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RESEARCH REPORT

Residential firewood consumption of socially vulnerable rural families in the semi-arid region of Bahia



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Realization:

AKSAAM – Adapting Knowledge for Sustainable Agriculture and Access to Markets

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1. PRESENTATION

The use of firewood in Brazilian households, according to Gioda (2019), is related to three aspects: purchasing power, availability, and cultural aspects. Accordingly, Moraes, Martins, and Trigo (2008) state that this is the main fuel for many low-income families, especially those living in rural areas, as it is easily available for manual collection and with no need for financial expenses. As for cultural aspects, Ramos and Albuquerque (2012) claim that many families cook in wood stoves as a matter of tradition because they like the taste of the food prepared in it and they facilitate the preparation of traditional foods that take a greater time to cook.

On the other hand, Specht (2013) states that the use of firewood for domestic purposes is correlated with three major negative impacts: (i) formation of artificial trails and clearings as well as the removal of forest biomass due to wood extraction in forests when firewood originates from native vegetation; (ii) health problems for direct users of this fuel, as the use of firewood usually occurs in traditional and inefficient stoves, which release much smoke, especially when these are inside homes; and (iii) the use of firewood as domestic fuel is responsible for a considerable part of greenhouse gas emissions.

According to Gioda (2019), most of the total firewood extracted in Brazil, comes from the Northeast due to the vegetal extraction carried out in the Caatinga region, and approximately 80% of the firewood taken from this biome is used as an energy source. When not carried out sustainably, respecting the regeneration of natural vegetation, the extraction of firewood becomes one of the leading causes of deforestation, degradation, change in precipitation regime in the region, and desertification of the Caatinga biome (GIODA, 2019). This situation can become unsustainable and irreversible in the long run.

Given this context, this report aims to: (i) identify the main characteristics of households and their respective wood stoves; (ii) identify the forms of access to firewood and their origin in terms of tree species; (iii) quantify the consumption of firewood for food preparation in residential wood stoves; and (iv) estimate the daily consumption of firewood per household. To this end, the target group of this research consists of families residing in rural communities, mostly classified as poor or extremely poor, from municipalities in the semi-arid region of northern Bahia.

Statistics on firewood consumption, specifically for domestic use in rural areas, are difficult to obtain in Brazil. Still, a literature review indicated a high disparity in the existing information on the annual consumption of firewood by families from different regions across the country. Field studies showed a variation of 0.7 to 11.5 kg per person per day (from 0.76 to 12.7 tons per household per year) (VALE et al., 2003; GIODA, 2019; CARVALHO et al., 2014; FRANCELINO et al., 2013; REGUEIRA, 2010; SGARBI, 2013). Thus, the present study has been developed with survey data from a field study of rural households for northern Bahia to overcome such disparities.

Therefore, the present report consists, in addition to this introductory part, of four more sections. The second section presents the sampling plan used in the study, which details the study area, the sample size, the method of selection of surveyed households, and the statistical estimators used. In the third section, the research results are exposed. In the fourth section, photographic records of the stoves of surveyed households show how precarious they are. Finally, in the fifth section, the final considerations of the study are presented.

2. SAMPLING PLAN

2.1. Study area

The sampling plan presented below aims to measure the residential consumption of firewood in socially vulnerable rural households from the semi-arid region of Bahia. The study area covers 460 rural communities located in four territories, selected based on the degree of poverty, HDI, and the concentration of family farmers (Figures 1 and 2). Thus, the following territories have been identified:

- **Rural Territory of Produzindo Sementes** - located in the municipalities of Capim Grosso and Quixabeira, involves the community of Jacuípe Basin.
- **Rural Territory of Flor da Caatinga** - inserted in the municipality of Juazeiro, involves the community of Sertão do São Francisco.
- **Rural Territory of Pró-Sucesso** - located in the municipalities of Curaçá and Uauá, in the community of Sertão do São Francisco.
- **Rural Territory of União** - located in the municipality of Sento Sé, in the community of Sertão do São Francisco.
- **Rural Territory of Arco-Íris** - located in the municipality of Pilão Arcado, in the community of Sertão do São Francisco.
- **Rural Territory of Construindo um Futuro Melhor** - located in the municipality of Casa Nova, in the community of Sertão do São Francisco.
- **Rural Territory of Missão da Terra** - located in the municipality of Jacobina, in the community of Piemonte da Diamantina.
- **Territory of Sementes da Vida** - located in the municipality of Campo Formoso, in the community of Piemonte Norte do Itapicuru.

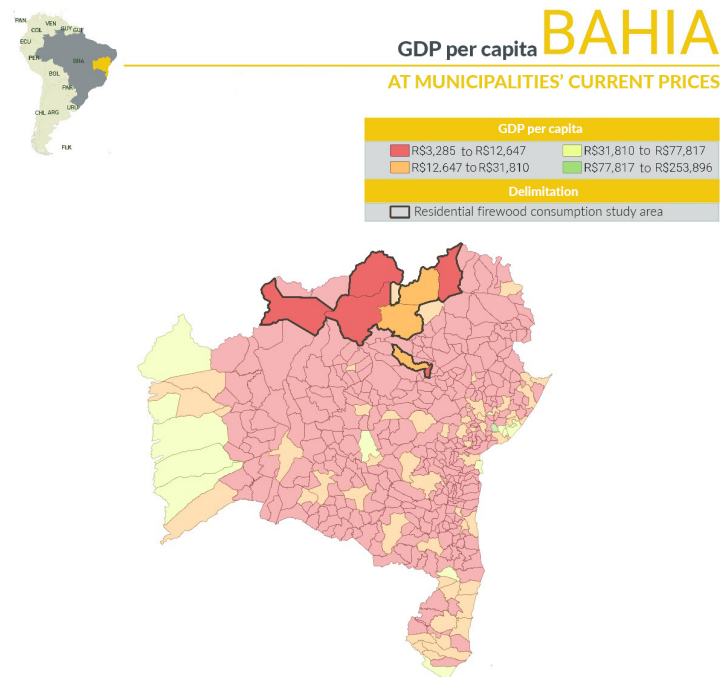


Figure 1: GDP per capita at the municipality level for the state of Bahia, Brazil

Source: IBGE, 2019.



Municipal Human Development Index - MHDÍ BAHIA

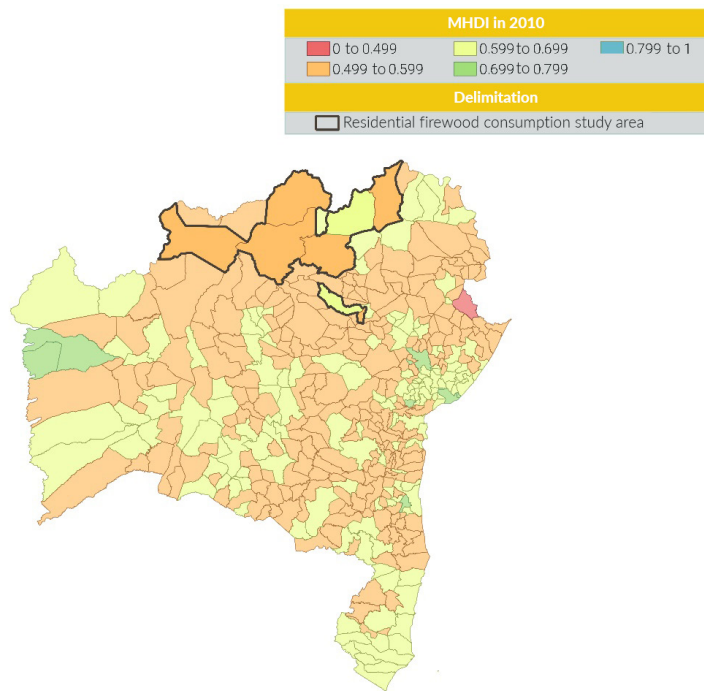


Figure 2: MHDÍ at the municipality level for the state of Bahia, Brazil

Source: PNUD, 2010

The statistical principles adopted in the sampling plan are based on the studies by Barbetta (2011) and Yamamoto and Landim (2015).

Thus, the construction of the sampling plan considered the database of rural households not benefited by IFAD projects in the state of Bahia. At the time of baseline preparation, these households were surveyed in 2018 by the Pró- Semiárido Project (PSA), comprising the research's control group, i.e., those that are not benefitting from the project. Ultimately, this group serves as a comparison to the treatment group (PSA beneficiaries) in the impact assessment study.

The control group is composed of 1,227 households. Of these, 148 were randomly selected (~8%), representing the present research's target group.

In the context of the COVID-19 pandemic, some households selected for the field study refused to be surveyed due to the social restriction measures in force at the time. Other randomly selected households were also unable to participate in the study as their wood stoves were inoperative or non-existent. In both cases, households were promptly replaced by others from the same community or other communities in the same municipalities, considering poor rural households.

2.2. Sample size

The following information was considered to estimate the sample size

- A population of 20,000 households (N = 20,000);
- A degree of certainty of approximately 92% (E = 8%); and
- An estimated sample size of 148 households (n = 148).

As recommended by Barbetta (2011) for sample surveys of this nature and considering the pioneering nature of the regional study, through 148 households (described in Table 1), spatially distributed, the number of 8 Rural Community Agents (ACR) working in the selected communities was obtained. The proportions of households per municipality in the sample are shown in Figure 3.

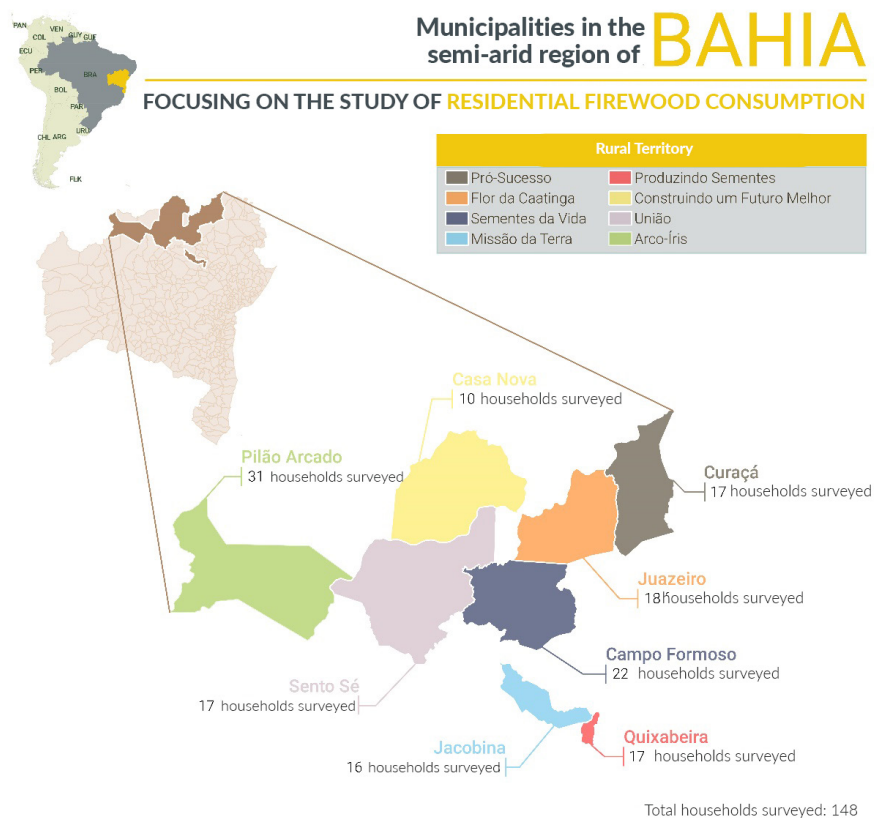


Figure 3: Map of the study region with the number of units sampled per municipality
Source: Research data.

2.3. Selection method

Aiming at territorial and population representativeness, eight rural communities were selected among all that the Pró-Semiárido Project monitors. The selection of each of these communities was also based on the proportionality of the number of households, as shown in Figure 4.

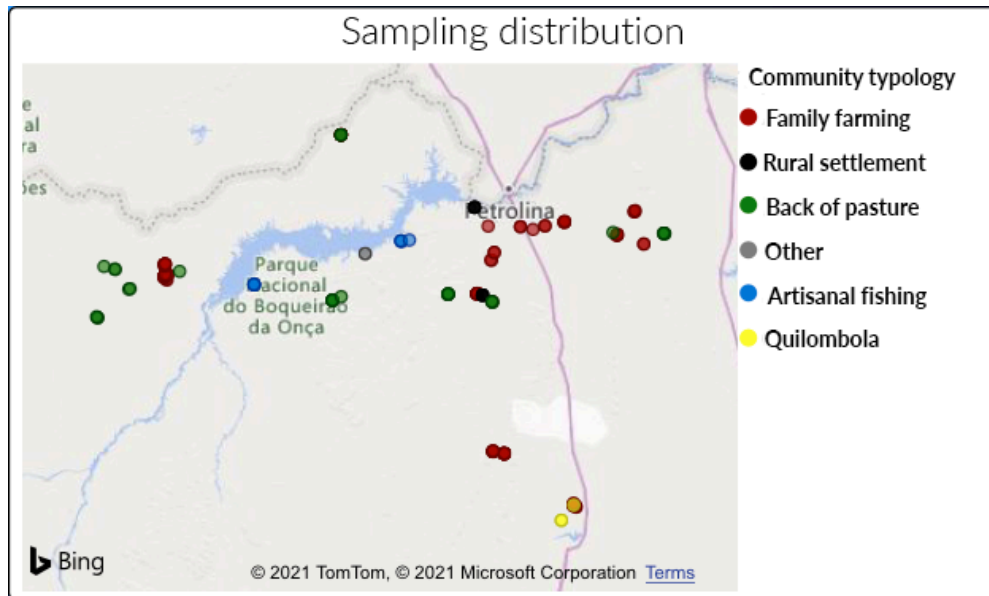


Figure 4: Map of the sampling plan aiming at territorial and population representativeness
 Source: Research data.

2.4. Statistical estimators

According to Ferreira (2009), when data is collected through random sampling, a population proportion can be estimated even if stratified without evidence of differences between strata. This is done through the formula $\hat{p} = \frac{x}{n}$, where x represents the favorable cases for the study in a sample of size n.

The maximum likely difference between the observed sample proportion and the true value of the population proportion is called the margin of error or maximum error of the estimate. This margin of error is given by $E = Z_{\alpha/2} \sqrt{\frac{\hat{p}\hat{q}}{n}}$, where $Z_{\alpha/2}$ is a critical value that separates extreme tail areas from the standard normal distribution. Also, the sum of the estimated proportions results in the unit.

Hence, \hat{p} will have a probability of $1 - \alpha$ being within a margin of error of the population proportion. Therefore, it is possible to establish a confidence interval for the population ratio $\hat{p} - E \leq p \leq \hat{p} + E$.

3. RESULTS OF THE FIREWOOD CONSUMPTION SURVEY

3.1. General survey data

From August 24 to August 30, 2021, the field study was carried out by nine interviewers who visited eight municipalities in the semi-arid region of Bahia (Figure 5). Primary data obtained through the application of a survey, comprised of open questions carried out using electronic devices.

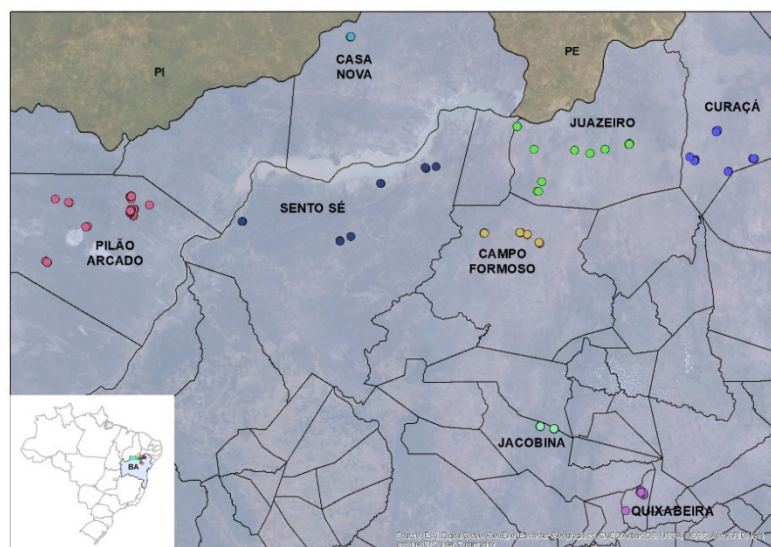


Figure 5: Spatial distribution of surveyed households
Source: Research data.

In the eight municipalities considered, 42 rural communities of six different typologies were visited, accessing the 148 households who were surveyed (Table 1).

Table 1: Number of households surveyed per community typology

Community typology	Total communities visited	Number of households surveyed
Family farming	22	95
Back of pasture	13	32
Rural settlement	2	7
Quilombola	2	3
Artisanal Fishing	2	9
Other	1	2
TOTAL	42	148

Source: Research data.

Of the 148 respondents, 63% are women, and 37% are men. The total number of residents is 398 adults and 128 children/youths (up to 18 years old), totaling 526 individuals. Therefore, on average, there are 3.55 individuals per household.

Among the families visited, 97% live in owned houses and only 3% in houses borrowed by a relative or friend.

Concerning average income, the survey found out that each household earns R\$ 904.52 per month. This value is below the national minimum wage, which, in 2021, corresponds to R\$ 1,100.00.

3.2. The use of wood stove for food preparation

Of the total number of respondents, 45% reported that the household's kitchen is located outside the residence (Figure 6), 42% inside the residence (Figure 7), and 13% said they have the kitchen inside, but the wood stove is in the outdoor area.



Figure 6: Example of kitchen located outside the residence, municipality of Pilão Arcado, Barreiro do Vicente community
Source: Field research collection.



Figure 7: Example of kitchen located inside the residence, municipality of Campo Formoso, Baixinha community
Source: Field research collection.

Regarding the type of stove used for food preparation, 32% informed that they only have a wood stove (exemplified in Figures 8 and 9), and 68% informed that they have both wood and gas stoves. In addition, none of the respondents have any other type of equipment to prepare food, such as a microwave.



Figure 8: Example of a wood stove
Source: Field research collection.



Figure 9: Example of a wood stove
Source: Field research collection.

Regarding the time the household has had a wood stove, 54.7% reported having it for at least 21 years up to 50 years. On the other hand, only 17.6% reported having the stove for less than 10 years, as shown in Table 2. Therefore, the use of wood stoves has been present in the daily lives of most of the surveyed households for several years.

Table 2: Time interval that households have a wood stove

Time the household has had a wood stove	Number of households	Percentage of households
Up to 10 years	26	17,6%
From 11 to 20 years	28	18,9%
From 21 to 50 years	81	54,7%
Over 50 years old.	13	8,8%
TOTAL	148	100%

Source: Research data.

The survey also quantified how long wood stoves remain lit during the day. According to the graphic in Figure 10, 26% of households keep the stove on for up to eight hours a day. In addition, in 65% of the households, the stove remains lit for more than eight hours.

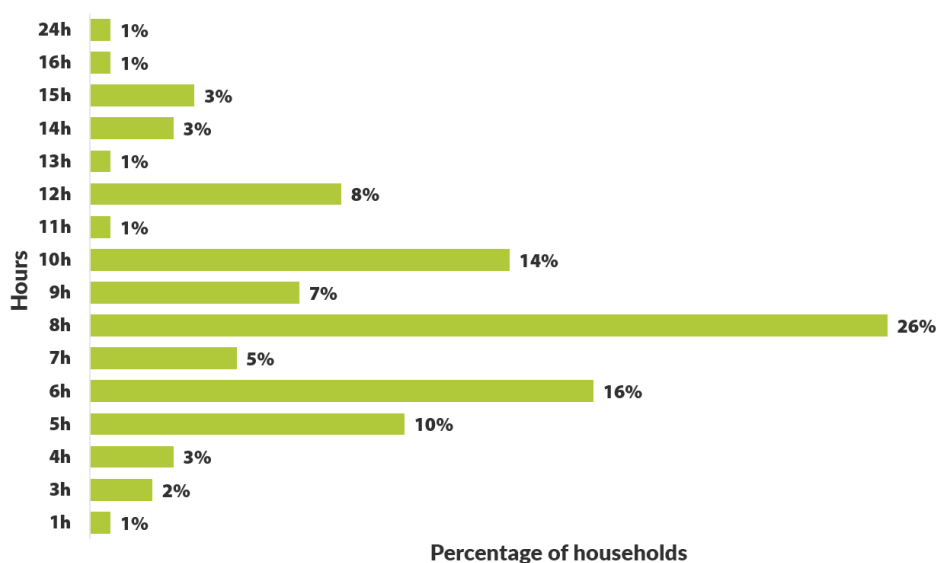


Figure 10: Percentage of households per hours of burning wood stove per day

Source: Research data.

Regarding access to firewood, 97% reported that they gather it, while 3% buy it. Among the households whose members gather firewood, 43% reported doing it on their own land, 16% on community land, and 10% on public land. The remaining 31% has been collected from more than one location (own and/or community and/or public land).

On average, household members travel two kilometers to gather firewood and return to their homes, with an average duration of two hours. On average, household members need to gather firewood 4.5 times per month. Therefore, household members need to travel nine kilometers per month, spending nine hours in the process of firewood gathering. The survey also found that firewood gathering is carried out by men (47%), women (47%), and children (6%).

About the type of firewood, the most gathered is Catingueira (scientific name *Poincianella pyramidalis*), which was cited by 69% of respondents. Subsequently, there is Angico (67%) (scientific name *Anadenanthera colubrina*), as shown in Table 3.

Table 3: Percentage of households that gather firewood by tree species

Type of firewood	Percentage of households
Catingueira	69%
Angico	67%
Jurema Preta	43%
Aroeira	38%
Algaroba	27%
Pereiro	22%
Marmeleiro	13%
Camumbi	8%
Espinheiro	8%
Calumba	6%
Juá	3%
Velame	1%
Cajueiro	1%
Outra	37%

Source: Research results.

Note: The sum of the percentages exceeds 100% as respondents can gather firewood of more than one species of tree.

Another relevant aspect is that all households reportedly gather firewood in areas of native forest, i.e., no households plant vegetation for use in the wood stove. In Figure 11, there is an example of firewood stored for household consumption.



Figure 11: Example of the storage of firewood gathered for consumption on the stove

Source: Field research photo collection.

In terms of monthly household consumption of firewood, interviewers used a precision scale to estimate it, asking respondents about the amount of firewood needed for daily consumption. As a result, the survey measured a total daily consumption of 1,940 kg of firewood for the 148 households surveyed. This translates into an average household consumption of 13.11 kg of firewood per day.

3.3. The use of a gas stove for food preparation

Through the research, it was found that 101 households use gas stoves in addition to the wood one. Specifically, in 32% of these households, there is a need to replace the cylinder every two months, while 39% do the replacement in a period longer than three months (Table 4).

Table 4: Lifetime of a gas cylinder

Duration of 1 cylinder (months)	Number of households	Percentage
1	11	11%
1,5	12	12%
2	32	32%
2,5	7	7%
3	16	16%
3,5	6	6%
4	7	7%
4,5	1	1%
5	2	2%
6	4	4%
More than 6	3	3%
TOTAL	101	100%

Source: Research results.

Respondents also reported that the cost of a cylinder could range from R\$82.00 (representing 7.5% of the national minimum wage) to R\$120.00 (representing 11% of the national minimum wage). Considering that the average monthly household income is R\$904.52, the purchase of a cylinder per month has a significant impact on the households' financial resources.

4. PHOTOGRAPHIC RECORD OF FIELD RESEARCH: VIEWING THE SITUATION OF SURVEYED HOUSEHOLDS STOVES

Figures 12 to 25 are some of the photographic records obtained during the field research and demonstrate the current state of the structure used as a wood stove by some households.



Figure 12: Example of a wood stove, municipality of Campo Formoso - Baixinha Community
Source: Field research collection



Figure 13: Example of a wood stove, municipality of Campo Formoso - Baixinha Community
Source: Field research collection.



Figure 14: Example of a wood stove, municipality of Pilão Arcado - Barreiro do Vicente Community
Source: Field research collection.



Figure 15: Example of a wood stove, municipality of Curaçá - Fazenda Parente Community
Source: Field research collection.



Figure 16: Example of a wood stove, municipality of Curaçá - Fazenda Parente Community
Source: Field research collection.



Figure 17: Example of a wood stove, municipality of Pilão Arcado - Barreiro do Vicente Community
Source: Field research collection.



Figure 18: Example of a wood stove, municipality of Juazeiro - Maria Simões Settlement
Source: Field research collection.



Figure 19: Example of a wood stove, municipality of Juazeiro - Maria Simões Settlement
Source: Field research collection.



Figure 20: Example of a wood stove, municipality of Juazeiro - Maria Simões Settlement
Source: Field research collection.



Figure 21: Example of a wood stove, municipality of Quixabeira - Pimenteiras Community
Source: Field research collection.



Figure 22: Example of a wood stove, municipality of Pilão Arcado - Mosquito Community
Source: Field research collection.



Figure 23: Example of a wood stove, municipality of Pilão Arcado - Mosquito Community
Source: Field research collection



Figure 24: Example of a wood stove, municipality of Sento Sé - Retiro de Cima Community
Source: Field research collection.



Figure 25: Example of a wood stove, municipality of Sento Sé - Retiro de Cima Community
Source: Field research collection.

5. FINAL CONSIDERATIONS

This study highlights the main characteristics of domestic consumption of firewood in vulnerable households from the semi-arid region of Bahia. Through the photographic records from field research, it is noticed that the stoves are in a precarious state and that, in 42% of the cases, they are in closed environments. Associating the precarious and rudimentary structure of the stoves, such as the absence of chimneys, one can directly infer the damage to the health of household members. As Moraes, Martins, and Trigos (2008) reported, rudimentary stoves, which are often located inside houses, result in low energy efficiency and, consequently, use more firewood and release large amounts of gases and particles. In other words, in addition to increasing deforestation, there cause harmful effects on people's health.

The estimated average consumption of firewood was 13.11 kg per household per day, corresponding to an annual consumption of 4,785.15 kg of firewood per household. In addition, it was observed that the average per capita consumption is equivalent to 3.69 kg per individual per day in a household, considering that each household has on average 3.55 members. This average consumption is equivalent to CO₂e emissions of about 6.77727 tCO₂e of GHG (CO₂, CH₄, and N₂O) per household per year¹.

In this sense, it is concluded that for households located in the semi-arid region of Bahia, it is essential to have alternatives to current stoves to improve energy efficiency and sustainability in the region located in the Caatinga biome. In addition to the environmental and climatic aspects already mentioned (reduction of deforestation, conservation of the biome's ecosystem services, and even avoiding the desertification process), in social terms, the implementation of eco-efficient stoves can help improve the health conditions of household members by reducing the emission of toxic smoke inside homes. It can also be added that the reduction in the consumption of firewood could generate savings for households. With less time spent cooking and collecting firewood, beneficiaries, particularly women, avoid any insecurity in the firewood collection process and have greater opportunities to diversify income-generating activities, improving livelihoods for the household members.

1 Note: Detailed calculations are in Annex 2 of the proposal for Livelihoods Funds

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