environment. The following calculation was made to determinate the total CO_2 equivalent emissions generated by cooking fires in rural Mexico per day:

$$[(27 \text{ million people}) * (2 \text{ kg wood fuel})] * [0.693 \text{ kg of } CO_2 \text{ equivalent emissions}] = 37{,}422{,}000 \text{ kg of } CO_2 \text{ equivalent emissions}$$

Therefore 37,422 tons of CO_2 equivalent are released into the atmosphere by cooking fires in Mexico every day. Table 4 shows the monthly amount of wood fuel in kilograms used for cooking per family in the community of Patamban before and after the Patsari Stove was in use[28].

ASPECTS	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee12
1. WOOD*	70 kg	390 kg***	60 kg	325 kg	260 kg	130 kg
2. WOOD**	31.5 kg	234 kg	30 kg	162.5 kg	78 kg	104 kg
3. SAVING	38.5 kg	156 kg	30 kg	162.5 kg	182 kg	26 kg

*Before using the Patsari Stove
** After using the Patsari Stove
*** A family of seven (each spends 1.86 kg of fuel wood per day)

Table 4: Wood fuel savings in Patamban

(Source: Personal Communication, Interviewees 3/4/5/6/7/12, 2008)

The amount of CO_2 equivalent emissions saved by six families (therefore six Patsari Stoves) in the Patamban community could be calculated by the following:

(595 kg in total of saved wood fuel) * (0.693 kg of CO_2 equivalent emissions) = 412 kg of CO_2 equivalent emissions saved

If 412 kilograms of CO_2 equivalent emissions saved are divided by the number of Patsari Stoves, the result is that every Patsari Stove could save up to 68.66 kilograms of CO_2 equivalent emissions on average per month, meaning that every year a Patsari Stove could save around 824 kilograms of CO_2 equivalent per year. Adding the HotPot into the kilograms of CO_2 equivalent emissions savings, we know that 936 kilograms of wood could be saved every year if ten families adopt it (see subchapter 4.1.). Thus the savings of CO_2 equivalent emissions from ten rural households can be calculated by the following:

(936 kg of wood) * (0.693 kg of CO_2 equivalent emissions) = 648 kg of CO_2 equivalent emissions saved

[28] Weights come from the amount of logs (from animal and m³ loads) that were estimated according to the women's perceptions, exact measures were impossible to obtain considering the time and the technology available. 1 log = 1 kg

Therefore each HotPot can save on an average 64.8 kilograms of CO_2 equivalent emissions per year. This study recognizes that one of the main functions of forest ecosystems (or any other biomass) is carbon fixation (Tucker 1999). Due to this natural cycle, any emission of CO_2 released into the atmosphere generated by wood fuel combustion belongs to it. Therefore what this analysis is showing only concerns the issue of saving certain amount of GHGs from being emitted into the atmosphere every time wood fuel is used for cooking. When cooking is perform in a Patsari Stove two facts contribute to these savings. Less wood is burned and it occurs in a combustion chamber that encourages a complete combustion releasing all the carbon as CO_2 instead of other GHGs (e.g. methane) with longer and greater global warming potential (WEA 2000).

4.4 The Sustainability Perch

Rural households in Michoacan tout the typical local perch or what they call *mojarra* as a special meal. In honor of this fact that I personally experienced in some occasions, the following Casual Loop Diagram or CLD[29] (Figure 13) was named *'The Sustainability Perch'*. The figure is meant to be used as a simple and pedagogic explanatory method for understanding the entire system and its holism.

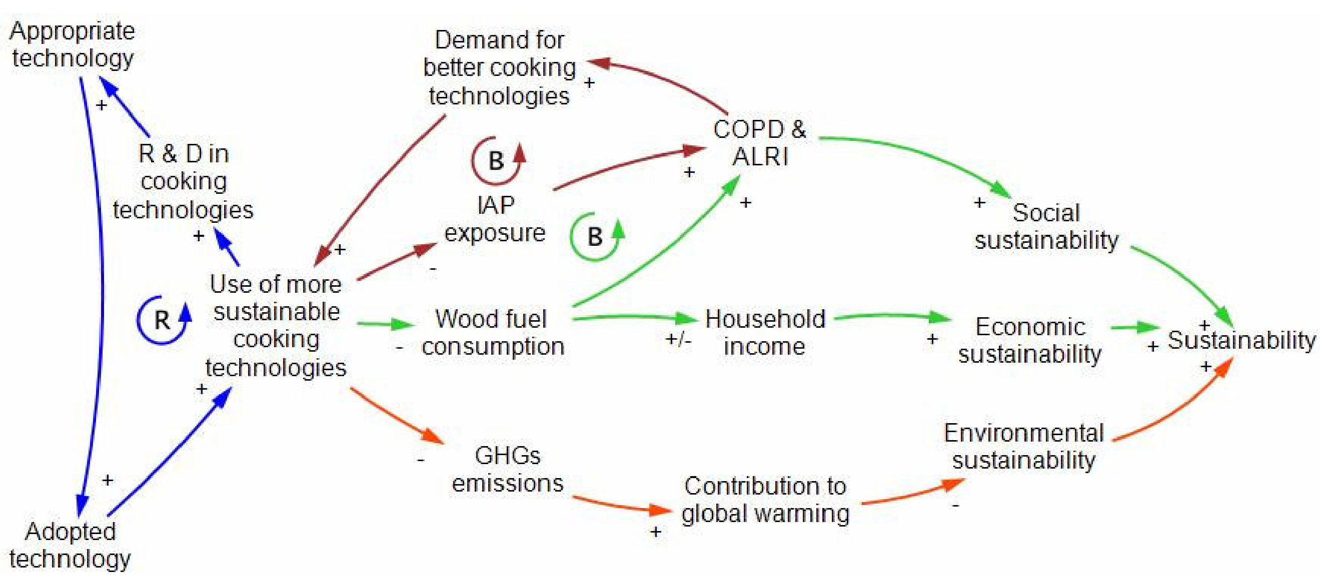


Figure 13: The Sustainability Perch

(Source: Velasco 2008)

[29] A CLD is one tool of system analysis approach in order to understand the links within all systems between drivers and their actions, which reinforce or balance the system as a whole

The tail of the perch is the driver of the system as well as its reinforcing loop (blue arrows). The body of the perch is conformed by the three ways (social, economic and environmental) sustainability (the mouth) is enhanced. It is presumed by this thesis that the more a technology is appropriate, the more it will be adopted, therefore its usage will increase, leading to an increment on research and development (R&D) in cooking technologies that will result on more appropriate technologies available (reinforcement loop). This reinforcement loop links with the system through the usage of a more sustainable cooking technology (Patsari Stove and/or HotPot), and from here the three pillars of sustainability drive into its consequences. The social and economic pillars occur inside the rural household (green arrows), thus they belong to the local context. Concerning the social pillar, an increase on the usage of a more sustainable cooking technology leads to less exposure to IAP and therefore less COPD and ALRI, which as a result enhance the social sustainability. Regarding the economic pillar an increase on the usage of the technologies leads to less wood fuel consumption (also to less consumption of LPG), which could lead to an increase on the income of the household or a decrease (therefore the +/-). The decrease could be the results of what is call the '*Rebound Effect*'[30]. An increase on the household income increases economic sustainability and the result is an increase in the general concept of sustainability. Moreover, the environmental path works on a global scale (red arrows). The usage of a more sustainable cooking technology decreases the GHGs emissions, which leads to less contribution to global warming and thereby the enhancement of sustainability through another of its pillars; the environmental. Two balancing loops (brown and green) exist within the system and together with the reinforcement loop maintain the system running. Both balancing loops are encouraged by the demand for better cooking technologies (brown arrows) that lead to the usage of more sustainable cooking technologies closing both loops into its balance. One balancing loop (brown) drives through the decrease on the exposure to IAP that encourages less COPD and ALRI and therefore increases the demand for better innovations in cooking technologies, a demand that could come either from the rural families or from any other institution in the country or worldwide (e.g. SSA, SAGARPA, FAO, WHO). The other balancing loop (green) drives from the decrease on wood fuel consumption which also decreases the COPD and ALRI which in turn increases the demand for better innovations in cooking technologies, ending up in an increased use of more sustainable cooking technologies. The following paragraphs will dissect the concepts that are subject of discussion within the system according to the theoretical ambition of this thesis.

An appropriate technology (AT) must meet certain requirements which were previously explained in chapter 3. Table 5 shows the reasons that frame the Patsari Stove and the HotPot into this concept, as well as a score

[30] Decreasing the expenses on wood fuel or LPG generate savings that could generate expenses in any other thing for the household decreasing then the household income. These expenses could be designated for buying more food or for making improvements within the rural kitchen. Both things are detected to occur in this case study. The last one will be address in the next Subchapter

according to these reasons. Albeit in some cases just some of the parameters are fulfilled, both are recognized as AT in this study.

APPROPRIATE TECHNOLOGY	THE PATSARI STOVE	THE HOTPOT
Low cost	Bad	Bad
Operation simplicity	Very good	Very good
Responds to users' needs	Excellent	Very good
Employs local materials and labour	Very good	Regular
Uses renewable resources	Good	Excellent
Improves rural livelihood	Very good	Very good
Cultural adaptability	Excellent	Good
Suitability for the rural setting	Very good	Very good

Table 5: Appropriate more sustainable cooking technologies

(Source: Velasco 2008)

An AT could also be framed within a concept of adaptation according to the different settings where it performs. Concerning the Patsari Stove's two-directional benefit in relation to the heat that generates while is in use (briefly mentioned in subchapter 4.2). The following fact explains in detail the concept of adaptation. In La Lajita women complain about the heat that is constantly produced by the *fogon* as they have to be very close to it for several hours (between 4 and 6 hours) when they are making tortillas (Masera et al. 2005). They get hot and sweaty and it is very uncomfortable. On the other hand, in Patamban, despite the IAP exposure, many women are pleased to be close to the fire during the cold season in order to get warm. The Patsari Stove can store a lot of heat (see Footnote 7) and it can also be conveniently approached from the front or from the sides. In the first case the heat is intense and it can easily keep you warm for hours, in the second case you can not feel much heat, personal exposure in several occasions for both cases support this statement. The interesting thing is that one can use it for tortilla making approaching it from the front or any side. This is then why women in La Lajita as well as in Patamban find it comfortable to use, all according to their need for surrounding heat or not during the cooking.

There are several reasons that could influence the adoption of the Patsari Stove and the HotPot. Table 5 shows that both technologies have the potential to be adopted according to their features and the statement of this thesis. Rogers (2003) remarks the importance of seeing the diffusion of a new technology as a social process.

Therefore he explains the importance of looking on how this new technology is compatible with the values, beliefs and past experiences of the individuals in the social system. Rural families in both communities have long traditional experience in cooking with wood fuel. Their grandmothers, mothers and themselves have usually cooked in a *fogon* throughout their lives. It has been the center of the family gathering and part of their culture (Personal Communication, Interviewee 1, 2008). Therefore it is clear after doing this research that the Patsari Stove has closer approach to the values, beliefs and past experiences of the members of rural communities than the HotPot. There are some cases where women were not even interesting on trying the HotPot (Personal Communication, Interviewees 21/23, 2008), which supports what Rogers (2003) refers to as 'rejection'. The interviewees were generally enthusiastic about having a Patsari Stove as soon as possible. Throughout the analysis this study shows that albeit this constrains HotPots and Patsari Stoves have a high rate of adoption.

Rogers' (2003) Innovation-Development Process (Figure 10) has been consumed within this thesis already at an early level. It is within this process where diffusion and adoption of a new technology or innovation takes place. Throughout the introduction of this thesis, it is stated in detail how much the technology is needed (phase 1). Basic research and applied research (phase 2) have developed (phase 3) in the design of what this study recognizes as more sustainable cooking technologies (i.e. the Patsari Stove and the HotPot). Its commercialization (phase 4), which includes production, manufacturing, packing, marketing and distribution, is currently taking place by a national and international transdiciplinary group of stakeholders[31] (GIRA, CIECO, UNAM, Integrated Logistic Solutions, FMCN, SHE) (Personal Communication, Interviewees 1/2/27, 2008; SHE 2006; Xanic 2007). At the same time, the diffusion and the adoption phases (phase 5) of both technologies is currently taking place in rural communities in Mexico as the results of this study also indicate. Innovators and potential early adopters show their enthusiastic evidence as a result of the diffusion:

> Since the very first day I heard about the HotPot and the Patsari, I wanted to try it! (Ignacia Espino, La Lajita, 2008)

Rogers (2003) explains that in this phase of the Innovation-Development Process the adoption occurs and finally the consequences of this adoption that will be discussed in the next subchapter. It is the Innovation-Decision Process that explains in detail how an adoption occurs. In this second process members of a social system get knowledge and form an attitude toward the new cooking technology. This knowledge will lead to adoption or rejection of the innovation in what Rogers recognizes as the 'confirmation' stage. It is also in this process where

[31] At this moment both cooking technologies have a name internationally. They are both produced in Mexico but marketing goes beyond the oceans (e.g. SHE, The Ashden Awards)

they start using it and through the usage they decide to confirm that is a more sustainable cooking technology. This last stage of the process has an extreme importance within this study because as the analysis shows, is when the members of the rural communities in La Lajita and Patamban could remark the benefits from cooking with these technologies. These benefits are directly reflected in their health, their fuel consumption and even the time they spend on cooking:

> The Patsari Stove is a benefit for the entire family… it is health for the whole family (Micaela Franco, La Lajita, 2008)

> The good thing about the HotPot is that you can leave the beans for hours and go do something else meanwhile, and then when you come back they are not burnt and they ready to eat (Micaela Franco, La Lajita, 2008)

Adopters even combine technologies for cooking a special meal like the following statement shows:

> I fry the rice with tomato in my Patsari and then I put it in the HotPot and after three hours it is ready, the flavor is so good, the original flavor stays with the food because it is cooked slowly (Filiberta Vazquez, La Lajita, 2008)

It is also in this phase of confirmation that adopters could have discontinuance on the adoption of the cooking technology, something that occurred in some cases with the HotPot in La Lajita (Personal Communication, Interviewees 14/15/17/20, 2008) as well as the Patsari Stove in only one case (Personal Communication, Interviewee 23, 2008). Adopters of the Patsari Stove manage and maintain their Stoves once they have reached the confirmation stage within the adoption phase. This is also what Troncoso et al. 2007 calls '*appropriation*', shaped by the adopters' motivation, interest, commitment and organization to achieve a successful development. From this point, the last stage from Rogers' Innovation-Development Process (see Figure 10) is reached; the Consequences from adopting a more sustainable cooking technology that are reflected in the entire kitchen, something that will be exposed in the next paragraphs.

4.5 The Smoke Out of the Kitchen

Rogers (2003) remarks the importance of the last stage in the Innovation-Development Process; the Consequences phase. These are the changes that occur after the adoption of an innovation or technology. In this research, the changes from adopting a more sustainable cooking technology reflect within the rural kitchen and therefore in the entire family.

The Patsari Stove came to change our kitchen for better, we painted it, cleaned it and made it pretty for good (Micaela Franco, La Lajita, 2008)

Kitchens suffer modifications in order to be improved and the impacts are reflected in more than that:

…now we can eat all together close to the chimney… I bring a chair and a table and I pass around the just made tortillas to my husband and children… (Ignacia Espino, La Lajita, 2008)

Having the smoke out of the kitchen motivates the members of the family to gather in the kitchen. This gathering takes place close to the Patsari Stove because there is a feeling of security. The smoke-free ambiance enhances social sustainability by the time shared together while the food is cooked, eaten and afterwards. Figure 14 shows how the kitchen of Ester Hernandez in Patamban changed in three weeks. The right side of the pictures shows how the *fogon* within the kitchen generated a great amount of smoke the first time I visited Esther's household. The next day a Patsari Stove was constructed and right after a few days of being in use, it became the most important and attractive item within the kitchen (Personal Communication, Interviewee 3, 2008).

Figure 14: Esther's kitchen before and after the Patsari Stove

(Source: Velasco, Patamban 2008)

Improving any site in a Mexican rural household takes time. This is also the case of the kitchen. There is not money, time or even willingness to do it. But paradigms framed by the idea that it is the kitchen the last place in the rural household that suffers improvements are broken after a Patsari Stoves is adopted. In some cases the Stoves are decorated with ceramic tile. Figure 15 shows Leonarda's Patsari Stove after some time of usage and a few months later when enough money was saved for its improvements. Leonarda also became a change agent by the training she received on how to construct a Patsari Stove and later on she become the local constructer of Patsari Stoves in La Lajita.

Figure 15: Leonarda's Patsari Stove before and after

(Source: Velasco, La Lajita 2008)

Going back to the two-directional benefit regarding the heat that is generated while the Patsari Stove operates (briefly mentioned in subchapter 4.2 and addressed in subchapter 4.4), give an opportunity to meet some of the challenges within the consequences phase. In Patamban, kitchens tent to be insulated to keep the heat from the *fogon*, but one side of the roof at least, is open to let some of the smoke out. After a Patsari Stove is constructed and used, no more smoke will stay inside but the aperture in the roof will remain. This can lead for the smoke to come inside the kitchen again or to lose all the heat that a Patsari Stove could provide for heating purposes. Therefore in this case a consequence from adopting a new cooking technology solves one issue but it may release another one. Awareness on this by the time a Patsari Stove is constructed is the solution.

5. Conclusions and Recommendations

Sustainable development is framed by ensuring general prosperity without damaging the condition of the present generations and assuring the same conditions for the ones that are to come. This also must be done by taking good care of the society, the economy and the environment at the same time. This thesis is framed by transdisciplinary knowledge allocated within social, economic and environmental facts of a worldwide problematique. The findings and discussion within this research confirms that through the adoption of a more sustainable cooking technology such as the ICS Patsari Stove and the SCD HotPot, three pillars of sustainability (social, economic and environmental) are enhanced in two rural communities in the state of Michoacan, Mexico.

Concerning the social and economic pillars, the effects can be seen in the rural household. While a Patsari Stove operates PM exposure decreases 35 percent in median 24-hour $PM_{2.5}$ personal exposure, and 74 percent in median 48-hour $PM_{2.5}$ concentrations in kitchens (Armendariz et al. 2008). Concerning CO decreases 77 percent for median 48-hour kitchen concentrations and 78 percent for median 24-hours personal exposures (Ibid). Regarding the economic pillar, a Patsari Stove could save from 20 to 70 percent of wood fuel compared to the *fogon*. LPG consumption decreases a minimum of 17 percent and in some cases it is totally replaced as a source of fuel for cooking. The consequences from these drops on cooking fuels result in long-term money savings that in several cases are designated for acquiring more food or for buying something else to make improvements in the rural kitchen. Regarding the environmental pillar, the effects are achieved in a global context. Results and calculations show that a Patsari Stove could save up to 824 kilograms of CO_2 equivalent emissions per year, while a HotPot can save 64.8 kilograms of CO_2 equivalent emissions per year. All the following results could frame both cooking technologies within global standards for validation as sustainable energy sources (Boyle 2004; WEA 2000).

In order for a cooking technology to be adopted it should be an appropriate technology. Several aspects must be considered before a cooking technology can be classified within this group. Both cooking technologies have shown high rate of adoption in La Lajita and the Patsari Stove in Patamban. This shows that both technologies are appropriate cooking technologies for the Mexican rural context. Cooking is more than a daily activity in these communities; it is a way of life which naturally implicates specific traditions and culture. The Patsari Stove and the HotPot have shown the potential to become part of the '*multiple fuel*' strategy for cooking in rural Mexico (Masera et al. 2000; Masera et al. 2005). But not to overcome everything that the *fogon* could represent to the members of rural communities in Michoacan. Even though after the adoption of the Patsari Stove the *fogon* in some cases is completely abandoned, while in some others it is still part of the cooking technologies but it is placed outside in order to avoid the exposure to IAP.

A solar cooking device such as the HotPot could have a greater rate of adoption in places where the wood is a scarce resource or where women face a high risk while collecting the wood fuel. It is also of major importance that sufficient resources such as time, money and staff are designated for training the members of the rural communities that it is possible to cook with the sunlight, how to perform this task and that it will not have any negative impact on the food you cook. Since members of rural communities in Mexico are used to cook mainly with wood fuel, this fact means dealing with culture and tradition on the way they cook, which is complex but not impossible like this case shows.

Results from bringing up appropriate more sustainable cooking technologies into the Mexican rural context is releasing a grassroots launch cooking phenomena that starts locally but whose impacts could be measured globally. At the beginning it happens on a small scale with a top-down approach. A few families in the rural community adopt the technologies, later the rumors about the technology are spread, now with a bottom-up approach. But to reach the rural families that most need these technologies, the cost of both cooking technologies should be somehow subsidized, because it is still very high considering an uncertain monthly income of the majority of the rural households in Mexico.

The following paragraphs show shortly some recommendations as a result of this study:

- A strong network between NGOs is necessary to integrate an effective programme on the reduction of wood fuel consumption for cooking in rural communities in Mexico. They should be well coordinated in order to promote both technologies like in the case of La Lajita. The HotPot should be offered as a complementary cooking technology every time. Both cooking technologies together have the capacity of integrating a strong cooking package for rural communities in Mexico or any other rural communities worldwide where *fittingness* exists.

- The use of wood fuel for cooking in a Patsari Stove or any other improved wood-burning stove could be reinforced in terms of sustainability by being accompanied with some type of sustainable harvesting performed through reforestation done by the users.

- Once a Patsari Stove is adopted it could also be encouraged by GIRA that micro-enterprises devoted to making tortillas develop. With the aim of reinforcing the rural household’s income as well as women’s independence.

- Awareness on the damaging effect from the IAP exposure could come from the medical centers in the communities. Doctors in charge of the community are always seen as very respectful members of the social system, even if they just visit the communities once every two weeks or less.

5.1 Final Reflection

The diffusion of new cooking technologies, as any other diffusion of innovations, is complex and it should be treated as such. There are several aspects that should be taken into account and they should be accomplished in order to achieve any success. It is a social process (Rogers 2003) that concerns many different aspects that keep a dynamic system running and changing through time. Creating the wrong idea about the Patsari Stove and the HotPot could lead to the rejection of adopting these cooking technologies which could result in a big collapse of all the efforts and investments to effectively diffuse and allocate them along all possible Mexican rural communities, specially where they are most need it. Currently the overall scenario is fed by the positive grassroots' attitude towards the technologies. I experience this myself through all my formal and informal study visits, farmed by my long conversations with women, men and even children (the future householders). They are generally motivated to try new cooking technologies that could help them improve their health, economy, environment and daily tasks. Several rural families are already experiencing the benefits and consequences of adopting what my thesis recognizes as more sustainable cooking technologies.

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7. Appendix

7.1 Appendix 1. Interviewees

Interviewee 1. Karin Troncoso. PhD GIRA. Mexico City. Interviewed on 29th January 2008.
Interviewee 2. Mariana Diaz. Head Coordinator of the HotPot in FMCN. Mexico City. Interviewed on 28th February 2008 & 28th April 2008.
Interviewee 3. Esther Hernandez, Habitant of Patamban. Interviewed on 4th & 26th March 2008.
Interviewee 4. Guadalupe Ayungua, Habitant of Patamban. Interviewed on 4th & 27th March 2008.
Interviewee 5. Raquel Ayungua, Habitant of Patamban. Interviewed on 4th & 27th March 2008.
Interviewee 6. Cecilia Martinez, Habitant of Patamban. Interviewed on 4th & 27th March 2008.
Interviewee 7. Maria de la Luz Valentin, Habitant of Patamban.Interviewed on 4th & 26th March 2008.
Interviewee 8. Susana Tellez. Habitant of Patamban. Interviewed on 4th March 2008.
Interviewee 9. Maria de Jesus Gutierrez. Habitant of Patmaban. Interviewed on 5th & 26th March 2008.
Interviewee 10. Consuelo Castillo. Habitant of Patamban. Interviewed on 5th & 26th March 2008.
Interviewee 11. Guadalupe Lagunas. Habitant of Patmaban. Interviewed on 5th March 2008.
Interviewee 12. Francisca Bautizta. Habitant of Patamban. Interviewed on 5th & 26th March 2008.
Interviewee 13. Felix. Technician GIRA. Interviewed on 5th & 8th March 2008.
Interviewee 14. Micaela Franco. Habitant of La Lajita. Interviewed on 8th of March 2008.
Interviewee 15. Modesta Farias and Husband. Habitant of La Lajita. Interviewed on 9th of March 2008.
Interviewee 16. Maria Dolores. Habitant of La Lajita. Interviewed on 9th of March 2008.
Interviewee 17. Filiberta Vazquez. Habitant of La Lajita. Interviewed on 9th of March 2008.
Interviewee 18. Ignacia Espino. Habitant of La Lajita. Interviewed on 9th of March 2008.
Interviewee 19. Clara Padilla. Habitant of La Lajita. Interviewed on 9th of March 2008.
Interviewee 20. Leonarda Aleman. Habitant of La Lajita. Interviewed on 9th of March 2008.
Interviewee 21. Estefania. Habitant of La Lajita. Interviewed on 9th of March 2008.
Interviewee 22. Pedro Jiménez. Habitant of La Lajita. Interviewed on 9th of March 2008.
Interviewee 23. Belen and Roselia. Habitants of La Lajita. Interviewed on 9th of March 2008.
Interviewee 24. Antonia Torres. Habitant of La Lajita. Interviewed on 10th March 2008.
Interviewee 25. Adelina Herrera. Habitant of La Lajita. Interviewed on 10th of March 2008.
Interviewee 26. Juana Vazquez and Husband. Habitants of La Lajita. Interviewed on 10th of March 2008.
Interviewee 27. Victor Berrueta. Head Coordinator of the Patsari Stove in GIRA, Patzcuaro, Michoacan. Interviewed on 13th of March 2008.

7.2 Appendix 2. Interviews formats

La Lajita
Name, Age, Language, Children, Cooking fuel(s):
Frequency of usage
1. How many times a day you use your Patsari Stove?
2. How many times a week you use your HotPot?

Types of food cooked with each technology
1. What do you cook in your Patsari Stove?
2. What do you cook in your HotPot?

Willingness to pay

1. How much would you have paid for your Patsari Stove?
2. How much would you have paid for your HotPot?
3. Would you recommend it? Why?

Possible obstacles

1. What has been the main obstacle for using your Patsari Stove?
2. What has been the main obstacle for using your HotPot?
3. How did you solve these issues?

Evaluation about each technology

1. What is your opinion about the big *"comal"?*
2. What is your opinion about the small *"comals"?*
3. What is your opinion about the flue?
4. What is your opinion about cooking only with the sunlight?
5. Do you feel comfortable with that?

Socio-economic and environmental impacts

1. What is happening now with the smoke?
2. How is your health? And your children's health? Any differences?
3. Are there any changes concerning the wood consumption?
4. Are there any changes concerning the LPG consumption?
5. Have you noticed any time/money savings?
6. If so, in what percentage of your monthly income?
7. What have you done with this time/money?

Kitchen improvements/impacts

1. What other benefits have you remarked from the usage of the Patsari stove? And from the usage of the HotPot?
2. What transformation has suffered your kitchen?
3. Is the gathering of the family taking place in the kitchen now? Concerning what activities?
4. Can you mention any other relevant aspect concerning the gathering of the whole family in the kitchen?
5. What else would you like to say about the Patsari Stove?
6. What else would you like to say about the HotPot?

Patamban 1

Name, Age, Language, Children, Cooking Fuel(s)

Social aspects

1. Does the smoke from the open fire bother you?
2. In which way the smoke bothers you?
3. Have you visited the doctor in consequence of being exposed to the smoke?
4. When was the last time?
5. Are the children around when you are cooking?
6. Have the children visited the doctor in consequences of being exposed to the smoke?
7. Have you had or any of the children any accident (burned) with the open fire?
8. How do you obtain the wood that you use for cooking?
9. Who is responsible for collecting the wood?
10. Have you or your husband had or any of the children any back or knee problems for carrying the wood?

Economic aspects

1. Which technology do you have for cooking at this moment?
2. What do you cook in each technology?
3. How much LPG do you spend per month?
4. How much wood do you spend per month?
5. Do you buy or collect the wood?

6. Do you feel that you are spending money on fuel that is designated to be spend on food?

Environmental aspects

1. Have you noticed any change on the walking distance in order to collect the wood?
2. Why do you think this is happening?
3. Do you see fewer trees/vegetation in the area?
4. When you go to *la leña* do you also cut trees or just pick up wood from the ground?
5. Do you feel that the reduction in the number of trees is due to the cooking done with wood?
6. Do you think the smoke that you produce with your cooking affects others? In which way?

The Patsari Stove

1. Why are you going to get a Patsari Stove?
2. What are you expecting from the Stove?
3. What have you heard from the Stove so far?
4. How do you feel about having a Patsari Stove very soon?
5. In which aspects of your life, health, economy do you think the Patsari Stove is going to have influence?
6. Who in the family is not enthusiastic about the future acquisition?
7. Are you planning on giving any commercial use to the Stove?
8. If you have more leisure time and some extra money have you though what to do with it?
9. Do you think your kitchen is going to turn into a different place? In what way?

Patamban 2

Perception/Acceptance/Adoption

1. Is your Stove working according to your expectations? (Let's take a look into your expectations from the previous interview)
2. How many times per day do you use your Stove? How many times per week?
3. What do you cook in your stove? What habits of your cooking or your kitchen in general have changed because of the Stove? Are you back on making your own tortillas now?
4. How much would you be willing to pay for the Stove?
5. Would you recommend the stove? Why?
6. What special cares does your stove requires? How often do you clean your Stove?
7. What has been the most difficult part concerning the acceptance of the Stove?
8. What have you done in order to solve these issues?
9. Do you have any suggestions for a better performance of the Stove?
10. What would you change in the stove, any improvements, why it could be better this way?

Health and fuel consumption effects

1. What is happening now with the smoke?
2. How is your health? And your children's health? Any differences?
3. Are there any changes concerning the wood consumption?
4. Are there any changes concerning the LPG consumption?
5. Have you noticed any time/money savings?
6. If so, in what percentage of your monthly income?
7. What have you done with this time/money?

Kitchen effects

1. What other benefits have you remarked from the usage of the Stove?
2. What transformation has suffered your kitchen?
3. Is the gathering of the family taking place in the kitchen now? Concerning what activities?
4. Can you mention any other relevant aspect concerning the gathering of the whole family in the kitchen?
5. What else would you like to say about the Patsari Stove?