Impact Evaluation of Improved Stove Use among Dolo-beer Breweries in Burkina Faso – FAFASO

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This impact evaluation report is part of an assignment by the Policy and Operations Evaluation Department (IOB) of the Netherlands Ministry of Foreign Affairs. It pertains to a series of impact evaluations of renewable energy and development programmes supported by the Netherlands, with a focus on the medium and long term effects of these programmes on end-users or final beneficiaries. A characteristic of these studies is the use of quantitative research techniques, in combination with qualitative techniques, to get insight in the magnitude of effects. The purpose of the impact evaluations is to account for assistance provided and to draw lessons from the findings for improvement of policy and policy implementation. The results of these impact evaluations will be input to a policy evaluation of the "Promoting Renewable Energy Programme" (PREP) to be concluded in 2014.

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Tables, figures and boxes

List of abbreviations

CCT	Controlled cooking test
CFA F	Communautés Françaises d'Afrique Francs
Diff-in-Diff	Difference in difference
EnDev	Energising Development
FAFASO	Foyer Amélioré au Burkina Faso
GIZ	Gesellschaft für Internationale Zusammenarbeit
ICS	Improved cooking stoves
IOB	Policy and Operations Evaluation Department of the Netherlands Ministry of Foreign Affairs
IRSAT	Institut de Recherches en Sciences Appliquées et Technologies
OLS-CS	Ordinary least squares – cross section
PREP	Promoting Renewable Energy Programme
PS	Propensity scores
PSM	Propensity score matching
Sd	Standard deviation
S.E.	Standard error

Exchange rates

EUR 1 = CFA F 655 (official exchange rate, used if nothing else is indicated)

EUR 1 = CFA F 175 (PPP 2010)

1. Introduction: Why local breweries are a concern

Today, around 2.7 billion people in developing countries rely on the traditional use of biomass, mostly firewood or charcoal, for cooking. In many dry countries this contributes to deforestation and severe health problems as the related smoke emissions cause respiratory diseases (World Health Organization, 2009). Improved cooking stoves (ICS) potentially help to alleviate these negative implications of woodfuel usage since they increase the efficiency of the cooking process thereby reducing the woodfuel consumption per meal. However, households are not the only users of woodfuel. Restaurants and traditional manufacturing activities such as the brewage of local beer, brick makers, some food processing activities or the production of Shea butter are in many regions of Sub-Saharan Africa very common and consume a substantial share of total woodfuel.[2]

Improved cooking stove interventions typically ignore these users by focusing only on the preparation of meals within private households. A notable exception is FAFASO or 'Foyer Amélioré au Burkina Faso' which is implemented by the *Deutsche Gesellschaft für Internationale Zusammenarbeit* (GIZ, previously GTZ).[3] FAFASO targets next to private households also social institutions and the three groups mentioned above: restaurants, local breweries and small producers of Shea butter. The intervention consists of the training of masons specialised in constructing stoves for professional use as well as sensitization, and marketing campaigns. This report summarizes the findings from an assessment of FAFASO's impact on local breweries. The focus is on adoption of the 'new technology' and firewood consumption. A mixed-method approach is used, i.e. the assessment relies on qualitative interviews and field visits as well as on a longitudinal database constructed by conducting two surveys, one in 2010[4] and one in 2012, using a structured questionnaire and interviewing almost 300 local breweries each time. This assessment complements an assessment of FAFASO's impact on private households (Bensch et al., 2013).

The literature rigorously evaluating ICS interventions is relatively thin. Most studies that have been written almost exclusively focus on the related household pollution and health impacts (Smith-Sivertsen et al., 2009; Masera et al., 2007; Diaz et al., 2007; Yu, 2011; Hanna et al., 2012) and typically look at stoves intended for household cooking. Moreover, most studies consider the Asian or Latin American context. However, a few rigorous assessments focus on Sub-Saharan Africa. Bensch and Peters (2012) and Burwen and Levine (2012) designed and implemented randomised controlled trials investigating ICS impacts in rural Senegal and rural Ghana. Whereas Bensch and Peters (2012) find substantial effects on firewood consumption (and self-reported health), Burwen and Levine (2012) found only very small and mostly insignificant effects. However, for the latter study it is not clear whether the used stove model was really adapted to the local context. Moreover, to assess the effects on charcoal consumption of a programme in *urban* Senegal, Bensch and Peters (2013) applied quasi-experimental methods. The authors found that on average ICS using households save 25% of charcoal per stove utilization if compared to households using traditional stoves. The program under assessment in the latter study is similar to GIZ' FAFASO in Burkina which has been assessed in the report preceding this report (Bensch et al., 2013). Similar to the results for Senegal, a

2 The Ministry of Environment in Burkina Faso estimates that local beer producers alone account for 52% of the firewood consumed in Ouagadougou.

3 FAFASO is co-financed by the Netherlands Ministry of Foreign Affairs and the German Federal Ministry for Economic Cooperation and Development.

4 The 2010 survey was financed by the GIZ and implemented by IRSAT (Institut de Recherches en Sciences Appliquées et Technologies). It has been kindly made available for this evaluation.

saving rate of about 25% if compared to a traditional three stone stove could be identified. This is remarkable, but still below the potential savings of about 40% achieved in controlled cooking tests, showing the need to test the effectiveness of new technologies under real world conditions and based on a sufficiently large and representative sample. This is also the main point of Hanna et al. (2012) who find in contrast to many of the other studies mentioned above only very weak if not insignificant medium-term effects on wood consumption and in particular health outcomes (though the study has its own weaknesses). The authors stress that the absence of any effects can be explained by the failure of households to use and maintain the stoves regularly and appropriately.

Obviously next to the impact on wood savings conditional on adoption, it is crucial to investigate who is adopting an improved cook stove in a first place, in particular if offered through the market. For the case of FAFASO, Bensch et al. (2013) show that understanding uptake behaviour is complex, but a lot seems to suggest that cash and credit constraints matter, i.e. although many households know that improved stoves exist and do not doubt the potential savings, they cannot afford the investment costs upfront. Lewis and Pattanayak (2012) have conducted a systematic review on this question ('Who adopts improved fuels and cook stoves'). They also conclude that most studies find that households with greater income are more likely to use more expensive (and cleaner and healthier) energy. Moreover they find positive effects of both education and female household headship on adoption. However, they also stress the need to scrutinize more rigorously the role of socio-psychological drivers, such as discount rates, risk aversion, peer pressure as well as contextual factors such as local institutions and the quality of the supply chain. A major difference of this report to the existing literature is that here the focus is on professional - in fact exclusively female - users where factors of adoption and usage behaviour might again be different.

The remainder of this report is structured as follows. Section 2 introduces the business of making dolo and describes the approach chosen by FAFASO. Section 3 lays out the evaluation questions. Section 4 presents the quantitative and qualitative methods used for assessment. Section 5 discusses the results along three dimensions: adoption, wood savings and sustainability. Section 6 concludes.

2. The business of making 'dolo' and the 'FAFASO' intervention

FAFASO is implemented by the GIZ under the umbrella of the Dutch-German energy partnership Energising Development (EnDev). EnDev receives funding from the Dutch Promoting Renewable Energy Programme (PREP) and is coordinated across 18 countries by GIZ in co-operation with the Dutch Agency for Sustainability and Innovation, Agency NL. The goal of EnDev has been to actively promote and provide sustainable access to modern energy services. EnDev focuses on energy for cooking, energy for lighting and household applications, energy for social infrastructure, and energy for productive use. By 2013, more than 10.33 million people have gained access to either electricity or improved cookstoves. The activity under evaluation, FAFASO, targets three types of actors: households, social institutions, such as schools, and microenterprises. This report evaluates the productive use component, the promotion of improved cookstoves for local beer breweries, the dolotières.

The FAFASO intervention differs from other earlier ICS promotion programmes in Burkina Faso mainly because it does not provide direct subsidies. Instead, it rather focuses on the training of ICS producers (whitesmiths, potters and masons), sensitization, and marketing campaigns. FAFASO started in 2005 to promote ICS in two cities, the capital, Ouagadougou and Bobo-Dioulasso, Burkina

Faso's second largest city. Initially the program started with cooking stoves for private households. Later the program also started to target professional users especially restaurants and breweries of the local beer 'dolo'. In 2006, the GIZ placed large test stoves for productive use in 20 restaurants in Ouagadougou. In 2007 the program started to organise special exhibitions and workshops, principally addressed at those restaurant owners that are well connected and assume a certain lead-function in their sector ('*restauratrices leader*'). Other special exhibitions and trade fairs followed in 2008. In Bobo-Dioulasso sensitisation campaigns, also targeted at restaurants, started in 2009. The success of stoves for cooking that are also sold as Roumdé certainly also helped to promote stoves among professional users.

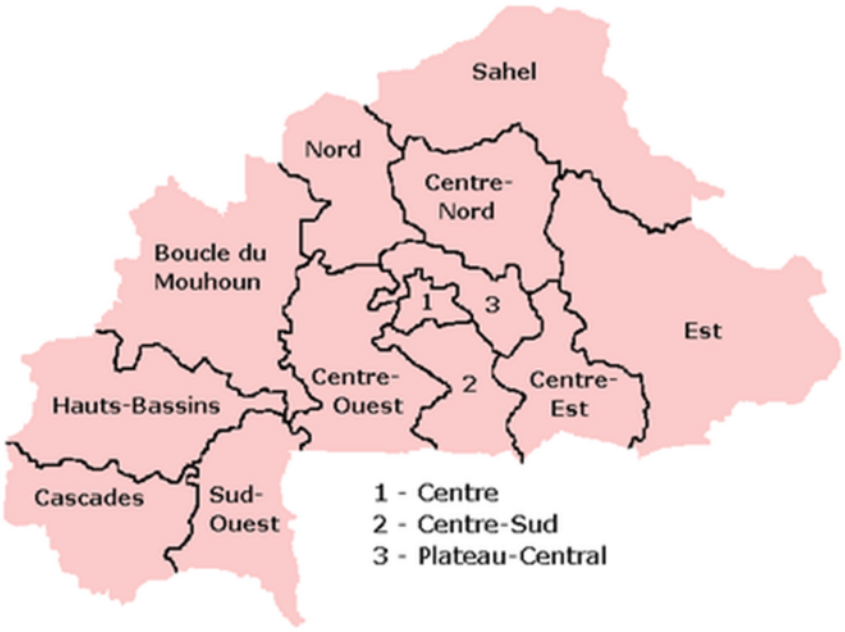
In 2008 the GIZ started to train masons in constructing special stoves for dolo breweries that are designed to curb firewood consumption in the brewing process, since the production of dolo needs a lot of energy, typically firewood, because once the basis of the beer, the sorghum, is crushed and ground into a paste (malt), it needs to be boiled for more than a day. The training of masons was first concentrated in communities[5] in the *Est* region (Fada, Pama, Diapaga, Logobou, Gayérie, Piéla, Bogandé) and *Sud-Ouest* region (Dano, Dissin, Diédougou, Gaoua, Batié, Kampti) of the country and was implemented in collaboration with dolo producer associations. From 2008 onwards such trainings were repeatedly organized. In Ouagadougou and Bobo-Dioulasso city, these trainings started in 2010 (in Bobo-Dioulasso six months later than in Ouagadougou). This was accompanied by sensitization campaigns among dolo producers in both cities and in the rural communities around Ouagadougou and by the installation of test stoves in breweries where the dolotières had some model or leader-role ('*femme leader*'). Further masons were trained in the *Centre-Est* region (Oualgaye, Koupela and Tenkodogo). FAFASO has also established partnerships with other organisations such as UNODI (*Plateau Central*) and the Dutch SNV (*Boucle de Mouhon*) that follow FAFASO's model and train masons and do the marketing. Producers of Shea butter (and *Soumbala*, a condiment) were targeted from 2012 onwards. For this purpose masons are currently trained in Koudougou (*Centre-Ouest*) and Manga (*Centre-Sud*). [6]

The funding window under evaluation here (01/10-12/12) had the objective to disseminate in total 4,500 improved cook stoves to professional users, including dolo breweries (FAFASO, 2012). Table 1 shows the number of installed Dolo stoves in 2010, 2011, 2012 and the first quarter of 2013. The number of installations peaked in 2010 in the regions *Sud-Ouest* and *Est* and in 2011 in Ouagadougou and Bobo-Dioulasso. In 2012 the number of installations decreased significantly. By the end of 2012, 2,317 stoves had been installed. The decline from 2012 onwards might be due to market saturation. The early awareness campaigns by the FAFASO seem to have been quite successful, so that by 2012 all those that had made plans to invest in such a stove had already bought one.

[5] Communities are groups of villages that constitute a small administrative unit.

[6] This information has been obtained in personal communications with FAFASO.

Figure 1: Map of Burkina Faso with regions



Source: Wikipedia.

Table 1: Number of improved dolo stoves (Roumdé) installed by location and year

Location	2010	2011	2012	2013	Total
Ouagadougou	93	592	181	19	885
Bobo-Dioulasso	29	336	58	0	423
Sud-Ouest	280	241	143	48	712
Est	154	105	105	0	364
Total	556	1,274	487	67	2,384

Source: FAFASO, 30 March 2013.

The improved cookstoves made for breweries – 'Roumdé stoves' hereafter - are much larger than the household cook stoves and are made of clay and bricks rather than metal.[7] These stoves are fixed and typically comprise between two and five huge cauldrons (although different sizes exist), the so-called 'marmites' (if made of aluminium) or 'canaris' (if made of clay). Aluminium is more widespread in Ouagadougou and clay in Bobo-Dioulasso. In front is an always-open door to the combustion chamber through which the firewood is loaded; typically by using entire trunks of wood that are by and by moved into the oven. A typical stove easily spans the surface of three to four square metres with the cauldrons arranged symmetrically over this space. Photographs of these stoves and a typical brewery are shown in Annex 1 (Photo 1 and Photo 7). The set of pictures also shows a traditional stove that mainly consists of a set of cauldrons that is lifted by a few bricks allowing moving firewood under the cauldrons (Photos 2-5). Some slightly modified versions of these traditional stoves exist, which have some sort of combustion chamber, but are not of the same quality than the Roumdé (Photo 6). A Roumdé costs about CFA F 27,500 (or EUR 42, official exchange rate used)[8] without the cauldrons. Aluminium cauldrons (*marmite*) cost depending on the size between CFA F 20,000 (EUR 30) and CFA F 60,000 (EUR 90) and are hence more expensive than the Roumdé it-self and much

[7] "Roumdé" is the brand name chosen by the GIZ. Roumdé means "the preferred" in the national language Mooré.

[8] Note that in 2010 PPP, the price of a Roumdé is rougly EUR 157.14 (Penn World Tables version 7.1).

more expensive than clay cauldrons, but they also have a much longer life-span than the latter. Cauldrons made of clay often crack if the stove is overheated. Aluminium cauldrons can in principle melt, but it seems that this happens only very rarely. Because changing the cauldrons with a Roumdé is also expensive, since the upper mantle of the stove needs to be opened, some dolotières switch from clay to aluminium when they buy a Roumdé.

According to the GIZ a Roumdé saves at least 60% to 70% of the firewood needed with a traditional stove for one brewing process. However, it seems that the saving rate goes rapidly down if the improved stove is badly maintained. In one field test conducted by the *Institut de Recherches en Sciences Appliquées et Technologies* (IRSAT) a damaged improved stove even needed more firewood per litre of dolo than a traditional stove (Sanogo et al., 2011), confirming that a rigorous assessment of the effectiveness of such stoves requires a test under real world conditions where conditions include the status of the stove and how the stove is used.

Making dolo is a tradition, the formula and the art of doing it is transmitted from one generation to the next. The activity is exclusively done by women (the so-called "Dolotières"), typically Christian or animist, since Muslim women are not allowed to make alcohol. The alcohol arises once the boiling of the malt is done. By adding yeast and by letting it ferment, the beer – dolo – is produced. When the dolo is ready, the women typically fill up big plastic barrels of it. They then sell either directly to customers or to other retailers. For the customers, most dolotières have a so-called cabaret, typically some benches to a shady spot outside the courtyard (see Annex 1, Photo 9). Usually, the cabaret scene is geared towards simple socializing. Excessive drunkenness is rare. People start passing through around eight or nine in the morning, on their way to work. Others come during the day or on their way back from work. Those who consume in the cabaret drink it from a so-called "calabashe". For take-away the breweries usually use empty soda bottles or plastic containers. A litre bottle of dolo is sold for about CFA F 150 (EUR 0.23).

In urban areas the typical brewery is located in a backyard has one or several stoves, additional cauldrons and barrels to stock raw materials, intermediate outputs, residuals and the final product, the dolo. Wood is stocked at the side or outside the yard. The piles of wood can be relatively large, since most breweries purchase wood for several brewings (see Annex 1, Photo 10). In rural areas the stoves are sometimes not placed in a private yard but in the public space, typically a central square. Different women share then these stoves and share costs or pay a rent to the owner. These women sell their dolo typically on the market.

3. Evaluation questions

The focus of this evaluation is on adoption of the 'new technology' and firewood savings associated with the use of this technology. Reduced wood consumption may in turn reduce the costs of production and, hence, increase profits. Moreover, FAFASO stoves are of a better quality than most other stoves that are in use, they are expected to have a longer lifespan and to need less maintenance and repair. This again may reduce the costs of production. Finally, FAFASO's awareness and information campaigns as well as instructions for the Dolotières provided by the mason who is building the stove may lead to behavioural changes and induce further cost savings. We ignore possible health effects. First, because they are not an intended outcome of the project and, second, because their direct measurement would require either medical expertise or a large sample size – both is not possible with the budget made available for this study. However, if wood consumption is

substantially reduced, it is likely that this comes together with a reduction in smoke emissions. We also do not examine possible externalities, for instance on the sellers of firewood and alike.

A broader objective of the FAFASO activities is to target in particular women. This is relevant since women are usually the persons who cook and hence are exposed to the harmful smoke emissions. Moreover in rural areas, women are often responsible for firewood collection and thus also have to bear important time costs. Such a focus is not necessary for this evaluation as by tradition Dolo is brewed and marketed by women. In our data set almost all respondents are female (in fact there are three men, probably responding for their wives).

Besides the consideration of impacts, the evaluation also considers two dimensions of sustainability. First, the assessment of the sustainability at the level of the breweries, in particular rates of adoption and, second at the level of the market, i.e. whether FAFASO's strategy is sustainable and whether the market is likely to last once FAFASO reduces and finally stops its activities.

Box 1: Evaluation questions on the level of outcomes and impacts

Outcome

- How many breweries own a Roumdé? How many use the Roumdé and how often do they use it?
- What are the socio-economic characteristics of the breweries that use a Roumdé - who adopts?

Impact

- How much fuel wood, in value and quantity, is effectively saved per litre of Dolo produced?

Sustainability

- Can uptake of improved Roumdé stoves be further expanded?
- Is FAFASO's strategy sustainable and is the market likely to last?
- How much did it cost to reduce producer costs by EUR 1 among Roumdé users?
- How much did it cost to save 1kg of firewood among Roumdé users?

4. Methods used: A mixed methods approach

The assessment is based on a mixed methods approach using representative survey data and information from field visits, in-depth interviews with stakeholders and other experts as well as focus group discussions. The data and methods used for analysis are presented in this section.

4.1 Representative survey data and descriptive statistics

In 2010 the IRSAT, conducted a census to count all dolo breweries in greater Ouagadougou and Bobo-Dioulasso, i.e. including their surrounding (rural) villages (Sanogo et al., 2011). This census revealed that in and around Ouagadougou 2,397 breweries are operating. In and around Bobo-Dioulasso the count was 1,144 breweries (Sanogo et al., 2011). Because the census had been conducted at the end of the rainy season and some breweries temporally close in that period of the year, the actual number might even be a bit higher.

From this list of breweries, IRSAT then randomly selected 219 breweries - 158 in and around Ouagadougou and 61 in and around Bobo-Dioulasso. The chosen sample size was based on power calculations such that it would allow distinguishing with sufficient statistical precision the difference in wood consumption between different types of stoves (Sanogo et al., 2011). With the help of a dolo producers association, the selected breweries were then contacted and interviewed. The used questionnaire collected information about the socio-demographic characteristics of these breweries and the people working there, the brewing process including wood consumption and about the awareness and possibly use of improved cook stoves. This information was used by IRSAT to produce a report commissioned by the GIZ to better target and design the FAFASO activities, in particular the promotion of improved stoves for breweries that only started in 2010 (see Sanogo et al., 2011). The survey information was complemented by a visit to three different breweries and the supervision of an entire two-day brewing process. The main aim of these visits was to measure accurately the consumption of wood and other inputs such as malt and water.

Table 2: Sample composition (2010, 2012, panel)

	Breweries interviewed in…		
	2010	2012	Both years
Ouagadougou	156	178	72
Bobo-Dialousso	61	83	16
Total	217	261	88

Note: The survey was conducted in and around both cities, even if around Bobo-Dialousso FAFASO did not conduct any marketing activities.
Source: Own calculations, based on Brewery Surveys 2010 and 2012.

For the purpose of this assessment and in accord with IRSAT, the GIZ and IOB, it had been decided to make use of the same sampling frame to re-interview as many as possible breweries from the 2010 sample and to add, depending on the experienced attrition, new breweries. Hence, exactly two years later, i.e. in September 2012, in total 261 breweries, 178 in and around Ouagadougou and 83 in and around Bobo-Dioulasso, were visited and interviewed. Regarding Bobo-Dioulasso it is important to note that no FAFASO activities have been taken place in the rural communities of Bobo-Dioulasso. The interviews were conducted by staff from IRSAT again with support from the association of breweries. The field work was accompanied by an RWI/ISS intern. Attrition turned out to be quite high. From the 261 breweries, 88 had already been interviewed in 2010. Many of the breweries visited in 2010 refused to participate again in the survey, some were not present the days the interviewers came and again others had stopped their activity, either temporally or definitely. Absence was often due to the fact that during this period of the year labour is needed for agricultural

field work. New breweries were randomly drawn from the list of all breweries registered through IRSAT's census. Table 2 documents the sample composition in 2010 and 2012. Below it is analyzed to what extent attrition is associated with particular characteristics of the breweries.

For the 2012 survey, a preparatory mission was conducted in August 2012 to develop the methodology further together with IRSAT. The questionnaire used in 2010, has been enriched by a number of additional questions that allow scrutinizing the impact of improved stoves on wood consumption. Information on and related to wood consumption was only incompletely collected in 2010. In particular, information related to the stoves in use were asked separately for every stove such as the type of the stove, its quality status, its age, its price, the number of cauldrons, the material of the pots and their size. The questionnaire included also more questions about the use of inputs and the awareness of and attitudes towards improved stoves. The questionnaire had been tested in the field prior to the survey. Both questionnaires, IRSAT's of 2010 and the RWI/ISS' of 2012, are included in Annex 5 of this report. Table 3 presents some basic statistics of the interviewed owners of the breweries, the so-called *dolotières*. The respondents are on average around 45 years old. Only a quarter of them have completed primary school. Two-thirds belong to the ethnic group of the Mossi, the dominant group in Ouagadougou. The remaining third belongs to the group of Bobo, the dominant group in Bobo-Dioulasso. In 2012 30% of all breweries interviewed were located in rural areas, i.e. outside of the city in one of the neighboring villages. Most respondents are already for a long time in business, 15 years on average. Overall, the distribution of the characteristics is very stable between 2010 and 2012, suggesting that the sampling of new breweries to replace the drop-outs did not reduce the representativeness of the sample.

Table 3: Characteristics of respondents

	2010	2012
Age (years)	43.7	45.9
At least primary completed (=1)	0.24	0.23
Ethnic group		
Mossi (=1)	0.67	0.63
Bobo (=1)	0.25	0.27
In Dolo business (years)	14.4	16.4
Ouagadougou/Centre Region	0.72	0.68
Urban (=1)		0.30
N	217	261

Note: Urban/rural has not been coded in 2010

Source: Own calculations, based on Brewery Surveys 2010 and 2012.

Obviously, wood consumption is the central outcome of this evaluation. Ideally, it would be measured by weighing the actual amount of wood used per brewing. It was clear from the start that field visits as done by IRSAT in 2010 in three cases, where staff virtually stayed the full two days of a brewing process and weighed all inputs including the wood, could not be organized for a large, and thus representative, sample. It would probably also not have been desirable. Since such a close observation will most likely come along with what is called in the literature "Hawthorne effects", i.e. subjects are likely to modify their behavior being experimentally measured simply in response to the fact that they know they are being studied. Hence, RWI/ISS proposed a procedure where a

sufficiently large amount of wood would have been weighed before the start of a brewing and put aside. The brewery would then have used exclusively wood from that pile. At the end of the brewery survey staff would have returned and weighed the remaining wood of the pile. The difference between the initial and final weight would have given the amount of wood used. Although RWI/ISS staff successfully tested that procedure in the field and would have been in the position to organize the related logistical issues, IRSAT had concerns and objected to its implementation, mainly because they thought it would be a too substantial intrusion in the business of the dolotières and would probably also be very difficult logistically.[9] Hence IRSAT and RWI/ISS agreed to ask the dolotières to provide an estimate of the value of consumed wood. IRSAT was confident that the dolotières know very well how much they consume and indeed as will be seen below, the provided information is coherent suggesting that measurement error and in particular systematic (i.e. non-classical) measurement error is not a major issue. In fact breweries buy their wood very regularly and hence seem generally to have a good feeling of how much wood they use.

Table 4 presents some descriptive statistics, now only based on the 2012 survey for which the information has been elicited in more detail. We show the characteristics separately for Ouagadougou and Bobo-Dioulasso and for Bobo-Dioulasso also separately for the city, as only there FAFASO has been active. Breweries in Ouagadougou have on average 1.8 stoves. Breweries in Bobo-Dioulasso are somewhat smaller. In Ouagadougou 0.8 stoves, i.e. less than 50% of these stoves are Roumdé stoves. In Bobo-Dioulasso only 0.3 stoves are Roumdé stoves, i.e. less than 25%. However, if the count is limited to the city of Bobo-Dioulasso, the average number is 0.77, which is then more than 50%. In Ouagadougou and Bobo-Dioulasso respectively 0.85 and 0.42 fall into the category 'improved traditional stoves' (0.62 in Bobo-Dioulasso city). Stoves in Ouagadougou typically have four cauldrons, in Bobo-Dioulasso even five or six, mostly four symmetrically ordered and one or two additional cauldrons placed in the middle. Whereas in Ouagadougou aluminum cauldrons are more common; in Bobo-Dioulasso clay cauldrons are more frequently used. In Bobo-Dioulasso the common view among consumers is that dolo beer only has its authentic taste if it is brewed in clay cauldrons. The reported age of the stove (not necessarily the cauldrons) is relatively high, more than eight years on average, in Bobo-Dioulasso even a bit more. The enumerators classified most stoves as being in good quality, in particular in Bobo-Dioulasso; some have cracks or a broken door, and only few are really shabby. Doors typically break when complete trunks of trees are little by little moved into the stove. Moreover, the high temperature that is achieved with a stove damages the cauldrons. Another typical cause of damage is rain and animals that search protection in the stoves when not in use. Their scraping damages the inner mantle of the stove. However, given the simplicity of traditional stoves, they are also less subject to obvious damages and, hence, their quality is very often reported to be good.

Most breweries brew twice a week. 38% of the Ouagadougou sample and 17% of the Bobo-Dioulasso sample make only use of a Roumdé. The average brewing is much larger in Ouagadougou compared to Bobo-Dioulasso. In Ouagadougou almost 370 liters are produced with one brewing. This requires as input about 85 kg of malt and 7 barrels of water. The water-malt ratio determines the quality of the beer and also has an important influence on the required quantity of wood. In Bobo-Dioulasso many breweries produce their own malt and use less water; hence their beer has a higher

[9] It is important to emphasize, though, that RWI/ISS discussed the approach with more than a dozen dolotières during the preparatory mission. Both the RWI/ISS preparatory mission team and the IRSAT field staff were convinced that the dolotières were willing to cooperate and do not consider it an unreasonable intrusion in their business. Furthermore, any additional logistical effort would have been organized and paid by RWI/ISS.

Table 4: Characteristics of breweries in 2012

	Ouaga		Bobo		Bobo city only	
	mean	sd	mean	sd	mean	sd
Number of paid employees	1.09	2.05	0.37	0.74	1.00	0.98
Number of stoves	1.79	0.92	0.48	0.50	1.50	0.58
Distribution of stoves by type						
Number of traditional stoves	0.12	0.45	0.48	0.50	0.12	0.33
Number of improved traditional stoves	0.85	0.91	0.42	0.59	0.62	0.75
Number of Roumdé stoves	0.81	1.02	0.27	0.61	0.77	0.82
Share of breweries with at least one Roumdé	0.49		0.18		0.54	0.51
Number of cauldrons	6.58	3.52	5.89	2.65	8.08	3.07
Type of cauldrons (shares of stoves)						
Aluminum	0.93	0.25	0.01	0.11	0	0
Clay	0.04	0.21	0.98	0.15	1.00	-
Age of stove	8.51	12.41	10.34	9.58	9.38	11.23
Condition of stoves (shares of stoves)						
Good	0.50	0.44	0.85	0.35	0.61	0.48
Cracks	0.36	0.45	0.11	0.30	0.31	0.43
Shaby	0.14	0.31	0.04	0.16	0.08	0.20
Number of brewings per week	1.99	0.85	1.71	1.60	1.58	0.88
Share of brewing days by type of stove						
Improved traditional stove	0.51	0.42	0.95	0.48	0.38	0.50
Roumdé stove	0.44	0.48	0.17	0.38	0.50	0.51
Share breweries using only improved Roumdé	0.38		0.17		0.50	0.51
Quantity of Dolo per brewing (in liter)	368.91	277.80	159.45	79.24	217.50	95.43
Quantity of malt per brewing (in kg)	85.37	77.72	41.26	16.77	57.24	18.55
Quantity of water per brewing (in barrel)	7.26	8.08	2.70	1.07	3.65	0.98
Expenditure for firewood per brewing*	8,956.90	9,939.61	4,149.67	2,968.83	7,375.00	2,096.72
Wood delivery (share of breweries)						
Collecting or cutting wood	0.02		0.08		0	0
Buys in small quantities	0.22		0.34		0.35	0.49
By cart	0.40		0.46		0.23	0.43
By lorry	0.03		0.01		0.38	0.20
By truck	0.32		0.12		0.38	0.50
Number of observations	178		83		26	

Note: *Not counting those who collect or cut their own fire wood. In Bobo-Dialousso marketing campaigns and training activities of masons have been limited to the city of Bobo-Dialousso that is why we show all statistics also separately for the city of Bobo-Dialousso.

Source: Own calculations, based on Brewery Surveys 2012.

concentration compared to the dolo produced in Ouagadougou. The average brewery in Ouagadougou has a monthly turnover of about EUR 500 to EUR 1,000 (assuming that a litre of dolo is sold at CFA F 100 to 200). Wood and other intermediate inputs account for about EUR 200, such that

the average value added that is generated is in the context given quite remarkable, even if the variance around the mean is quite substantial.[10]

On average, a brewing in Ouagadougou requires wood of a value of about CFA F 8,957 (or EUR 13.70) or CFA F 24.2 per litre of dolo.[11] In Bobo-Dioulasso we find an average of CFA F 25 per litre (CFA F 34 per litre in Bobo-Dioulasso city).[12] Beyond possible efficiency differences, there are at least two additional factors affecting the cost per litre: On the one hand, wood is a bit cheaper in Bobo-Dioulasso compared to Ouagadougou. On the other hand, breweries in Bobo-Dioulasso use different stoves and cauldrons and buy, as can be seen at the end of Table 3, more frequently their wood in smaller quantities, which typically means they have to pay a higher unit price compared to larger purchase. In Ouagadougou about 32% of all breweries get their wood by truck and hence have typically a huge pile of wood they take from. This can be seen in Annex 1 (Photo 10). One reason why breweries decide to buy in small quantities despite the higher price is that this prevents, at least in the rainy season, the wood of getting wet. Surprisingly, even the larger breweries, that systematically buy huge piles of wood, very often do not have a roof to protect their wood from humidity. In the rural part of Bobo-Dioulasso, some of the smaller breweries still collect or cut their own wood (8% of all breweries surveyed).

4.2 Focus group discussions, expert interviews, field visits

To complement the information drawn from the representative survey, intensive field work was undertaken before and after the implementation of the survey. Interviews were conducted with the GIZ staff managing the project, project collaborators, a group of trained masons and a dolo producer association. Moreover, more than ten breweries were visited in Ouagadougou and Bobo-Dioulasso and in-depth interviews were conducted with the woman owning/renting and managing the brewery and staff. The gathered information allowed getting a better understanding about the organization and process of dolo production, to adequately design the questionnaire of the survey and to enrich and complement the results from the quantitative impact assessment based on the survey data.

4.3 Methods used for impact assessment

The central evaluation question relates to the reduction in fuel wood consumption that is associated with the use of a Roumdé stove. Precisely, we focus on fuel wood consumption per litre of dolo brewed. In principle, a straightforward approach to obtain this information could be to undertake a controlled cooking (or brewing) test (CCT). Here, the same amount of dolo beer is prepared using a traditional stove and a Roumdé. Afterwards, the fuel wood consumption in both cases is compared. However, such tests cannot provide more than an estimate of the *potential* savings associated with the use of an improved stove, since the *effective* savings in real-world breweries might deviate from such tests for various reasons. First, breweries may use simultaneously different cooking stoves, i.e.

[10] The survey did not directly ask for turnover, value added or profits as most dolotières would not accept to give an answer or, at least a 'correct' answer. Hence, these numbers are simply derived from the information about the quantity of dolo produced, the average price per litre and the information about some cost categories.

[11] Not counting those breweries that collect their fire wood and hence have not declared any wood expenditure.

[12] Please note the consistency in these estimates. If the data was plaqued by systematic errors, one would not expect such stable figures.

improved and traditional ones. Second, it is unlikely that a dolotière in a CCT under observation behaves as she would behave under day-to-day conditions (known as the Hawthorne effect); for example, in reality the dolotière may do a number of activities simultaneously and, hence, cannot dedicate the same attention to her stove as a brewer in a controlled cooking test or the dolotière may have to work with inexperienced staff unable to use the full potential of an improved stove. Third, as mentioned above, the effectiveness of a stove may decline over time due to inappropriate maintenance. Fourth, a CCT, being conducted only with few breweries, can obviously not account for the heterogeneity across all operating breweries. Hence, in order to assess the effective savings, a large representative household survey which captures the diversity of real-world cooking practices is required. Such data can then be used, under some assumptions, which are outlined below, to estimate in a credible way the causal effect of using an improved stove compared to the usage of alternative stove types. In formal terms, the ideal evaluation framework would be to calculate the average treatment effect on the treated *M* as follows

$$M = E(Y(T = 1) \mid T = 1) - E(Y(T = 0) \mid T = 1). \quad [1]$$

Here, *M* is simply the difference of the conditional expectations *E* for the impact variable *Y* (e.g. fuel wood consumption) under treatment (*Y(T=1)*) and under the counterfactual of not receiving treatment (*Y(T=0)*) amongst those who actually received the treatment *(Y|T=1*). In our case, treatment refers to the usage of a Roumdé stove. Obviously, this counterfactual situation does not exist. Breweries can only be observed in one of both situations, either with or without an improved cooking stove. A frequently advocated way out is to randomise the treatment and to compare a sufficiently large group of treated units with a group of untreated (or control) units. In the present case, randomisation was however not an option since the program roll-out was already planned and a randomization would have been difficult to implement given the marked based approach of the GIZ intervention.

Hence, in absence of a randomised controlled trial, it is necessary to employ quasi-experimental methods. Two such approaches can be implemented in the present case: First, an estimator where all non-users, i.e. all observations in the comparison group, are weighted according to their empirical propensity (score) to use a Roumdé given their observable characteristics; second, a difference-in-difference estimator. The latter is possible since two rounds of data are available. The key idea of propensity score weighing is that the weighing renders both groups comparable with respect to their observable characteristics. This is a special variant of a matching estimator. The key idea of the difference-in-difference estimator is to compare the changes in fuel wood consumption over time for those that adopted between both surveys a Roumdé and those who did not. The exact formulas of both estimators and further explanations are given in Annex 2.

The inconvenience of the matching estimator is that unobserved heterogeneity between matched treated and untreated dolotières cannot be ruled out. Even if both groups are balanced across a large number of observable characteristics, it can never be excluded that there are still unobservable characteristics that are correlated with both ownership of a Roumdé and fuel wood consumption. For example the investment in an improved stove might be undertaken especially by those dolotières that are particularly astute and thus have a lower fuel wood consumption anyway. However, as shown below, with the data at hand it is possible to explain a very large part of the variance in ownership suggesting that the role of unobserved variables is maybe not crucial. The size of the breweries for instance comes out as a very important determinant.

The advantage of the difference-in-difference estimator is that selection effects can be controlled as long as these stem from time-invariant characteristics, such as birth cohort, education or astuteness. However, a strong implicit assumption is that both groups would have evolved in the same way in absence of the program (*parallel trend assumption*). Another drawback specific to the case under study is that only a relatively small sub-sample of all dolotières has been interviewed in both years. This sub-sample may not be representative of all dolotières. However, representativeness can be tested by regressing an indicator variable 'being surveyed in both years' on a set of characteristics observed in 2010. Annex 3 shows the result of such a regression. It can be seen that none of the included explanatory variables is significant, except size of the brewery as measured by the quantity of dolo made per brewing. The overrepresentation of larger breweries could introduce a bias if size of the brewery also has an effect on improved stove adoption and the consumption of firewood per litre made. Hence, it will be important to take into account the size of breweries.

The quantitative assessment is complemented by an analysis using the information from the focus group discussions, expert interviews and field visits. This information will allow analyzing in depth why some dolotières invest in an improved stove and others not and, hence, to understand better the underlying self-selection mechanisms and how in turn this may influence the estimated wood savings. As will be seen below, the qualitative information shows that the role of maintenance costs are more of an issue than the survey responses suggest. The additional information will also help to interpret the size of the measured impacts. Focus group discussions revealed for instance that in many breweries staff is not aware of or at least not interested in the savings potential of a Roumdé and in fact continue to use the same quantity of fuel wood as with the traditional stove. More generally, traditions seem to play a very important role in dolo breweries, the art of making the beer is transmitted from generation to generation and does not necessarily follow standard economic principles in the narrower sense.

The principal outcome indicator we focus on is the quantity of fuel wood used per brewing process evaluated at its market price. The 'treatment' is coded in two different ways: either by a binary variable 'having or not having an improved dolo stove' or by a variable measuring the share of stove-days per brewing process that are provided by improved dolo stoves. If a brewery uses two stoves for production and one brewing lasts two days over which both stoves are continuously in use then each stove provides two stove-days. If one of the two stoves is an improved stove, the share of stove-days provided by an improved stove is 50%. Using these variables it is possible to estimate percentage reduction of fuel wood per brewing process if an improved dolo stove is in use, or, more precisely, the relative reduction of fuel wood consumption as the number of stove-days with an improved stove increases. The concept of stove-days is a better concept than just usage of an improved stove, whenever breweries work with different stoves simultaneously. Since, the quantity of dolo produced per brewing differs across breweries, as do the quantities of malt and water used, the quality of the stove and so on; these factors need to be included in the estimations. Eventually, this allows computing the average savings for Roumdé users per litre of dolo made.

5. Results

5.1 Penetration of improved stoves and development since 2010

As can be seen in Table 5, in 2012 40% of all interviewed breweries owned and used a Roumdé stove (49% in urban and rural Ouagadogou combined and 54% in Bobo-Dioulasso city, cf. Table 4). Two years earlier, in 2010, i.e. a few months after FAFASO had started to market dolo stoves (first in Ouagadougou and later in Bobo-Dioulasso); the overall adoption rate was 12%.

Table 5: Number of Roumdé stoves in sample by location and year

	2010	2012
Roumdé stove (cross-section)		
Ouaga, count	26	88
Share	0.12	0.34
Bobo, count	0	15
Share	0	0.06
N	217	261
Roumdé stove (Panel)		
Ouaga, count	21	35
Share	0.24	0.40
Bobo, count	0	4
Share	0	0.05
N	88	

Source: Own calculations, based on Brewery Surveys 2010 and 2012.

Among those breweries that produce with more than one stove and have adopted an improved stove (43% of all adopters), the average share of improved stoves is about 85%, i.e. the share of breweries using traditional and improved stoves simultaneously is relatively small.

5.2 Determinants of adoption

In what follows the determinants of Roumdé adoption are examined. In a first step a probit regression model is used to analyze the correlation between a range of socio-economic characteristics of the dolotières and characteristics of their breweries and the adoption of a Roumdé. In a second step, the role of these determinants and other factors are further scrutinized using the insights from the field visits, in-depth interviews and focus group discussions.

5.2.1 Quantitative analysis

Theoretical considerations

Theoretically, one would expect that adoption depends on at least four sets of variables: First, it should depend on the degree of energy inefficiency in the before-situation, i.e. breweries that have a high consumption of firewood per litre of dolo made should gain most from the adoption of an improved stove. Second, adoption is also the more beneficial the higher the price of firewood. Third, adoption should depend on access to information, i.e. dolotières need to be aware that improved

stoves exist and what their savings potential is. Access to information should in turn be related to education, age, location and the interaction with other Dolotières. Fourth, it should depend on the dolotière's ability-to-pay and her access to credit. Poor dolotières without access to credit are unlikely to adopt an ICS.

Selection of explanatory variables

Based on these considerations, the following explanatory variables are included in the quantitative analysis: the age and age squared of the dolotière, her education, the number of years she is in business, the quantity of dolo she produces per brewing process as well as binary variables indicating whether the brewery is in Ouagadougou or in Bobo-Dioulasso and whether it is located in the urban area or outside the town in a rural community. The latter is particularly important, as in the rural communities of Bobo-Dioulasso no direct marketing has taken place and masons have not been trained specifically. The survey does not contain good proxies for wealth or even access to credit, as they are typically very time-consuming in interviews. Dolotières are furthermore said to be relatively suspicious (according to our field research staff) and questions seeking for information on wealth would have decreased their cooperativeness to accurately conduct the interview. We therefore abandoned wealth related questions in order not to jeopardize the compliance rate in our survey. However, from other studies that investigate the investment behaviour of informal firms in Ouagadougou and other West-African agglomerations, it is known that access to capital is generally an important constraint (Grimm et al., 2011, 2012). This is further discussed in conjunction with the insights from the qualitative analysis.

Discussion of results

The results of the regression analysis are shown in Table 6. Given that the quantity of dolo produced per brewing may change with the adoption of an improved stove, and hence this variable has to be considered as endogenous, two sets of regressions are presented: one with the quantity of dolo made on the right-hand-side and one without. Table 6 shows marginal effects, these show the change in the probability of having a Roumdé if the independent variable is increased at the margin while all other variables are evaluated at their sample mean. Changes are either in absolute units or in percent, if the explanatory variable is in a logarithmic form. For binary (0/1) variables, the 'marginal' change corresponds to a change from 0 to 1.

The marginal effects shown in Column (1) of Table 5, suggest that the probability of adoption is higher by 20% if the dolotière has at least completed primary education. The number of years in business has also a significant effect. Each additional year in business increases the probability of adoption by about 7%. However, the squared term is negative suggesting that this effect gets smaller with age. Adoption in the Ouagadougou region is much higher than in the Bobo-Dioulasso region, however this advantage mainly relates to the rural area of Ouagadougou. The reason for this has been given above. If the quantity of dolo is added to the list of regressors, the results suggest that for every percentage increase in the quantity of dolo produced, the probability of adoption increases by 0.20 percent. The age of the dolotière does not have a significant effect on adoption. The ethnic affiliation does have a weakly significant effect, but given the dominance of Mossi in Ouagadougou and Bobo in Bobo-Dioulasso it is difficult to disentangle this effect from the location effect.

Table 6: Uptake of Roumdé stoves, probit model, marginal effects

Dep. Var.: Uses a Roumdé stove	Coeff. (S.E.)	Coeff. (S.E.)
Ln quantity of Dolo per brewing (in liter)		0.199
		(0.070)***
Age dolotière	0.008	0.008
	(0.022)	(0.022)
Age dolotière (sq.)	0.000	0.000
	(0.000)	(0.000)
At least primary completed (=1)	0.200	0.170
	(0.078)**	(0.080)**
Mossi (=1)	0.214	0.227
	(0.121)*	(0.123)*
Bobo (=1)	0.272	0.304
	(0.185)	(0.183)*
In Dolo business (years)	0.030	0.024
	(0.012)**	(0.012)*
In Dolo business (years) (sq.)	-0.001	0.000
	(0.000)*	(0.000)
Ouagadougou/Centre Region	0.600	0.542
	(0.089)***	(0.103)***
Urban (=1)	0.774	0.740
	(0.104)***	(0.117)***
Ouagad. X Urban (Interaction)	-0.547	-0.552
	(0.051)***	(0.051)***
Pseudo R2	0.236	0.261
N	253	253

Notes: The coefficients show marginal effects, i.e. the change in the probability of uptake for a one unit-change in the explanatory variable (or a change from 0 to 1 for binary categorical variables). * significant at 10%, ** significant at 5%, *** significant at 1%. Robust standard errors in parentheses.
Source: Own estimations, based on Brewery Survey in 2012.

Awareness of Roumdé stoves and appreciation

The used questionnaire also included a module asking the dolotières without a Roumdé whether they know the Roumdé and if so, where they have heard about it. The results to this question are shown in Table 7. It can be seen that about 60% of the non-users know the Roumdé. Most of them, about 79%, have heard about it from neighbors and other dolotières. Another 10% know the Roumdé from FAFASO marketing campaigns and 6% have heard about them from their masons.

Table 7: Awareness of Roumdé stoves

Among those without a Roumdé …	
Knows the Roumdé	0.605
Source of knowledge	
Marketing FAFASO	0.096
Through neighbours/other dolotieres	0.787
Through the masons	0.053
Other	0.064

Source: Own estimations, based on Brewery Survey in 2012.

The module asked also those who have a Roumdé stove or owned one in the past what they think are disadvantages. Table 7 shows, that the most often reported problems have to do with maintenance: 16% say the life-span is too short, 15% complain about the low quality of the door and another 4% refer directly to the costs of maintenance (hence 35% of the problems relate directly or indirectly to maintenance). Smoke emissions or wood consumption are not reported to be a problem.

Table 8: Appreciation of Roumdé stoves – perceived disadvantages

Among those who have or had a Roumdé	
What are the disadvantages?	
Short life-span	0.193
Maintenance	0.039
Low quality of door	0.154
Not specified	0.614

Note: Enumerators failed to systematically record the reasons for the category "other"
Source: Own estimations, based on Brewery Survey in 2012.

The survey also asked the dolotières about the annual maintenance costs. A simple mean comparison indeed shows that Roumdé users spend more than three times the amount on maintenance than users of traditional stoves. This issue is explored in more detail below.

5.2.2 Qualitative analysis

Through in-depth interviews and focus group discussions, the determinants of uptake have been further explored. In general dolotières did not doubt the higher efficiency of a Roumdé, although it was often mentioned that it requires a lot of effort to train someone using the Roumdé in a way that less wood than with a traditional stove is consumed. Put differently, it seems that the adoption of an improved stove does not necessarily come along with the necessary behavioural change allowing to realise the full potential fuel savings. Despite the new stove, many dolotières and their helpers simply seem to continue to work as they have always worked.

The two other key constraints of Roumdé adoption that were frequently mentioned were, first, that indeed maintenance costs are a problem and, second, that the investment costs of adoption are for many simply too high. Maintenance is a problem, because the way a Roumdé is conceived, makes

changing the cauldrons more difficult than with a traditional stove. Whereas with a traditional stove, a cauldron can simply be removed, with a Roumdé the change requires to break the mantle of the stove. This is, obviously, much more cumbersome, time-consuming and expensive. Typically, the change of cauldrons needs to be done by a mason and costs about CFA F 1,000 to 2,000[13] (although some dolotières were trained by FAFASO to enable them to make the change themselves). Given the intense heat, cauldrons made of clay have a relatively short life-span and need to be changed regularly; hence, some Dolotières believe if they switch to a Roumdé gains from reduced firewood consumption are more than off-set by the higher costs for maintenance. Switching to aluminum cauldrons would solve the problem of maintenance somehow as they have a longer life-span (a couple of years),[14] but it adds substantially to the investment that needs to be made up front. Depending on the size a cauldron costs between CFA F 20,000/30,000 (size 30) and CFA F 50,000/60,000 (size 60).

Increased maintenance costs are also related to the brittleness of the door of improved stoves (see Annex 1, Photos 8 and 9). Since dolotières use relatively large trunks of wood, the doors often break; as they would either require to use smaller pieces of wood or at least to fill the stove with much more care. Repairing the doors is expensive in terms of time and money. Whereas a traditional stove can be maintained by the dolotières themselves, Roumdé stoves usually require a trained mason. Leaving the door broken in turn or at least not repairing it in a professional way substantially reduces the efficiency of the stove. A Roumdé stove is also more sensitive to rainfall. Many dolotières said that after the rainy season, the mantle is heavily damaged and frequently needs a professional repair. Traditional stoves might also be damaged by the wetness, but they are easier to repair and hence do not necessarily require professional help.

Moreover, it was also mentioned by many respondents that traditional stoves typically have five to six cauldrons, whereas Roumdés have only four. Hence, a Roumdé offers less brewing capacity but needs more or less the same space. Finally, in the Bobo-Dioulasso region some dolotières lease their stove, i.e. dolotières come to a brewery, brew the dolo and pay for the stove usage. Given that they do not have to pay directly for the maintenance costs, moral hazard is a potential problem, i.e. the lessee may not use the stove with the necessary care, hence lessors may prefer to rent out simple, traditional stoves, which are less damageable and, thus, also require less maintenance.

A final issue which can further explain lower take-up rates around Bobo-Dioulasso (besides lower program activity) is that 8% of all breweries still report to collect their own firewood (compared to 2% in and around Ouagadougou). As a consequence, the efficiency of their stove in terms of wood consumption is less of an issue and, hence, the incentive to buy a Roumdé might be somewhat lower depending on how they perceive the time cost implied by the firewood collection.

5.3 Estimated wood savings

5.3.1 Quantitative impact assessment

In this section, the impact of Roumdé usage on firewood consumption in monetary terms is assessed. As explained above, two different estimators are used: First, one based on the difference in firewood

[13] Cost estimate of changing the cauldrons obtained from FAFASO.

[14] It is difficult to provide an exact number here, as it depends a lot on how and how often they are used.

consumption between Roumdé users and non-users in 2012, where all breweries without a Roumdé are weighted according to their empirical propensity to adopt a Roumdé; second, one based on the difference in the change in wood consumption between those breweries that adopted an ICS between 2010 and 2012 and those that did not.[15] As also explained above, improved stove usage is modeled in two alternative ways: first, just using an indicator variable that takes the value one if the brewery used at least one Roumdé. Second, a variable that measures the share of brewing stove-days for which an improved stove is used. The latter is only used for the cross-sectional comparisons.

Before the results of the econometric analysis are discussed, it is worth looking at the distribution of firewood expenditures per brewing process across the size distribution of brewings. This is shown in Figure 2. The size of a brewing is measured through the quantity of dolo produced. Up to the 13th vintile (65%), there is apparently no systematic difference in firewood consumption between breweries that use a traditional or improved traditional stove and breweries that use a Roumdé stove. However, this comparison does obviously not control for a number of potentially confounding effects, i.e. variables that are correlated with both using an improved stove and wood expenditures. Hence, the analysis turns now to the econometric multivariate analysis.

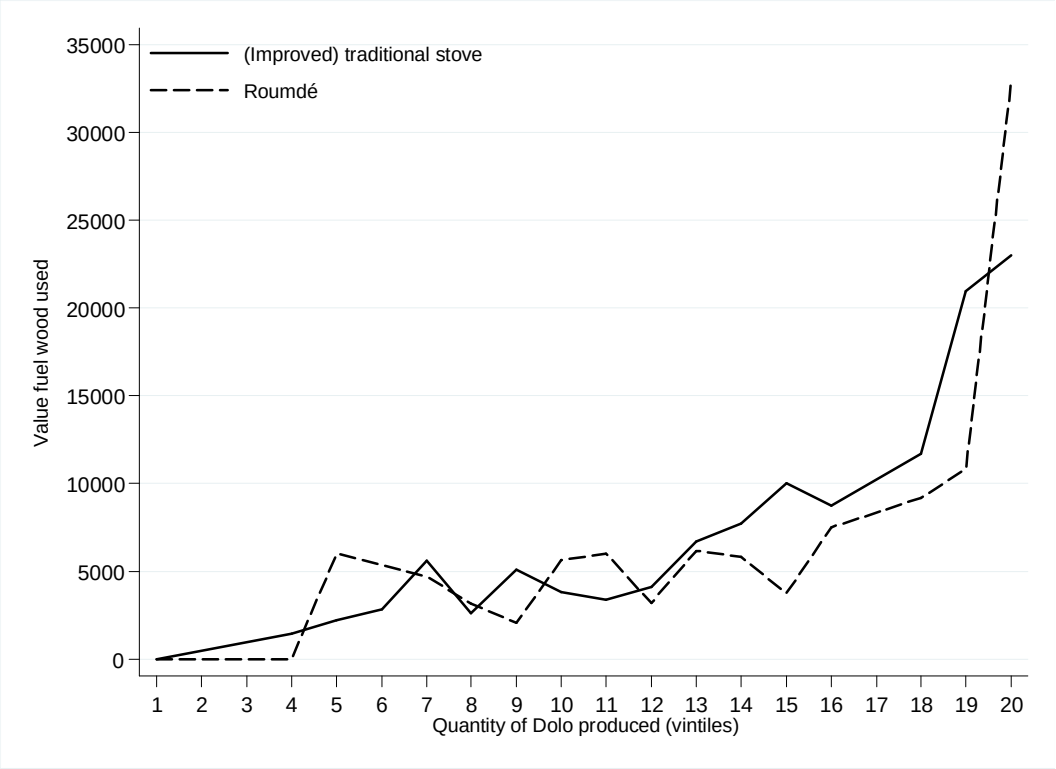
The key results from the econometric assessment are shown in Table 9 and in full detail in Annex 3. The results suggest that breweries that use at least one Roumdé (they might still use traditional stoves in addition in case they use more than one stove) spend about 18% less on firewood per brewing process than breweries that use a traditional or improved traditional stoves (but no Roumdé stove). These estimates control for the quality of the stove, for the quantity of dolo per brewing, the quantity of malt used, the quantity of water used, the number of cauldrons used, the source of the firewood purchase, the age and age squared of the dolotières, her education, her ethnicity, the time she is already in business and indicator variables for Ouagadougou, urban areas, and the corresponding interaction effect. The difference-in-difference estimator is similar in magnitude, but less precisely estimated, mainly due to the very small sample size. Because, the 2010 survey does not allow distinguishing traditional and improved traditional stoves, both categories are lumped together in the reference category. Hence what is estimated are savings relative to a mix of both types of stoves. These savings should be somewhat lower than those that one would obtain if measured in comparison to traditional stoves only.

Since a non-negligible share of breweries use Roumdés and traditional stoves simultaneously, these estimates provide for an accurate assessment of how much more firewood is consumed in *non-Roumdé using breweries*. However, it does not provide for an estimation of how much firewood could be saved if *all brewing processes* were prepared on a Roumdé stove. For this purpose, the share of stove-days that fall on a Roumdé stove is used as treatment variable. This is only possible with the 2012 data set. Moreover, the reference category is now also split into days that fall on a traditional stove and days that fall on an improved traditional stove. The results that come out of that specification are shown in the lower part of Table 9. The estimated coefficient ranges between 0.36 and 0.38 depending on which version of the propensity score weights is used (see Annex 2, Table A.1). This implies that a brewery that would switch from no Roumdé stove to only Roumdé stoves, realizes savings in firewood per brewing by about 36% to 38%. This saving rate is by roughly 40% smaller than what could theoretically be achieved (0.37/0.60). Remarkably, improved traditional

[15] Because of the small number of observations in the panel sample, the latter model does however not include brewery fixed-effects, i.e. it is a diff-in-diff estimator, but not a fixed-effects panel estimator.

stoves are at least associated with a saving rate of about 20%. Yet, the estimate is not very precise (p=16.7 to p=23.6).

Figure 2: Firewood expenditures across the size distribution of brewings (per brewing process)



Source: Own estimations, based on Brewery Surveys 2010 and 2012.

Taken together the results show that the estimates are quite robust to the exact specification and weights chosen. However, a few potential sources of bias need to be discussed. First, the estimate might be downward biased, as the value of wood consumption might be reported with error. Second, the estimate might be upward biased, if uptake is correlated with unobservables that are associated with less wood consumption, such as astuteness. Of course, the bias could also be in the opposite direction, if Roumdé stoves were adopted by breweries that have unobservable characteristics that are associated with lower efficiency. However, the similarity of the saving rates identified through the matching estimator on the one hand and the difference-in-difference estimator on the other hand, suggests that the bias that stems from unobserved heterogeneity is rather negligible. Finally, there could be a problem of reverse causality: breweries with a lower consumption of firewood per litre of dolo produced are in a better position than less efficient breweries to invest in an improved stove, leading again to an overestimated saving rate. The latter is particularly relevant if credit markets fail, which in the case of dolo breweries is certainly very frequently the case. Hence, in sum there are biases in different directions, which however partly offset each other. Hence, there are good reasons to believe that the above estimate is sufficiently close to the true saving rate. This is also confirmed by the fact, that the gap between the saving rate actually achieved and the potentially possible saving rate is in line with the found gap for household cooking stoves. Bensch et al. (2013) find that users of Roumdé cook stoves realize firewood savings relative to traditional three-

stones of roughly 24%, whereas the potential saving, as indicated through controlled cooking tests, stands at 40%.

Table 9: Impact of Roumdé usage on firewood consumption in CFA F (log)

	OLS-CS 2012 PS-weights I	OLS-CS 2012 PS-weights II	Diff-in-Diff non-param.	Diff-in-Diff parametric
Uses a traditional/improved traditional stove	Ref.	Ref.	Ref.	Ref.
Uses a Roumdé stove	-0.182***	-0.187***	-0.213	-0.143
	(0.064)	(0.064)	(0.612)	(0.340)
N	*236*	*236*	*66*	*66*
Share of brewing-stove-days with a traditional stove	Ref.	Ref.		
Share of brewing-stove-days with an improved traditional stove	-.200	-0.214		
	(0.168)	(0.154)		
Share of brewing-stove-days with a Roumdé stove	-0.358	-0.376		
	(0.163)**	(0.153)**		
N	*236*	*236*		

Notes: The results of each regression are shown in detail in Annex 4. * significant at 10%, ** significant at 5%, *** significant at 1%. Robust standard errors in parentheses.
Source: Own estimations, based on Brewery Surveys 2010 and 2012.

A look at the included control variables (see Annex 3, Table A.3) reveals some further interesting insights. First and not surprisingly, the production parameters such as the quantity of malt and water used and the number of cauldrons employed matter a lot for firewood consumption. Second, whether the wood was bought from a small retailer or a sort of "wholesale dealer" has only little effect. Third, the dolotière's education level has also no effect. Fourth, the location in Ouagadougou or Bobo-Dioulasso matters, as this does not only capture differences in the price of firewood, but also differences in the way dolo is produced.

Table 10 below converts the estimated saving rate into savings per litre of dolo produced, both in monetary terms and in terms of kg of firewood. The reported mean firewood consumption per litre of dolo (i.e. dividing total wood expenditures by the size of the brewing) is about CFA F 24.50. 36% of that are CFA F 8.82. Using an average price of firewood of CFA F 50 per kg, allows calculating the quantity of saved firewood per litre of dolo of 0.176 kg. The total savings per brewing amount to 42.3 kg of wood or CFA F 2,117. Table 10 provides the same calculation also if instead of traditional stoves, improved traditional stoves are used as a reference category. Assuming two brewing processes per week, these estimates suggest that the investment in a Roumdé is amortised after 6.5 weeks if a simple traditional stove is used as reference and after 14.7 weeks if an improved traditional stove is used as reference. Given that the estimated life-span of the Roumdé is much longer, buying a Roumdé seems to be a reasonable investment as long as wood has to be bought and cannot just be collected, which seems to apply for almost all dolotières we interviewed since more than 90% in our sample reported to buy their firewood. If maintenance costs are taken into account, the amortisation periods extend to 7.5 and 21.2 weeks.

Table 10: Wood savings related to Roumdé usage in terms of value and quantity

	Ref.: traditional stove	Ref.: improved traditional stove
Estimated saving rate	36%	16%
Mean firewood expenditure per litre of dolo	CFA F 24.50	CFA F 24.50
Saved firewood expenditures per litre of dolo	CFA F 8.82	CFA F 3.92
Price of firewood per kg	CFA F 50.00	CFA F 50.00
Saved firewood in kg per litre of dolo	0.176 kg	0.078 kg
Average size of a brewing (median)	240 liter	240 liter
Saved firewood per brewing in kg	42.336 kg	18.720 kg
Saved firewood per brewing in CFA F	CFA F 2,116.80	CFA F 936.00
Price of a Roumdé stove	CFA F 27,500	CFA F 27,500
Weeks until amortisation, 2 brewings per week assumed	6.5	14.7
Weeks until amortisation accounting for maintenance costs (CFA F 30,000 assumed annually)	7.5	21.2

Source: Own estimations, based on Brewery Surveys 2010 and 2012.

5.3.2 Reasons for the 'inefficient' use of Roumdé stoves - evidence from the qualitative assessment tools

Three factors seem particularly important for the realized savings with a Roumdé stove. First, in a typical brewery work - next to the dolotière - several other persons. Even if the dolotière has some sense of how to use the improved cook stove efficiently, the other staff members do not necessarily know. Second, even if staff know how to use a Roumdé in principle, they may not necessarily follow these rules, but rather stick to the procedures they have always applied. As explained above brewing dolo is not just a productive activity; it is an artisanry that follows first of all a tradition where the adoption of new technologies is quite uncommon. For instance, not a single brewery has been found that brews with LPG, although that would be absolutely possible and be even more energy efficient, as the temperature could be regulated over the two days in any time according to need.[16] As explained already above, the fact that dolotières stick to traditions is for instance also visible from the fact that most users of a Roumdé fill the stove despite the narrow door with the same large and complete trunks that are used for traditional stoves, which do not have a door and mostly no combustion chamber – obviously, besides traditions, snugness may also play a role here. Third, the field visits showed that many of the improved stoves are in a very bad condition (in fact more than what the distribution of *reported* quality in the survey suggests). In particular the door and the inner of the combustion chamber were often damaged, due to the common practice of forcing huge trunks through the small door. These damages obviously reduce the efficiency of Roumdés quite significantly. As reported already above, tests on various production sites conducted by IRSAT even suggest that heavily damaged improved stoves are hardly better, in fact maybe even worse, as IRSAT states, than traditional stoves (Sanogo et al., 2011). The latter would imply, if in the estimations

[16] Another reason why LPG is not used, apart from traditions, is that the LPG stoves that are offered for the purpose of brewing dolo are very expensive, in fact much more expensive than Roumdé stoves. The GIZ reports costs of at least EUR 2,000.

above we could better account for the quality of the used stoves, the estimated saving rate should be closer to the potentially possible 60%.

5.3.3 Unintended effects

The only important unintended effect worth mentioning is the fact that, as discussed in length above, that a Roumdé stove implies much higher maintenance costs than a traditional stove.

5.4 Sustainability

5.4.1 Are current users likely to adhere to the improved technology?

Despite the relative short time the dolo component of FAFASO is already running, the market for Roumdé stoves is relatively well established. A large number of masons have been trained and the product is well known. Given the relatively high saving rates and hence the short period of amortisation, it is likely that most current users will renew their investment and adhere to the Roumdé technology. Among the reported problems of current users are in particular issues related to quality, life-span and direct maintenance costs. Although the direct and indirect maintenance costs do not substantially lower the return on investment for current users they seem to present more of a psychological hurdle as changings the cauldrons and repairing frequently the door is perceived as cumbersome and very time consuming. Again, while these problems are unlikely to prevent current users from adhering to the Roumdé, they may be a deterrent for the further expansion of uptake-rates as this information is spread to breweries that have not yet adopted the technology (see below).

5.4.2 Can uptake be further expanded?

Among non-users more than 60% have heard about these stoves, although rather from neighbours, friends or other dolotières, than through the marketing activities organised by FAFASO. Hence, in principle uptake can be further expanded. However, there are also a number of threats that may hinder further expansion. These are discussed in what follows.

1. Most dolotières perceive the up-front investment costs of a Roumdé as very high. This is in particular true for those who have not yet adopted the technology as these breweries are rather at the lower end of the size-distribution (compare Table 6). In particular these smaller breweries have to be considered as cash and credit constrained. The CFA F 27,500 that needs to be paid for a Roumdé stove may seem moderate compared to the average weekly turnover and the economic return computed above, however, in the given context – the national poverty line is 108,374 CFA F per person per year (!) - and given the many competing needs (business and in particular household-related, such as food, health and education expenditures for the family and relatives) this has to be seen as a major investment. Moreover, ideally the investment should also include, if not yet available, expensive metal cauldrons costing, depending on the size, between CFA F 20,000 and CFA F 60,000. Since in this context household and production decisions are hardly separable and given the high insecurity in which these households operate, households typically prefer to engage in

precautionary savings instead of investment in an irreversible asset (i.e. in case of a health shock, a Roumdé cannot be depleted). This is a recurrent observation throughout the low income country context: despite high marginal returns to investment, (re-) investment rates are typically surprising low (see e.g. Fafchamps and Pender, 1997; De Mel et al., 2009; Grimm et al., 2011; Fafchamps et al. 2011). Hence, finally many breweries will (have to) decide to adopt a cheaper, inferior technology. To be clear, the reason is probably less rooted in the inability to notice the high potential return, but rather in the highly imperfect capital and insurance markets. Similar arguments have also been put forward for the relatively low up-take rates of household cook stoves (Bensch et al., 2013). A simple credit system that would allow dolotières to pay their investment over a period of three months would be the logical program extension in this case.

2. The in-depth interviews and focus group discussions revealed that maintenance costs related to Roumdé stoves are an additional problem that dolotières take into account when deciding about uptake. Changing the cauldrons is often done by a mason and hence is much more costly than changing the cauldrons of a traditional stove. Avoiding a frequent replacement requires to invest in aluminium cauldrons, but these cauldrons are very expensive and hence add substantially to the investment costs. Another problem arises due to the sensitivity of the doors of the stoves. Indeed, the quantitative survey shows that users of traditional and improved traditional stoves spend about CFA F 9,000 annually on maintenance, whereas users of Roumdé stoves report to spend CFA F 30,000 on maintenance. If the costs are compared in a multivariate regression framework, i.e. accounting for differences in size of the brewery and so on, users of Roumdé stoves still pay on average 50% more on maintenance than users of traditional and improved traditional stoves. Hence, uptake may be further increased if the Roumdé can be designed in a way that changing the cauldrons is easier and cheaper and by reinforcing the door with metal sheets. Further training for users is certainly an option worth to explore. This may not only have effects on maintenance and the life-span of a stove but also on its efficiency.

3. As has been shown above, the penetration of improved traditional stoves in Ouagadougou is as high as Roumdé stoves. These stoves are much cheaper than the Roumdé, although it is difficult to give an exact price, as this is a very heterogeneous set of stoves. 35% of all improved traditional stoves are even self-made. Hence, there is a risk that these stoves squeeze Roumdé stoves out of the market or that producers of Roumdé reduce the quality of their stoves to be competitive. Therefore, awareness and a strict product labelling are important to prevent this to happen.

4. The producer association reported that they expect (and already observe) that the market for dolo beer will shrink as more and more consumers prefer industrially produced standardized beverages. This has to do with new life-styles, but also with a general rise in income even if incomes haven't grown a lot in the past two decades and are by international standards still very low. If the market shrinks, many dolotières will probably abstain from making costly investments of which they are unsure whether they will really pay-off.

5.4.3 Is FAFASO's strategy sustainable and will the market last?

FAFASO has spent about EUR 100,000 on the set up of a market for improved dolo stoves. These costs refer to direct cash outlays and include basically the training of the masons and the marketing activities, but not the share of FAFASO's costs for personnel that is allocated to the dolo activities and other general program costs.[17] 2,348 stoves have been installed so far. This implies that each stove has been subsidized with about EUR 42.60 so far (i.e. the implied subsidy will be further reduced if further stoves are produced on past project costs). Assuming a life-span of two years, two brewings processes per week over 39 weeks (or 9 months) a year and assuming that all Roumdé replaced a traditional stove this compares to EUR 1,085,173 of net savings (i.e. also accounting for the investment costs). Reducing the producer costs of dolotières by EUR 1 costs about EUR 0.09. Using the estimate of 42kg of firewood saved per brewing process the program costs (incl. the costs for the stoves) imply that EUR 0.013 are necessary to save 1kg of firewood.

These computations do of course not include the broader environmental benefits, as well as the lost income for sellers and traders of firewood. It does also not include the possible positive health effects on dolotières thanks to possibly reduced smoke emissions and the possibly adverse health effects of increased dolo consumption among the broader population. Furthermore, it has to be taken into account that it is FAFASO's objective to establish a sustainable market for Roumdé brewing stoves. If one assumes that many more Dolotières switch to a Roumdé in the future without incurring (substantially) higher expenditures on FAFASO's side this will of course bring down the cost-benefit ratios above.

Whereas the association of dolotières seems to be quite a strong and very engaged group, the association of masons seems to be less dynamic (although in Ouagadougou and Bobo-Dioulasso their associations are even recognised by the state). Obviously, it is difficult to extrapolate from such subjective impressions, but commitment will be crucial for the sustainability of the market, once the GIZ reduces its engagement. The masons showed in particular only limited innovative potential; many might be inclined to offer lower quality instead of marketing quality and strive for further quality improvements to gain further market shares. However, according to the GIZ the project monitoring does so far not reveal any problems with the quality of the installed stoves. FAFASO recently started to train many 'dolo masons' in constructing stoves for the production of shea butter. This should enlarge their market and hence to ensure that they stay with the program.

The government seems to be interested in the program and agrees with the chosen strategy in principle, but shows only little active engagement. Commitment from the Government, though, will be the pivotal element for the sustainability of the approach, since upon GIZ's withdrawal from the sector support a Burkinabè institution needs to take over sensitisation and marketing campaigns and in particular to institutionalize the quality assurance.

[17] This is a very rough estimate and covers the period 2010 and 2011. The Project accounting does in principle not allow separating what has been spent specifically on dolo stoves. More precisely, the estimate of EUR 100,000 includes training courses (about EUR 10,000 to 12,000 each), refresher courses for masons, the marketing activities including a TV spot, trade fairs, the installation of demonstration stoves and the production and distribution of information material on stove usage.

6. Conclusion

The GIZ started to foster market creation for improved stoves for local beer producers in Burkina Faso in 2010. This intervention includes the development of a stove in collaboration with local experts, the training of masons in constructing such a stove, the set-up of a sales network and the launch of awareness and commercial campaigns. In 2012, i.e. two years later about 50% of all breweries in Ouagadougou and Bobo-Dioulasso city (see Table 4) have adopted the new technology; however since then the trend of adoption is downward sloping. The number of new installations decreased abruptly (see Table 1). It is difficult to provide the exact reason for this reversal of the trend, but market saturation is one possible explanation.

Yet, the present evaluation estimated that in comparison with traditional stoves users, users save on average almost 40% of the wood needed with a traditional stove or CFA F 8.82 per litre of dolo produced. Per brewing the savings amount to CFA F 2,117 corresponding to roughly 42 kg of firewood. This is a third less than what controlled cooking tests have indicated as potential savings, but the implied inefficiency is comparable to what can be observed for households that use improved cooking stoves. Under these conditions a Roumdé stove is amortized after about 7 weeks. However, it turns out that traditional improved stoves are also an improvement over the simple traditional stoves, savings associated with them amount to roughly half of what is possible with a Roumdé. Given its lower price - in fact often it is self-made - many dolotières seem to choose that alternative. Moreover, Roumdé stoves imply significant costs of maintenance, repairs to the door are frequent and the change of cauldrons is a bit cumbersome and expensive. This latter aspect, in conjunction with the relatively high cost of adoption, is a deterrent of uptake. It should be explored whether changes to the design of the stove with the potential to reduce maintenance costs is a feasible option. Moreover, given the difficulty of taking a credit, it would be worth to explore whether a simple system of credits can be introduced and further enhance uptake. In terms of cost effectiveness, the program implies that it costs about EUR 0.09 to reduce the energy expenditures of dolotières by one Euro. In terms of firewood, it is found that reducing firewood by 1kg costs about EUR 0.013.

Annexes:

Annex

Annex 1: Photographs

Photo 1: A typical dolo brewery

Photo 2: A traditional dolo stove (a)

Source: IRSAT.

Photo 3: A traditional dolo stove (b)

Photo 4: A traditional dolo stove (c)

Photo 5: A traditional dolo stove (d)

Photo 6: An improved traditional stove

Photo 7: A Roumdé stove

Source IRSAT.

Photo 8: A Roumdé stove with a broken door (a)

Photo 9: A Roumdé stove with a broken door (b)

Photo 10: A typical dolo cabaret

Photo 11: A pile of wood in front of a brewery

Annex 2: Details of impact assessment methods

Impact assessment by propensity score weighing (cross-section 2012)

As it has been discussed in Section 4, a major problem of the impact evaluation that needs to be overcome is non-random-selection into the treatment group, i.e. the users of Roumdé stoves may systematically differ along a number of characteristics from non-Roumdé users and these characteristics might be correlated with wood consumption. Hence, there is a risk to attribute effects to the use of an improved stove which in reality are due to the differences in characteristics in both groups. The straightforward solution to redress at least the bias that stems from observable differences is to control for these differences in the regressions that relate outcomes and treatment. A superior method in terms of the precision of the impact estimates is to apply 'propensity score matching (PSM)'.[18] The matching estimator ensures that the comparison is limited to very homogenous groups, i.e. groups of observations that are equally likely – or have the same propensity – based on observable characteristics to own a stove. Put differently, it is assumed that the Roumdé users that are observed would behave – in case they would not own a Roumdé – in the same way as the matched non-users to which they are compared.

PSM is based on an econometric regression model where the decision to use a stove is regressed on the observables that potentially affect both the decision to use a stove and the outcome variables (see Schmidt and Augurzky, 2001). The thereby estimated probability of using a stove given the observable characteristics represents the propensity score. The treatment and control households are then solely matched on this propensity score. This reduces the matching from a multi-dimensional problem (where the number of dimensions depends on the number of available variables) to a one-dimensional problem. The fundamental assumption for the validity of this matching approach is that, when observable characteristics that can be considered as not responding to the treatment (i.e. to the usage of an improved stove) are balanced between the two groups; the larger the number of available characteristics, the higher the chance that this assumption holds true.

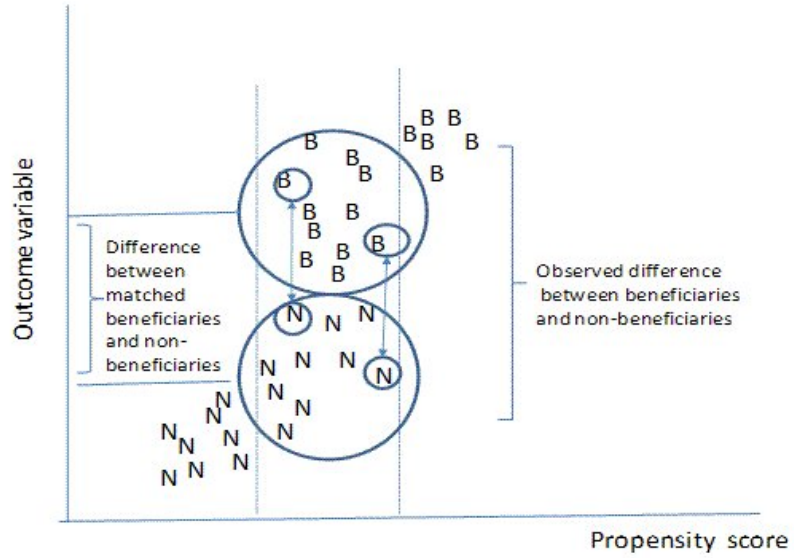
The figure below provides an intuitive graphical representation of the matching method. The "N" represents a sample of non-treated controls, while the "B" represents treated individuals. The two dimensions of the graph are the outcome and the propensity score. In this stylized example, two matches are indicated with two small circles connected by an arrow. They are matched due to similar propensity score values. The same holds for all individuals in the larger circles, while those "N" and "B" outside the circles do not find a suitable match and are therefore not considered. The figure also shows that the difference between the means of matched treated and control individuals can be substantially different from the difference between the means of all treated and control individuals. Given that in the present case the sample size is relatively small and the impact assessment needs to be done separately for different pairs of stoves (Roumdé stoves vs. traditional stoves and Roumdé stoves vs. improved traditional stoves) the standard matching approach is not feasible as the number of cases in the various treatment and control groups would be too small.

In this case it is better to rely on a special variant of the matching approach, proposed by Hirano, Imbens and Ridder (2003) and further discussed in Hirano and Imbens (2001) in which the inverse of the propensity score is used to weight each observation in the treated group, and the inverse of one

[18] Besides PSM, the literature proposes a number of other matching estimators (see e.g. Cameron and Trivedi, 2009).

minus the propensity score (i.e. the propensity of not being in the treated group) in the control (see Hirano and Imbens, 2001; Posner and Ash, 2012). This formula is used to determine the average treatment effect, whereas Brunell and DiNardo (2004) provide an extension thereof for the treatment effect on the treated (see below), which will be used in this study. Weighting has the nice property of including all the available data and does not depend on random sampling. The risk is, as shown by Freedman and Berk (2008) that weighting may increase random error in the estimates, and bias the estimated standard errors downward, even if the selection mechanism is well understood.

Figure A.1: Graphical representation of matching on propensity score



Source: European Commission (2009).

The implementation of the procedure involved the following steps. First a probit model of being a user of a Roumdé stove has been estimated:

$$\Pr_i(T_i = 1) = \theta(\beta_0 + X_{il}'\beta_l + \omega_i), \quad \text{(A.1)}$$

where the dependent variable is the binary outcome of a brewery *i* having an ICS. The underlying latent variable is the conditional probability of having an ICS. The matrix stands for a set of observable household characteristics *X* explaining stove ownership and the vector *ß* are the associated effects that are estimated. ω stands for the error term and *Θ* stands for the cumulative standard normal distribution function, i.e. the underlying probability distribution in a probit model.

Formally, the propensity score is defined as

$$e_i(x_i) = \Pr_i(T_i = 1 \mid X_{il}) \quad \text{with} \quad 0 < e_i(x_i) < 1. \quad \text{(A.2)}$$

To attain the average treatment effect on the treated, weights can be computed from these propensity scores as outlined in Brunell and DiNardo (2004) for both treatment and control observations, denominated $\mu^{Ti=1}$ and μ^{C} respectively:

$$\mu_i^{T=1} = 1 \text{ and } \mu^C = \frac{Pr(T=1|X)}{1 - Pr(T=1|X)} \times \frac{p^C}{p^T},$$

(A.3)

where p^T to the fraction of treatment observations and p^C to the fraction of control observations. The Table below shows the differences in the household characteristics used to estimate the probit model above before and after reweighting. It can be seen that the reweighing procedure leads to an almost perfect balance; none of the differences between the group of owners and non-owners is statistically significant anymore.

Table A.1: Test of balancing property of matching procedure

	User of Roumdé stove	Non-user of Roumdé stove unweighted	Non-user of Roumdé stove weighted	Pre-weighing difference
Variable set weights I				
Ln quantity of Dolo per brewing (in liter)	5,753	5,313	5,722	***
Age dolotière	46,911	45,340	47,512	
Age dolotière (sq.)	2313,149	2168,948	2376,088	
At least primary completed (=1)	0,388	0,135	0,361	***
In Dolo business (years)	18,553	15,151	17,725	***
In Dolo business (years) (sq)	432,553	325,818	408,905	**
Ouagadougou/Centre Region	0,854	0,381	0,849	***
Urban (=1)	0,330	0,160	0,327	***
Ouagad. X Urban (Interaction)	0,194	0,116	0,187	**
Variable set weights II				
Ln number of cauldrons	2,409	2,251	2,456	***
Ln quantity of Dolo per brewing (in liter)	5,753	5,313	5,737	***
Quantity of malt per brewing (in kg)	4,264	3,915	4,283	***
Quantity of water per brewing (in barrel)	1,775	1,288	1,792	***
Wood delivery (share of breweries)				
By cart	0,359	0,226	0,362	***
By lorry	0,019	0,016	0,017	
By truck	0,447	0,066	0,472	***
At least primary completed (=1)	0,388	0,135	0,385	***
Ouagadougou/Centre Region	0,854	0,381	0,874	***
Urban (=1)	0,330	0,160	0,292	***
Ouagad. X Urban (Interaction)	0,194	0,116	0,176	**

Note: Difference: * significant at 10%, ** significant at 5%, *** significant at 1%. Values for Roumdé stove users are identical before and after weighting as a weight of 1 is assigned to these observations.

The impact evaluation is then based on the following regression model:

$$\ln \tilde{Y}_i = \beta_0 + \beta_1 \widetilde{ITS}_i + \beta_2 \tilde{IS}_i + \beta_3 \tilde{X}_i + \beta_4 \tilde{Z}_i + u_i, \quad \text{(A.4)}$$

where ln $\tilde{Y}_i$ stands for the outcome of interest: expenditure for firewood per brewing. The tilde indicates that all observations are reweighed with the propensity score-based weights. $\widetilde{ITS}_i$ and $\widetilde{IS}_i$ are indicator variables taking the value one if a given brewery uses an improved traditional or a Roumdé stove respectively or alternatively are shares measuring the share of brewing days that fall on improved traditional and improved stoves respectively. Hence, β_1 and β_2 are the main coefficients of interest, the saving rates associated with these two types of stoves. The saving rates are always in relation to traditional stoves. $\tilde{X}_i$ stands for a vector of characteristics relative to the brewery and the observed brewing such as the quality status of the used stoves, the number of cauldrons, the quantity of dolo produced per liter, the quantities of malt and water used and the mode of wood provision. $\tilde{Z}_i$ stands for a vector of characteristics of the dolotière such as the number of years the dolotière is already in business, her age, age squared, education, ethnic affiliation and her location. The term u_i stands for the error term.

The difference-in-difference estimator (panel data 2010/12)

As explained in Section 4.3, the diff-in-diff estimator relies on a comparison of breweries with and without an improved stove before and after the roll-out of the program. The dissemination of stoves really started in 2010. Hence, the 2010 survey can be considered as a pre-program baseline. The few breweries that had already an improved stove in the 2010 survey are removed from the sample. Using both rounds of the survey, the difference is calculated between the observed mean outcomes for the breweries with and without improved stove before and after the start of the program.

Hence, with the baseline data at hand, it is possible to estimate impacts by assuming that unobserved heterogeneity is time invariant and uncorrelated with improved stove ownership over time. This assumption is weaker than the conditional exogeneity assumption made above, i.e. that having a stove is exogenous conditional on the included regressors in Equation (A.4). The diff-in-diff estimator can be calculated non-parametrically or in a parametric regression framework thus allowing controlling for time-varying characteristics that could still lead to a bias if omitted. The regression can be specified as follows:

$$\ln Y_{it} = \beta_0 + \beta_1 IS_{it} \times t_t^{2012} + \beta_2 t_t^{2012} + \beta_3 IS_i + \beta_4 X_{it} + \beta_4 Z_i + u_{it}, \quad \text{(A.5)}$$

where the variables follow the same notation than above. The subscript t indicates time. t_t^{2012} is an indicator variable taking the value one if a given observation is made in 2012. The coefficient of interest, the saving rate associated with the use of an improved stove, is given by β_1, the effect of the interaction effect of treatment and time conditional of time effects and being in the treatment group.

Since the 2010 survey does not allow to distinguish traditional from improved traditional stoves, Equation (A.5) does not include *ITS*. Moreover, given the small sample size of the panel[19], individual fixed-effects cannot be added to Equation (A.5), i.e. only time-constant heterogeneity between users and non-users is removed. Introducing individual fixed-effects would in contrast allow removing the entire time-constant heterogeneity. However, a limited set of observed time-constant characteristics, Z_i, can be added to the list of regressors to capture some of the remaining within-group heterogeneity.

[19] The panel includes only 88 breweries. Given further missing information in outcomes and/or some of the explanatory variables, the diff-in-diff estimator is even only based on 66 observations.

Annex 3: Analysis of attrition

As explained in Section 4.1, many breweries interviewed in 2010 could not be re-interviewed in 2012, mainly because they did not want to respond to the questionnaire again, because they were absent when the interviewers came (even repeated times) or because they have stopped their activity (or not re-opened after a seasonal break). To assess whether drop outs may bias the results drawn from the analysis of the panel data, it can be tested whether the probability of a drop-out varies systematically with observable characteristics of the brewery and the dolotière. If this is not the case, it might be assumed that drop-outs are largely random and do not bias the assessment. However, it is obvious that non-observable characteristics could still play a role and that these are correlated with the outcomes of interest. The following table shows results from a probit model that regresses a binary variable whether a given brewery has been interviewed in both years (i.e. did not drop out) on a set of brewery and dolotière characteristics.

Table A.2: Analysis of drop-outs, probit model

Dep. var.: interviewed in 2012 given that an interview took place in 2010 (=1)	Coeff. (S.E.)
Age	0.003
	(0.011)
Mossi (=1)	-0.372
	(0.410)
Bobo (=1)	-0.353
	(0.501)
In Dolo business (years)	-0.007
	(0.012)
Ouaga	0.281
	(0.451)
Has improved stove (in 2010)	0.271
	(0.267)
Ln of quantity dolo produced (in 2010)	0.539**
	(0.217)
Constant	-3.120***
	(1.158)
N	192

Notes: Due to missing information in the characteristics, 25 observations had to be excluded from this regression.
Source: Own estimations, based on Brewery Surveys 2010 and 2012.

The results show that none of the explanatory variables is significant, except size of the brewery as measured by the quantity of dolo produced per brewing. The overrepresentation of larger breweries could introduce a bias if size of the brewery also has an effect on improved stove adoption and the consumption of firewood per liter produced. Hence, it will be important to take into account the size of breweries when selecting the control group (i.e. when computing the propensity score-based weights, see Annex 2).

Annex 4: Detailed regressions results

Table A.3: Details of regressions shown in Table 9 (impact of Roumdé on firewood consumption)

	OLS-CS 2012 PS-weights I	OLS-CS 2012 PS-weights II	OLS-CS 2012 PS-weights I	OLS-CS 2012 PS-weights II	Diff-in-Diff param.
Type of stove used[a)]					
Traditional/traditional improved stove	Ref.	Ref.			Ref.
Roumdé stove	-0.182***	-0.185***			-0.143
	(0.064)	(0.064)			(0.340)
Type of stove used by share of brewing days					
Traditional stove			Ref.	Ref.	
Improved traditional stove			-0.199	-0.214	
			(0.168)	(0.154)	
Roumdé stove			-0.358**	-0.376**	
			(0.163)	(0.153)	
Condition of stove by share of brewing days					
Good	Ref.	Ref.	Ref.	Ref.	
Cracks	0.036	0.071	0.053	0.094	
	(0.081)	(0.073)	(0.083)	(0.075)	
Shaby	0.104	0.070	0.080	0.071	
	(0.135)	(0.106)	(0.116)	(0.102)	
Ln Number of cauldrons	0.428***	0.314***	0.434***	0.307***	
	(0.120)	(0.096)	(0.124)	(0.095)	
Ln quantity of Dolo per brewing (in liter)	0.045	0.138	0.065	0.157	0.083
	(0.126)	(0.116)	(0.123)	(0.114)	(0.274)
Ln quantity of malt per brewing (in kg)	0.491**	0.404**	0.458**	0.371**	1.112***
	(0.205)	(0.168)	(0.197)	(0.166)	(0.272)
Ln quantity of water per brewing (in barrel)	0.119	0.258*	0.118	0.268*	
	(0.172)	(0.141)	(0.165)	(0.136)	
Wood delivery (share of breweries)					
Buys in small quantities	Ref.	Ref.	Ref.	Ref.	Ref.
By cart	-0.037	-0.038	-0.045	-0.057	-0.250
	(0.084)	(0.075)	(0.083)	(0.073)	(0.160)
By lorry	-0.007	0.022	-0.029	0.007	0.268
	(0.101)	(0.095)	(0.112)	(0.104)	(0.249)
By truck	0.155*	0.102	0.157*	0.102	0.343
	(0.079)	(0.075)	(0.082)	(0.077)	(0.281)
Age dolotière	-0.059**	-0.048*	-0.064***	-0.054**	
	(0.025)	(0.025)	(0.024)	(0.025)	
Age dolotière (sq.)	0.001***	0.001**	0.001***	0.001**	
	(0.000)	(0.000)	(0.000)	(0.000)	
At least primary completed (=1)	0.129	0.005	0.122	0.002	-0.184
	(0.113)	(0.080)	(0.107)	(0.078)	(0.230)

Table continues next page.

Table A.3: Table (*… continued*)

	OLS-CS 2012 PS-weights I	OLS-CS 2012 PS-weights II	OLS-CS 2012 PS-weights I	OLS-CS 2012 PS-weights II	Diff-in-Diff param.
Ethnic group					
Mossi (=1)	-0.166	-0.233**	-0.196	-0.257**	-0.415*
	(0.131)	(0.117)	(0.121)	(0.116)	(0.221)
Bobo (=1)	0.165	0.159	0.141	0.170	-0.719**
	(0.117)	(0.110)	(0.121)	(0.112)	(0.313)
Other (=1)	Ref.	Ref.	Ref.	Ref.	Ref.
ln Dolo business (years)	0.006	-0.001	0.009	-0.002	
	(0.010)	(0.011)	(0.011)	(0.011)	
ln Dolo business (years) (sq)	-0.000	-0.000	-0.000	-0.000	
	(0.000)	(0.000)	(0.000)	(0.000)	
Ouagadougou/Centre Region	0.802***	0.705***	0.875***	0.799***	-0.299
	(0.133)	(0.129)	(0.165)	(0.160)	(0.322)
Urban (=1)	0.968***	0.934***	1.013***	0.993***	
	(0.095)	(0.093)	(0.126)	(0.115)	
Ouagad. X Urban (Interaction)	-0.730***	-0.730***	-0.754***	-0.772***	
	(0.127)	(0.119)	(0.142)	(0.129)	
Time effect (2012)					-0.561***
					(0.163)
Treatment group (user of Roumdé)					-0.038
					(0.275)
Intercept	5.565***	5.416***	5.842***	5.714***	-1.235
	(0.887)	(0.792)	(0.767)	(0.768)	(1.499)
R-squared	0.766	0.806	0.768	0.807	0.655
N	236	236	236	236	66

Notes: * significant at 10%, ** significant at 5%, *** significant at 1%. Robust standard errors in parentheses.

Source: Own estimations, based on Brewery Surveys 2010 and 2012.

Annex 3: Questionnaires used

IRSAT's questionnaire of 2010

Questionnaire sur la production de bière de sorgho rouge

Introduction :

Identification du producteur

Nom producteur ……

N° téléphone : ……

Durée dans l'activité Dolo: ……..

N° Secteur : …… Nom du Quartier :

……

Ethnie : …… Age : …….. Religion :

……..

Niveau d'instruction : non instruite primaire secondaire

Situation matrimoniale : mariée célibataire veuve

Nombre total des membres de la famille :

……

Activités principales : ……

……..

Autres activités :

……

Si elle est mariée :

Quel est le secteur d'activité (groupe socio-économique) du mari

- dépendant secteur public …
- dépendant secteur privé formel
- dépendant secteur privé informel …
- indépendant secteur privé formel
- indépendant secteur privé informel …
- indépendant agricole
- apprenti …
- aide familial
- sans activité
- autre, precisez ……

Comment **vous approvisionnez-vous** en bois de chauffe ?

Camion ( ) Camionnette ( ) Charrette ( ) En détail ( )

En kg……

Pour quelle durée ?.....

Combien cela vous coûte-t-il ?.....

Quels sont vos foyers actuellement ?

	Foyer 1		**Foyer 2**		**Foyer 3**		**Foyer 4**		**Foyer 5**	
Type de foyer	FT	FA	FT	FA	FT	FA	FT	FA	FT	FA
Type[1] et Taille des marmites sur le foyer										
Quel est le nombre de fois où vous utilisez ce foyer par semaine ?										
Durant la préparation pendant combien de jours ce foyer est allumé ?										
Quelle est la quantité de bois nécessaire pour une préparation avec ce foyer?										
Quelle quantité de dolo produisez-vous lors d'une préparation avec ce foyer?.										
Depuis quand utilisez-vous ce Foyer?										
Combien avez-vous payé pour l'installation du Foyer ?										

(1) type : Canari : C – Auminium : A

Quelle **est votre source d'approvisionnement en eau** pour la préparation du dolo ?

1- puits ( ) 2-bonne fontaine ( ) 3-robinet dans la cours ( )

A combien s'élèvent vos dépenses en eau pour une préparation ?.....

A combien s'élèvent vos dépenses en eau pour un mois ?.....

Comment **vous procurez-vous le malt** destiné à la préparation du dolo ? :

……..

.....…….....

.....

Quelle est la quantité malt nécessaire par préparation

?.....

Combien cette quantité vous coûte-elle par

préparation?.....

Quelle est la quantité d'eau est nécessaire pour cette quantité de malt

?.....

Quelle quantité de dolo obtenez-vous avec cette quantité de malt

?…….

Comment procédez-vous à la vente de votre dolo :

□ Vente aux revendeurs □ vente directe aux clients □ autres :

……

Quelle mesure vous vous servez pour la vente du dolo ?.....

□ Bouteille □ Bidon □ Calebasse □ Canari (préciser le volume)….

Quel est le prix de vente par litre?.....FCFA

Combien de clients avez-vous par

semaine?.....

Quelle est votre vente totale par

semaine?..... litre

Personnel employé

Quel est le nombre de personnes que vous employez ?.....

Quel est le nombre de personnes que vous payez ?.....

Quelle est la situation matrimoniale de chacune d'elles ……

Combien payez-vous chaque employé par mois ?.....FCFA

Questions relatives à des projections

Que pensez-vous de l'évolution de la clientèle au cours des 5 dernières années?

.....

.....
.....
Les combustibles sont-il
disponibles?.....
Connaissez-vous d'autres types d'énergie
?.....
Si oui, lesquelles
?.....

Résidus de Production

Quels sont les résidus de la production du dolo ?.....

1-Charbon de bois ( ) 2-Drêches ( ) 3- autres ( )…….

Valeurs des résidus

1-Quantité de Charbon de bois / production : …….Valeurs : ……..F CFA

2-Quantité de Drêches / production : ……. Valeurs : ……..F CFA

Utilisation des Foyers améliorés

Connaissez-vous les foyers améliorés à Dolo? : Oui □ Non □

En Avez-vous entendu parler :…….. Oui □ Non □

Avez-vous vu : ……. Oui □ Non □

Avez-vous possédé : …….. Oui □ Non □

En possédez-vous ? …….. Oui □ Non □

Comment avez-vous connu les foyers améliorés à Dolo :

Radio : □ Télévision : □ Par un maçon □

Par un Projet : □ de Bouche à oreille □

Autres (préciser) ……

Qui vous construit vos foyers :

Un maçon spécialisé en foyer ? □

N'importe quel maçon que vous trouvez ? □

Vous-même ? □

Autres (préciser)……..

Trouvez-vous facilement un constructeur de foyer :Oui □ Non □

Combien vous coûte la construction d'un foyer : ?

Quelle est la durée de vie d'un foyer :

Qui est chargé de la maintenance de votre foyer :

Le maçon qui l'a construit □ Vous-même : □ N'importe qui □

Quelles maintenances faites vous sur le foyer et à quelle fréquence : ……

……..……

……

Quels sont les coûts de la maintenance par an?.....

Votre Appréciation sur les foyers améliorés à Dolo

	Oui	Non
Economique	□	□
Pratique (confort)	□	□
Rapide	□	□
Facile	□	□

Autre à préciser:

.....

Quels sont les inconvénients des foyers améliorés à Dolo :?

Courte durée de vie…… □

Coût de construction : …… □

Entretien :…… ……. □

Lenteur :…… …….. □

Consomme autant de bois que le foyer traditionnel de bois :…… □

Mauvaise qualité de la porte…….. □

Mauvaise qualité de l'intérieur de la chambre de ……. □

Qualité de la combustion…… □

On ne peut pas charger beaucoup de bois……. □

Chaleur intense …… □

Trop de fumée …… □

Autres à préciser

:……

Que faudrait-il améliorer sur les foyers :

Résistance : □

Prix : □

Facilité d'utilisation : □

Entretien : □

Qualité des foyers □

Autre(s) à préciser : .....

....

……

……. .....

Si vous ne possédez pas de foyer amélioré dites Pourquoi :

Pas intéressé □

Prix élevé □

Ne sais pas où trouver un constructeur □

N'est pas convaincu de l'efficacité □

Jamais entendu parler avant □

Découragé après en avoir possédé à cause :

Résistance faible : □

Inefficacité : □

Difficultés de manipulation □

Autre(s):.....

.....

.....

Votre cabaret est il en sous-location : Oui □ Non □

Les usagers des foyers ont-ils déjà été formés à l'utilisation des foyers :

Oui □ Non □

Si oui par qui et quand : ……

Questionnaire sur la production de bière de sorgho rouge

Numéro de Fiche : |___|___|___|

0 : Eléments d'identification

1. Région : |___|___| (*Hauts bassin : 9 – Centre : 3)*
2. Province : .....
3. Commune.....:.....
4. Ville/village :..... :.....
5. Type de localité (1. Urbain/ 2. Rural) : |___|
6. Secteur : |___|___|
7. Quartier: .....
8. Date de l'enquête: |___|___|/|___|___|/|___|___|

Jour /Mois/ Année

Nom enquêteur :.....

I. Identification du producteur

1. Nom producteur .....
2. N° téléphone : |___|___|-|___|___|-|___|___| - |___|___|
3. Durée dans l'activité Dolo: |___|___|
4. Ethnie : |___|

1. Mossi 2. Bobo 3. Samo 4. Gourounsi 5. Bissa 6. Dagari
7. Lobi 8. Gourmantché 9. Marka 10. Peulh 10. Autres

1. Age : |___|___|
2. Sexe : |___| : *1. M / 2. F*
3. Religion : |___|

1. Chrétien- 2. Animiste – 3 . Musulman 4. Autres 5. NSP

4. Niveau d'instruction : non instruite primaire secondaire
5. Situation Matrimoniale : |___|

1. Mariée 2. Célibataire 3. Veuve 4. Non concerné par le mariage

1

6. Nombre total des membres de la famille : |___|___|

7. Activités principales : |___|

   1. *Dolotière - 2. Commercante – 3. Ménagère – 4. Restauratrice – 5 Autres*

8. Autres activités : |___|

0. *Rien – 1. Dolotière - 2. Commercante – 3. Ménagère – 4. Restauratrice – 5 Autres*

II. Les Foyers

9. Comment vous approvisionnez-vous en bois de chauffe ?

   Camion Camionnette Charrette En détail

10. Combien payez-vous pour un approvisionnement? |___||___||___||___||___||___| FCFA

11. Durée d'une préparation (# de jours)? |___| jours

12. Les foyers que vous utilisent, vous appartiennent-ils ?

    Oui Non

13. Quels sont vos foyers actuellement ?

Les Foyers	1. Foyer 1			2. Foyer 2			3. Foyer 3			4. Foyer 4			5. Foyer 5		
a. Type de foyer[1]	FT	FAT	FA	FT	FA	FA	FT	FAT	FA	FT	FAT	FA	FT	FAT	FA
b. Foyer Roumdé	Oui	Non	NSP	Oui	Non	NSP	Oui	Non	NSP	Oui	Non	NSP	Oui	Non	NSP
c. État de foyer en général	1. Bonne 2. Fissures 3. Dégradé			1. Bonne 2. Fissures 3. Dégradé			1 Bonne 2 Fissures 3 Dégradé			1. Bonne 2. Fissures 3. Dégradé			1. Bonne 2. Fissures 3. Dégradé		
d. État des portes	1. Bonne 2. Réparation nécessaire			1. Bonne 2. Réparation nécessaire			1. Bonne 2. Réparation nécessaire			1. Bonne 2. Réparation nécessaire			1. Bonne 2. Réparation nécessaire		

[1] FT = foyer traditionnel
FAT = foyer artisanal
FA = foyer amelioré

	3. Détruite		3. Détruite		3. Détruite		3. Détruite		3. Détruite	
e. Intérieur	1. Bonne 2. Réparation nécessaire 3. Détruite		1. Bonne 2. Réparation nécessaire 3. Détruite		1. Bonne 2. Réparation nécessaire 3. Détruite		1. Bonne 2. Réparation nécessaire 3. Détruite		1. Bonne 2. Réparation nécessaire 3. Détruite	
f. Depuis combien d'années utilisez-vous ce foyer?	------ an ----- mois		------ an ----- mois		------ an ----- mois		------ an ----- mois		------ an ----- mois	
g. Combien avez-vous payé pour l'installation du foyer ?**	1 2 3 4		1 2 3 4		1 2 3 4		1 2 3 4		1 2 3 4	
Les Marmites	**Foyer 1**		**Foyer 2**		**Foyer 3**		**Foyer 4**		**Foyer 5**	
h. Nombre des marmites sur le foyer										
i. Type[2] des marmites sur le foyer	C	A	C	A	C	A	C	A	C	A
j. Taille des marmites sur le foyer	20 - 25 - 30 - 50 -60 – 99 – C*		20 - 25 - 30 - 50 -60 – 99 - C		20 - 25 - 30 - 50 -60 – 99 - C		20 - 25 - 30 - 50 -60 – 99 -C		20 - 25 - 30 - 50 -60 – 99-C	
k. Durant la préparation combien de jours ce foyer est allumé ?										

* 99 : mélange de tailles de canaris. C : marmite céramique uniquement

1. 0 à 25000 - 2. 25001 à 50000 – 3. 50 001 à 100 000 – 4. NSP

III. La production de dolo

14. Parlons maintenant d'une préparation de Dolo. Indiquez-les foyers que vous utilisez par préparation.

[2] C : Canari
A: Aumininum

foyer 1 foyer 2 foyer 3 foyer 4 foyer 5

15. Combien de Dolo produisez-vous par préparation en total avec ce(s) foyer(s)?

Volume : |_||_||_||_|litres

16. Quelles sont vos dépenses en bois de chauffe par préparation (en FCFA |_||_||_||_||_||_|.FCFA

17. Combien de préparations réalisez-vous par semaine en total? |_|

18. Quelle est votre source d'approvisionnement en eau pour la préparation du dolo ?

puits bonne fontaine robinet dans la cours

19. Comment vous procurez-vous le malt destiné à la préparation du dolo ?

malteuse commercial lieu de production

20. Quelle est la quantité malt nécessaire par préparation (indiquez le nombre de sacs)?

tine : |_||_| (nombre de tines)

sac de 50 kg : |_||_| (nombre de sacs)

sac de 100 kg : |_||_| (nombre de sacs)

21. Combien cette quantité vous coûte? |_||_||_||_||_|.. FCFA

22. Quelle est la quantité d'eau qui est nécessaire pour cette quantité de malt ? |_||_||_| **Barriques**

23. A combien s'élèvent vos dépenses en eau pour une préparation ? |_||_||_||_||_| **FCFA**

24. Quel est le nombre de personnes que vous employez ? |_||_| **personnes**

25. Combien payez-vous chaque employé par préparation ? .. |_||_||_||_||_| FCFA

26. Quels sont les résidus de la production du dolo ?

Charbon Drêche Autres, précisez : .....

27. Quantité de Charbon de bois / production :

Sac de 50 kg : |_| - **Plat :** |_|- **Seau :** |_| -

Valeurs : |_||_||_||_| F CFA – Consommation famillale : |__|

28. Quantité de drêches / filtre : |_||_| Valeurs : |_||_||_||_|F CFA

29. A Combien estimez-vous tous les autres dépenses par préparation comme le loyer de foyer (le cas échéant), etc.? |_|I_|I_|I_|F CFA

IV. La Vente

30. Vendez-vous aux revendeurs?

oui non

31. Combien de revendeurs avez-vous ? : |_|I_|

32. Sur la dernière préparation quel volume a été vendu:

Aux revendeurs : |_|I_|I_| litres --- en vente directe : |_|I_|I_| litres

33. Aux revendeurs, quel est le prix de vente par bidon de

1.....l? |_|I_|I_|I_|FCFA

2.....l? |_|I_|I_|I_|FCFA

3.....l? |_|I_|I_|I_|FCFA

4.....l? |_|I_|I_|I_|FCFA

5.....l? |_|I_|I_|I_|FCFA

34. Aux clients directs, quel est le prix de vente par calebasse? |_|I_|I_| FCFA

V. Les foyers améliorés

Si la dolotière ne possède pas un foyer amélioré :

35. Connaissez-vous les foyers améliorés à Dolo?

oui non

Si non, continuez avec question 49.

Si oui :

36. D'où connaissez-vous les Foyers Améliorés?

Sensibilisation FAFASO

des voisins/autres dolotières

5

des vendeurs de bois

Par les maçons

Radio

Télévision

Par un projet

De bouche à oreille

autre : .....

Si la dolotière n'a pas de Foyer Amélioré en ce moment :

37. Avez-vous jamais possédé un Foyer Amélioré?

oui non

a. **Si oui, pourquoi plus?**

Faible résistance

Inefficacité

Difficultés de manipulation

Autre(s) : .....

b. **Si non, pourquoi?**

Pas intéressé

Prix élevé

Ne sais pas où trouver un constructeur

N'est pas convaincu de l'efficacité

Jamais entendu parler avant :

Autre(s):.....

Si la dolotière possède ou a déjà possédé un foyer amélioré :

38. Quels sont les inconvénients des foyers améliorés à Dolo?

Courte durée de vie.....

Coût de construction : .....

Entretien :..... .....

Lenteur :..... .....

Consomme autant de bois que le foyer traditionnel.....

Mauvaise qualité de la porte.....

Mauvaise qualité de l'intérieur de la chambre de .....

combustion.....

On ne peut pas charger assez de bois.....

Chaleur intense .....

Trop de fumée .....

Autres à préciser :.....

39. Qui vous construit vos foyers?

Un maçon spécialisé en foyer

N'importe quel maçon que vous trouvez

Vous-même

Autres (préciser).....

40. Trouvez-vous facilement un constructeur de foyer?

Oui Non

41. Qui est chargé de la maintenance de votre foyer?

Le maçon qui l'a construit Vous-même N'importe qui

42. Connaissez vous vos dépenses de la maintenance par an?.

7

a. **Oui :** **Montant :** .....FCFA

b. Non

43. Votre cabaret est-il en sous location

Oui Non

44. Combien de dolotières sous-louent le cabaret ? |_||_|

45. Ont-elles déjà été formées à l'utilisation des foyers?

Oui Non

46. Combien de jours par semaine le cabaret est-il sous loué ? |_|

8

Annex 4:

References

Bensch G., M. Grimm, K. Peter, J. Peters and L. Tasciotti (2013), Impact Evaluation of Improved Stove Use in Burkina Faso – FAFASO, Evaluation Department, Ministry of Foreign Affairs, The Netherlands.

Bensch G. and J. Peters (2012), A Recipe for Success? Impact Evidence from a Field Experiment on Improved Stoves in Senegal. *Ruhr Economic Papers* #325, RWI, Essen.

Bensch G. and J. Peters (2013), Alleviating Deforestation Pressures? Impacts of Improved Stove Dissemination on Charcoal Consumption in Urban Senegal. *Land Economics*, forthcoming.

Brunell T.L. and J. DiNardo (2004), A Propensity Score Reweighting Approach to Estimating the Partisan Effects of Full Turnout in American Presidential Elections. *Political Analysis* 12 (1): 28-45.

Burwen J. and D.I. Levine (2012), A Rapid Assessment Randomized-controlled Trial of Improved Cookstoves in Rural Ghana. *Energy for Sustainable Development* 16 (3): 328-338.

Cameron A.C. and P.K. Trivedi (2005), *Microeconometrics: Methods and Applications*. Cambridge University Press, New York.

De Mel, S., D. McKenzie and C. Woodruff (2008), Returns to Capital in Microenterprises: Evidence from a Field Experiment. *Quarterly Journal of Economics*, 123 (4): 1329-1372.

Diaz E., *T. Smith-Sivertsen, D. Pope, R.T. Lie, A. Diaz, J. McCracken, B. Arana, K.R. Smith and N. Bruce* (2007), Eye Discomfort, Headache and Back Pain among Mayan Guatemalan Women Taking Part in a Randomized Stove Intervention Trial. *Journal of Epidemiology and Community Health* 61 (1): 74-79.

European Commission (2009), Evaluating Socio Economic Development, Sourcebook 2: Methods & Techniques. Propensity score matching. http://ec.europa.eu/regional_policy/sources/docgener/evaluation/evalsed/sourcebooks/method_techniques/counterfactual_impact_evaluation/propensity/propensity_details_en.htm

Fafchamps, M., D. McKenzie, S. Quinn and C. Woodruff (2011), When is capital enough to get female microenterprises growing? Evidence from a randomized experiment in Ghana. CEPR Discussion Papers with number 8466. CEPR, London.

Fafchamps, M. and J. Pender (1997), Precautionary Saving, Credit Constraints, and Irreversible Investment: Theory and Evidence from Semi-Arid India. *Journal of Business and Economic Statistics*, 15(2): 180-194.

Freedman D.A. and R.A. Berk (2008), Weighting Regressions by Propensity Scores. *Evaluation Review*, 32 (4): 392-409.

Grimm M., J. Krüger and J. Lay (2011), Barriers to entry and returns to capital in informal activities: Evidence from Sub-Saharan Africa. *Review of Income and Wealth*, 57: S27-S53.

Grimm M., S. Lange and J. Lay (2012) Credit-constrained in risky activities? The determinants of the capital stocks of micro and small firms in Western Africa. GIGA Working Paper No. 185, Giga, Hamburg.

Hanna R., E. Duflo and M. Greenstone (2012), Up in Smoke: the Influence of Household Behavior on the Long-run Impact of Improved Cooking Stoves. *Massachusetts Institute of Technology Department of Economics Working Paper* 12-10, Boston.

Hirano K. and G.W. Imbens (2001), Estimation of Causal Effects using Propensity Score Weighting: An Application to Data on Right Heart Catheterization. *Health Services and Outcomes Research Methodology* 2: 259-278.

Hirano K., G.W. Imbens and G. Ridder (2003), Efficient Estimation of Average Treatment Effects Using the Estimated Propensity Score. *Econometrica* 71 (4): 1161-1189.

Lewis J.J. and S.K. Pattanayak (2012), Who Adopts Improved Fuels and Cookstoves? A Systematic Review. *Environmental Health Perspectives*, 120 (5).

Masera O., R. Edwards, C.A. Arnez, V. Berrueta, M. Johnson, L.R. Bracho, H. Riojas-Rodriguez and K.R. Smith (2007), Impact of "Patsari" improved cookstoves on Indoor Air Quality in Michoacán, Mexico, GIRA's *Energy for Sustainable Development*, 6 (2): 45-56.

Posner M.A. and A.S. Ash (2012), Comparing Weighting Methods in Propensity Score Analysis. Mimeo, Villanova University.

Sanogo O., T. Traoré/Zizien, C. Roamba and D. Zerbo (2011), Etude de la Production de dolo dans la région Centre et dans la zone de Bobo-Dioulasso, IRSAT, Ouagadougou, Burkina Faso.

Smith-Sivertsen T., E. Díaz, D. Pope, R.T. Lie, A. Diaz, J. McCracken, P. Bakke, B. Arana, K.R. Smith and N. Bruce (2009), Effect of Reducing Indoor Air Pollution on Women's Respiratory Symptoms and Lung Function: The RESPIRE Randomized Trial, Guatemala. American Journal of Epidemiology, 170: 211-220.

World Health Organization, WHO (2009a), Global health risks – Mortality and burden of disease attributable to selected major risks. Geneva, Switzerland.

Yu F. (2011), Indoor Air Pollution and Children's Health: Net Benefits from Stove and Behavioral Interventions in Rural China. Environmental and Resource Economics, 50 (4): 495-514.