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Social perceptions about a technological innovation for fuelwood cooking: Case study in rural Mexico

Karin Troncoso*, Alicia Castillo, Omar Masera, Leticia Merino

Universidad Nacional Autónoma de México, Mexico

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Abstract

The widespread use of traditional biomass fuels in open fires in developing countries brings about serious health effects, besides high fuelwood consumption. A technological innovation—i.e., improved cookstoves—reduce fuel consumption and address the health effects of indoor air pollution. Implementation projects have been conducted worldwide, but have frequently faced very low success rates. Different demographic and socio-economic factors have been analysed to explain low rates but there are almost no studies that try to understand, from the users' perspective, the factors involved when choosing among different cooking technologies. Through a qualitative methodological approach we documented the adoption of improved cookstoves through the implementation programme of a Mexican NGO. Results showed that although the programme raised public awareness, the improved cookstoves did not reach the poorest sector. The socioeconomic level was found positively correlated with the adoption of the improved cookstoves, but neither the age nor the educational levels were. Payment of the stove did not seem to be an adoption factor. Differences among individual users were more significant than differences between communities. Finally as men are the principal fuelwood harvesters, they should be considered as an important group in diffusion programs.

Keywords: Diffusion programs; Fuelwood; Social perceptions

1. Introduction

It is estimated that worldwide more than two billion people use fuelwood as their only fuel (IEA, 2002). In Mexico's rural sector fuelwood is the main domestic fuel, used by approximately 25 million people, mainly for cooking (INEGI, 2000; Masera et al., 2005). In most cases fuelwood is used in open fires (usually consisting of three stones on the kitchen floor, surrounding a fire), which besides having low energy efficiency, are a source of indoor air pollution. Continual exposure to smoke and suspended particles is a cause of a number of health problems. These problems have been identified by the World Development Report as one of the four most critical health problems worldwide, and one of the main causes of death among young rural children (Barnes et al., 1994; Bates et al., 2005; Saatkamp et al., 2000; Smith et al., 2000).

In urban areas fuelwood for cooking has been gradually substituted by liquefied petroleum gas (LPG) or other modern fuels (Arnold et al., 2003). However, in rural areas this process has been slow and oriented towards complementing rather than substitute fuelwood, in what has been called a "multiple fuel" strategy (Masera et al., 2000). Considering these factors, the need to develop technological solutions that address the problems of open fires has been identified.

Since the mid-1970s, a number of models of improved wood-burning cookstoves (ICS) have been developed that address the two main drawbacks of open fires, by including a combustion chamber and a tube to take the smoke outdoors. In addition, ICS have environmental benefits, particularly, by diminishing fuelwood consumption; they may reduce the emission of greenhouse gases (Barnes et al., 1994) (see Table 1).

In Mexico, a number of improved cookstove dissemination programmes have been implemented during the last 30 years. They have faced a significant resistance to change among users, and, therefore, have had a limited impact. Their main drawbacks have been their patronising approach,

*Corresponding author. Tel.: +52 55 5623 2777; fax: +52 55 5623 2719.
E-mail address: karin@oikos.unam.mx (K. Troncoso).

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Table 1
Comparison of fuelwood cooking technologies

Rural technology: open fire	High fuelwood consumption	• Increases the cost of fuelwood consumption • May contribute to deforestation • Increases harvest time
	Indoor air pollution	• Damages people's health • Smokes the kitchen and the food
Appropriate technology: improved cookstove	Fuelwood savings	• Drops harvest distance • Saves time and money • Mitigates climate change
	No indoor air pollution	• Reduces discomfort and illnesses • Keeps kitchen and dishes clean

their focus on technical aspects and their disregard of users' priorities (Díaz-Jiménez and Masera, 2000).

Experience shows that there is no simple solution. By and large users do not switch fuels or technologies, but follow a multiple use strategy whereby new cooking technologies and fuels are used without abandoning traditional systems. In Mexico, for instance, 31% of households where fuelwood is used use LPG as well (Masera et al., 2005). Examining people's perceptions, as well as the visions of the different stakeholders may lead to a better understanding of the technological options that people in rural areas really have.

Different to other analysis of implementation projects where the aim has been to prove adoption rates in relation to demographic and socio-economic factors, the interest of this study was to acknowledge the character of users as people with different histories, visions, motivations and expectations. Considering the factors known to influence the adoption of technologies and the obstacles that have been found in the diffusion of improved cookstoves, this study aims to understand people perceptions about a technological innovation in rural Mexico by carrying out a case study in the Purhépecha region.

2. Conceptual principles that frame this study

2.1. The adoption of innovations in rural areas

The adoption of a new technology takes time, especially when the innovation needs to be adopted independently by each individual. It has been found that in every community there are individuals with different attitudes towards the innovations. According to Rogers (1995) and Van den Ban and Hawkins (1996), whenever an innovation is offered in a rural community, there is usually a group of early adopters: enthusiastic and responsive people that are ready to accept innovations. As long as they are respected by the community, they fulfil the role of models for the rest. There is a second group that will rapidly follow the first one in adopting the technology. A third group of sceptics see any new idea with caution and will accept it only under economic or social pressure. Finally, there are those who have their point of reference in the past and who accept an innovation only when it will probably have been surpassed by another innovation; their scope seldom reaches beyond the local social milieu and they are suspicious vis-à-vis innovations and innovators.

Rogers (1995) defines diffusion as the process through which an innovation is communicated through certain channels in a certain time period between the members of a social system. It is by means of the diffusion process that people can get to know an innovation and perceive it as something useful. The diffusion process becomes self-sustaining when a critical mass of users is reached. In that moment the individuals perceive that the innovation has been adopted by everyone.

An implementation programme focused only on the diffusion of technology, as appropriate as it may be, and which disregards the need to make people aware of the proposed innovation, the organisation, the training of local technicians, and the external technical support structures, is unlikely to reach people beyond those that are directly trained (Roling, 1988).

In order to be adopted by users, a technology must represent a relative advantage; it must be more useful than the one it is substituting. It must also be compatible with the attitudes, values, beliefs and needs of potential users, for any innovation that goes against an entrenched custom in a community is unlikely to be adopted. It must also be easy to understand and implement, and its effects and benefits must be visible (Van den Ban and Hawkins, 1996). The technology adoption process does not end when the user accepts to adopt it; a follow-up to the innovation is needed to verify that the expected benefits have actually been delivered. Only when the user becomes independent in the management and maintenance of a new technology, it can be said that it has been accepted (Rogers, 1986). Lastly, the appropriation of technology can only be achieved through people. It is their motivation, understanding, interest, commitment and organisation that make possible a successful development (Roling, 1988).

2.2. Appropriate technologies

In order to assess the role a stove implementation project has in the design, diffusion and adoption of a new technology, it is important to examine whether this

technology is appropriate to solve the cooking needs of local inhabitants.

Appropriate technology is a concept crafted in the early seventies as a response to the need to develop technologies that could satisfy rural people needs (Shumacher, 1973). A technology can be labelled as *appropriate* when it is simple, it responds to users' basic needs, it respects the local culture, it employs local materials and labour as much as possible, it uses the resources in a rational and renewable manner, and it recognises the technological tradition of rural people (Aguilar, 1990). This definition leads to a number of questions in the case of ICS: What is the origin of the idea to design a technology that saves fuel and reduces the exposure to smoke? How do we know whether the solutions provided by improved cookstoves do really meet the needs of the people as they perceive them?

Historically, the interest for ICS came first from governments and environmental organisations that became concerned about the possible link between fuelwood harvesting and deforestation. Global air pollution effects of biomass fuel use were examined. It has been widely demonstrated that fuelwood harvesting is seldom a cause of deforestation (Hurst and Barnett, 1990; Masera, 1994), and, on the contrary, fuelwood scarcity if often the consequence of the resource exploitation brought about by other activities such as the timber industry or the enlargement of the agricultural frontier. However, greenhouse gas emissions are significant: it was estimated that seven percent of global greenhouse gas emissions are brought about by biomass fuel combustion (Ahuja, 1990). (This contribution is mainly made up by greenhouse gases other than CO_2, since net CO_2 emissions are null when the biomass is sustainably harvested.) Exposure to smoke was later identified as a serious health problem, especially for women and small children. Summing up, the designs of improved cookstoves have mainly been driven by the perceptions of external stakeholders, and actual people's perceptions have played a minor role. It is necessary, therefore, to start acknowledging what the users' needs are in terms of cooking technologies.

2.3. Gender perspectives

Fuelwood is an essential aspect in the life of most women in the rural areas of the planet. Although fuelwood harvesting is not a female-only activity, cooking is. Gender is consequently a key factor in the analysis of fuelwood use. The gender concept refers to the social system of roles, privileges, attributes, and relationships between men and women, which are not due to physiological motives, but rather to social customs. Gender roles shape our identity, determining how we are perceived and how we are expected to think and behave (Khamati-Njenga and Clancy, 2005).

In the case of fuelwood use, a gender perspective implies exploring and analysing the issue by taking into account that resource scarcity affects men and women in different ways, mainly regarding the different roles played in the day-to-day tasks, the time these activities require, the practical needs of each individual, and the resource access and control (Skutsch, 2005). Women, and notably poor women in developing countries, work more hours per day than men, not only at home but often in arduous agricultural activities too (Skutsch, 2005). Even though in Mexico women traditionally are not involved in agricultural activities, this situation is changing due to the migration of men to the USA.

3. The case study: an improved cookstove programme in the Purhépecha Region, Mexico

3.1. The implementation project

The Interdisciplinary Group of Appropriate Rural Technology (GIRA), is an NGO with more that 15 years experience in the implementation of improved cookstove projects. At present they are carrying out a project in the Purhépecha Region of the state of Michoacan, located in the southwest of Mexico. A high percentage of the population belongs to the Purhépeha ethnic group and conserves their language and deep-rooted traditions (GIRA, 2003).

The project is jointly conducted by the NGO, the Ecosystem Research Centre of the National University of Mexico (UNAM), the University of Berkeley (GIRA, 2003) and other institutions. The project is funded by the Shell Foundation, the Health Ministry of Mexico, and other donors. It started in February 2003 and will finish in July 2006. The final objective of this project is the construction of 1500 improved cookstoves in 35 rural communities. In order to fulfil this objective, a cookstove model called *Patsari* was tailor-designed for this region (see Fig. 1). (The Patsari stove comes in two models made out of clay and sand. Its design includes several improvements to the Lorena model, like the use of a mould, custom-made parts and improvements to combustion chambers and tunnels, in order to increase its efficiency and its durability.)

An integrated training and dissemination strategy was prepared by GIRA (Masera et al., 2005) which included a dissemination team formed by a local development worker (woman) with previous experience in similar projects and two cookstove technicians. The development worker was in charge of organising meetings with women in which the health problems linked to the exposure to smoke were explained, and the benefits of improved cookstoves were introduced. Lists of interested people were produced after the meetings. Cookstoves were then constructed by local builders, proposed by the local authority and trained by the NGO field technicians, in order to favour reproducibility and to enable community members to turn to him/her at any time to have a stove built. Materials and labour costs of most stoves were covered by users. Stove cost was between US$25 and $45, depending on the availability of subsidy (an amount

Fig. 1. The *Patsari* cookstove model.

in the order of magnitude of the weekly family income in rural Mexico). Unlike previous improved cookstoves experiences in Mexico, this project provides a follow-up to stove construction: the builder visits every household up to three times after construction and offers technical assistance in stove use and maintenance.

4. Social perceptions study

The aim of this study was to understand what social, cultural, economic and environmental factors are involved in users' decisions when choosing a cooking technology and to address the role of the interplay between the different stakeholders of the cookstoves implementation programs in this region.

A qualitative research methodology was chosen since this approach enables social action to be understood from the viewpoints of the different stakeholders (Taylor and Bogdan, 1987), by studying people in their natural context and by trying to understand their actions in terms of the meaning given by them (Denzin and Lincoln, 2000). The knowledge is therefore reached through the reconstruction of these subjective meanings (Robottom and Hart, 1993).

4.1. Methodology

In order to assess whether wood scarcity was a factor of adoption, three communities with different resource access conditions were selected for this first stage:

- Copándaro, where the access to the wood is very good (less than 30 min walk).
- Las Tablas, with an average access to the wood (30–60 min walk).
- El Sobrado, where the resource is scarce (more than 60 min walk) and most people has to buy it (fuelwood cost varies between US$5 and 10 per family per week).

All three communities are in the same stage of implementation: 1 year after the construction of the improved cookstoves. They all have a similar access to LPG, although the number of homes with LPG stoves varies between communities. Interviews were conducted with both adopters of *Patsari* stoves and women who did not accept to try the innovation. Although the main objective of the study was the analysis of the GIRA project, 15 interviews were conducted with beneficiaries of another (municipality-sponsored) cookstove implementation project, enabling the authors to make a preliminary comparison of the technology adoption results under different approaches.

This additional implementation project was carried out in Las Tablas (a community where GIRA had previously worked). Fifty-five cookstoves (see Fig. 2) were built by the local authorities with the assistance of another NGO (ORCA). The stoves were given for free.

Specific methods used in this research were participant observation and semi-structured interviews. During the first stage of the research, interviews were conducted with a number of stakeholders, with a focus on the users. An interview guide was in turn tested in a pilot group in the community of Comachuén with 11 women. The interviews were transcribed and analysed using the Atlas Ti® qualitative analysis software. Samples were taken with

Fig. 2. The municipality-sponsored cookstove model.

the "snow ball" method interviewing initially the first woman who accepted to try the cookstove in each community, and continuing with individuals that were identified in these firsts' interviews. The size of the sample was decided by saturation (interviews ceased when people stopped contributing new elements to the research).

A special treatment was followed in the case of Copándaro because of the very high percentage of cookstoves built (50 out of a total of 63 homes): almost half the community was sampled in order to understand the project success and to apply some statistical tests, particularly aimed at observing whether the age, the years of formal education and the socioeconomic level were related to a better adoption of improved cookstoves. (These variables arose from the interviews with GIRA team, see below.) The level of adoption was determined according to several parameters: whether or not the woman accepted to build an improved cookstove; if the cookstove constructed was in a condition that allowed it to perform the duties it was designed for; whether it had received an adequate maintenance; and lastly the frequency of use and level of satisfaction.

A total of 85 semi-structured interviews were conducted in the 3 communities[1]: 52 to users (out of which 37 are users of *Patsari* cookstoves built by the GIRA project), 15 to non-users (out of which 5 rely only on LPG), and 18 to other stakeholders (five local authorities, two builders and 11 project team members). The interviews to project team members enabled reconstructing the NGO implementation history. (The characteristics of each community and the number of interviews carried out are shown in Table 2.)

Table 2
Characteristics of the three communities[a]

	Copándaro	Las Tablas	El Sobrado
Total population	286	452	696
Households			
Total number of households	63	98	111
Using LPG	23 (37%)	24 (24%)	28 (25%)
Using firewood	58 (92%)	92 (94%)	101 (91%)
Patsari cookstoves built	50	18	13
Municipality-sponsored cookstoves built		55	
Interviews			
To *Patsari* cookstove users	20	11	6
To municipality-sponsored cookstove users		15	
To other women	6	3	6

[a]Population, households, LPG use and firewood use data from INEGI (2000). Note that LPG users reported by INEGI are less than the number observed in the community of Copándaro, showed in the discussion chapter.

4.2. Results

4.2.1. Fuelwood use

Even though fuelwood users devote between 0.5 and 2.5 h per day to fuel harvesting (Masera, 1990), the interviews showed that women do not confer any economic value to this activity. Despite some users recognised the effort required carrying the wood, by and large the no-value perception is dominant.

> I don't care if I use too much and run out of fuel![2]

Only for five ICS users, fuelwood saving was a reason for having an improved cookstove built.

As explained above, access to the resource is not homogeneous. Whereas in Copándaro all users harvest fuelwood themselves, in El Sobrado 85% of them buy it. The particular conditions of users vary widely as well. Some women need to carry fuelwood themselves on their back every day (12.5%), while in other households men bring the whole year's supply on a truck (2%) (see Fig. 3).

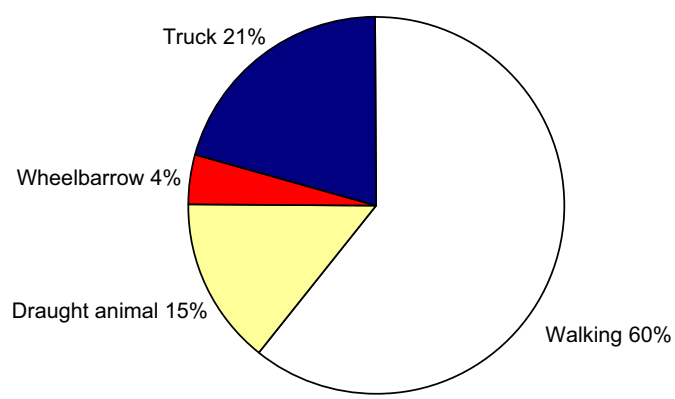

Fig. 3. Fuelwood harvesting methods.

These particular conditions are connected with the difficulties met by users to provide dry fuelwood and cut it in small pieces, a requirement for a proper functioning of the *Patsari* stoves.

> If the wood is wet the stove does not heat, I tell my husband—the Patsari requires special wood.

In this respect, single women are at a disadvantage because nobody helps them to chip wood (20% of users face this problem) and often they lack room to keep it dry in the rainy season (10%). Getting adequate fuel is, therefore, a harder chore for these women. Fuelwood harvesting is perceived as a heavy task by 48% of the interviewees and 70% reported that their husband or another man in the family fulfils this task. This varies among communities (see Fig. 4).

As explained above, deforestation is rarely caused by fuelwood harvesting, and only two users acknowledged

[1]Even though some men were interviewed, only the interviews to women are considered in this study.

[2]All quotes are from the women (stove users or non-users) who were interviewed.

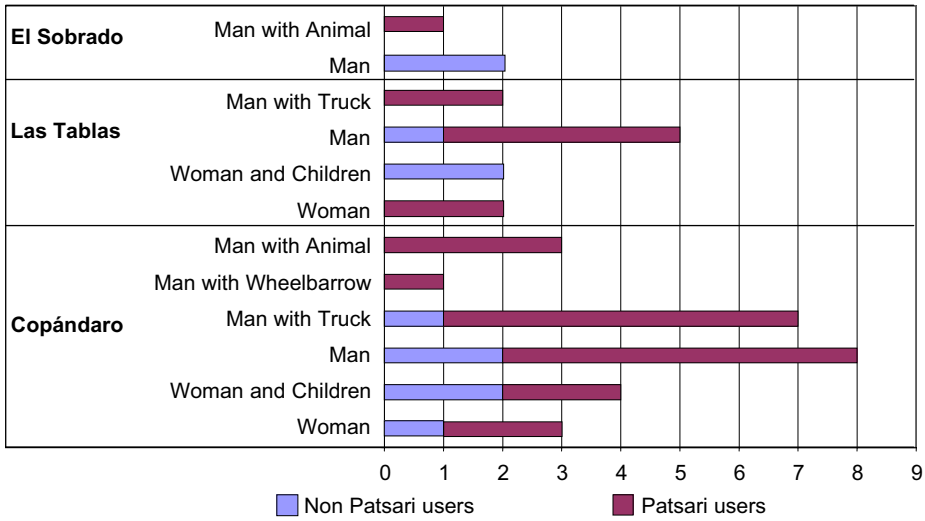

Fig. 4. Fuelwood harvesting by gender.

cutting trees to get their fuel supply. Nevertheless, some users link wood scarcity to deforestation:

> Some time ago it was easier to carry wood, 'cause there were not so many people collecting wood and running down the forest.

4.2.2. Cooking technologies

4.2.2.1. Open fire. The open fire is widely used in rural areas and women who do not have access to another technology use it every day for all their cooking activities. Women who use other technologies relied on an open fire for some specific tasks, namely *nixtamal* (a mixture of maize and lime that is cooked and then grinded to make *tortillas*) cooking, water heating and space heating.

By and large, women appreciate the versatility of the open fire as compared to an ICS: it can be made anywhere, at any time, and since it is on the floor it does not require the user to lift heavy pots to the height of a stove. In addition, wood pieces of any size can be used, and the fire heats the pot directly, thereby achieving a faster heat transfer. Finally, some users report to use the open fire just because they are used to.

> I prefer the Patsari stove, but, you see, even if one prefers here, one is used to do it over there.

Interviewees also identified a number of problems of open fires, especially connected to the smoke they produce. It is interesting to note that almost the same percentage of women complained about smoke as a health problem (40%) than about smoke getting the kitchen dirty (37%).

4.2.2.2. LPG. A number of reasons were put forward by women to prefer LPG: it is faster (74%), easier to use (18%), and is a particularly good option during the rainy season (12%). Only two women argued that they preferred LPG in order to avoid fuelwood harvesting. Regarding problems with LPG, price comes on top[3] (80% of interviewees) and the inability to make *tortillas* comes second (68%). Out of the 10 women who lack an improved cookstove and use the open fire, only 3 use an LPG stove as well. In contrast, 80% of stove users have access to LPG cookstoves. Two hypotheses may be suggested that could help explain this difference. The first is that improved stove users have a higher income (and, therefore, higher access to LPG), and the second is that the fact that they already use two different cooking technologies makes them more prone to try a third one.

4.2.2.3. Improved cookstoves. Most interviewees were aware of the problems that are addressed by improved cookstoves: 81% of users stated that the stove helps to take the smoke out of the kitchen, whereas the remaining 19% did not manifest any awareness of this problem or explicitly declared that indoor smoke represented no problem. Only 51% of the women mentioned fuelwood savings as an advantage of improved stoves.

For a number of stove users, the main reason for having a stove built is aesthetic, either because they look beautiful (12%) or because they keep the kitchen clean (12%). Some of them stressed as well that the new stoves helped to recover the kitchen as a place for family gathering.

When asked who made the decision for having or not having a stove made, the majority replied that they made the decision themselves (70%). In all these cases the husband either agreed or was absent.

> He does not say anything, because, you see, one is the only one who knows, one is the one who uses it and

[3]LPG use varies between families. A 30 kg tank costs around U.S.$28 (this can be 4 days salary) and lasts between one month and four months. Considering fuel efficiencies, the actual cost per MJ of purchased fuelwood and LPG is almost the same (Masera, 1994).

simply it is me who knows whether I have enough for gas or not.

Forty percent of those without an improved stove stated that the reason for not having a stove built was that the husband had said that he would rather build it himself, but in all the cases such a promise had not been kept. Since some women live with their mothers-in-law, her opinion was also considered important. Two interviewees said that the reason for not having a stove built was their mothers-in-law's opposition.

A wide variety of problems of improved cookstoves were mentioned by users. The small entrance to the chamber involves problems for lighting the fire and for chipping the wood down to small sizes. Some complaints concerned specifically the secondary *comales* of the improved cookstoves (a *comal* is a ceramic dish or metal hotplate for cooking *tortillas*): users would prefer having independent combustion chambers or being able to put heavy pots such as the ones used for *nixtamal*. Lastly, some people complained that improved cookstoves are not good to heat the room in winter.

Some interviewees distrusted the local builders and stressed that the NGO stove technician should have built all the stoves himself. In one community in particular the local builder was the target of criticisms.

Stove maintenance showed to be an important issue: 48% of stove users were giving inadequate maintenance or no maintenance at all, and another 25% are providing excessive maintenance to their stoves (once every time the stove is used).

For a number of potential users of improved cookstoves, price is an important barrier: 35% of the interviewees without ICS argued that they could not afford it.

The location of the stove in the house was an important factor. When the stove is built in a provisional place or outdoors, it is unlikely to be appropriated by the users. Out of the 63 ICS that were visited during the interviews, 35% were built in the existing kitchen, 21% in a detached room for fuelwood use, 33% in a shed, 7% outdoors, and 4% in an uninhabited house.

> I asked the builder to put the stove over there, because, you know, my husband will build for me the fuelwood kitchen there.

Approximately 21% of the ICS are damaged to some extent. In most cases the damage was made by enlarging the fuelwood entrance to fit larger pieces of wood. 37% of stoves are used on a daily basis, 32% twice or three times per week, 14% percent once a week, 12% less than once a week, and 5% are never used. Note that stove use has to do with cooking practices and with the access to other fuels and technologies.

A number of stove users recounted that getting used to this very different technology engaged time and effort. The adoption depends therefore on the ability of the user to face the many changes involved and to be relentless.

With regards to flavour, a controversy arose between those that felt that meals cooked with fuelwood tasted better (52%) and those that found no difference between LPG and fuelwood (48%). Among users of ICS, 70% found no difference between the meals prepared on the open fire or the ICS. As for the rest, some users preferred the flavour of ICS meals because they are not smoked and some preferred the flavour of open fire meals, especially beans cooked in the traditional clay pots.

It is relevant to stress that 25% of interviewees were buying rather than preparing *tortillas*. They argued that they no longer grow maize or that making *tortillas* requires too much effort.

> I don't like machine-made tortillas; it is always better to have your own maize.

Since *tortilla* making is one of the most energy-intensive activities, in households or communities where *tortillas* are bought, the potential impact of stove dissemination projects will be reduced.

An important cultural aspect is who takes or influences the decision to build an improved cookstove. Even though it was observed that in the majority of cases the husband supported the woman in the construction of the stove, it was also clear that without the husband's agreement the stove was not built. In the rural areas of Mexico the woman's opinion is still subject to the man's opinion.

A comparison between the three technologies is shown in Table 3.

4.3. The case of Copándaro

The community of Copándaro borders the tourist area of the Zirahuen Lake, and is, therefore, in better economic conditions as compared to other communities of the region. It is not an indigenous community and has good access to fuelwood in the surrounding forest.

The community has 63 households (INEGI, 2000) and 50 improved cookstoves were built, which constitutes a remarkably high percentage. For this reason an exhaustive study was carried out and nearly 50% of the population were interviewed.

Twenty interviews were carried out with the users of improved cookstoves and 6 with non-users. The local builder was interviewed, as well as the local authority.

The results were analysed in order to prove some hypotheses that emerged as the research was in progress. In particular we wanted to verify whether the socioeconomic level, the age of the possible user and her formal education level were related to a better adoption of an improved cookstove. Participant observation and information from interviews were used to categorise every woman in the study in accordance with her socioeconomic level (factors like the house materials, size and conditions where considered), while the age and the number of years of formal education were collected at the time of the interview. The adoption level was determined depending

Table 3
Comparison between the three cooking technologies

Technology	Reasons for using it	Benefits	Problems
Open fire	• Is faster • Provides space heating • Supports heavy pots • Accepts large logs • Is customary	• Is cheap • Is versatile • Does not require learning new skills	• Smoke is a nuisance • Smoke gets the kitchen dirty • Smoke is a health problem • Smokes the food
LPG	• Is faster • Is easier to use • Is suitable when there is no fuelwood • Is convenient • Does not smoke	• Is handy	• Is expensive • Is unsuitable to make *tortillas* • Does not heat the kitchen
Improved cookstove	• Does not smoke • Is aesthetic • Saves fuelwood • Is better for health	• Saves fuelwood • Recovers the kitchen as a place for family reunion • The user does not get too hot	• Its entrance is small • Is difficult to light • Its maintenance is difficult • Needs special fuelwood • Requires learning new skills

Table 4
Frequency table for the interdependence between socio-economic level and adoption level in Copándaro

Adoption	*Socio-economic level*					Total
	Very low	Low	Middle-low	Middle	Middle-high	
Very bad	1	3	1	0	0	5
Bad	1	3	0	2	2	8
Regular	0	0	1	2	1	4
Good	0	0	1	3	1	5
Very good	0	0	0	1	2	3
Total	2	6	3	8	6	25

on whether the woman had an improved cookstove built, the conditions of the stove and her level of satisfaction.[4]

To obtain the relation between the level of adoption and the socioeconomic level, a Spearman correlation test was performed. A correlation coefficient $rs = 0.58$ was found, which reflects a mild relationship between the two variables (see Table 4).

It should be noticed that there was not a single woman in the very low or the low socioeconomic level that had at least a regular level of adoption. Neither there is any woman with a middle or middle-high socioeconomic level that had a very bad adoption of the stove.

The Spearman correlation test was performed to obtain an interrelation between the level of adoption and the age, and a coefficient of $rs = -0.03$ was found. This indicates that there was not relation between the two variables.

Likewise, the same test was used to get the interrelation between the level of adoption and the educational level, obtaining a coefficient of $rs = 0.18$. This showed a very low level of correlation between the two variables.

These results could have been affected by the sample size. Since every variable has 5 possible values, there were 25 different categories resulting from all combination options. In the age test, the numerical variable had to be transformed into categories, with the resulting loss of information. Therefore, future tests will be carried out including the whole study data.

4.4. Comparison between the two different implementation projects

Looking at the two different implementation projects in the region, the one that was executed by GIRA stands out due to its broad regional impact.

[4]Very Bad: The woman did not build a cookstove. Bad: She built the cookstove but modified it or even destroyed it. Regular: She uses it in an irregular way and is not completely satisfied. Good: She uses the stove regularly but had some problems of maintenance or use. Very Good: She uses it daily and is completely satisfied.

The project that was implemented in Las Tablas by the local municipality and an NGO is also noteworthy. The design of the stove is basically a Lorena,[5] and it has two entrances for fuelwood, one for the big *comal* to make *tortillas* and a smaller one for a pot. The main advantage for the users is the control and versatility that this stove allows. The fact that the stove was free allowed the project to reach the people with higher needs, and a very high level of adoption was found (93%, or 14 out of 15, with stoves still operating 8 months after construction). However, the improved cookstove has some design problems: it is crumbling and the fire reaches the chimney, which will not stand the high heat for long time and might soon collapse.

Despite the short life expectancy of the stove, the result is very good and it can be seen from the interviews that the previous awareness raising work made by the GIRA project had a learning effect on women. At a later stage of this study, a further follow-up to this other project will be conducted.

5. Discussion

This first approximation to understand the adoption process of fuel wood cooking technologies, considering the perspectives of local users, allowed us to recognise some factors that are playing a relevant part in the diffusion and adoption process and that should be considered when implementing projects in rural contexts of developing countries. In our study, different types of attitudes about an innovation were distinguished among women. We could identify one woman in the sample, who was ready to try the technology even before knowing its possible benefits; 6 women who were ready to try it as soon as they understood the benefits; 30 women who accepted to try it once their leaders tried it; 15 women (in Las Tablas) who were ready to try the new improved cookstove in a second round; and 4 sceptics who were unwilling to accept the innovation.[6]

The benefits that the *Patsari* brings about—saving wood and taking the smoke out of the kitchen—are widely palpable for users and even for those that decided not to have one built. It is interesting to notice that, although fuelwood saving was not one of the main reasons to build a *Patsari*, it was the main benefit that was reported after having adopted the new technology. This can lead to a future spread of interest among the communities.

5.1. Technology

Our assessment showed that *Patsaris* are well adapted to fulfil the main cooking necessities in rural Mexico—*tortilla* making—as well as to prepare a variety of dishes. However, it is not as good as the open fire for some cooking activities, such as *nixtamal* cooking, for boiling large amounts of water and for space heating. At present, almost nobody has stopped using the open fire altogether for these activities. The characteristics of ICS make them unsuitable to fulfil all these tasks unless women are ready to sacrifice heat or speed in order to save wood and keep the smoke out of the kitchen. The interviews showed that only very few women were ready to do that.

However, results from GIRA indoor air pollution team (Arméndariz et al., 2007) and the stove performance team (GIRA, 2004) showed a decrease of 70% in indoor air pollution, 50% on personal exposure and of 44% of wood consumption, respectively, in multiple cooking strategy houses. So, even if most women have not completely stopped using open fires, they are receiving substantive benefits from access to clean wood burning cookstoves.

Although a good effort was made to train local people to build improved cookstoves, the need for external supplies limits the possibilities of the local builder to carry on the enterprise by him/herself, at least until a critical market size is achieved.

The technology implemented by GIRA was designed keeping in mind the regional needs of these people. Nevertheless, some aspects were detected that should be taken into consideration for further design work. The most relevant regards the small size of the fuelwood entrance, which means that users have trouble in lighting the fire and complain about not being able to put bigger pieces of fuelwood. Considering the good appropriation of the other technology in Las Tablas, a direct access to both *comales* could be a good improvement, since women like to have direct control over their fire. Finally, a simpler maintenance will keep women going with the new technology. (To solve these problems, the NGO developed recently a modified *Patsari* stove with larger entrance and minimal maintenance that is showing faster adoption among users in others communities.)

The first 15 days of stove use were detected as the critical stage. According to the evidences, during this period the physical presence of a person who can address the problems as soon as they appear is essential. This will prevent users from making inappropriate modifications to the ICS at the expense of their performance.

5.2. The implementation project

The implementation project followed by GIRA attempted to engage possible users and was focused not just in the construction of *Patsari* stoves but also on rising people's awareness, training local builders and contributing

[5]The Lorena stove was originally designed in Guatemala. Its name comes from the combination between *lodo* (clay) and *arena* (sand) in Spanish.

[6]There were other women who had not had an ICS built but expressed an intention of having it in the future. Only 4 women expressly said that they would not build it at all. It is interesting that all of them were old women.

to their organisation. They also provided follow-up evaluation to cookstove performance.

There is a need, however, to better include people's visions and opinions. It is interesting to note that, out of the initial hypotheses suggested by some team members about possible adoption factors (age, educational level, cookstove payment, and socioeconomic level), only the last one had a good degree of correlation. This emphasises the need to get a deeper understanding about the local people's perspectives regarding their adoption reasons, motivations and obstacles. With respect to age, even though a few old women adopted a *Patsari*, all women who rejected the new technology were old women. More studies need to be conducted focusing on this age group separately.

According to Rogers' theory of diffusion models (Rogers and Kincaid, 1981), this implementation project corresponds to a centralized model based on a one way model of communication, rather than a decentralised one in which participants create and share information in order to reach a mutual understanding. The use of a linear model can be explained by the NGO's search of a replicable model that could be used in other regions of the country, reflecting the complexity of the trade-offs between trying acknowledging particular people needs, and being able to reach more people. It reflects also the contradiction of having a numeric goal of 1500 cookstoves defined before knowing the actual people's response.

The diffusion process fulfilled its objective of raising women's awareness about the two main aspects that the ICS address: indoor air pollution and high fuelwood consumption. However, a clash between the different needs and timing of people and the project schedule was observed. The community of Las Tablas is a good example. While with the GIRA project 18 cookstoves were built, later on with the second implementation project 55 improved cookstoves were built. This second project did not offer an extended diffusion programme but did not need it either. One possible explanation is that stoves were offered for free, but 12 women who already had paid for *Patsari* stoves destroyed them in order to build the new model, apparently due to the more appealing characteristics of the new technology. The second model implemented is simpler too; so, even when no follow-up was offered, they did not seem to have needed it. Finally, the awareness raising activities carried out by GIRA gave fruits in a year time: when asked, women said that they already knew the advantages of this kind of technology and when they were offered a second chance they took the best of it.

5.3. The users

A gender perspective was taken into account by the project team and both the design and the implementation project were conceived by taking into consideration the possible users of this technology.

In terms of adoption the results were very good, although it should be stressed that the poorest women still did not have access to the new technology, yet their consumption patterns make them the neediest sector. Despite the diffusion reaching almost everybody, some women did not have the economic capacity to pay for a stove. Others could pay for it but could not pass through the cultural barriers, which led many stoves to eventually lose their properties and become *improved open fires*. It is necessary, therefore, to devise special strategies to include these sectors, which will almost certainly require subsidies that are beyond the economic capacity of the local NGOs. Looking at the experience of the improved cookstoves that were built in Las Tablas by the municipality, it was evident that giving the stoves for free was not a problem and helped reaching the poorest women, some of whom at the time could not afford to pay for the *Patsari*.

5.4. Differences between communities

The adoption was very different among the diverse communities, but these differences were related with the differences between women's circumstances. In Copándaro, all adoption categories are present to various extents. In Las Tablas the adoption goes to the extremes: either very successful or very unsuccessful cases. In El Sobrado the adoption was generally poor. These differences could be due to several factors: the community of Copándaro, where 50 cookstoves were built, had three types of users: (i) women who could not learn to use appropriately the stoves and made modifications or even destroyed them; (ii) women who because of their cooking practices only used the stove sporadically or never used it, and (iii) women who could learn to use it properly and used it very often, keeping it clean and in good working conditions. This community has a better socioeconomic level than the average and many women no longer make *tortillas* but buy them. Some would make them only once per week. In such a community a question arises if the impact of a new technology is sufficiently important to justify an intervention.

The results in Las Tablas were affected by the municipality-sponsored project. Many women, who would otherwise have appeared with a regular adoption, appeared with a bad adoption because they destroyed their *Patsaris* in order to build the new cookstove.

El Sobrado presents problems attributable to the local builder, which had to do with the construction itself and with the follow up process. Interestingly, though, this same person was in charge of building the *Patsaris* in Las Tablas too, where no lack of confidence or complaints were observed. She was the only woman trained to build *Patsaris* in the whole region, and possibly her condition as woman influenced on her lack of credibility in her own community.

The LPG consumption was also different between communities. By looking at Table 5, it is possible to notice that the adoption is somehow related to the use of LPG: all houses that do not use LPG have a regular, bad o very bad

Table 5
Adoption levels and LPG use by community

Community	Copándaro					Las Tablas					El Sobrado				
Adoption level	VG	G	R	B	VB	VG	G	R	B	VB	VG	G	R	B	VB
Interviewees	2	5	4	7	5	3	1	0	1	6	1	1	1	3	5
Percentage	9	22	17	30	22	27	9	0	9	55	9	9	9	27	46
Number of LPG users	2	5	3	4	3	3	1	0	0	3	1	1	0	2	3
Percentage	100	100	80	57	60	100	100	0	0	50	100	100	0	66	60

adoption level. This is an interesting finding that raises interesting questions for future research.

In all other aspects there is no significant difference between the communities, and the differences between individual characteristics and circumstances seem to be more relevant.

It is evident that the adoption in El Sobrado was not any better given its scarcity conditions. This is not a surprise given that fuelwood saving is not a perceived need for the majority of rural people. It is also likely that, since men are the ones who gather the fuelwood, women are less interested in this aspect and more interested in keeping the smoke out of the kitchen. Until now it has been assumed that women are the main beneficiaries of this technology, yet the new findings show the need to include men as well, in order to document their perceptions about the new technology.

Finally, the GIRA project is a very good effort and has managed to raise people health and environmental awareness and to solve the indoor air pollution problems of many women and children. It is important that the NGO continues developing implementation programmes by following an adaptative management approach through which they can continuously modify the ICS model and the diffusion programme. In this context, the findings of this study can reverberate in next efforts. This is a big challenge, considering that 25% of the Mexican population relies on fuelwood as cooking fuel. Given the increase in oil prices, this number is expected to rise.

6. Conclusions

In this first step of the research we were able to document the evolution of the implementation programme followed by a local NGO, and notice its learning process. The following conclusions related to the implementation of cookstove dissemination programs were derived.

(A) The differences among individuals seem to be more relevant than the differences between communities and their social context. Women who could take the best of the innovation were the ones who had a potential need for this technology, especially the ones who use fuelwood on a daily basis and who resented the presence of smoke in the kitchen. However, this by itself was not enough. An open attitude toward changes was also observed: enthusiastic women, not necessarily with many years of formal education, but rather with an open mind, seem likely to become the early adopters.

(B) The adoption process of a technological innovation is slow and often requires many successive attempts in order to be able to permeate people's thinking. It is important that every implementation programme contemplates returning to a community later on, in order to give the opportunity to the "late majority" (Rogers, 1995) to adopt the innovation.

(C) Men should be considered as an important group in diffusion programs.

(D) The particular cooking practices in rural Mexico are fuelwood intensive and demand a performance which is very difficult to achieve by an ICS: high temperatures are needed to make the *nixtamal*, and a constant low temperature needs to be kept to cook *tortillas*. For this reason, a complete technology change is unlikely to happen and it is necessary to better document the impacts of multiple use of technologies.

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