Biogas Dissemination Scale-Up Programme (NBPE+)

Report
of
Bio-digester Users' Survey (BUS), 2019

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Acronyms

ABPP	Africa Biogas Partnership Programme
BCE	Biogas Construction Enterprises
BUS	Biogas Users' Survey
CDM	Clean Development Mechanism
CRGE	Climate Resilient Green Growth
EREDPC	Ethiopian Rural Energy Development and Promotion Centre
HH/s	Household/s
Hivos	Humanist Institute for International Development Cooperation
KG	Kilogrammes
MEA	Mining and Energy Agency
MFIs	Micro-finance Institutions
MoWIE	Ministry of Water, Irrigation & Energy
NBPCU	National Biogas Programme Coordination Unit
NBPE	National Biogas Programme of Ethiopia
NBPE+	Biogas Dissemination Scale-Up Program
PAV	Production, Administration & Verification
PID	Program Implementation Document
PoA	Programme of Activities
RBPCU	Regional Biogas Programme Coordination Unit
SLM	Sustainable Land Management
SNNPR	Southern Nations, Nationalities and Peoples' Region
SNV	Netherlands Development Organization
TVET	Technical and Vocational Education and Training

EXECUTIVE SUMMARY

In view of the fact that biogas is one of the alternative renewable energy sources, the Ethiopian government had launched consecutive 5-year biogas programmes since 2009 with the aim of promoting biogas energy for domestic uses. Biogas Dissemination Scale-up Program (NBPE+) was introduced in April 2017 by SNV with the aim of ensuring continuity, scale-up and expansion of efforts and achievements made under NBPE-I and NBPE-II. The overall objective is to improve the living standards of farmers and their families in 8 regions of the country. Until April 11, 2019, a total of 23, 802 household size bio-digesters were constructed.

The BUS mainly serves three purposes: (1) a basis for monitoring and evaluation of the effects of biogas and bio-slurry use on households; (2) a basis to provide regular feedback for necessary improvements or review of the programme or its approaches and activities and (3) it serves to establish the woody biomass usage per household as per the guidelines of the Clean Development Mechanism's small-scale approved methodology.

This study focused on biogas uses that joined the program in the period 2015 – 2017 and employed both quantitative and qualitative data collection methods. Quantitative information was primarily collected form biogas users' directly using structured questionnaire and direct observation techniques. The study used Electronic Data Capturing (EDC) technique and a total of 200 biogas users were interviewed in 16 woredas of eight zone administrations of the four survey regions, namely Tigray, Amhara, Oromia and SNNP. Qualitative information was also collected from primary sources including Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) as well as from secondary sources such as documents review.

Survey Findings

Household characteristics

A total of 200 households were surveyed and out of these 92% are male-headed households; 7.5% female headed households and 0.5% child-headed households. The average family size of surveyed households is 7.31 with gender composition of male (3.81) and female (3.5). Agriculture is the dominant sector which the livelihood of majority of surveyed communities based in. The majority of respondents (97%) reported that agriculture is their household's major source of income. Employment activities, business such as petty trades and daily labour works are also practiced by members of households. The average cattle holdings are 5.33 cow/oxen, 1.38 equines, 2.07 goats/sheep and 5.68 of calf, poultry, etc.

Majority of biogas users (36%) use lakes/rivers/ponds as the main source of water for household uses. Households with water sources out of their compound, on average it takes about 16 minutes to reach the nearest water sources. On average, 94.4% of households have a toilet in their compound and among these, on average, 84% of toilets are connected to the biogas system. 44.5% houses have electric connectivity to their houses, in which the majority (51.4) obtain electric from solar power.

Decision making process

Woreda energy offices and technicians are the well-known promoters of the biogas technology in rural communities. Above 81% of respondents stated that they have heard about the technology for the first time from woreda offices and technicians. Different driving motives were also mentioned by respondents that inspire them to decide installing biogas plant for household uses. Need for lighting, cooking energy and organic fertilizer are the three most important factors behind installing biogas plants by surveyed households with 91%, 87% and 78.5% proportion of respondents respectively. Only 32% of biogas users from Tigray and SNNP regions took loans to partly finance their plant construction.

Biogas functionality and service delivery performance

Households install biogas systems mainly for cooking, lighting and organic fertilizer. In this regard the national average functionality rate is 79% with slight variations among survey regions. More specifically, 30% of the systems are functioning without significant problem, 22% are functioning with minor problems and other 27% are functioning, but with major problems. 21% of the plants are found totally not functional. Most of the stated problems associated to mal-functionality of the biogas plants include problems with appliances, pipes, fittings and valves, lack of skills, spare parts and inputs, crack down of bio-digesters and absence of adequate after-sale services.

In survey areas, the majority of biogas users (45%) feed their plant once a day and 28% of them feed their plant weekly on average. Other 22% of the users also feed their plant in two days. Only 5% of surveyed households report that they feed their biogas twice a day with water and dung to generate gas and bio-slurry. About 97% of households also reported that they use all available dungs to feed their biogas. The amount of input (dung and water) that users feed their biogas plant at a time is low compared to the recommended amount.

Users' training and after-sale services

As clearly stated in the PID, training and after-sale services are integral part of the program for smooth and effective implementation. Among surveyed biogas users about 65% of them reported that they/member of their family have got trainings on biogas (mostly the post-construction orientations) and masons and woreda technicians are those who deliver trainings/post-construction orientations. About 84% of respondents have reported that they have received one or more types of after-sale services after the construction of their biogas plant. However, significant share of biogas users who received after-sale services were not satisfied with the services they received.

Socio-economic impacts of biogas technology

Small-scale biogas plants have a proven capacity of improving quality of life among rural communities and help reduce global warming impacts if used appropriately. Overall, 89% of respondents have reported that the health condition of their family members have improved after they started using biogas energy. After the introduction of biogas technology in their household, 68% of respondents stated that abuse and violence against women and girls has highly reduced. 93% of respondents also reported that biogas has helped women to be involved in social and income generating activities. Reduction in households' monthly energy expenditure is also another benefit users enjoy from their biogas plants. Out of the surveyed biogas users, 57% of them reported that their monthly energy expenditure has reduced due to using biogas energy. On average, households have saved about 110 ETB per month from their energy expenditure. By using biogas light, students have got an opportunity to study during evening and night. 65% of respondents reported that children begun to study in the evening and night which was not common in rural communities before the installation of the biogas plant. As reported by survey respondents, the average study hours of children in the evening/during the night has improved from about 2 hours and 30 minutes to 3 hours and 20 minutes.

Biogas technology and the organic fertilizer farmers obtain as co-product has improved users' agricultural productivity from 17.58 quintals of product per hectare to 19.02 quintals of agricultural product per hectare. Demand for chemical fertilizer has also significantly reduced from 105 kilogram to 77.52 kilogram after the biogas. 67% of organic fertilizer users in their farm practice reported that paste has reduced in their farm where they applied organic fertilizer and 84% of organic fertilizer users stated that demand for chemical fertilizers has reduces significantly.

Environmental impact

It is also interesting that biogas has reduced households' consumption of biomass which directly contributes for environmental protection and related positive outcomes. Overall, weekly consumption of firewood in survey areas is declined by 21% (from 73 kilograms to 60.5 kilograms per week). Due to inability of the existing biogas plants to be used for baking injera, almost all of the respondents use biomass as alternative source of energy along with the biogas. Households' weekly demand for charcoal had declined by above three folds (from 19 kilograms to 4.7 kilograms per week).

Conclusion

Biogas technology has significant potential to mitigate several problems related to ecological imbalance, minimizing crucial fuel demand, improving hygiene and health, and thus, resulting in an overall improvement in the quality of life in rural and semi-urban areas. In the study it is found that biogas technology has brought significant positive changes in the socioeconomic conditions of rural households and supports environmental protection efforts. It helped users to improve their health condition, reduced women and children work burden allowed them to be involved valuable economic/social activities. It also significantly reduced their vulnerability for violence and helped children to study their education for longer time in the evening and during the night using biogas light. Biogas has reduced expenditures households incur for energy as well as chemical fertilizer and improved farmers' agricultural productivity. It also reduced households' woody biomass consumption.

Recommendation

Information dissemination and awareness creation: as survey results revealed, information dissemination efforts are insufficient and available information sources are very limited. It is thus important to consider all available channels, especially with wider coverage such as national and local mass media to promote the technology and build community awareness.

Users' trainings are critical: the technology is generally new and the effort is to promote this new technology in rural and semi-urban areas, where educated manpower is scarce. There is no also accumulated/capitalized knowledge and experience regarding this technology at community level in rural societies, because the technology is introduced very recently. Hence, due attention should be given to pre-construction and post-construction trainings tailored with the specific needs of rural communities. Refresher trainings and experience sharing visits must also be integral parts of the users' capacity building efforts.

Provide adequate after-sale services: no matter what the level of support from the government and other stakeholders is, the performance of the biogas plants and their functionality ultimately depends on the users' commitment and capability to use the technology. However, considering the educational level of family heads/family members in rural communities, biogas users can hardly address all the problems and issues emerged with their biogas system by themselves. So they need continuous follow-up and support to make them effectively operate their biogas system and enjoy its benefits to the maximum possible level.

Improve accessibility of spare parts and appliances: since the biogas sub-sector is underdeveloped and at an infant stage in the country, so far it doesn't develop the market that supply materials and spare parts, which calls strong hands of the government and all relevant stakeholders to fill the market gap. When the owners are not able to use their biogas for intended purposes properly (mostly due to lack of materials and spare parts), they lack interest to maintain the functionality of their biogas and gradually they might cease feeding and operating it. Hence, it is critical to find the mechanism through which biogas-related materials and parts are accessible to rural communities easily.

Improve local infrastructure and capacity of technicians at woreda level: woreda technicians are the most important actors in serving the biogas users at grassroots level, as they are at the lowest structure of the program and have direct contact with biogas users. Capacity of woreda offices in terms of logistics, structures and systems need to be strengthened. Existing technicians also need refresher trainings skill enhancement exposures to better serve the biogas users.

Strengthen existing information and communication system: For such newly introduced technologies with large expansion prospects, effective service delivery system and communication mechanisms are required. Information must be collected continuously, analysed properly and utilized effectively, especially at regional level. Appropriate and sufficient supervision and monitoring system should be in place by SNV to make sure that the services provided in the field comply with the standards set at the PID.

1. INTRODUCTION

1.1 Background

Building on its positive recent development record, Ethiopia intends to reach middle-income status by 2025. As stated in the country's development plants, (GTP-I and GTP-II), reaching this goal will require boosting agricultural productivity, strengthening the industrial base, and fostering export growth, which result in a sharp increase in GHG emissions and unsustainable use of natural resources. To avoid such negative effects, the government has developed a strategy to build a green economy. The draft National Energy Policy also envisioned ensuring access to affordable, clean and modern energy for all citizens by 2025, which calls for collaborated efforts of the government as well as local and international partners.

National Biogas Program of Ethiopia (NBPE) has been under implementation since 2009 with the aim of promoting domestic biogas and develops a commercially viable market for biogas sector in the country. Ministry of Water, Irrigation & Electricity (MoWIE) is hosting the program on behalf of the Government of Ethiopia and is implementing through the regional energy bureaus of agencies, together with the Woreda energy offices and private sector. The basic systems and capacities have been put in place that could enable for large scale dissemination of bio-digesters throughout the country.

The first phase of the NBPE culminated on December 31st, 2013. Official sources have stated that 8,161 plants in the targeted four large regions were built. The second phase of the NBPE was implemented between 2014 and 2017 and aims to construct 20,000 additional biogas plants. In 2014 alone, the government expects to build 3,600 bio-digesters in the four regions of implementation. Biogas Dissemination Scale-up Program (NBPE+) was introduced in April 2017 by SNV with the aim of ensuring continuity, scale-up and expansion of efforts and achievements made under NBPE-I and NBPE-II. The overall objective is to improve the living standards of farmers and their families, in the Ethiopian regions of Afar, Amhara, Benishangul-Gumuz, Gambela, Oromia, SNPPR, Somali and Tigray while reducing the over-exploitation of biomass cover in the 8 regions and reducing GHG emissions.

The programme targets 36,000 rural low income families, who have some 4 cattle for dung while they can spare a small piece of land and able to partially contribute with labour and cash or credit for bio digester. NBPE+ is a five year program and will continue operating until July, 2022. As NBPE II is still in progress and will continue to be so, NBPE+ operates in a way that ensures complementarity, avoid duplication and create synergies, wherever possible. A total of 21,735 household size bio-digesters are constructed till June 2018, under the NBPE-I, NBPE-II and NBPE+ in 6 regions of Ethiopia. The market is gradually developing, though private sector development is still in an infant stage.

The Biogas Users' Survey (BUS) is part of the monitoring framework applied by the programme providing relevant data to evaluate the impact of domestic biogas digester installations as experienced or perceived by the users. A periodic Bio-digester Users' Survey (BUS) is therefore being carried out in the program to assess the socio-economic and environmental impacts as well as other parameters to measure program effectiveness.

1.2 Objectives of BUS

The BUS will mainly serve three purposes: (1) a basis for monitoring and evaluation of the effects of biogas and bio-slurry use on households as it provides benchmark data on potential bio-digester users, on the expected benefits, as outlined above; (2) a basis to provide regular feedback for necessary improvements or review of the programme or its approaches and activities and (3) it serves to establish the woody biomass usage per household as per the guidelines of the Clean Development Mechanism's small-scale approved methodology.

Specifically this particular survey will have the following objectives:

a) Bio-digester functionality assessment: It is to determine proportion of the bio-digester systems that are functional with various degree and the reasons of non-functionality.

b) Socio-economic impacts assessment:
   a. Assessment of benefits and effects of biogas and bio-slurry on male and female headed households, including on health, time saving, socialisation, education, saving or income generation, etc.
   b. Extent in improvement in health outcomes: reduced incidence of respiratory/eye and other diseases related to fuels,
   c. Extent in increase in crop yield and income or decreased cost from use and sale of bio-slurry;
   d. Extent in workload reduction, mostly for women & children, in terms of hours of time saved per day; and
   e. Number of direct employment generated (and percentage of total jobs generated for women).

c) Local and global environmental impacts assessment: It is to assess the extent in reduction in deforestation, in terms of reduced annual use of woody biomass or firewood. For this, establish an annual average use of woody biomass before and after the installation of bio-digesters, and hence determine the reduction in use of the woody biomass. This will form the basis for calculation of reduction of Greenhouse Gas (GHG) emissions, which is a separate task to be done by DBE with support from the World Bank/CI-Dev.

d) Other Programme performances and parameters assessment:
   a. Ratio of households installing bio-digester with credit from MFIs/cooperatives; and
   b. Ratio of female headed and other disadvantaged households owning bio-digesters with or without credit from MFIs/cooperatives;
   c. Extent of users' overall satisfaction from the programme;
   d. If not satisfied, what are the issues (user training and after-sales service, user-friendliness of the technology, behaviours of the public sector and private sector actors, etc.); and
   e. Percentage of bio-digesters with two bio-slurry pits.

2. REVIEW OF RELATED LITRATURE

2.1 Country Context

2.1.1 Background

Ethiopia is strategically located in the north-eastern part of Africa popularly known as "the Horn of Africa". It shares boundary with the North and South Sudan on the west, Somalia and Djibouti on the East, Eritrea on the North and northwest and Kenya on the South. It is a country of great geographical diversity. A large part of the country comprises of high plateaus and mountain ranges with precipitous edges dissected by rushing streams. As the country is located within the tropics, its physical conditions and variations in altitude have resulted in great diversity of terrain, climate, soil, flora and fauna.

Figure 1: Ethiopia: the country and regional states

The 1995 federal constitution recognized nine regional states (Tigray, Afar, Amhara, Oromia, Somali, Benishangul-Gumuz, Southern Nations, Nationalities and Peoples (SNNPR), Gambella, and Harari), all of which were given considerable autonomy. In addition to the nine regions, there are two chartered cities-Addis Ababa, the federal capital, and Dire Dawa. The nine regions are hierarchically divided into zones, woreda, special-woreda, and kebele, the smallest City Administration administrative unit.

2.1.2 Socioeconomic condition

Ethiopia is the second largest populous country in Africa with 94 million population size scattered over a 1.1 million square kilometre territory and 83.2% of the population resided in rural areas (CSA, 2014). According to the same report, almost 50% of Ethiopia's population is under the age of 18. In 2007, the literacy rate of the population above 15 years of age was 39.9% of the population (46.2% for male and 33.3% female). It is evident that remarkable progress has been accomplished, especially in primary education, with a gross enrolment of more than 90%. However, both, secondary and tertiary education, have a lower percentage of enrolment with 37.2% and 8.2% respectively.

The lack of infrastructure is a significant burden for development, especially for the poorest people. According to Stevenson et al (2012), 77.3% of the Ethiopian population lacks access to clean water. Moreover, only 1% of the Ethiopian households have a tap inside the house, and 54.5% of the households get their water from unprotected wells or springs or directly from rivers or lakes. Furthermore, by 2007, 75.8% of the rural households did not have a toilet facility (CSA, 2010).

In order to improve economic and social performance, the Federal Democratic Republic of Ethiopia (FDRE) government has launched a set of periodical national programs to set the guidelines to steer its development. These are: Sustainable Development and Poverty Reduction Program (SDPRP) from 2002/03 to 2004/05; Plan for Accelerated and Sustained Development to End Poverty (PASDEP) from 2005/06 to 2009/10; Growth and Transformation Plan (GTP) from 2010/11 to 2014/15 and the current Growth and Transformation Plan II (GTP-II) from 2015/16 to 2019/20. Complementary to the abovementioned development programs, in 2011, the Ethiopian Government also launched the Climate-Resilient Green Economy (CRGE) with the aim to protect the country from the effects of climate change while developing a green economy (Federal Democratic Republic of Ethiopia, 2011).

Ethiopia has experienced a sustained economic growth over the last years. Ethiopia's economy is mainly based in services and agriculture, which contributed to 36.9.1% and 34.2% of the Gross Domestic Product (GDP), respectively by 2017. The share of industry sector (including construction) rose to 22.9% of GDP in the same year (World Bank, 2018). More than two decades ago, agriculture was the dominant economic activity (with a 68.9% contribution to the GDP in 1992). Nonetheless, the service sector has been gaining terrain over this time, thus becoming the main economic activity of Ethiopia. Meanwhile, the manufacturing sector has remained as a residual activity, with an average contribution to the GDP of 5.5% over this period.

2.1.3 Agricultural and environmental landscape

Agriculture becomes the second main economic activity next to the service sector in Ethiopia, accounting for 34.2% of the GDP by 2017 (World Bank, 2018). The country is believed to have one of the largest livestock populations in Africa (CSA, 2012). The majority of the agricultural production in Ethiopia is performed at a household level and farming is generally characterized by the combination of crop production and livestock breeding. Furthermore, these agricultural households are characterized by limitedly small land tenure and it is common for all the household members to contribute to the farm's activities. The rural holdings account for 96.8% of the total agricultural holdings and the vast majority (75.1% of the rural households) mixed their activities between crops and livestock (CSA, 2013).

Ethiopian farmers employ different practices in order to improve their crops' productivity. The most commonly used practice is to apply fertilizers. These synthetic fertilizers are applied to almost half of the cropland area and natural fertilizers are only applied to 10.2% of this land. Only 1.8% of the total cropland area employs irrigation practices. (CSA, 2013). One of the most worrying environmental trends in Ethiopia is the depletion of the forest coverage due to the extensive use of fuel wood. In 2008, forest coverage accounted for 2.7% of the total area of Ethiopia, being 40% more less than 35 years ago (Boers et al., 2008). The largest amount of forest is concentrated in the west of Ethiopia. However, most of the remaining forest has already been intervened and the percentage of untouched forest is residual.

2.1.4 Energy Sector

The energy sector in Ethiopia is mainly based on biomass. 92.9% of the primary energy consumption comes from biofuels and waste; 81.2% of which is supplied by woody biomass (Wolde-Ghiorgis, 2002). Furthermore, 93.5% of the primary energy consumption holds place at the household level. Therefore, when looking at the Ethiopian energy balance, it is valid to assume that the majority of the energy is supplied by fuel wood and that it is predominately consumed by rural households.

Imported oil, electricity and biofuels and waste are the major energy sources in Ethiopia which represent 6.0%, 1.1% and 92.9%, respectively. Hydroelectric plants, mostly supply the electricity that is required in Ethiopia. According to World Bank (2018), electricity access has reached 33.4% of the Ethiopian population (80.1% urban and 20.2% rural) in 2015. Specifically for biomass, 81.2% of the biomass that is consumed comes from woody biomass (especially firewood), followed by dung cakes and crop residue with a contribution of 9.1 and 8.1%, respectively. Other types of biomass are charcoal, bagasse and bio-briquettes (Wolde-Ghiorgis, 2002).

At the household level, 98.6% of the energy is supplied by biomass (IEA, 2014c). But, how is it consumed? According to Gebreegziabher (2007, 2014), between 50 and 60% of household energy demand is used to bake injera; a traditional fermented flatbread with a sour taste. Injera is baked on large batches using a clay plat covered with a lid made out of straw and dried cow manure (Simons, 2012). The baking process is highly inefficient and it predominantly uses a significant amount of firewood (Esthete et al., 2006). The rest of the energy is used for cooking other foods and for lighting.

2.1.5 The Biogas sub-sector

Biogas was first introduced in Ethiopia by Ambo Agricultural College around 1957 to supply the energy for welding agricultural tools. During the last two decades, around 1,000 biogas plants were deployed in Ethiopia with sizes ranging between 2.5 and 200 cubic meters for households, communities and institutions (Boers & Esthete, 2008). Between 1999 and 2002, Christopher Kellner, a German biogas expert, built 60 fixed-dome biogas plants through a bottom-up implementation approach. This deployment was partly done based on an Ethiopian-German development project named “Land Use Planning and Resource Management, Oromia” (LUPO). Since 2000, LEM-Ethiopia (a local NGO) started an awareness and promotion program with latrine-fed biogas digester in schools and households in regions like Amhara, Oromia and SNNPR (Worku, 2014).

In 2006, a technical team integrated by experts from the Ethiopian Rural Development and Promotion Centre (EREDPC) and SNV conducted a feasibility study to determine biogas potential in four Regions of Ethiopia which accounted for the largest number of inhabitants and livestock (Amhara, Oromia, SNNPR and Tigray). In 2015, another Report on Biogas Technical Feasibility study on biogas was conducted for Afar, Benishangul-Gumuz, Gambella and Somali Regions of Ethiopia.

2.2 National Biogas Program of Ethiopia (NBPE)

Inspired from the positive environment with regard to domestic biogas in Africa and with the aim to up-scale domestic biogas in Ethiopia, the Ethiopian National Biogas Program (NBPE) was developed and launched for a first stage of implementation between 2008 and 2013. From February to July 2007, a team from SNV and EREDPC conducted an extensive consultation process with relevant stakeholders in order to develop a Project Implementation Document or PID. In the end, the consensus was set to build 14,000 family-sized biogas plants between 2008 and 2013 and the NBPE was launched. The first years of implementation of the NBPE faced several obstacles in deploying the program. It is important to understand that by then, biogas was considered as new technology in the rural context and the response of the demand was slower than expected. The slow development of the NBPE was reflected in the small amount of biogas plants that were built. Consequently, in 2010, during an intermediate revision of the NBPE, the African Biogas Partnership Programme (ABPP) decided to reduce the initial target from 14,000 to 10,000 biogas plants by end of the first phase in 2013.

2.2.1 National Biogas Program of Ethiopia Phase I (NBPE-I)

The first phase of the Program was launched as National Biogas Program of Ethiopia – Phase I (NBPE-I) in 2009 and run for five consecutive years until 2013. This program targeted to install 10,000 bio-digesters in the four large regions of the country, namely Amhara, Oromia, SNNP and Tigray. Program participants were households with four or more local breed cattle (two in the case of hybrid), residing within thirty minutes walking distance from a water source, and willing to pay 60% of the investment cost in cash or through credit in the installation of the bio-digester with an optional toilet connection. The Ethiopian Government and donors covered the remaining 40% of the construction cost as an investment incentive. Meanwhile, government actively supports the dissemination of biogas technology through policy support and promotion, and as a result this first phase of the NBPE has enabled the construction of over 8,161 plants in the targeted four large regions.

2.2.2 National Biogas Program of Ethiopia Phase II (NBPE-II)

National Biogas Program of Ethiopia Phase II (NBPE-II) has also been under implementation since 2014 with the aim of improving the livelihood and quality of life of rural households in Ethiopia through the exploitation of market and non-market benefits of domestic biogas. This is intended to be realized through replacement of unsustainable utilization of wood and charcoal for cooking and lighting; the application of high-value organic fertilizer from the bio-slurry; and improvement of the overall economic situation of rural households. The specific objectives of NBPE-II project are to (1) attract and strengthen the capacity of relevant national and regional institutions and organizations in developing and promoting bio-digester technology as clean source of energy for cooking and lighting and (2) ensure the continued effective and efficient operation of the bio-digesters installed under NBPE-I and in NBPE-II; and in the process, maximizing the benefits of all bio-digesters installed. The program targeted the market-driven dissemination of 20,000 high quality biogas installations to provide households with access to clean energy for cooking and lighting and promote the use of bio-slurry as organic fertilizer in a scientific way. The Program continues running until March, 2019 and under this program alone, additional 12,538 bio-digesters are installed up to February 2019.

2.2.3 Biogas Dissemination Scale-up Program (NBPE+)

Biogas Dissemination Scale-up Program (NBPE+) has also been born in April 2017 with the aim of ensuring continuity, scale-up and expansion of efforts and achievements made under NBPE-I and NBPE-II. The overall objective is to improve the living standards of farmers and their families, in the Ethiopian regions of Afar, Amhara, Benishangul-Gumuz, Gambela, Oromia, SNPPR, Somali and Tigray while reducing the over-exploitation of biomass cover in the 8 regions and reducing GHG emissions. By developing a viable bio-digester sector embedded in an enabling institutional and policy environment, the programme also aims to contribute to increased economic and business development (particularly in rural areas) and the longer term objective of supporting the transition in Ethiopia to a more sustainable energy mix and corresponding socio-economic and environmental benefits. The programme targets 36,000 rural low income families, who have some 4 cattle for dung while they can spare a small piece of land and able to partially contribute with labour and cash or credit for bio digester. NBPE+ is a five year program and will continue operating until July, 2022. As NBPE II is still in progress and will continue to be so, NBPE+ operates in a way that ensures complementarity, avoid duplication and create synergies, wherever possible.

A total of 23,802 household size bio-digesters are constructed till April 11, 2019, under the NBPE-I, NBPE-II and NBPE+ in eight regions of Ethiopia. The market is gradually developing, though private sector development is still in an infant stage. The following chart presents the trend of household size bio-digester installation in Ethiopia:

2.2.4 Institutional setup

The NBPE consists of the main implementation framework for the dissemination of domestic biogas in Ethiopia, as its initial structure was developed in 2008 where multiple actors were assigned with specific roles and responsibilities. However, since then, the implementation structure of the NBPE has changed.

The NBPE was led at a Federal level by the EREDPC which was part of the former Ministry of Mines and Energy. A National Biogas Coordination Office (NBPCO) was created under the supervision of the EREDPC. Furthermore, in each of the regions Regional Biogas Coordination Offices (RBCO) were established. Moreover, the implementation of the NBPE is done at local level in coordination with the Woreda Administration and in collaboration with the private sector, consisting of individual masons that are trained by the NBPE. The role of SNV has been to provide technical assistance at a federal and regional level on topics such as the training of technicians, bio-slurry promotion and extension and private sector development.

3. SURVEY METHODOLOGY

3.1 Survey Regions

The 2019 biogas users' survey was conducted in the four large areas in which the program is being implemented, namely, Tigray, Amhara, Oromia and SNNP regional states.

3.1.1 Tigray Region

Tigray Region lies in the northernmost part of Ethiopia. The region is bordered by Eritrea in the north, Sudan in the west, Afar region in the East and Amhara region in the south west. The region is sub divided into seven administrative zones and 52 woredas (districts). Tigray has an estimated area of 53,638 square kilometres and a total population of 5,056,000 (CSA 2007 census projected for 2015). Over 80 % of the population resides in rural areas whose livelihoods depend on subsistence farming. In recent years, the industry and service sectors are increasingly becoming important. The region has an estimated cattle population of 2,665,129 with average cattle holding of 4.8 per household.

3.1.2 Amhara Region

Amhara Region is located in the north-western part of the country and bordered with Tigray region in the north, Afar region in the east, Oromia region in the south and Benishangul-Gumuz region in the south-west. The region consists of 10 administrative zones, one special zone, 105 woredas, and 78 urban centres. According to the 2007 Census, the region had a total population of 17,221,976 projected to grow to 20.7 million in 2016. Agriculture is the dominant sector which absorbs about 90 % of the population and generates about 70 % of the regional GDP. The estimated cattle population of the region is 10,275,527 with 4.0 average cattle holding per household.

3.1.3 Oromia Region

Oromia region sprawls over the largest part of the country and at present consists of 12 administrative zones and 180 woredas. Oromia region borders Afar, Amhara and Benshangul-Gumuz regions in the north, Kenya in the south, Somali region in the east, Sudan and Benishangul-Gumuz region in the west, SNNP and Gambella region in the south. According to the 2007 Census, the regional population size was 26,993,933 which is projected to reach 34.6 million in 2016. In the region, agriculture is the dominant economic sector in terms of generating employment as well as its share in the regional GDP. In the region, an estimated amount of 18,575,227 cattle population exists. The average cattle holding per household is 5.2.

3.1.4 SNNP Region

The Southern Nations, Nationalities and People's region (SNNP) is located in the south west Ethiopia. It borders Kenya to the south and South Sudan to the southwest. The total area of the region is approximately 118,000 square kilometres. The region is divided into nine zones, 72 woredas and five special woredas. Population density is about 151 people per square kilometre; making the region one of the most populous parts of the country. An estimated 88.9 per cent of the total population lives in rural areas. The region is home to 56 ethnic groups, with their own distinct geographical locations, languages, cultures and social identities. According to the 2007 Census, the region's population was 14.93 million and estimated to reach 19.53 million in 2016. The region has an estimated cattle population size of 8,815,689 (with average cattle holding of 4.4 per household).

3.2 Survey Design

3.2.1 Quantitative research design

According to project documents, a total of 7,802 bio-digesters were constructed in the period 2015 – 2017 which constitute the survey population in targeted regions. From this population size a representative samples were drawn. The sample size determination formula used for the purpose of this study is:

$$n = \left[\frac{Z^2_{\alpha/2} P(1-P)}{d^2}\right]$$

where *n* is the sample size from the population, *Z* is statistical value of Z for *a* level of significance, *P* is the degree of variability, *d* is the measure of precision and *p* is the estimated male-headed and female-headed ratio of households.

By inserting the value of our parameters we determined (90% CI, 0.5 P and 5.70 d), it gives total sample size of 200. Respondents were selected through a computerised multi-tier random sampling technique per region.

As shown on the table above, to ensure regional proportional representation, selection of samples was done in three-tiered way, first randomly sampling Zones, then woredas and finally households from sampled zones and woredas. Accordingly, the total 200 samples were selected from 16 woredas in 4 zones of the 4 targeted regions. Subdivision of the sample size into regions, zones and woredas was done on the basis of Proportional to Population Size (PPS) procedure. For this survey, 200 biogas users were selected and interviewed from the 16 sampled woredas which have 544 total number of biogas.

Region	Sampled zones	Sampled woredas	No. of users (2015-2017)	Sample size
Amhara	North Wollo	Raya Kobo	23	13
		Bugna	7	4
	West Gojjam	Bure Zuria	13	8
		Mecha	59	41
	Subtotal		**102**	**66**
Oromia	East Wollega	Sibu Sire	10	3
	Jimma	Gomma	44	20
		Limu Kosa	11	7
		Kersa	35	17
	Subtotal		**100**	**47**

Tigray	SE Tigray	Enderta	111	22
		Hintalo	90	17
		Degua Temben	22	3
	West Tigray	Wolkayit	3	2
	Subtotal		**226**	**44**
SNNP	Kembata Tembaro	Hadero	71	26
		Angecha	12	5
		Kacha Birra	27	10
	Gedeo	Wonago	6	2
	Subtotal		**116**	**43**
Total			**544**	**200**

Table 1: Sample sizes by survey woredas

3.2.2 Qualitative research activities

The qualitative approach describes and explains study phenomena in detail, based on a limited number of observations. Thematic analysis of the qualitative data was conducted throughout the survey. At the end, qualitative findings were discussed in the context of the quantitative outcomes to help explain converging and diverging information and contributing to the validation of results. For this study, in each survey region, two key informants interviews, and 1 focus group discussion were held. Data from qualitative tools were used to obtain information from within a community and to produce a valid estimate of the target group's opinion with regard biogas.

Key Informant Interviews (KIIs): A total of eight KIIs conducted with office representatives from RBPCUs, Agriculture Office, TVET, Rural Technology Office, Women and Children's Affairs Office, Environmental Protection Office, MFI and Mason. KIIs with these sector offices and stakeholders are conducted at woreda level except for RBPCU that exists only at regional level.

Focus Groups Discussions (FGDs): a total of 4 focus group discussions were conducted with biogas users in selected woredas of survey regions. The discussions were guided by FGD guideline prepared in advance and facilitated by skilled moderators.

3.2.3 Data collection process

Both quantitative and qualitative data were collected by experienced and well-trained data collectors. As recommended in the ToR, a total of 8 enumerators to conduct the quantitative survey and 4 qualitative data collectors to facilitate FGDs and conduct KIIs were employed. Sex of data collectors was also duly considered to capture gender aspects accurately, and to ensure women feel free to voice their views and opinions. All data collectors were also fluent in the language of the survey areas. Data collectors travelled in a team of three so that they help each other and quality is maintained. The quantitative data was collected using Electronic Data Capturing Method (EDCM) and to this effect, smart phones with well-developed survey application (Akvo flow) were employed.

4. SURVEY FINDINGS

4.1 Household characteristics

4.1.1 Respondents' profile

Overall, 200 individuals were interviewed in the selected zones and woredas of the four survey regions in the quantitative survey. 44 respondents (22%) were from Tigray region; 66 respondents (33%) from Amhara region; 47 respondents (23.5%) from Oromia region and the remaining 43 respondents (21.5%) from SNNP region. From the total respondents 135 (67.5%) were male and 65 (32.5) were female respondents with the mean age of 42.4 year old (14.383 std. dev.) Out of these respondents, 129 (64.5) respondents constitute heads of their family while the remaining 71 (35.5%) respondents were members of their household related to the head of the family as husband/wife (57.7%), son/daughter (33.8%) and other relatives (8.5%). As reported by non-household head respondents, 66 (93%) of household heads live with their family, while the rest 5 (7%) are not living with their family due to death, living in other places and leaving the country.

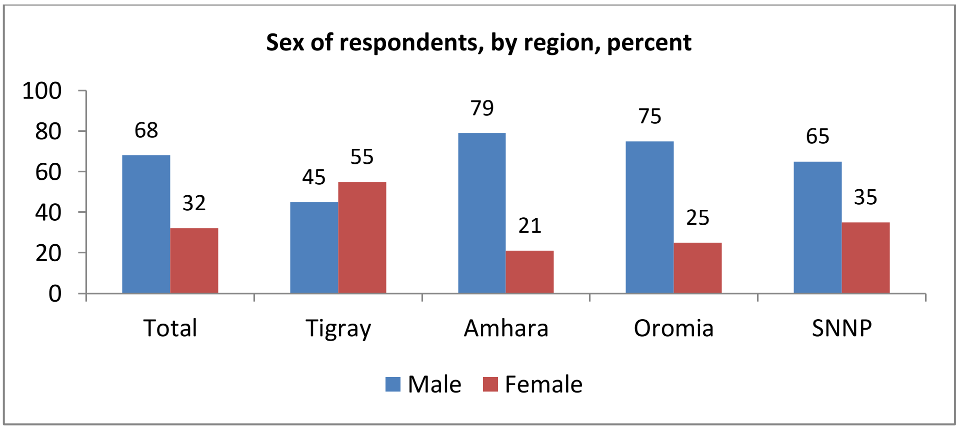


Figure 2: Sex of respondents, by region

4.1.2 Household structure

Among surveyed households, 184 (92%) are male-headed households; 7.5% female headed households and 0.5% child-headed households[1]. The average family size of surveyed households is also 7.31 with gender composition of male (3.81) and female (3.5). Age composition of households also consists of 3.53 below 18 year, 3.59 in the range of 18 – 65 years and 0.2 above 65 years. In terms of educational attainment, on average, 2.61 are illiterate/underage members of households while other 1.05 members are able to read and write (through informal education – adult education, religious education, etc.). From the statistical results, it is also found that from the average family size of 7.31 people per household, 1.24 are in the first cycle primary education (which is from grade 0 – 4) while other 1.33 members are in the second cycle primary education (which ranges from grade

[1] Child-headed households are households headed by the oldest son/daughter because both parents/caregivers are no longer living in the household for different reasons (death, migration, etc.)

levels 4 – 8). Others (0.75 people per household) are found in the grade levels of 8 – 12. Only few (0.39 members of family per household) have attended education above grade 12.

Region	Number of family members by age and sex (average)						
	Below 18 years		Ages 18 – 65		Above 65		Total family size
	Male	Female	Male	Female	Male	Female	
Tigray	1.95	1.89	1.57	1.41	.07	.09	6.98
Amhara	1.91	1.55	2.00	1.77	.14	.14	7.50
Oromia	1.53	1.68	1.70	1.66	.13	.06	6.77
SNNP	1.79	1.84	2.26	1.93	.07	.05	7.93
Total	1.81	1.72	1.89	1.70	.11	.09	7.31

Table 2: Number of family members by age and sex

4.1.3 Livelihood

Agriculture is the dominant sector which the livelihood of majority of surveyed communities based in. The majority of respondents (97%) reported that agriculture is their household's major source of income. In the surveyed households, some members also earn income from employment activities, own business such as petty trades and daily labour works to support household livelihoods. Next to agriculture, small business activities the second important economic activities followed by daily labour works. Some of respondents from Tigray, Oromia and SNNP regions reported that agriculture is not among the major income sources of their household. However, they still keep animals, which is the basic requirement for biogas installation and operation. Exceptionally, in Tigray region, 61.4% of respondents have reported that daily labour activities are among the major sources of income for their family. It is mainly attached with availability of commercial farms and high labour demand from the industrial sector in the region.

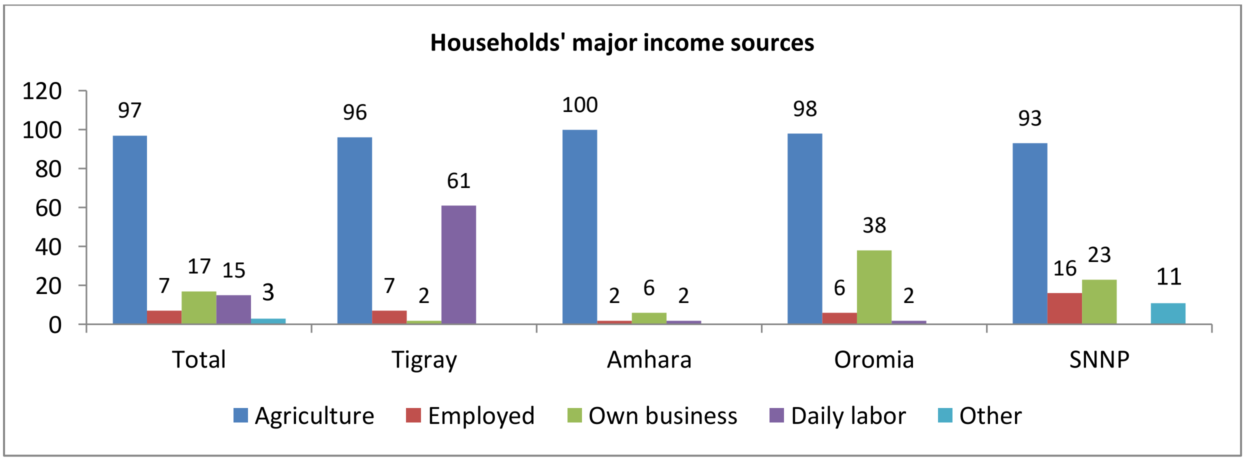


Figure 3: Households' major income sources

4.1.4 Animal holdings

For proper feeding and effective operation of the biogas plants, it is recommended biogas users to own certain number of cattle to get the minimum required amount of input. According the Program Implementation Document (PID) of the National Biogas Program of Ethiopia (NBPE) the minimum number of cattle required for $4M^3$ biogas plant is 4, while the number increases to 6, 8 and 10 cattle for $6M^3$, $8M^3$ and $10M^3$ biogas plants respectively. Looking into the statistical results from the quantitative data regarding households' cattle holdings, the average is 5.33 cow/oxen, 1.38 equines, 2.07 goats/sheep and 5.68 of calf, poultry, etc. Biogas users from Oromia and Amhara regions have the average number of cattle above the minimum requirements for the minimum plant size. Considering only large animals (cow, oxen and equines), the average number of cattle surveyed biogas users possess seems inadequate, especially for biogas plants larger than $4M^3$. The relationship between households' cattle holdings and plant feeding/plant performance will be investigated further.

Region	Number of livestock (Mean)			
	Cow/oxen	Sheep/goats	Equines	Poultry
Tigray	3.33	2.09	1.36	6.16
Amhara	5.47	1.74	.49	5.55
Oromia	8.10	3.33	3.62	5.95
SNNP	3.89	1.12	.31	5.14
Total	5.33	2.07	1.38	5.68

Table 3: Number of livestock

4.1.5 Access to water

Access to clean water is also another dimension of effective biogas operation which should be considered duly in the decision making process to own biogas plant. The minimum daily water requirement ranges from 20 – 50 litres depending on the size of the biogas. For the $4M^3$ biogas plant, the minimum daily water requirement is 20 litres, for the $6M^3$ 30 litres, for $8M^3$ 40 litres and for $10M^3$ 50 litres. Selection of potential biogas users is therefore made on the basis of households' access to the daily water requirement in a maximum of 15 minutes waking distance radius. Accordingly, the study investigated biogas users' access to water to feed their plant. As the statistical results show, majority of biogas users (36%) use lakes/rivers/ponds as the main source of water for household uses. 22% of respondents have also reported that public water walls are their main water sources. As per the statistical findings, about 17% of biogas users have pipe water in their compound and other 10% of users have water wall in their compound. The remaining 16% of households use public tap water for their households water need. In Tigray region public water wall is the main water source for about 64% of surveyed households. In Amhara region the main source of water is water walls in users' compound. Above 74% of biogas users in Oromia region get water from lakes/rivers/ponds. 40% of surveyed households also use public tap water as the main source of water for their household uses.

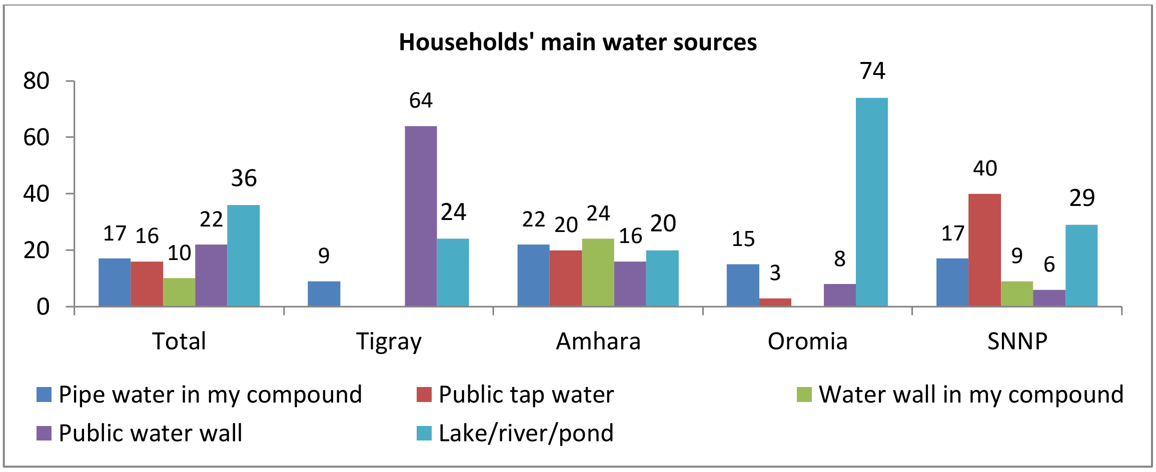


Figure 4: Households' main water sources

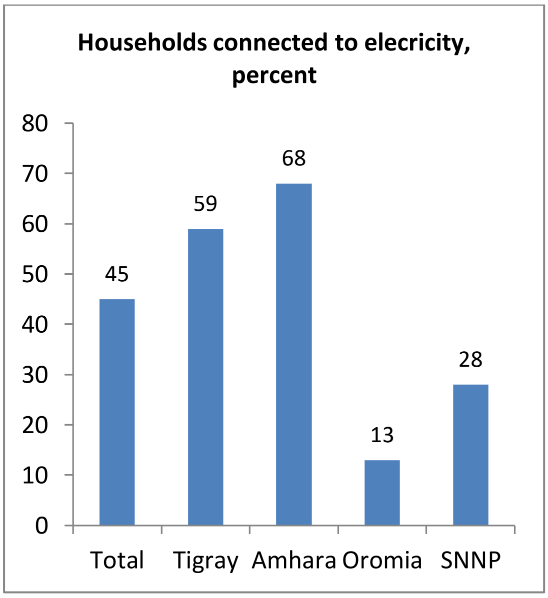
Households with water sources out of their compound, on average it takes about 16 minutes to reach the nearest water sources. It is a bit higher that of recommended in NBPE PID. Selection of biogas users requires that the nearest water source to biogas owners should not exceed 15 minutes of waking to reach there. In average terms, the distant water sources are observed in SNNP region with about 19 minutes of waking from home. In Tigray region, the average time length to reach the nearest water source is about 16 minutes. For Amhara and Oromia regions, the average times are about 15 minutes, approximately. There are also reports of extreme cases in survey regions, which are 40 minutes long in Tigray and Oromia regions and 30 minutes long in Amhara and SNNP regions.

4.1.6 Toilet

On average, 94.4% of households have a toilet in their compound. Regional figures show that 100% households in Tigray and Oromia regions, 91% in Amhara region and 87% in SNNP region have in-use toilets in their compound. Among these, on average, 84% of toilets are connected to the biogas system. 92% of toilets in Amhara region, 85% in Oromia region, 82% in Tigray region and 71% in SNNP region are connected to the biogas digester. As stated by respondents, main reasons for the toilets being not connected to the biogas system include possibility of bad smell with the slurry, cultural barriers and possibility of health problems from using toilets to feed the biogas plant.

4.1.7 Electric connectivity

Out of the surveyed households, it is reported that 44.5% houses have electric connectivity to their houses. The region with largest proportion of households with electric connectivity is Amhara region with 68.2% followed by Tigray region with 59.1%. 27.9% and 12.8% of households surveyed in SNNP and Oromia regions also reported that their houses are connected to electricity respectively. Regarding the sources of electricity, hydroelectric grid and solar energy are the main sources. Among those households with electric connectivity, the majority (51.4) obtain electric from solar power while others (44.4%) get power from hydroelectric grid. The remaining 4.4% get power from other sources such as diesel generators. In Amhara region, among households with electric connectivity, 84.4% of households use solar power for electric energy. Households with electric connectivity in Tigray, Oromia and SNNP regions, their homes are connected to hydroelectric grids with 59.3%, 83.3% and 100% proportions respectively.



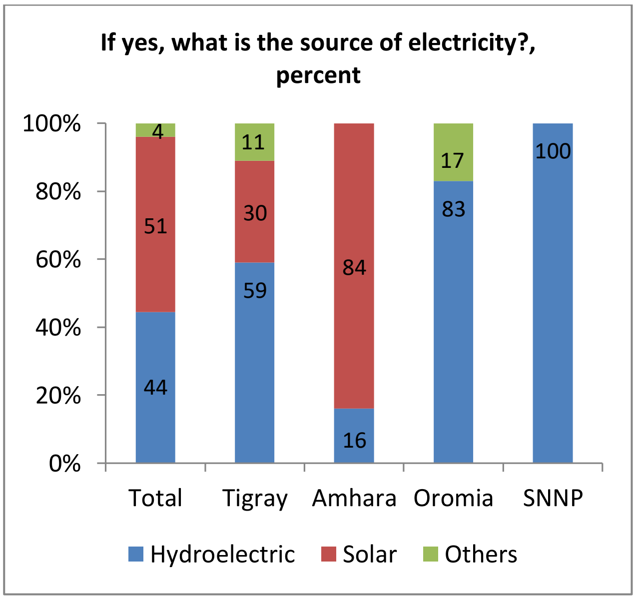


Figure 5: Households electric connectivity

4.2 Decision Making Process

Biogas in Ethiopia is generally a half-funded investment and entails certain requirements for biogas plant installation. Biogas plant seekers/potential users need to fulfil the following requirements so as to build a biogas plant. The requirements may vary depending on the size of the plant that the users want to construct.

- Owning at least 4 cows/oxen;
- Near access to water supply;
- Sufficient area for biogas plant instalment;
- Access to construction materials (sand, crushed and dry stone); and
- Physical capability to excavate the pit for biogas plant, to muddle up the manure with water, to enter the manure and put out the slurry from the digester.

A farm household is thus assumed to have energy preference over a set of alternative energy sources that are subjected to resources and budget constraints. It is also assumed that households know their energy problems and can state their own preferences given their demographic, socio-economic characteristics, environmental, institutional and other observable attributes. Access to information about biogas and level of community awareness, family structure and composition, problems households face from using other sources of energy, economic capacity, availability of technology and expertise, access to financial means, etc. are among the factors that influence households decision making process to install biogas plants. Some of these factors are analysed under this section.

4.2.1 Access to utilization of information about biogas

Household decision making process to install biogas plant at household level starts with getting information about the new system and their perception about the pros and cons of the technology. There are actually several stakeholders from federal to kebele (the lowest administrative unit) level structures responsible to promote the technology to rural communities. These actors include government institutions (federal, regional, zone, woreda and kebele authorities and offices), NGOs, the private sector (masons, BCEs), the mass media microfinance institutions and cooperatives.

In survey districts, biogas users were asked about where they heard about the biogas for the first time and gave their responses. According to the results, woreda energy offices and technicians are the well-known promoters of the biogas technology in rural communities. Above 81% of respondents stated that they have heard about the technology for the first time from woreda offices and technicians. Masons (52.5%) and kebele extension workers (39.5%) are also important information providers about the biogas in such communities. Other biogas users also play key role in dissemination of information about biogas technology as 30.5% of interviewed respondents reported that they got information about biogas from other users. Significant proportion of respondents (22.5%) also heard about biogas from community gatherings and village meetings.

Sources of information	Tigray	Amhara	Oromia	SNNP	Total
Promotional brochure/poster	9.1%	6.1%	0.0%	2.3%	4.5%
Village meetings	56.8%	7.6%	19.1%	14.0%	22.5%
Woreda technicians/DAs	81.8%	74.2%	97.9%	74.4%	81.5%
Kebele technicians/workers	63.6%	39.4%	42.6%	11.6%	39.5%
From an NGO/CBO	13.6%	3.0%	2.1%	0.0%	4.5%
From mason	84.1%	68.2%	2.1%	51.2%	52.5%
From community leaders	52.3%	0.0%	4.3%	2.3%	13.0%
From friends/relatives	27.3%	19.7%	6.4%	4.7%	15.0%
Other biogas users	59.1%	33.3%	2.1%	27.9%	30.5%
Others	2.3%	1.5%	0.0%	0.0%	1.0%

Table 4: Sources of information about biogas

However, mass media were not stated as important sources of information to access biogas-related information. Taking into account the area coverage as well as cost efficiency of these channels, further promotional efforts should pay attention to these options to disseminate information about biogas technology. The growing demand for electronic devices even in rural areas is also a propelling advantage to consider such media channels for awareness creation. Access to reliable information helps potential users make the right decision to install biogas and operate it properly to obtain the maximum possible benefit from the technology.

Different driving motives were also mentioned by respondents that inspire them to decide installing biogas plant for household uses. Need for lighting, cooking energy and organic fertilizer are the three most important factors behind installing biogas plants by surveyed households with 91%, 87% and 78.5% proportion of respondents respectively. Other relevant variables considered by households to start using biogas energy include the ever growing cost of/difficulty to get firewood and charcoal for cooking (70%), desire to save time, money and energy users incur from using other sources of energy (70.5%), desire to improve household sanitation (63%) and desire to improve health condition of family members (58%). Here it is important to note that even though need for lighting was mentioned as one of main important driving motives for installing biogas, it is observed that significant proportion of surveyed users have electric connectivity mainly from solar energy especially in Amhara and Tigray regions. This is discussed in FGDs and participants explained that they have started using solar energy recently as they have found it efficient and easy to use compared to the biogas light. However, they still use the biogas energy for lighting as well as cooking and producing organic fertilizer. It implies that current and future biogas promotion efforts should focus on signifying the multi-dimensional advantages besides its use for lighting purpose.

Considering the traditional and patriarchal family structures in most parts of the country, especially in rural communities, it is not surprising to see the household decisions to install biogas plants are mostly made by male household heads. 39.5% of respondents stated that decision to install biogas was made exclusively by the male head of the family. But still significantly large number of households reported that parents (29.5%) and all family members (27.5%) have discussed the issue together and made the decision to install biogas.

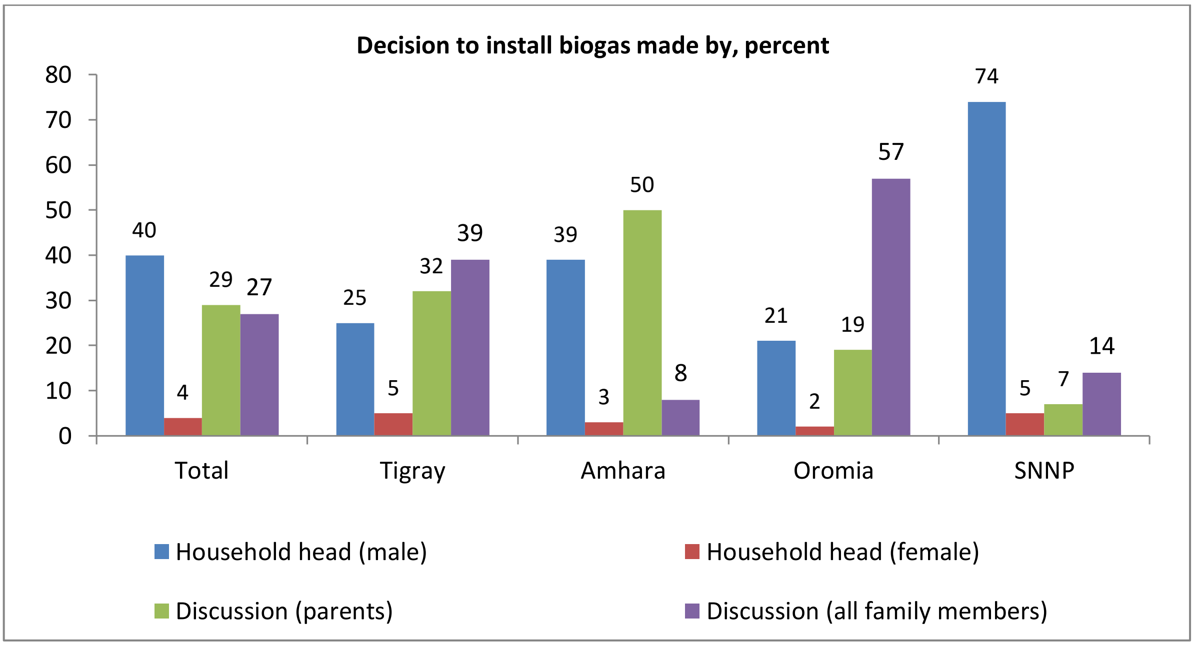


Figure 6: Decision to install biogas made

Except for the case of SNNP region, as depicted on the graphical presentation above, the majority of biogas plants were constructed after biogas users discuss either with the spouse or with all members of the family. In fact, family consensus is essential for effective operation of the biogas and its maximized benefits to the household.

4.2.2 Construction cost of biogas plants and financing schemes

The price of a biogas plant varies based on location and season, but the average price of a single biogas plant is estimated to be ETB 13,000 (582.7 USD) for a biogas plant with a $6M^3$ gas volume, ETB 13,500 (605.1 USD) for a biogas plant with a $8M^3$ gas volume, and ETB 14,000 (627.5 USD) for a biogas plant with a $10M^3$ gas volume. Of which, half of the price is subsidized by the federal government (10%), the regional government (5%), and the rest of the payment is funded by the Africa Biogas Partnership Program. SNV, on the other side, provides the technical support. Subsidies are given in the form of appliances (lamp, stove, iron bar, gas hose, and cement) that are crucial for the proper functioning of biogas plant. Local biogas adopters need to cover rest of the work, which is estimated to be half of the price of a biogas plant. These include the cost of construction inputs such as sand, crushed and dry stone, and labour cost. For those who are unable to afford the price, loan opportunities are arranged by the microfinance institutions.

From households' perspective, the majority of biogas users have covered what was expected from them to build the biogas by their own resources without taking loans. Only 32% of biogas users from Tigray and SNNP regions took loans to partly finance their plant construction. In Tigray region, 70.5% of biogas users utilize loan mostly through multi-purpose cooperatives and 74.5% of users in SNNP region took loans mainly from Omo Microfinance Institution to cover part of biogas construction costs. In Amhara and Oromia regions, biogas users finance their part of biogas construction cost from own resources without taking loans from formal financial institutions.

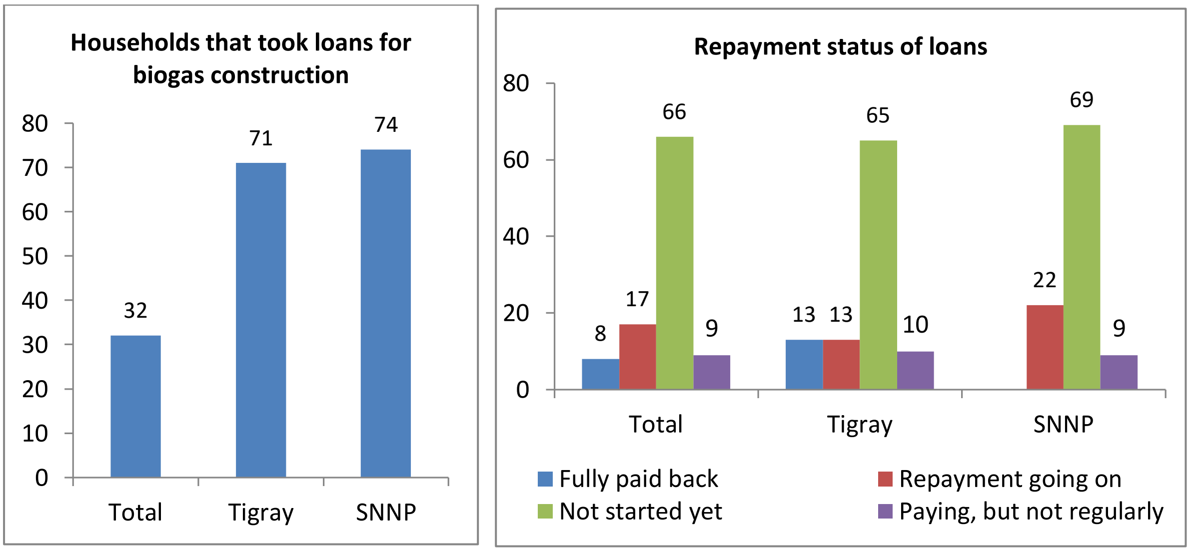


Figure 7: Household loan and repayment status

However, the loan repayment status is poor both in Tigray and SNNP regions. Only 13% of borrowers in Tigray region have fully paid their debt back while no one did in SNNP region. Reasons related to unclear payment schedule, lack of money to pay and expecting debt cancelation are the most frequently mentioned reasons for not paying the loan they took.

4.3 Biogas functionality and service delivery performance

4.3.1 Description of biogas plants installed

Biogas plants installed by surveyed users vary by their capacity, biogas model and number of slurry pits. As survey findings reveal, the majority of biogas users installed biogas plants with 6 M3 capacity. These users constitute above 80% of total users. Other 16% of users have biogas plants with 8 M3 capacity. The remaining are with 4 M3 (2%) and 10 M3 (1%). Among surveyed biogas plants, about 70% of the plants are Sinidu and the remaining 30% are Sinidu 2008 models. 78% of biogas plants are also with two slurry pits while the other 22% are with only one slurry pit.

Biogas description	Categories	Tigray	Amhara	Oromia	SNNP	Total
Biogas plant size (m3)	4 M3	0.0%	7.6%	0.0%	0.0%	2.5%
	6 M3	97.7%	59.1%	91.5%	83.7%	80.5%
	8 M3	2.3%	31.8%	6.4%	16.3%	16.0%
	10 M3	0.0%	1.5%	2.1%	0.0%	1.0%
Biogas model	Sinidu	50.0%	59.1%	89.4%	83.7%	69.5%
	Sinidu 2008	50.0%	40.9%	10.6%	16.3%	30.5%
Number of slurry pits	One	27.3%	29.1%	5.1%	25.7%	22.2%
	Two	72.7%	70.9%	94.9%	74.3%	77.8%

Table 5: Description of biogas plants

4.3.2 Functionality rates

Households install biogas systems mainly for cooking, lighting and to obtain organic fertilizer for agricultural activities. Hence a biogas plant to be counted as functional (with varying degrees) it should serve one of the purposes and users should feed the plant either on regular or irregular basis. Hence, the performance of the biogas plant was evaluated with respect to set of objectively defined parameters as follows:

Functional without notable problem: the biogas and its appliances work in a regular way without significant problem

Functional with minor problem: the biogas and some/all of its appliances work, but has minor problems which can be solved in short period of time (replacing broken lamp or the stove)

Functional with major problem: the biogas partly/fully works, but with serious problem which affects the performance of the biogas significantly such as gas leakages, irregular feedings and related problems, or any other problem which requires expertise to fix it)

System not functioning at all: the biogas is completely out of service for several reasons such as cracked dome, etc.

In this definition of functionality, the national average functionality rate is 79% with slight variations among survey regions[2]. Functionality details in each region are presented in the table and graph below:

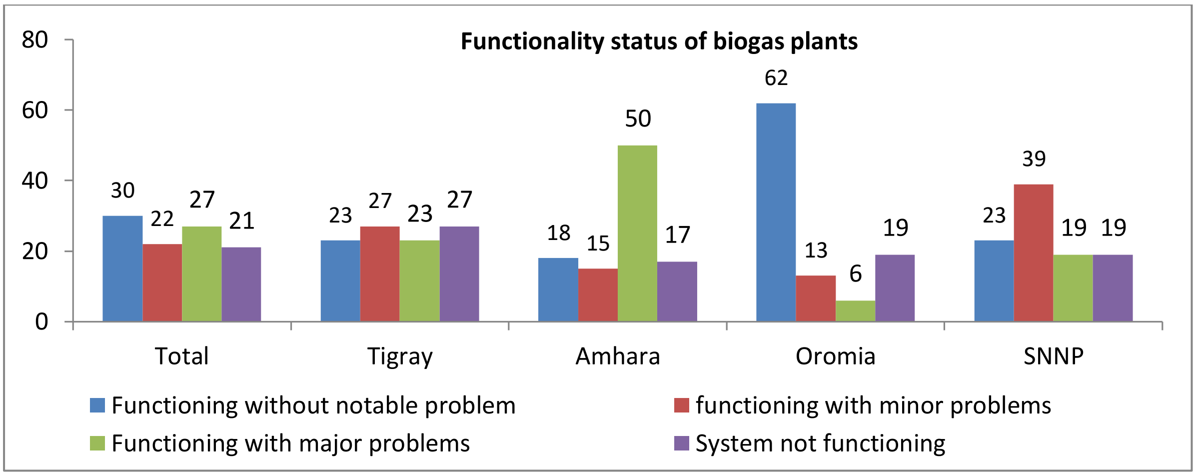


Figure 8: Functionality status of biogas plants

Respondents who replied that their biogas plant is not working properly/stopped working at all were also asked about the nature of the problems they are facing. The reasons stated by the respondents with respect to the functionality status of the biogas system are explained in the following box:

[2] The functionality rate of biogas plants in **NBPE+ intervention woredas**, namely Wolkayit and Raya Kobo is **87%**. More specifically, 40% of the plants are fully functional without any significant problem, 20% with minor problems and 27% with major problems. The remaining 13% of plants are not functional.

Problem with appliances: appliances (the lamp, lantern or the stove) are not functional. This can cause poor performance of the biogas or put the plant out of service as users become reluctant to use the system anymore especially when spare parts are not easily accessible. But they can still use the biogas for bio-slurry and organic fertilizer (e.g., the case of Amhara region).

Pipes cracked/broken: this also makes the gas to reduce/vanish before it gets to the appliances. If the damage is severe, it also makes fresh air enter the dome to gradually drain the digester and kill the bacteria. This problem significantly affects the performance of the biogas or makes the system fail at all.

Gas valves not functioning properly: if the valves at the dome, at the lamp or at the stove are not working properly, it is not possible to control gas flow and it causes poor outputs. It can also damage the appliances, especially the lantern, due to unbalanced flow of gas.

Water drain valve not functioning properly: If water drain is not checked periodically, it can cause serious problem by causing accumulation of water in the pipe. Usually users forget to check it on regular bases and it affects the performance of the biogas seriously.

Gas not reaching the appliances properly for unknown reason: this refers to the situation in which the plant generates gas as required, but the gas doesn't reach appliances properly due to several reasons such as blocked pipes (e.g. by slurry blockage or installation problem).

Biogas digester cracked/damaged: due to poor quality of construction or materials used and natural/man-made disaster. Usually, this problem makes the system to fail.

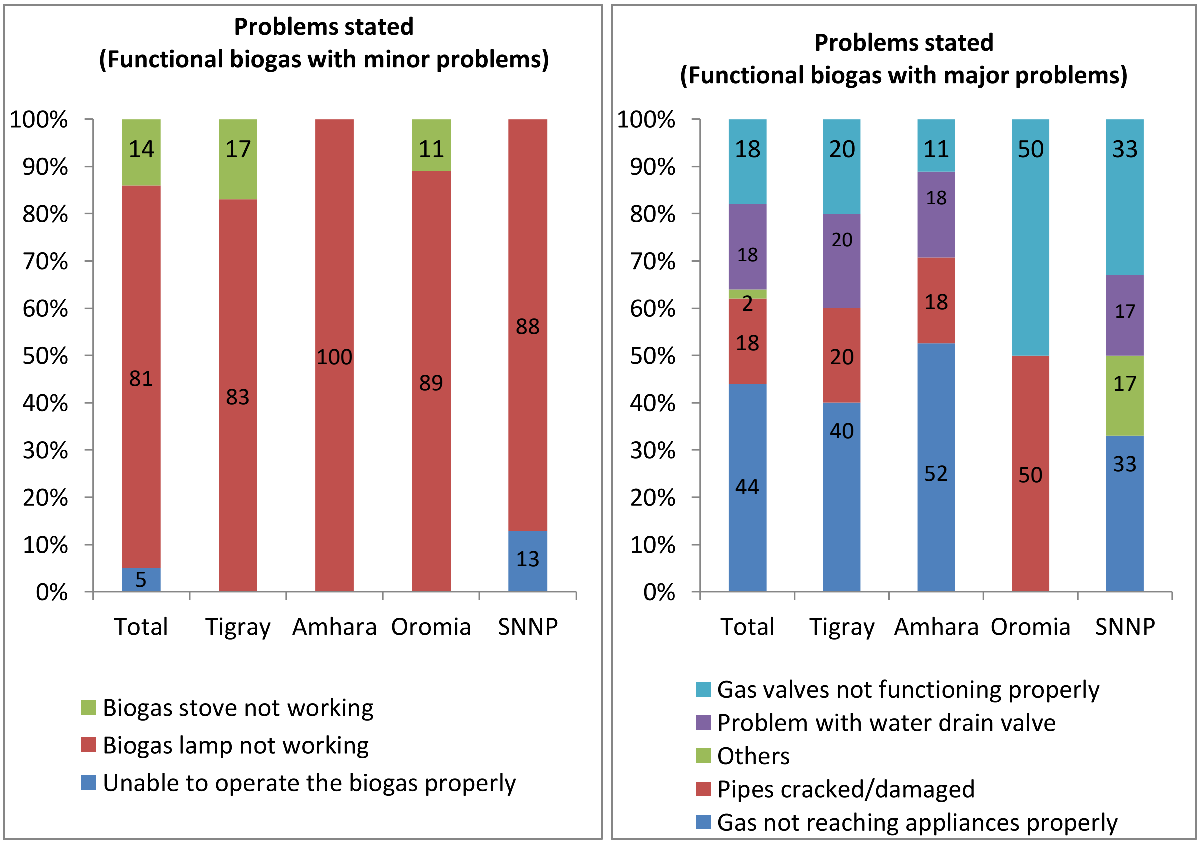


Figure 9: Problems affecting biogas functionality

As defined earlier, problems with appliances remain the dominant factor causing minor problems to the biogas plants. Overall, 81% of respondents indicated that their biogas lamp is damaged and need a replacement. Again, 14% of biogas users with minor problems reported that the problem is with the biogas stove. The remaining 5% of problems are related to capacity gaps to effectively operate the biogas system. Here, we can understand that creating the mechanisms through which biogas users can easily access spare parts and appliances for replacement means addressing these problems and improving the functionality rate of biogases.

On the other hand, problems related to gas transmission from the dome to the appliances due to gas leakages, blocked pipes and installation problems constitute about 44% of the causes for major problems with the biogas plants. Due to this reason, 44% of respondents with mal-functioning biogas plants stated that gas not adequately reaching their appliances and they are not using the biogas either for cooking or lighting. Especially, in Amhara region, biogas users with such problems operate their biogas mainly for the slurry and organic fertilizer needs. Other respondents also reported that cracks/damages with biogas pipes, problems with gas controlling valves and water drain valves are making using the biogas for cooking and lighting difficult. Such problems can be resolved only by engaging high level of maintenance with require engagement of the mason of biogas construction enterprises.

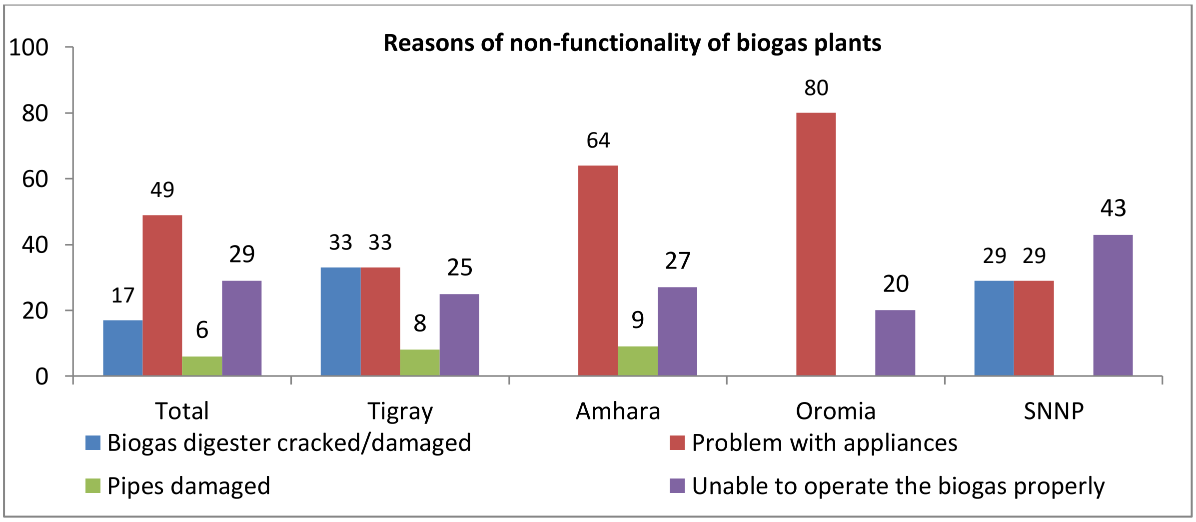


Figure 10: Reasons of non-functionality of biogas plants

The case of non-functionality is also similar to the above explained cases. Problems with appliances are the major cause (40%) for non-functionality of biogas systems. The difference here is that unlike those households which still use the biogas to produce organic fertilizer (the case of Amhara region); these households are not using it for the same purpose and are not feeding the plant at all. Lack of capability at household level to operate the biogas properly is also another important factor for the non-functionality of the biogas in survey regions. The overall percentage is 29% and it reaches as high as 43% in SNNP region. This problem is mainly caused by lack of skill and manpower at the household level to operate the biogas system. In one of the FGDs in Angecha woreda, Kembata-Tembaro zone, SNNP region, participants mentioned that after the installation of the biogas plants there are high probabilities that adult/young members of rural households migrate to other countries looking for better opportunities. In such cases, the households become unable to properly manage their system and discontinue feeding the plant at all.

4.3.3 Performance of functional biogas systems

Cooking, lighting and organic fertilizer are the most relevant purposes of biogas energy being demanded by rural households. Biogas plants which are functioning without any significant problems are believed to serve all these purposes on the basis of the feeding patterns by the users. The usage of those biogas systems with minor and major problems depends on the amount of gas generated and available for use and the functionality of appliances attached to the biogas system.

As evidenced from survey results, biogas plants with minor problems are used mainly for cooking purposes, implying that only the stove is working at the time of the interview. Meaning, the biogas lamp is the one having problem most of the times. Biogas plants with major problems are mainly used for generating organic fertilizer and it is evidenced mainly from statistical figures in Amhara region. To these households, producing organic fertilizer from biogas plant is equally important benefit they obtain from the technology. Most of the households use the biogas energy to cook wat (sauce), boil water and make coffee. The applicability of biogas energy to bake injera and other purposes which require large amount of gas and special appliances are at the very infant stage of development to be sued by biogas users. Only 5% of respondents stated that they use biogas energy to bake injera and they all are found in Amhara region. Most of the users do not feel comfortable for not being able to use the biogas energy to cook anything they want to cook. During the time of interview, most of the gages (54%) that measure the amount of gas generated from the plant are five and below five. 16% of the gages also read gas level in the range of 5 – 7 and 23% reads gas level above 7 at the time of observation.

4.3.4 Biogas feeding patterns

Family size biogas plant is sited within the homestead that is usually near to the cattle shed and the tasks of collection, stirring and feeding the substrates into the biogas digester are largely performed by members of household to whom the biogas system belong. Biogas feeding pattern is also among critical factors influencing the biogas system performance.

In survey areas, the majority of biogas users (45%) feed their plant once a day. 28% of them also reported that they feed their plant weekly on average. Other 22% of the users also feed their plant in two days. Only 5% of surveyed households report that they feed their biogas twice a day with water and dung to generate gas and bio-slurry. Exceptionally, 90% of households in Oromia region feed their biogas daily while 51% of users feed weekly in Tigray region.

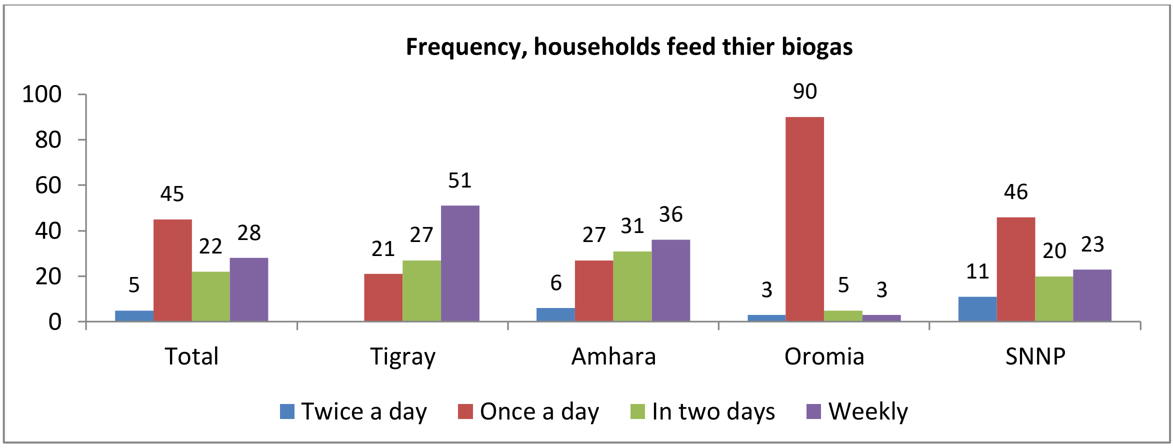


Figure 11: Frequency, households feed their biogas

Respondents were also asked why they feed their biogas plant in the stated intervals. According to the results, the majority of respondents (67% on average) claim that that is the only amount of dung they have to feed their biogas. Other 17% of respondents also replied that that is the amount of water available for biogas feeding. Only 11% of respondents reported that that is the capacity of their bio digester with respect to the amount of gas they need for household uses. The amount of dung and water these households feed their biogas plant at a time is also presented in the table below.

Region	**Statistics**	**Amount of input feeding at a time by biogas plant size (m3)**							
		4 M^3		**6 M^3**		**8 M^3**		**10 M^3**	
		Dung (kg)	**Water (ltr.)**	**Dung (kg)**	**Water (ltr.)**	**Dung (kg)**	**Water (ltr.)**	**Dung (kg)**	**Water (ltr.)**
Tigray	Mean			25.61	22.58				
	Std. Dev.			2.999	3.093				
	N			33	33				
Amhara	Mean	22.00	17.00	24.29	21.61	27.95	25.71	30.00	30.00
	Std. Dev.	4.472	4.472	4.454	3.614	2.924	3.273	.	.
	N	5	5	28	28	21	21	1	1
Oromia	Mean			25.27	22.43	35.00	20.00	35.00	30.00
	Std. Dev.			4.073	3.254	.	.	.	.
	N			37	37	1	1	1	1
SNNP	Mean			26.38	21.72	26.67	24.17		
	Std. Dev.			3.986	3.348	2.582	2.041		
	N			29	29	6	6		
Total	Mean	22.00	17.00	25.39	22.13	27.93	25.18	32.50	30.00
	Std. Dev.	4.472	4.472	3.914	3.305	3.126	3.186	3.536	.000
	N	5	5	127	127	28	28	2	2
Recommended feeding amount	Minimum	20	20	30	30	40	40	50	50
	Maximum	40	40	60	60	80	80	100	100

Table 6: Amount of input feeding at a time by biogas plant size

As shown on the table above, the amount of input (dung and water) that users feed their biogas plant at a time is at low level compared to the recommended amount of inputs biogas should be fed on daily basis. Only owners of 4 M^3 biogas plants feed their plant with the minimum required amount of dung. However, they still lack water to fulfil the minimum level. For the biogas sizes above 4 M^3, the input levels that users feed their biogas are far behind the recommended minimum amount of inputs (both dung and water). The results also show that the mixing proportions of dung and water by surveyed users are not balanced, which most likely indicate the scarcity of water users faced to feed their biogas.

About 97% of households also reported that they use all available dungs to feed their biogas which strengths the statement that biogas users lack sufficient amount of dung to their biogas plants. Even though most of biogas users reported that they have toilets in their compounds and mostly are connected to their bio-digester, there is no evidence that the volume of going to the biogas from the toilets compensates the deficit of dung and water. It is understood that these biogas users got the opportunity to plant biogas in their compound by fulfilling all the necessary requirements. However, as unveiled from households' amount of cattle holdings, the numbers of cattle has reduced from the minimum required amount. This could be as a result of selling of livestock, relocation of livestock or even loss of livestock for different reasons.

On average 25% of biogas users have only one slurry pits and the remaining 75% of users have biogas plants with 2 slurry pits. Biogas users with two slurry pits constitute 72% in Tigray region, 64% in Amhara region, 94% in Oromia region and 74% in SNNP region. Biogas users also reported the amount of bio-slurry and compost they produce from their biogas in a month. On average, biogas users in survey regions produce 123 litre of bio-slurry and 56 kilogram of compost from the biogas co-product. The amount of monthly slurry production varies from 84 litres in Tigray region to 128 litres in Amhara and SNNP regions. Monthly compost production also varies from 35 kilograms in Amhara region to 83 kilograms in SNNP region.

Product amount	Statistics	Tigray	Amhara	Oromia	SNNP	Total
Average amount of slurry do from the biogas in a month (litre)	Mean	84.17	128.80	142.69	128.43	123.70
	Std. Dev.	75.419	53.211	90.378	83.373	76.628
	N	30	55	39	35	159
Average amount of compost from the biogas in a month (kg)	Mean	49.39	35.49	62.10	83.71	56.44
	Std. Dev.	82.998	20.612	112.230	156.648	102.961
	N	33	45	39	35	152

Table 7: Amount of biogas co-products

From a multiple response question about how biogas users utilize the biogas co-product, it is found that the majority of households (85%) use the bio-slurry directly as a fertilizer and 57% of them again produce compost first and use as organic fertilizer in their agricultural activities.

4.4 Users' training and after-sale services

As clearly stated in the PID, training is an integral part of the program for smooth and effective implementation. The document recognized that training at different levels of program stakeholders is required as the program is new that entails a new technology and a new approach towards promotion, dissemination and effective operation of the technology. In the program document, it is mentioned that a one day pre-construction and one day post construction users' training will be delivered to biogas owners. After-sale services have also been emphasized including proper instruction of the user on the operation of the plant and maintenance as well as a guarantee of one year on appliances and two years on the civil structure of the plant. The guarantee provision includes at least two visits with an annual interval, starting six months after the completion of the plant.

Among surveyed biogas users about 65% of them reported that they/member of their family have got trainings on biogas. However, as discussed in FGDs and KIIs conducted in selected survey areas with selected informants, these trainings are mostly the post-construction orientations provided to biogas users about the operation of the biogas. It implies that most of the biogas users did not receive any kind of pre-construction and post construction trainings as planned in the PID. Masons and woreda technicians are those who deliver trainings/post-construction orientations to biogas users. 62% of respondents stated that they have got these trainings/orientations from the mason and other 36% of respondents obtained trainings and orientations from woreda technicians.

As reported by respondents, major topics addressed in the trainings/orientations include operating biogas (93%), using biogas co-products (90%), advantages of biogas technology (89%), maintain and troubleshooting biogas problems (63%) and obtaining assistance from biogas service providers (61%). All of the respondents (100%) who received trainings/orientations from masons and woreda technicians found the contents covered in the trainings highly relevant for effective operation of and maximized benefits from their biogas plant.

Distribution of printed materials to biogas users seems inadequate as revealed from surveyed results. Only few of biogas users replied that they have received resources such as brochures (19%), warranty card (39%) and users' manual (46%). As reflected in key informants' interview in survey areas, there are some attempts to produce and distribute information convoying materials at woreda offices and distributed to biogas users, but have never been adequate. Taking into account expansion of primary and higher level education in the country, it is important to pay attention to produce and distribute information materials to be used by household members of biogas users.

Other important segment of biogas users' service is after-sale service. After-sale service includes proper instruction of the user on the operation of the plant and maintenance as well as a guarantee of one year on appliances and two years on the civil structure of the plant[3].

[3] EREDPC/SNV Ethiopia, NBPE, Program Implementation Document (PID), p. 34

About 84% of respondents have reported that they have received one or more types of after-sale services after the construction of their biogas plant.

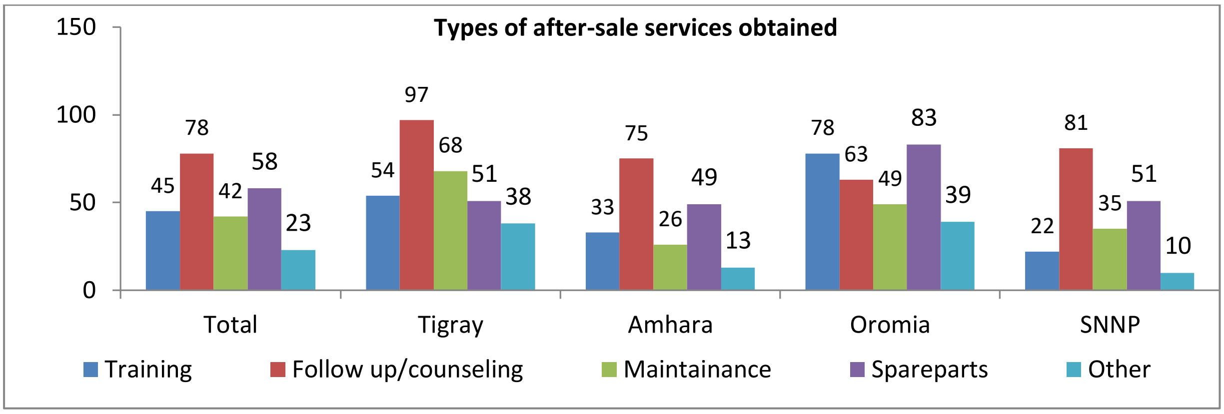


Figure 12: Types of after-sale services obtained

As reported by respondents, majority of biogas users (78%) have received follow up/counselling services from service providers followed by provision of spare parts (58%). Others also reported that trainings (for 45% of respondents) and maintenance are kinds of after-sale services they obtained from service providers. From the previous discussion, it has been mentioned that the performance of most of biogas plants is being affected from lack of maintenance services and spare parts. Coupled with low maintenance and spare parts provision capacity of concerned stakeholders, increasing demand for these services will continue affecting the performance of biogas plants unless stakeholders act accordingly. Most of the respondents (about 81%) who received after-sale services have also satisfied from the services provided by the woreda technicians and the mason.

However, significant share of biogas users who received after-sale services were not satisfied with the services they received. About 35% of respondents complained that the services were not satisfactory for different reasons. Among the most frequently mentioned reasons, unavailability of service providers whenever biogas users seek them (97%), lack of spare parts and appliances (97%) lack of timely response from service providers after the problems are reported by biogas users (93%) and lack of required skills to conduct effective maintenance (14.5%).

4.5 Socio-economic impacts of biogas technology

Small-scale biogas plants have a proven capacity of improving quality of life among rural communities and help reduce global warming impacts if used appropriately. It is one of a sustainable energy sources and the technology offers a unique set of benefits to the users and to the environment too. However, if used inappropriately, its benefits and expansion prospects may be compromised.

4.5.1 Impact on health and sanitation

Cooking on a biogas stove, instead of over an open fire, prevents the family from being exposed to smoke in the house. This in turn prevents deadly respiratory diseases caused by smoke. Above 45% of respondents expressed that they/members of their household have faced health problem/accident from using firewood for household energy needs. The proportion of household faced these problems reach as high as 66% in Oromia region. The most common types of health problems and accidents biogas users experienced before installing biogas plants include suffocation from smoke (92%), eye disease (78%), external body parts injury/burning (48%), respiratory disease (37%), fire accidents (25%), malaria (18%) and asthma (12%).

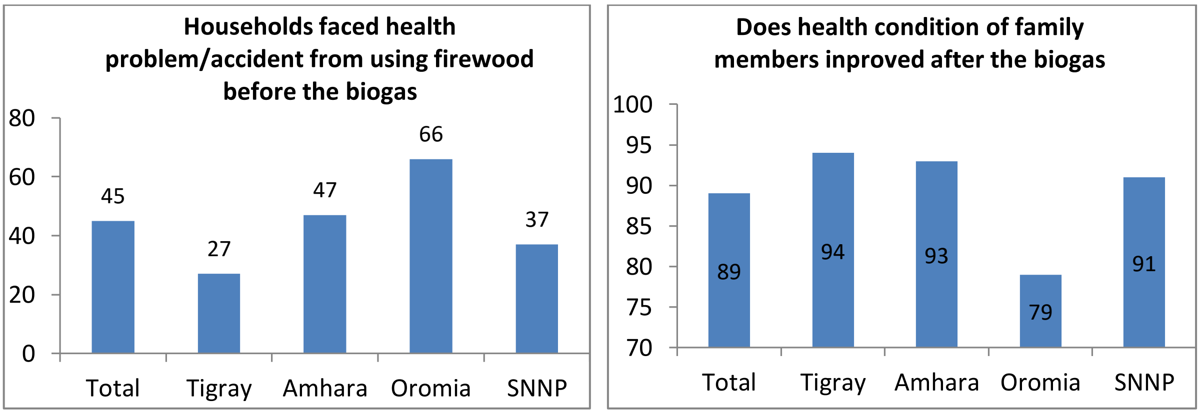


Figure 13: Changes in household health status

Among respondents who faced the above listed health related problems from using firewood as family energy source, most of them have reported that the situation has greatly improved after installing the biogas. 98% respondents affected from smoke suffocation expressed that the problem has reduced after the biogas. 97% of biogas user affected from external body parts injury also reported that the situation has now improved significantly. 94 % of respondents also reported that eye disease problem is now reduced significantly because of the biogas technology. Malaria, respiratory disease and asthma have reduced similarly as a result of the biogas at household level. Overall, 89% of respondents (94% in Tigray region, 93% in Amhara region, 79% in Oromia region and 91% in SNNP region) has reported that the health condition of their family members have improved after they started using biogas.

4.5.2 Impacts on violence against women and girls

From biogas users which used to collect firewood for household energy demand, 70.5% of respondents reported that adult females are the one who collect firewood on regular basis. 49.4% of them again stated that not only adult females, but girls also collect firewood to the household from the forest. 30%, 23% and 22% of these respondents also stated that adult males, boys and all members of households who have time to do so collect firewood, respectively. Besides, household members faced problems in collecting firewood including bearing extra work burden by women and girls (84%), children being late from school and shortage of time for study (68%), children stay without food and water (58%) and others.

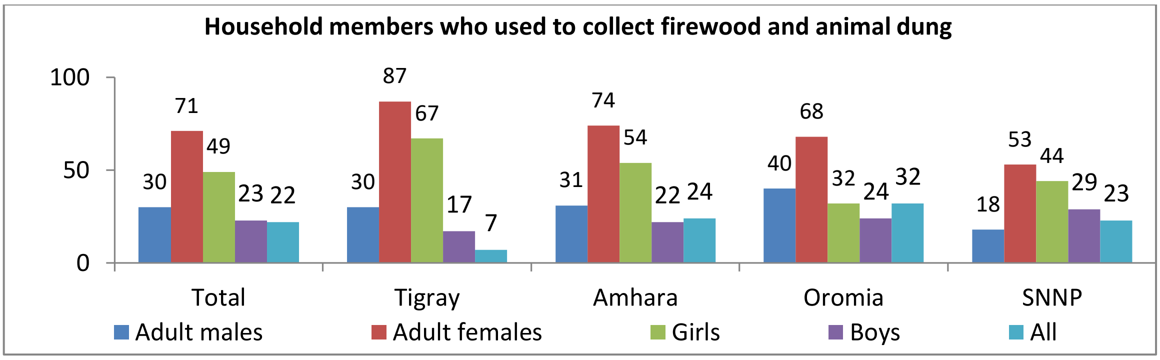


Figure 14: Household members who used to collect firewood and animal dung

After the introduction of biogas technology in their household, 68% of respondents stated that abuse and violence against women and girls has highly reduced. Other 20% and 10% of respondents reported that the violence and abuse against women and girls has slightly and fully reduced, respectively. As per quantitative results 93% of respondents reported that biogas has helped women to be involved in social and income generating activities. Again, 91% of respondents stated that using biogas for cooking reduced women's time to cook which women otherwise use for agriculture/IGA (71%), (adult) education (61%), social works (56%) and to spend with rest (41%).

4.5.3 Impact of biogas on households' energy expenditure

Reduction in households'' monthly energy expenditure is also another benefit users possibly enjoy from their biogas plants. Out of the surveyed biogas users, 57% of them reported that their monthly energy expenditure has reduced due to using biogas energy. The percentages of households who reported the same in Tigray, Amhara, Oromia and SNNP regions are 64%, 60%, 47% and 57% respectively. On average, households have saved about 110 ETB per month from their energy expenditure. The amount of money saved from household monthly energy expenditure for regions is ETB 127 for Tigray region; ETB 93 for Amhara region, ETB 126 for Oromia region and ETB 107 for SNNP region.

The proportion of biogas users who have reported their energy expenditure has reduced and the amount of money saved per month might seem low. However, it is not because firewood is not the dominant source of energy before the biogas. Rather, it shows that rural households not only purchase firewood from the market, (mostly) they also collect firewood from the forests by their own power without paying for it.

4.5.4 Impact of biogas on children's education and study time

By using biogas light, students have also an opportunity to study during evening and night. 65% of respondents reported that children begun to study in the evening and night which was not common in rural communities before the installation of the biogas plant. In Tigray region 51% of respondents, in Amhara region 58%, in Oromia region 92% and in SNNP region 66% of respondents expressed that their children became able to study their education during evening and night periods by using biogas lights.

As reported by survey respondents, the average study hours of children in the evening/during the night has improved from about 2 hours and 30 minutes to 3 hours and 20 minutes. That means children's study time in the evening and during the night by 50 minutes on average. The change varies from 30 minutes in Amhara region to an hour and 55 minutes in Oromia region. The changes in Tigray and SNNP regions are an hour and six minutes and an hour and 10 minutes respectively.

4.5.5 Impact of biogas on agricultural productively

The co-product of the biogas generation process is enriched organic compound which is perfect supplement to, or substitute for, chemical fertilizers. The fertilizers discharged from the digester can accelerate plant growth and resilience to disease, whereas commercial fertilizers contain chemicals that have toxic effects and can cause food poisoning, among other things. Bio-slurry is therefore an integral part of biogas operation that users seriously take in the decision making as well as operation of their biogas plants. Accordingly, biogas has significantly changed users' agricultural production as depicted in the table below.

Indicators	Tigray		Amhara		Oromia		SNNP		Total	
	Before	After	Before	After	Before	After	Before	After	Before	After
Area covered (hectare)	0.78	0.62	0.63	0.7	0.67	0.6	0.49	0.68	0.65	0.7
Chemical fertilizer used (kg)	69.58	64.24	96.11	94	198.5	79.08	51.94	62.43	105.2	77.52
Organic fertilizer used (kg)	79.8	114.5	30.5	219.3	32.7	231.8	139.1	132.4	69.5	181.9
Yield amount (quintal)	13.15	11.88	10.79	15.42	13.64	13.03	8.39	11.69	11.43	13.32
Productivity (area/yield)	16.85	19.16	17.12	22.02	20.35	21.71	17.12	17.19	17.58	19.02

Table 8: Impact of biogas on agricultural productivity

As shown in the table, biogas technology and the organic fertilizer farmers obtain as co-product has improved users' agricultural productivity from 17.58 quintals of product per hectare to 19.02 quintals of agricultural product per hectare. Demand for chemical fertilizer has also significantly reduced from 105 kilogram to 77.52 kilogram after the biogas. In contrast utilization of organic fertilizer for crop production has significantly improved from the average amount of 69 kilograms before the biogas to 181 kilograms after the biogas.

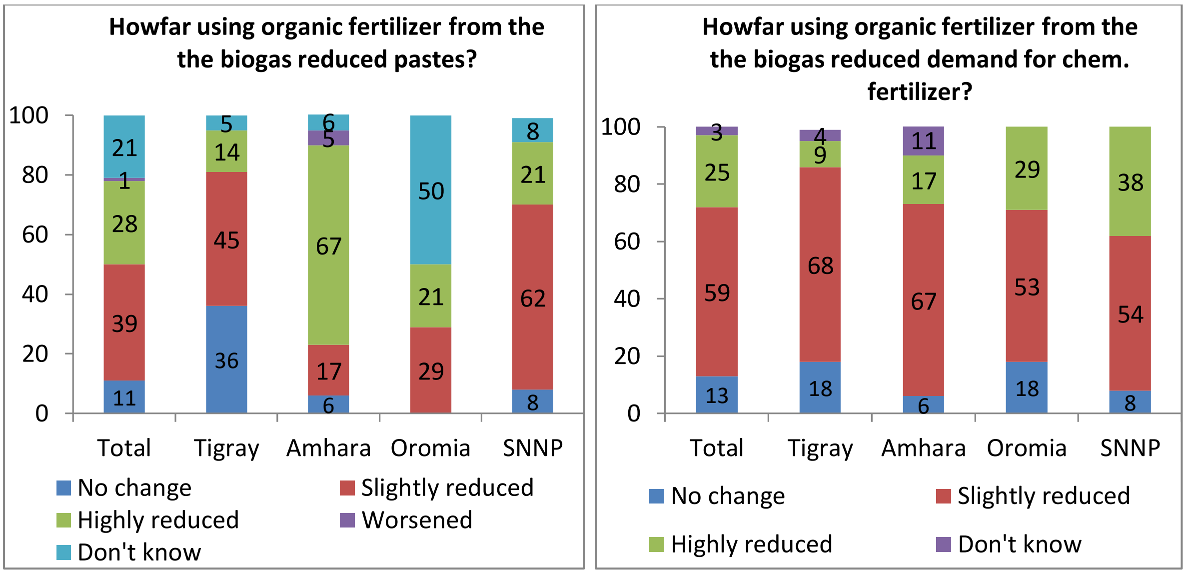


Figure 15: Impact of organic fertilizer

Biogas technology has also significant impact on intensification of pastes and demand for chemical fertilizers. The above couple of diagrams indicate to what level biogas reduces farm paste and demand for chemical fertilizer. As statistical figures show, 67% of organic fertilizer users reported that paste has reduced in their farm where they applied organic fertilizer and 84% of organic fertilizer users stated that demand for chemical fertilizers has reduces significantly. The impact of biogas technology in paste control is much appreciated in Amhara region where 67% of respondents reported that paste coverage has highly reduced.

4.5.6 Impact of biogas on creating employment opportunities

Alternatively, collection of fuel wood takes a big working time share in rural area and keep people (especially school going children and women) away from other productive pursuits. This way to reduce traditional biomass energy consumption can lead to saving time and offering better opportunities. Household members used to waste about 3 hours a week to collect firewood/animals dung. The person could distribute their saving time and utilize these couple of time for other productive purposes, including handy craft activities, agricultural activities, small business, livestock rearing, home gardening, better care to child education, recreation, etc.

Types of activities	Tigray	Amhara	Oromia	SNNP	Total
Education (adults education)	84.0%	52.8%	78.4%	36.4%	60.8%
To get rest	64.0%	24.5%	78.4%	15.2%	42.6%
For social works	72.0%	47.2%	81.1%	39.4%	58.1%
For agriculture	96.0%	54.7%	94.6%	51.5%	70.9%
IGAs (petty trade, handicrafts, etc)	4.0%	34.0%	27.0%	51.5%	31.1%

Table 9: Employment opportunities created as a result of biogas

Among other activities, as presented on the above table, 71% of respondents reported that they spend the time saved by using biogas energy mainly for agricultural production. It implies that, even involvement in agricultural activities by a family member is considered us unpaid family labour, it still has economic value that could be purchased from the labour market (the labour input by a family member) and from the products market (the product produced using family labour as an input). On the other hand, other 31% of respondents stated that using biogas energy for cooking and lighting as well as organic fertilizers creates an opportunity to engage in income generating activities such as petty trades and handicrafts. Among this females constitute about 32% of employment opportunities created.

4.6 Environmental impacts of biogas technology

It is evidenced that before they start using biogas, almost all (97%) of the households surveyed in the study use firewood as source of domestic energy. Dung cake, kerosene and charcoal are also important sources of household energy before the biogas.

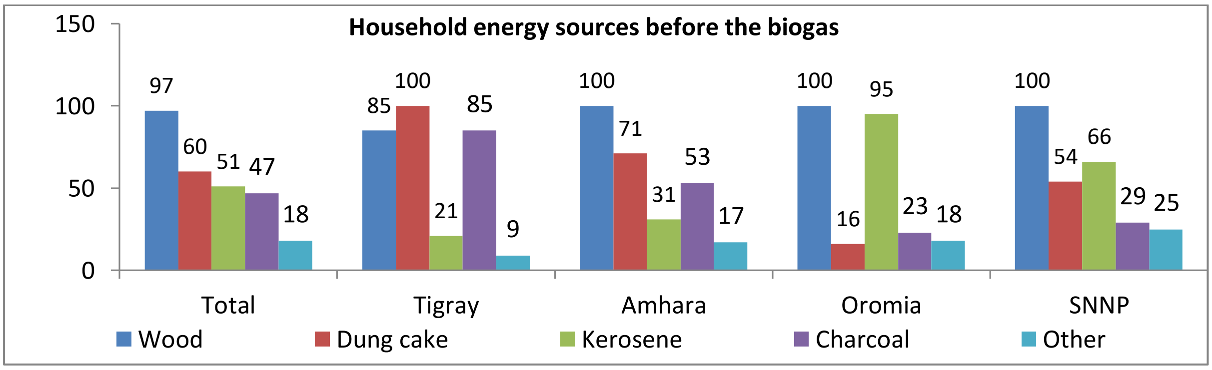


Figure 16: Household energy sources before the biogas

Those households using firewood as source of household energy were also asked from where they obtain firewood for domestic use. Most of households (74%) use won trees planted while other 59% use public (common area) forest and trees. Others also buy woods from private and governmental suppliers and 5% of respondents reported that they collect wood from protected government forests. These firewood users collect the wood in different forms including picking up dry twigs (84%), cutting of dead trees (68%), pruning of branches (67%), cutting of live trees (52%) and in other forms (6%). Here it is worrying to know that above half of the respondents use cutting of live trees as an option to get firewood, which contributes to environmental degradation and low productivity.

It is also interesting that biogas has reduced households' consumption of biomass which directly contributes for environmental protection and related positive outcomes. Overall, weekly consumption of firewood in survey areas is declined by 21% (from 73 kilograms to 60.5 kilograms per week). It seems that using biogas technology didn't bring significant decline it the amount of weekly firewood consumption and it is mainly because of households' demand for firewood for injera and related purposes. However, significant decline in using charcoal as energy source has been observed. Households' weekly demand for charcoal had declined by above three folds (from 19 kilograms to 4.7 kilograms per week). This can be explained straight forward by the fact that biogas energy can effectively substitute charcoal energy with the more safe and healthy energy source.

Biomass usage	Tigray		Amhara		Oromia		SNNP		Total	
	Before	After	Before	After	Before	After	Before	After	Before	After
Weekly firewood usage (kg)	74	56	75.5	64.5	69.5	62	71.5	58	73	60.5
Weekly charcoal usage (kg)	24.2	8.2	24.5	6	10.5	0.7	15	4.2	19	4.7

Reduction in Biomass Consumption					
Biomass type	Before	After	Reduction	Reduction/ Year, Kg	Reduction/Year, Kg - fuel wood equivalent (20%)[4]
Wood (kg/ week)	73	60.5	12.5	650	650
Charcoal (kg/week)	19	4.7	14.3	743	3,718
Total					4,368

Table 10: Households' biomass usage

The decline in biomass usage in survey regions also follow similar pattern. Due to inability of the existing biogas plants to be used for baking injera, almost all of the respondents use biomass as alternative source of energy along with the biogas. 78.3% of respondents reported that they use biomass for cooking sometimes while other 20% of respondents use biomass all the time.

Household respondents (48%) also stated that forest coverage is increasing in their locality. In contrary, 40% of other respondents claimed that forest coverage is reducing. Those who said forest coverage is increasing mentioned that expansion of alternative energy sources (95%), improving plantation (77%), and other factors contributed to the increasing trend of forest coverage in survey area. 73% of surveyed users also reported that other people are still cutting and using wood for fuel which further complicates environmental problems we are facing these days.

4.7 Users level of satisfaction from their biogas plant and its services

The beneficiaries only become satisfied when the biogas plant smoothly functions and the gas produced is sufficient, which is directly related to associated benefits like time saving in firewood collection, cooking, decrease in indoor smoke etc. Besides, the satisfaction is also directly linked with the post installation services. Surveyed households have been therefore asked about how far they are satisfied with the biogas and its related features and their responses are presented in the following diagrams.

[4] The conversion efficiency of conventional kilns are ranging 10 – 20 % (Wiskerke, 2008) and in some cases can go up to 30+ % (CDM, AMS-II.G. Version 10.0). In this case 20% conversion efficiency is used.

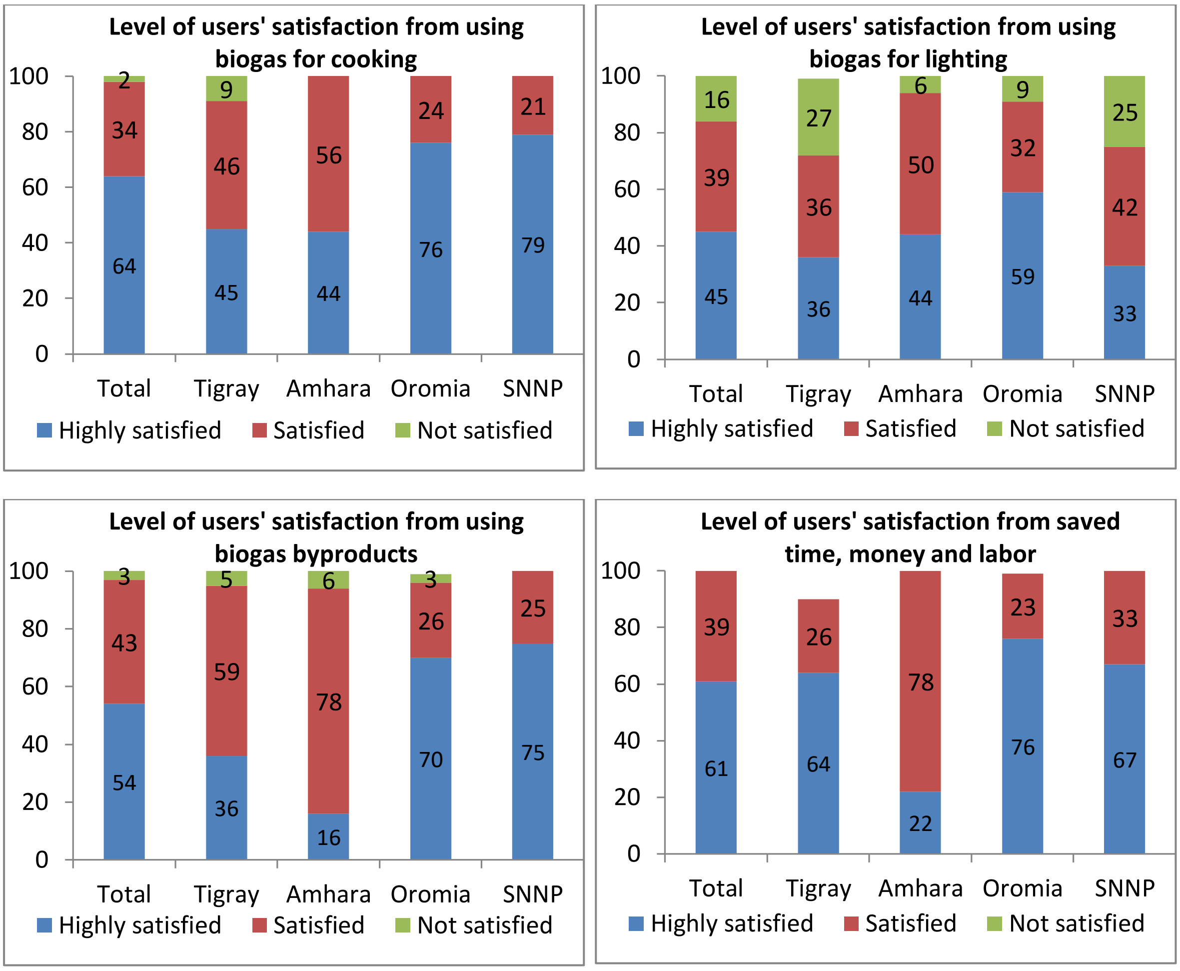


Figure 17: Users' level of satisfaction from biogas services

Regarding cooking services, 66.5% of respondents are highly satisfied while other 31.7% satisfied to some extent. Overall, about 98% of respondents have enjoyed a certain level of satisfaction from using biogas energy for cooking purposes. Only 2% of biogas users reacted that they are not totally satisfied from the cooking services of the biogas energy. Using biogas for lighting is, in contrary the benefit that significant proportions of users are dissatisfied about. While 45% of respondents reported that they are highly satisfied from the biogas light, other 39% are those who are satisfied to some level. The remaining 16% of respondents never satisfied with the biogas light.

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The government of Ethiopia is striving for rapid economic growth and better living standards of the people via poverty reduction and food self-sufficiency policies. Expansion of alternative energy sources is one of the accentuated developmental agendas of Ethiopia. In view of the fact that biogas is one of the alternative renewable energy sources, the Ethiopian government of had launched consecutive 5-year biogas programs since 2009 with the aim of promoting biogas energy for domestic uses. Until April 11, 2019, a total of 23,802 household size bio-digesters were constructed. This Biogas Users Survey was conducted with the aim of collecting relevant data to evaluate the impact of domestic biogas digester installations as experienced or perceived by the users.

Survey findings show that biogas users installed biogas plants with 4, 6, 8 and 10 m3 sizes on the basis of shared investment scheme with the government to cover construction costs. Local biogas adopters need to cover rest of the work, which is estimated to be half of the price of a biogas plant. From the survey, it’s found that 79% of installed biogas plants are functional with different degrees of functionality. 30% of the systems are functioning without significant problem, 22% are functioning with minor problems and other 27% are functioning, but with major problems. 21% of the plants are found totally not functional. Most of the stated problems associated to mal-functionality of the biogas plants include problems with appliances, pipes, fittings and valves, lack of skills to operate the biogas, lack of spare parts to replace broken appliances, crack down of bio-digesters, lack of inputs, etc. lack of inputs and adequate after-sale services are also areas which require due concern with program implementers.

Biogas technology has significant potential to mitigate several problems related to ecological imbalance, minimizing crucial fuel demand, improving hygiene and health, and thus, resulting in an overall improvement in the quality of life in rural and semi-urban areas. In the study it is found that biogas technology has brought significant positive changes in the socioeconomic conditions of rural households and supports environmental protection efforts. It helped users to improve their health condition, reduced women and children work burden allowed them to be involved valuable economic/social activities. It also significantly reduced their vulnerability for violence and helped children to study their education for longer time in the evening and during the night using biogas light. Biogas has reduced expenditures households incur for energy as well as chemical fertilizer and improved farmers’ agricultural productivity. It also reduced households’ woody biomass consumption. Most of surveyed biogas users are also satisfied with the benefits of the biogas energy.

5.2 Recommendations

Information dissemination and awareness creation: access to and utilization of alternative and renewable energy sources is at an infant stage in the country and the majority of rural population still depends on woody biomass for energy needs. Coupled with growing population pressure and environmental depletion, there is a great opportunity to promote and expand biogas technology in rural communities as renewable and sustainable source of energy. However, the potentials of this new technology don't seem well-internalized not alone by the communities, even by the current biogas users. As survey results revealed, information dissemination efforts are insufficient and available information sources are very limited. Awareness helps potential users to have complete information and make informed decisions to use biogas which in turn will have direct implication on the performance and functionality of the biogas after the construction. Hence it is important to consider all available channels, especially with wider coverage such as national and local mass media to promote the technology and build community awareness.

Users' trainings are critical: the technology is generally new and the effort is to promote this new technology in rural and semi-urban areas, where educated manpower is scarce. There is no also accumulated/capitalized knowledge and experience regarding this technology at community level in rural societies, because the technology is introduced very recently. As study results indicated, the proportion of respondents that haven't received any kind of training (except the post-construction orientation) is very large. Hence, due attention should be given to pre-construction and post-construction trainings tailored with the specific needs of rural communities. Refresher trainings and experience sharing visits must also be integral parts of the users' capacity building efforts. Standardized training manuals should be available to training facilitators and periodic training programs should be organized to the current biogas users. Model biogas users could also be identified in every village and use their potential to train other users at grassroots level.

Provide adequate after-sale services: no matter what the level of support from the government and other stakeholders is, the performance of the biogas plants and their functionality ultimately depends on the users' commitment and capability to use the technology. However, considering the educational level of family heads/family members in rural communities, biogas users can hardly address all the problems and issues emerged with their biogas system by themselves. So they need continuous follow-up and support to make them effectively operate their biogas system and enjoy its benefits to the maximum possible level. However, as discussed with program implementers in survey areas, the emphasis given to attract new biogas users to join the program is much higher than the attention given to the existing biogas users, which is somehow contradicting. Caution must be taken not to push as much current biogas users as newly attracted users. Significant number of respondents reported that they haven't received important after-sale services or they were not satisfied with the services provided.

Improve accessibility of spare parts and appliances: since the biogas sub-sector is underdeveloped and at an infant stage in the country, so far it doesn't develop the market that supply materials and spare parts, which calls strong hands of the government and all relevant stakeholders to fill the market gap. As evidenced from survey results, the performance and functionality of existing biogas plants are highly compromised due to unavailability of necessary spare parts and materials locally. When the owners are not able to use their biogas for intended purposes properly (mostly due to lack of materials and spare parts), they lack interest to maintain the functionality of their biogas and gradually they might cease feeding and operating it. Hence, it is critical to find the mechanism through which biogas-related materials and parts are accessible to rural communities easily.

Improve local infrastructure and capacity of technicians at woreda level: woreda technicians are the most important actors in serving the biogas users at grassroots level, as they are at the lowest structure of the program and have direct contact with biogas users. As mentioned by respondents, woreda technicians are the one who provided after-sale services to the majority of biogas users, not masons or BCEs. At the same time, it has been observed that significant numbers of respondents were not satisfied with the services they received, mainly due to unavailability of service providers (masons/BCEs) whenever they need the services. From woreda technicians, it has also been reflected that, the current infrastructure and capacity of the woreda offices are not adequate to accommodate the growing demand for services from biogas users. Capacities of woreda offices in terms of logistics, structures and systems need to be strengthened to enhance ensure after-sale services are delivered properly by masons/BCEs and effective monitoring and follow-up mechanisms are in place. Existing technicians also need refresher trainings skill enhancement exposures to better serve the biogas users.

Strengthen existing information and communication system: For such newly introduced technologies with large expansion prospects, effective service delivery system and communication mechanisms are required. Information must be collected continuously, analysed properly and utilized effectively, especially at regional level. The existing users' database needs to be updated and should including the functionality status of biogas plants. Appropriate and sufficient supervision and monitoring system should be in place by SNV to make sure that the services provided in the field comply with the standards set at the PID. Lower level structures complain that the responses from higher level structures of the program are usually inadequate. The monitoring is particularly needed to make sure that the services promised to biogas users in the PID reach the users in reality.

Annexes

1. References

Boers W, Workneh K, Esthete G. National biogas programme ethiopia programme implementation document. 2008.

CDM, AMS-II.G. Small-scale Methodology: Energy efficiency measures in thermal applications of non-renewable biomass, Version 10.0

CSA. Annual agricultural sample survey 2012/2013: livestock and livestock characteristics, 2; 2012.

CSA. Annual agricultural sample survey 2012/2013: farm management practices. 2013.

CSA, Population Projection of Ethiopia for All Regions At Wereda Level from 2014 - 2017. Addis Ababa : CSA.

Esthete G, Sonder K, ter Heegde F. Report on the feasibility study of a national programme for domestic biogas in Ethiopia. 2006.

Federal Democratic Republic of Ethiopia, Climate-Resilient Green Economy (CRGE) Strategy, Addis Ababa, 2011

Gebreegziabher Z. Household fuel consumption and resource use in rural–urban Ethiopia. Wageningen: Wageningen University; 2007.

Gebreegziabher Z. Interview with Dr. Zenebe Gebreegziabher, Senior Research Fellow at EDRI; 2014.

IEA. Ethiopia's Final Consumption ((2011)), ⟨http://www.iea.org/Sankey/index.html#?c=Ethiopia&s=Finalconsumption; 2014

NL Agency, Making charcoal production in Sub Sahara Africa sustainable, NL Energy and Climate Change, The Netherlands, December 2010.

Simons L. Fortune Cooker: Leon Simons at TEDxUtrechtUniversity. Utrecht, The Netherlands: TEDx Utrecht University; 2012.

Wiskerke, W. (2008). Towards a sustainable biomass energy supply for rural livelihoods in semi-arid areas. Shinyaya, Utrecht, University of Utrecht.

Wolde-Ghiorgis W. Renewable energy for rural development in Ethiopia: the case for new energy policies and institutional reform. Energy Policy 2002;30:1095–105. http://dx.doi.org/10.1016/S0301-4215(02)00061-7.

Worku M. Interview with Mogues Worku, Executive Director of LEM – Ethiopia; 2014.

2. Data collection tools

SNV NETHERLANDS DEVELOPMENT ORGANIZATION
[BIOGAS USERS' SURVEY (BUS)]
[NATIONAL BIOGAS PROGRAM OF ETHIOPIA]
[JANUARY 2019]

QUESTIONNAIRE IDENTIFICATION NUMBER

[____|____|____|____|____]

Introduction:

"My name is **[name of the enumerator]** and I'm working for MoWIE, NBPE and we're interviewing people here in your locality in order to find out information from biogas users about the performance of biogas digesters, maintenance service, satisfaction level of program participants, etc.. The survey will help the program obtain timely and relevant information to be used for future interventions in order to improve the benefits of using biogas technology to the users and farther the effectiveness of the program."

Confidentiality and consent:

As you are a biogas user, I'm going to ask you some questions. Your answers are completely confidential and will never be used for purposes other than biogas program improvement endeavors. your honest answers to these questions will help us better understand the existing situation regarding effectiveness of biogas technology in your locality. We would greatly appreciate your help in responding to this survey. The survey will take about 45 minutes. Would you be willing to participate?"

____

(Signature of interviewer certifying that informed consent has been given verbally by respondent)

INTERVIEWER'S INFORMATION	
Name of interviewer	
Date of the interview	
Time of the interview	Started [_______] Ended [_______]
Signature of the interviewer	
Name of the supervisor	
Signature of the supervisor	

0	**RESPONDENT'S/OWNER'S PROFILE**			
001	Region	Region Code	[__|__]	
002	Zone	Zone Code	[__|__]	
003	Woreda	Woreda Code	[__|__]	
004	Kebele			
005	Name of the respondent			
006	Sex of the respondent	Male Female	1 2	
007	Age of the respondent	Age in years	[____]	
008	Contact information (mobile)			
008	Are you the head of the household	Yes No	1 2	→ 016
011	If no, what is your relation with the head of the household?	Wife/husband Parent (mother/father) Offspring (son/daughter) Other relative Hired worker Other___________________________________	1 2 3 4 5 6	
012	If no, what is the name of head of the household			
013	Sex of head of the household	Male Female	1 2	
014	Telephone (mobile)			
015	Is the head of the household currently living in the household?	Yes No	1 2	
016	If no what is the reason?	Not alive/dead Temporarily living in other place Permanently living in other place (in Ethiopia) Permanently living in other place (abroad) Other___________________________________	1 2 3 4 5	
	BIOGAS PLANT DETAILS			
016	Biogas plant id. no.:			
017	Biogas plant size (m3)	4 m^3 6 m^3 8 m^3 10 m^3	1 2 3 4	
	Biogas plant type	Sinidu Sinidu 2008 SSD BSD	1 2 3 4	
018	Year of construction	Year (EC)	[______]	
019	Plant installed by (name of the company/mason)			

No.	Questions and Filters	Coding categories		Skip to
1	**GENERAL INFORMATION**			
101	Type of the household	Male headed Female headed Child headed Others, specify ______________________________	1 2 3 4	
102	Number of family members currently living in the household by age and sex	<18 years Male Female	[__|__] [__|__]	
		18 – 65 years Male Female	[__|__] [__|__]	
		> 65 years Male Female	[__|__] [__|__]	
103	Educational status of household members	Illiterate Read and write (informal education) Up to grade 4 Grades 4 – 8 Grades 8 – 12 Above grade 12	[__|__] [__|__] [__|__] [__|__] [__|__] [__|__]	
104	Household's major means of livelihood (multiple answers possible)	Agriculture Service/Job holder/employed Business owner/self-employed Daily laborer Other, specify ______________________________	1 2 3 4 5	
105	Is your house connected with electricity?	Yes No	1 2	 → 107
106	If Yes, what is the source of the electric power?	Electric grid Solar PV Other ________________________	1 2 3	
107	Do you (your household) have a toilet?	Yes _______________ No, we use open space (backyard and forest)	1 2	
2	**BIOGAS PLANT CONSTRUCTION AND DECISION MAKING**			
201	How did you know first about biogas? (multiple answers possible)	Promotional brochure/poster Village workshop, community conversation, etc. From Woreda offices/technicians/Das/Promotors From kebele offices/technician From an NGO/CBO From mason/BCE From community leaders From friends/relatives Other biogas owners Other: _____________________________________	1 2 3 4 5 6 7 8 9 10	
202	Why did you decide to install a biogas plant? (multiple answers possible)	To get subsidy Because it is difficult to find wood and charcoal Because loan (from MFIs etc.) is available To make cooking more convenient To use biogas for lighting To avoid burning dung and use it as manure To have good fertilizer To save money To improve sanitation To improve family health Other, specify _______________________________	 1 2 3 4 5 6 7 8 9	

No.	Questions and Filters	Coding categories		Skip to
203	Who in your family took the decision to install a biogas plant?	The head of household, male member The head of household, female member Son or daughter After discussions between husband and wife After discussions in the family Other: ____________________	1 2 3 4 5 6	
204	How much money did the construction cost in total? (with estimation of cost of appliances and accessories)	Total construction cost in birr I don't know	[_____] 0	
205	What and how much did you contribute to the construction of your biogas plant? (multiple answers possible)	Cash Labor (man-day) Materials Transportation service Other, specify ____________________ I did not pay any (did not contribute any)	[_____] [_____] [_____] [_____] [_____] 00	
206	Did the government cover or contribute (cash or kind) to help you construct the biogas plant?	Yes No Don't know	1 2 3	 → 209
207	If yes, what and how much did the government contribute to the construction of your biogas plant? More than one response possible	Cash Masson/technician Material Transportation service	[_____] [_____] [_____] [_____]	
208	If you received material support, please list	Cement Sand Bricks Iron bars Other, specify____________________ I don't know	1 2 3 4 5 0	
209	Did you take loan to install the plant?	Yes No	1 2	 → 301
210	If yes, who provided you the loan?	Family member or friend Bank/ MFIs Savings and Credit coop/union Government Other____________________	1 2 3 4 5	
211	If you took loan, how much did you borrow?	Money borrowed (in birr) Don't know	[_____] 0	
212	If you had borrowed, what is the repayment status?	Fully paid back Repayment started, going as planned Repayment not started until now Repayment schedule not fixed, it is open	1 2 3 4	
213	If you did not complete the repayment, how long will you be repaying?	Remaining repayment periods (months) I do not know	[_____] 2	
214	If you are not repaying, why not?	The repayment schedule is not clear and fixed I have not money to pay back I expect the lender will cancel it one day Other____________________ No response	1 2 3 4 5	
3	**BIOGAS PLANT FUNCTIONALITY AND PERFORMANCE**			
301	Are the biogas plant and its appliances currently functional?	Yes all functions (cooking and lighting) Partially working (only cooking) Partially working (only lighting) Not functional at all	1 2 3 4	 → 304 → 304 → 305

No.	Questions and Filters	Coding categories		Skip to
302	If not functional at all, since when is not functioning?	Starting from the date installed Within 6 months of functionality After 6 months of functionality After 12 months of functionality After two years of functionality After three years of functionality	1 2 3 4 5 6	
303	What are the main causes for the non-functionality of the biogas system? (multiple answers possible)	Unavailability of animal dung Unavailability of water The biogas unit cracked Water in the pipeline Lack of spare parts (pipelines, lamp, etc.) Other technical problems Lack of know-how to operate the system Don't know	1 2 3 4 5 6 7 8	
306	If functional/partially (for cooking), what do you cook using the biogas energy alone? (multiple response possible)	Only Wat (sauce) Only Coffee/water Only Injera Only Bread Everything I want	1 2 3 4 5	
307	If you cook only part of your food and drink materials, what is the reason?	System not installed I do not have materials There is no enough biogas energy to cook all I do not know if it was possible	1 2 3 4	
	What is the level of gas generated at the time of interview (by direct observation)	0 – 5 5 – 7 7 – 10 No reading (meter not functional)	1 2 3 4	
308	How many light bulbs do you have in your house?	# of bulbs daily working by the biogas light	[_____]	
309	What is your source of water?	Tap water in my compound Community tap payable waterline (bono) Underground water in my compound Underground water in the community Lake, river, springs Other__________________________	1 2 3 4 5 6	
310	If your source of water is outside of your home, how long will it take you to reach the nearest water source?	Minutes I don't know	[_____] 2	
311	If you have a toilet, is it connected to the biogas plant?	Yes No	1 2	→ 317
312	If not, what is the reason?	We did not realize it was possible Mason/company did not suggest Extra cost burden Fear of foul smell Socio-cultural reasons Fear of health problems from the slurry Other: ______________________________	1 2 3 4 5 6 7	
313	Do you think there are/ would be any problems from attaching toilets to biogas plants?	I don't think Yes, I think it's not clean/hygienic Yes, I think it's unsophisticated and primitive Yes, I would not like to handle the bio-slurry Yes, the gas would be dirty and affect our food	1 2 3 4 5	

No.	Questions and Filters	Coding categories		Skip to
314	Number of livestock currently owned by the household and kept in the barn close to the household	Cow/oxen Sheep/goats Equines (horse, donkey) Others (specify)	[_____] [_____] [_____] [_____]	
315	How frequently and how much are you feeding biomass and water to your biogas plant? (if required ask the amount in buckets and convert to kg. approximately)	Twice a day (kg) Once a day (kg) Every other day (kg) Once a week (kg) Others (specify) ____________________________	[_____] [_____] [_____] [_____] [_____]	
316	Why do you feed the plant by the above intervals?	That is the capacity of the plant That is the volume of input available to the plant Other	1 2 3	
317	Who often (as a regular duty) feeds the biogas digester with water and biomass?	Adult Male Adult Female Children (girls) Children (boys) Whoever has time and assigned	1 2 3 4 5	
318	Do you use all available animal dung to generate biogas?	Yes No	1 2	→ 326
319	If not, why not?	The biogas I am producing is sufficient I use animal dungs for other purposes like manure/compost and marketing I have no labor to carry on all animal dungs, mix with water and use it I have no enough water to mix and dilute more dungs than this amount Other______________________________________	1 2 3 4 5	
320	Do you sell animal dungs (dry or wet)?	Yes No	1 2	
321	For what other purposes do you use animal dungs and wastes?	I use it as organic fertilizer (compost) It is not used, just wasted I give it to other people just to clean the barn Others, (specify)_____________________________	1 2 3 4	
322	How many bio-slurry pits do your bio-digester has? (direct observation)	# of bio-slurry pits	[_____]	
323	How frequently the pits get filled?	In a week In two weeks In three weeks In a month	1 2 3 4	
324	How much kg. of compost/slurry is being ready every month? You can ask the amount in donkey load and then convert into kgs.	Slurry: Amount (liters) Slurry: Amount (jerry can) Compost: Amount (kg) Compost: Amount (donkey load)	[_____] [_____] [_____] [_____]	
325	What do you do with the biogas byproduct (bio-slurry)?	Use for vegetable production (organic fertilizer) I dry it and used as a cooking fuel (dry material) Sell to others who need it Do not use it. It flows out, gets dry and wasted	1 2 3 4	
326	If you are selling slurry or compost, then how much and at what price?	(see table below)		

Items	Kg./liter sold	% of total produced (approx.)	Price (birr/kg of liter)
Slurry			
Compost			

No.	Questions and Filters	Coding categories		Skip to
4	**USERS' TRAINING AND AFTER-SALE SERVICES**			
401	Has anyone in your family received training on how to operate and maintain the biogas system?	Yes, there was sufficient training on the plant parts, systems and maintenance related issues Training was given but not sufficient Training was given but no reference materials Yes, oral explanation given by mason Yes, oral explanation by Woreda technician Yes, in village session only No training received at all	1 2 3 4 5 6 7	
402	If yes, by whom the training was provided?	By the mason/BCEs By woreda tecnicians/Das, Promotors Other biogas user/s Other, specify_______________________________ Don't know	1 2 3 4 5	
403	Who organized the training?	Woreda office NGO/CBO Other, specify_______________________________ Don't know	1 2 3 4	
404	Which main topics were covered by the training? (multiple answers possible)	Uses of the biogas energy How to operate the biogas How to maintain the biogas system How to use the bio-slurry How to get technical support from gov't offices Other, specify_______________________________ Other, specify_______________________________ Don't know	1 2 3 4 5 6 7 8	
405	Did you get the training important to effectively use your biogas plant?	Yes No Don't know	1 2 3	
406	Which documents did you receive from the program?	Poster/booklets Warrantee certificate User manual Other, specify: _____________________________	1 2 3 4	
407	Did you get after-sale services for your biogas plant after the completion of the construction?	Yes No Don't know	1 2 3	
408	What kind of after-sale services you got?	Training Counseling/follow-up Maintenance Appliances and spare parts Periodic system check-up Other, specify_______________________________	1 2 3 4 5 6	
409	If yes, by whom the services are provided?	Woreda technicians Mason/BCE Other biogas users Other, specify_______________________________	1 2 3 4	

<table>
<tr><th>No.</th><th>Questions and Filters</th><th>Coding categories</th><th>Skip to</th></tr>
<tr><td>410</td><td>How frequently after-sale service providers come to visit the plant?</td><td>Daily 1
Weekly 2
Monthly 3
Quarterly 4
Biannually 5
Annually 6
Never came 7
Other____ 8</td><td></td></tr>
<tr><td>411</td><td>If you have a problem with biogas system, who would you contact?</td><td>Don’t know 1
Village chief 2
The mason 3
Woreda technician 4
Office of Water & electricity technician 5
Other: ______________________ 6</td><td></td></tr>
<tr><td>412</td><td>Are you satisfied with the technical assistances provided to you?</td><td>Yes 1
no 2</td><td></td></tr>
<tr><td>413</td><td>If no, what are the problems you faced?</td><td>They are not available/accessible when I need them for help 1
They don’t come promptly after I report a problem 2
The services they provide are not effective due to capacity problem 3
They don’t have spare parts to replace broken ones 4
Other, specify________________________________ 5</td><td></td></tr>
<tr><td>5</td><td colspan="2">IMPACTS OF BIOGAS ON HEALTH AND SOCIO-ECONOMIC OUTCOMES OF USERS</td><td></td></tr>
<tr><td>501</td><td>Before the biogas plant, did you or any of your family get health problems because of firewood, dung and conventional energy smokes?</td><td>Yes, I and my family have such experiences 1
No, I and my family have no experiences 2</td><td>→ 403</td></tr>
<tr><td>502</td><td>If your answer is yes, what was the problem (injury)? (Multiple response possible</td><td>Suffocation by smoke 1
Burning 2
Fire accident, loss of property 3</td><td></td></tr>
<tr><td>503</td><td>Did you observe any positive impact of biogas on the health condition of members of your household?</td><td>No significant impact observed 1
Yes positive impacts observed 2
I don’t know 3</td><td></td></tr>
<tr><td>504</td><td>If yes, to what extent has the biogas plant contributed to your family health and fire hazard?</td><td colspan="2"><table>
<tr><th>Disease Incidence</th><th>Radically Reduced</th><th>Reduced</th><th>Not Reduced</th><th>Don’t Know</th></tr>
<tr><td>Eye infection diseases</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Respiratory</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Cough</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Fire related injury</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Mosquito caused diseases</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Nuisance</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Other _________________</td><td></td><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>505</td><td>If health problems not completely avoided, why do you think the smoke is not reduced?</td><td>Still using firewood, dung, etc. in parallel 1
When biogas is not sufficient and runs out, firewood, dung, etc. is used to cook 2
Others, specify 3</td><td></td></tr>
<tr><td>506</td><td>Before the biogas, did you use animals dung/dung cake as your source of energy?</td><td>Yes 1
No 2
I don’t know 3</td><td>→ 408</td></tr>
</table>

No.	Questions and Filters	Coding categories		Skip to
507	If yes, what were the impacts of preparing dung? (Multiple response possible)	Takes long time & compete with other activities including schooling It has sanitation and hygiene related problems We used to carry long distances to dispose Other ___________________	1 2 3 4	
508	Have any members of your family suffered from biogas originated fire accidents during last 12 Months?	Yes No	1 2	 → 412
509	Before the biogas, did you use firewood as your source of energy?	Yes No I don't know	1 2 3	
510	If yes, who did mostly collect the firewood?	Adult Male Adult Female Both Children (girls) Children (boys)	1 2 3 4 5	
511	If Yes, how long did it take to collect the firewood in a day?	≤ 1 hour 1 – 3 hours 3 – 6 hours 6 – 9 hours It takes the whole day	1 2 3 4 5	
512	What problems and disadvantages have you and your family being experienced during wood, dung cake and other biomass collection and transportation? (multiple answers possible)	Children and women had extra burdens Girls & women were exposed to abuse & violence Injuries while collecting and carrying wood Exposed to wild animal attacks Children used to be late from school, shortage of time for study Children stay without food and water in forests	1 2 3 4 5 6	
513	To what extent has abuses and violence against girls and women reduced because of the biogas plant?	Totally avoided (removed) Significantly reduced Reduced Remained the same	1 2 3 4	
514	To what extent has the biogas plant helped women to engage in social and productive activities?	Significantly assisted Moderately assisted Remained the same	1 2 3	
515	Do you save any time by cooking with your biogas stove instead of wood or charcoal?	Yes No	1 2	 → 416
516	If yes, how much time did you save?	Time saved (minutes per day) Don't know/no response	[_____] 0	
517	How do the family members use time saved due to biogas installation? (multiple answers possible)	Literacy classes Recreation Social works Agricultural Work Study Income Generating Activity	1 2 3 4 5 6	
518	Do you save any money by cooking with your biogas stove instead of wood or charcoal?	Yes No	1 2	 → 419
519	If yes, how much money did you save?	Birr saved per month Don't know/no response	[_____] 0	
520	Do your children study in the evening and night without limit using the biogas light?	Yes Sometimes yes, because there is shortage of energy No	1 2 3	

No.	Questions and Filters	Coding categories		Skip to
521	How long do you children study using the biogas light?	They study until they are tired They study until mid-night and starting early in the morning They study only until family affairs including eating finished	1 2 3	
522	For how many hours do your children study in the evening	Study hours BEFORE the biogas (hrs.) Study hours AFTER the biogas (hrs.)	[____] [____]	
523	Using the table below, record what and how much were the three major crops the user produced with/without chemical/organic fertilizer before and after the biogas.			

Before the biogas					After the biogas				
Crop	Area (hctr.)	Fertilizer used (kg)		Yield (quintal)	Crop	Area (hctr.)	Fertilizer used (kg)		Yield (quintal)
		Chem.	Orgn.				Chem.	Orgn.	

No.	Questions and Filters	Coding categories		Skip to
524	What are the impacts of slurry manure application on the incidences of insects and diseases on crops?	No Effect Decreased a little Decreased greatly Don't know	1 2 3 4	
525	Have you decreased the use of chemical fertilizers after you install your biogas system?	No Decreased a little Decreased greatly Don't know	1 2 3 4	
6	**LOCAL/GLOBAL ENVIRONMENTAL IMPACT OF BIOGAS**			
601	What were your sources of domestic energy (cooking, lighting and heating) before the biogas plant? (Multiple response possible)	Wood Dung cake Kerosene LPG Electricity Other sources, specify _______________	1 2 3 4 5 6	
602	If you used to collect and use wood as energy sources, what were the sources of the wood?	Own trees planted Public (common area) forest and trees Government forest (protected) Buying from private and government forest	1 2 3 4	
603	If you used firewood before biogas, how did you collect firewood? (multiple answers possible)	Pick up dry twigs Pruning of branches Cutting of live trees Cutting of dead trees	1 2 3 4	
604	What is the estimated amount of woody biomass you use for your domestic cooking and lighting energy? (ask them daily consumption and change to month if it is easier)	(see table below)		

Items (expenses/month)	Before the biogas	Current
Wood (human/animal load)		
Charcoal (sack)		

No.	Questions and Filters	Coding categories		Skip to
605	Has your total energy expenditure reduced since your biogas system was installed?	Yes No	1 2	 → 507
606	If yes, how much it was reduced?	Birr per month Don't know/unable to estimate	[_____] 0	
607	Do you still use wood, dung or charcoal for cooking?	Yes, I always use wood, dung or charcoal to cook Yes, sometimes I use a wood, dung or charcoal to cook No, I fully cook with biogas	1 2 3	 → 509

No.	Questions and Filters	Coding categories		Skip to
608	Why do you still use wood, dung cake or charcoal for cooking?	Because there is no enough biogas to cooking even small things	1	
		Because the biogas energy is not helpful to bake injera and bread	2	
		Because I need wood/dung cake/ charcoal to prepare some special dishes (e.g. grilling meat) or liquor	3	
609	How has the forest or tree coverage changed over past years in your surrounding (the source of firewood or charcoal)?	Increased	1	
		Decreased	2	→ 511
		The same	3	→ 511
610	If your answer is increasing forest cover, what are the main reasons? (Multiple response possible)	Increasing # of households are using alternative energy sources	1	
		More trees are being planted and lands are closed	2	
		Individuals plant trees every year on their lands	3	
		All are causes for increased forest cover	4	
611	Do other people from your neighbor cut and use wood for their energy needs?	Yes	1	
		No	2	
7	**BIOGAS USERS SATISFUCTION FROM THE PROGRAM**			
701	Is your biogas system properly functioning?	Yes, without a problem	1	→ 603
		Yes, but with some minor problems	2	
		Yes, but with some major problems	3	
		Not functional at all	4	→ 603
702	If **Yes, but with some minor/major problems,** what are these problems you are facing with your plant?	Shortage of water	1	
		Shortage of animal dung	2	
		Shortage of other biomasses to feed the plant	3	
		Lack of technical skill expert to maintain the system	4	
		Lack of money to maintain the system Not interested to function it	5	
703	What are the main advantages of the biogas compared to conventional fuel (e.g.: wood)? (More than one possible answer)	Cooking is faster	1	
		Cooking is more convenient	2	
		Kitchen is cleaner	3	
		Cleaning dishes is easier/faster	4	
		Less problems from smoke	5	
		Don't need to collect wood or prepare dung cake	6	
		Absence of abuse and violence against girls and women	7	
		Others: ___________________________	8	
704	How much you are satisfied with your biogas plant? **1= not satisfied, 2= partially satisfied, 3= fully satisfied**	(see table below)		

Satisfaction with the plant	1	2	3
Cooking service			
Lighting service			
Slurry use			
Time saving			
Health benefits			
Environmental benefits			

No.	Questions and Filters	Coding categories		Skip to
705	If not fully satisfied, what are the reasons for not being fully satisfied? **(answers can be more than one)**	Insufficient gas for cooking/lighting Energy need not met fully from the biogas Difficult to operate Frequently encounter technical problems Creates more chore in collecting dung and water Food cooked by biogas is not tasty Post-construction service is not given Lack of spare parts and appliance in the market Others: ________________________________	1 2 3 4 5 6 7 8 9	
706	What do you think about the cost of your biogas system compared to its benefits to you?	The cost is ok, because I get great benefits from the same It is expensive compared to the benefits The cost is insignificant compared to the benefits	1 2 3	
707	GPS reading	Latitude Longitude	[____] [____]	
708	Photograph of the respondent and the biogas plant			

Focus Group Discussion Guiding Questions

What are the sources of information and the status of public awareness about biogas technology?

Probe: *Who and how provide information about biogas technology in the locality? How far the information is relevant and the means is appropriate?*

How a decision to have a biogas plant is made and how was the construction process?

Probe: *Why and who decides to have a biogas plant in your households? How did communities finance the construction of the plant? Which inputs were difficult to get and how did you manage to get them? Are there financial facilities providing loan/credit services to help biogas plant construction in your locality? Is the credit/loan service adequate and relevant?*

How far biogas plants are functional and serving energy needs in the locality?

Probe: *For what purposes biogas energy is being used mostly by users? Is there a difference among family members in using the biogas energy for their particular purposes (for example women for cooking, men and children for lighting)? How much bio-slurry biogas users produce? For what purposes bio-slurry is being used in the locality? What are the advantages of using the bio-slurry? Are toilets attached to biogas plants in the locality? If yes how it is helpful? If not, why? How do you evaluate the training, follow-up and technical support provision efforts by the woreda technician and the mason? What are major problems with biogas plants related to feeding, repair, etc.? How do you manage solving these problems?*

Benefits from using biogas plants and users' satisfaction level

Probe: *What major benefits people get from using biogas plants (from lighting, cooking, fertilizer, and etc. points of views in terms of money, time, health, environment, productivity, etc.. Before/after comparison is important)? Are people generally satisfied with these benefits from their biogas plants? If yes, how? If not, why not? Do biogas plant owners still use other traditional energy sources like fuel wood, dung, etc.? If yes, why? Do you observe any health problems or improvements in health condition in your household from using biogas? What are the impacts of biogas energy on agricultural production, children's education, women's participation in social as well as economic activities? Do you still use biomasses for our energy needs? How much? Why? How do you observe the impacts of biogas energy in improving environmental condition? How far you are satisfied with biogas technology? What are factors for user's satisfaction?*

Do you have any additional comments?

Probe: *What are your suggestions to the program to convince other farmers to invest for this biogas system? Do you have any other suggestions for improving the biogas program?*

KII Guiding questions

1. What is the mission of your organization in serving people in this area?
2. What your organization does, particularly with regards to Biogas Technology?
3. What is the relationship between your organization and the MoWIE regarding the national biogas program design, planning and implementation and monitoring?
4. If you have any information, how far people in this locality are using biogas technology?
5. What positive impacts have been observed in the lives of people in this area?
6. What your organization does in promoting the technology and maximizing positive impacts of biogas in this locality?
7. How do you evaluate the performance of the biogas program in Ethiopia (successes and gaps)?
8. What do you think are the reasons for success and factors that hindered the successful implementation of the program (if not to your level of expectation and to its program plan and budget)?
9. To what extent has the GoE/MoWIE/NBPE used your products and services to effectively and efficiently implement and manage the biogas program?
10. What are the challenges and opportunities of promoting biogas technology in this area?
11. Considering the current biogas technology and its demand as a renewable energy sources, food security, public health and related social and climatic benefits as well as based on your experience, what do you recommend to GoE so that it can make the utmost benefit out of this technology?

3. Survey Methodology

Defining the survey population

Our survey population, from which we are draw our sample households constitutes:

- Households in Amhara, Oromia, Tigray and SNNP regional states (survey regions)
- With bio-digester plants built with the support of NBPE
- With biogas plants constructed in the period 2015 – 2017

According to project documents, a total of 7,802 bio-digesters were constructed in the period 2015 – 2017 and the owners of these biogas plants establish our survey population. Number of biogas plants built in each project period for each region is presented in the table below.

Region	2015	2016	2017	Total
Oromia	364	736	756	**1,856**
Amhara	601	724	1,330	**2,655**
SNNPR	513	603	503	**1,619**
Tigray	782	490	400	**1,672**
Total	**2,260**	**2,553**	**2,989**	**7,802**

Based on these numbers, our sample size, the randomization process and its distribution among survey areas on the basis of Proportional to Population Size (PPS) procedure are discussed below.

Sample size determination

The factors and parameters that must be considered in determining the sample size are many but they revolve chiefly around the measurement objectives of the survey. Sample size determination in terms of the key estimates desired, target population, precision and confidence level wanted and clustering is discussed below.

1. *Z* statistic (*Z*): In these studies, investigators present their results with **90% confidence intervals** (CI).

2. Degree of Variability (P): The other factor, the degree of variability in the attributes being measured, refers to the distribution of attributes in the population. The more heterogeneous a population, the larger the sample size required to obtain a given level of precision. The less variable (more homogeneous) a population, the smaller the sample size. A proportion of 50% indicates a greater level of variability than either 20% or 80%. This is because 20% and 80% indicate that a large majority do not or do, respectively, have the attribute of interest. Because a proportion of 0.5 indicates the maximum variability in a population, it is often used in determining a more conservative sample size, that is, the sample size may be larger than if the true variability of the population attribute were used. Accordingly, as we are conducting the survey in four different regions, we use **50% (0.5) degree of variability** to ensure maximum representation of the population in all survey areas.

3. Precision (d): It is very important for investigators to understand this value well. From the formula, it can be conceived that the sample size varies inversely with the square of the precision (d^2). At the end of a study, we need to present the prevalence with its 90% confidence interval. For our purpose d will be set below 10% and to have a total sample size of 200, as recommended in the ToR, **we will set d at 5.70%.**

The sample size determination formula used for the purpose of this study is:

$$n = \left[\frac{Z_{\alpha/2}^2 P(1-P)}{d^2}\right]$$

where n is the sample size from the population, Z is statistical value of Z for a level of significance, P is the degree of variability, d is the measure of precision and p is the estimated male-headed and female-headed ratio of households.

By inserting the value of our parameters we determined above (90% CI, 0.5 P and 5.70 d), it gives total sample size of 200. In addition we allow for possible invalid entries or missed values. Therefore, if we take **5%** more of our required sample size, the total sample size becomes **210 households** with bio-digesters. This sample size will then be subdivided into regions, zones and woredas on the basis of Proportional to Population Size (PPS) procedure.

Randomization Process

It is this mathematical nature of probability samples that permits scientifically-grounded estimates to be made from the survey. More importantly it is the foundation upon which the sample estimates can be inferred to represent the total population from which the sample was drawn. Hence, we apply a probability sampling at each stage of the sample selection process in order for the requirements to be met. For example, the first stage of selection generally involves choosing geographically-defined units such as woredas. The last stage involves selecting the specific households or persons to be interviewed. Those two stages and any intervening ones must utilize probability methods for proper sampling.

Overall, sample areas determination is done through the following steps:

- First we have listed all intervention zonal administrations for each region and select two from each region on random basis using MS-Excel.
- For each selected zonal administration, woredas were also listed and sample woredas drown randomly from the list using MS-Excel. Two woredas were slected from each zonal administration. Sample biogas users surveyed in the study were then selected through the same random sampling procedure.

4. List of surveyed biogas users

No.	Region	Zone	Woreda	User's Name	Sex	Telephone	Latitude	Longitude	Elev.	Picture of the respondent at the time of interview
1	Tigray	South East	Degua Temben	CHERKOS AREYA	Male	912345467	13.65118	39.17377	2594.3	https://akvoflow-89.s3.amazonaws.com/images/c43775fb-aaeb-4b09-ae25-1aaa64466ec7.jpg
2	Tigray	South East	Degua Temben	TEAME AREGA	Male	933924961	13.63859	39.39881	2601.0	https://akvoflow-89.s3.amazonaws.com/images/89514655-64f7-4a40-9c6b-4f08ef485ddd.jpg
3	Tigray	South East	Degua Temben	TEKLEHAYMANOT G/HI WET	Male	914240715	13.64455	39.15742	2282.7	https://akvoflow-89.s3.amazonaws.com/images/c6090385-9f23-4646-af74-0264ae05627d.jpg
4	Tigray	South East	Enderta	YOSEF G/KIROS	Male	928937769	13.41186	39.62767	2356.1	https://akvoflow-89.s3.amazonaws.com/images/7dcdd246-a787-42f5-9adb-95218572a196.jpg
5	Tigray	South East	Enderta	FIKADU HADGU	Male	978449709	13.39680	39.62621	2741.6	https://akvoflow-89.s3.amazonaws.com/images/a395c606-e629-4590-9059-3c9947ff2cdf.jpg
6	Tigray	South East	Enderta	NIGUS ADRESOM	Male	978620160	13.39350	39.62501	2502.8	https://akvoflow-89.s3.amazonaws.com/images/3c8b45d0-aa1f-4012-b1ef-b35a2eba0197.jpg
7	Tigray	South East	Enderta	LILAY HADISH	Male	914872979	13.38142	39.62931	2341.2	https://akvoflow-89.s3.amazonaws.com/images/e17d9f2d-bd8d-4e96-b2f1-f07cb278c13f.jpg
8	Tigray	South East	Enderta	ASEFA G/HER	Male	945475378	13.38273	39.62802	2345.7	https://akvoflow-89.s3.amazonaws.com/images/9ae4ed88-3f86-4a36-87d5-4c45fa25cb52.jpg
9	Tigray	South East	Enderta	TEKA HAILU	Male	962586243	13.35174	39.63221	2242.0	https://akvoflow-89.s3.amazonaws.com/images/fa598f4d-ddce-46d4-808c-16eefb1bf54a.jpg
10	Tigray	South East	Enderta	TESFAMICHEAL MEHARI	Male	923934929	13.35732	39.59525	2180.4	https://akvoflow-89.s3.amazonaws.com/images/b5f15b5e-dbe5-45c1-a61c-a2fe90aad286.jpg
11	Tigray	South East	Enderta	YEMANE GEBREZGI	Male	914890515	13.37701	39.56879	2260.8	https://akvoflow-89.s3.amazonaws.com/images/cbeae343-6c81-483d-a0a5-72698d64a21e.jpg
12	Tigray	South East	Enderta	TEAME MEHARI	Male		13.35535	39.52497	2349.0	https://akvoflow-89.s3.amazonaws.com/images/d9d965d6-b246-443f-a86a-4155433deca3.jpg
13	Tigray	South East	Enderta	SEGED ABRHA	Male	928928367	13.35854	39.52637	2280.5	https://akvoflow-89.s3.amazonaws.com/images/a0f9d11d-f779-40f7-b054-0318f7e7221f.jpg
14	Tigray	South East	Enderta	MEBRAHTU AMANUEL	Male	937020531	13.35910	39.52435	2271.8	https://akvoflow-89.s3.amazonaws.com/images/56db37c9-42e1-4a9a-9a32-a4f53745c158.jpg
15	Tigray	South East	Enderta	MOGOS EQUAR	Male	914126423	13.37014	39.51751	2182.3	https://akvoflow-89.s3.amazonaws.com/images/b5e6b352-7cc8-4b0e-8c35-0ad73fbc0ac6.jpg
16	Tigray	South East	Enderta	HAGAZI KIROS	Male	928928369	13.35603	39.52578	2267.5	https://akvoflow-89.s3.amazonaws.com/images/dc0ccab6-602f-4b87-9201-a588cfa5fbf4.jpg
17	Tigray	South East	Enderta	TADELE AYNALEM	Male	914198801	13.58192	39.43346	1935.1	https://akvoflow-89.s3.amazonaws.com/images/06dc1c51-37d5-481b-a2b1-c7ec90e55253.jpg
18	Tigray	South East	Enderta	K/YILMA HAGOS	Male		13.57748	39.43304	1910.7	https://akvoflow-89.s3.amazonaws.com/images/1dae41f8-

No.	Region	Zone	Woreda	User's Name	Sex	Telephone	Latitude	Longitude	Elev.	Picture of the respondent at the time of interview
										027c-41a5-9d03-012b5a5910ab.jpg
19	Tigray	South East	Enderta	GERECHEAL G/HANNES	Male	914104127	13.53459	39.42240	1872.2	https://akvoflow-89.s3.amazonaws.com/images/bcde41c8-cde6-4bf0-a8ce-06b64214fb69.jpg
20	Tigray	South East	Enderta	TEKA NEGASH	Male	979402245	13.58021	39.43325	1973.3	https://akvoflow-89.s3.amazonaws.com/images/9172d1d6-c546-44c1-807f-3b25473a9cc5.jpg
21	Tigray	South East	Enderta	BRHANE HAILE	Male	914210772	13.48557	39.47447	2153.7	https://akvoflow-89.s3.amazonaws.com/images/2f0ed347-3b0f-4620-8b47-9e26e9fe26b4.jpg
22	Tigray	South East	Enderta	TSEGAY HIYETE	Male	914198651	13.36319	39.52705	2354.1	https://akvoflow-89.s3.amazonaws.com/images/e40bbd06-89bf-49c4-8ba4-89fb28cbeabf.jpg
23	Tigray	South East	Enderta	DESTA GIRMAY	Male	914397638	13.36642	39.52979	2294.1	https://akvoflow-89.s3.amazonaws.com/images/5f9b4e1b-55aa-450c-9cc6-cad125d60d7b.jpg
24	Tigray	South East	Enderta	KIDANU TADELE	Male	914423429	13.36730	39.52900	2299.5	https://akvoflow-89.s3.amazonaws.com/images/d1857332-f644-4a7e-aa03-0298b0cf38f0.jpg
25	Tigray	South East	Enderta	W/RO YESHI HAILU	Female	914198651	13.36303	39.52680	2325.3	https://akvoflow-89.s3.amazonaws.com/images/329460cc-f13b-4c0c-a48f-452ca669a3f5.jpg
26	Tigray	South East	Hintalo	KIBROM ABREHA	Male	911151493	13.22961	39.50790	2067.7	https://akvoflow-89.s3.amazonaws.com/images/610959f0-78f4-494a-9286-c34b77b73bce.jpg
27	Tigray	South East	Hintalo	KAHSAY W/GWORGIS	Male		13.10324	39.49931	2053.5	https://akvoflow-89.s3.amazonaws.com/images/855f4982-de64-4a2e-b76f-89736f5a5031.jpg
28	Tigray	South East	Hintalo	HALEKA YIGZAW REDAE	Male	939225650	13.06396	39.72755	1332.9	https://akvoflow-89.s3.amazonaws.com/images/c494c042-85c8-485b-b46e-635ba3e38563.jpg
29	Tigray	South East	Hintalo	KESHI NGUS HAGOS	Male	953022490	13.06883	39.70391	2325.7	https://akvoflow-89.s3.amazonaws.com/images/bacabf42-14b9-4d72-805b-595c55b6420b.jpg
30	Tigray	South East	Hintalo	K.G/SLASE BERHE	Male	949744778	13.07405	39.70929	2309.0	https://akvoflow-89.s3.amazonaws.com/images/a4bededa-9fc3-47d7-8e63-689237384aa9.jpg
31	Tigray	South East	Hintalo	KESHI HAFTOM HAILU	Male	943636189	13.07294	39.70250	2458.8	https://akvoflow-89.s3.amazonaws.com/images/39d300de-8f87-4b1c-a3a0-0f8780394d3a.jpg
32	Tigray	South East	Hintalo	SBHATO AMINE	Male	914422063	13.07451	39.70051	2347.5	https://akvoflow-89.s3.amazonaws.com/images/2c6ad869-40a0-4969-b40a-ef7326de5d90.jpg
33	Tigray	South East	Hintalo	MERESU ABADI	Male		13.25170	39.46737	2098.1	https://akvoflow-89.s3.amazonaws.com/images/a1e8c040-31b9-4ea3-b80a-9f04ae84db6a.jpg
34	Tigray	South East	Hintalo	HALEKA WELDAY ETSAY	Male	935798985	13.24964	39.46750	2046.9	https://akvoflow-89.s3.amazonaws.com/images/21e0214f-4976-4747-a293-ee830405be56.jpg
35	Tigray	South East	Hintalo	KAHSAY NEGESE	Male	937616805	13.25179	39.46740	2047.0	https://akvoflow-89.s3.amazonaws.com/images/f4a6cb86-ebc2-4908-9ab3-4bfbcfd0a54c.jpg
36	Tigray	South East	Hintalo	G/HER HAFTU	Male	948492308	13.07405	39.72313	2358.2	https://akvoflow-89.s3.amazonaws.com/images/e6f025c9-e390-429b-b2c1-f3211334273d.jpg

No.	Region	Zone	Woreda	User's Name	Sex	Telephone	Latitude	Longitude	Elev.	Picture of the respondent at the time of interview
37	Tigray	South East	Hintalo	ABREHA WAHID	Male	914008960	13.08953	39.48564	2020.4	https://akvoflow-89.s3.amazonaws.com/images/c059459d-921a-4cc0-b142-c71d97cf0aab.jpg
38	Tigray	South East	Hintalo	MEKONEN KAHSAY	Male		12.98894	39.66274	2258.3	https://akvoflow-89.s3.amazonaws.com/images/e93e01e6-278e-43eb-97b1-c4afd846e8a4.jpg
39	Tigray	South East	Hintalo	HALEKAMEHARI GRMAY	Male	969459704	13.07322	39.49355	2145.7	https://akvoflow-89.s3.amazonaws.com/images/bb150542-5df1-4353-99ed-b61e5b7fd087.jpg
40	Tigray	South East	Hintalo	ABREHA G/HIWET	Male	983522604	12.98256	39.67554	2162.4	https://akvoflow-89.s3.amazonaws.com/images/557d823b-132c-465b-a25d-c9218b4ee3c4.jpg
41	Tigray	South East	Hintalo	KESHI TEKLE HAGOS	Male	908211486	12.98078	39.67266	2229.7	https://akvoflow-89.s3.amazonaws.com/images/5ed95165-d379-40e3-91ce-83ff5b61ee17.jpg
42	Tigray	South East	Hintalo	KESH W/GEBREAL TESFAY	Male		12.98829	39.66086	2234.4	https://akvoflow-89.s3.amazonaws.com/images/e10a4801-30cb-4e69-857b-0baf7dac94db.jpg
43	Tigray	West	Wolkayt	BIRHANE SHUMYE	Male	914251954	13.75798	37.32168	1995.4	https://akvoflow-89.s3.amazonaws.com/images/29b77a87-073c-4b61-835a-0711831e8d94.jpg
44	Tigray	West	Wolkayt	HAGOS ALEMU	Male	914223460	13.74212	37.31122	2046.1	https://akvoflow-89.s3.amazonaws.com/images/de11dfbf-e806-480f-aea5-7cff862077d5.jpg
45	Amhara	West Gojjam	Bure zuriya	ASRESIE AKLILU	Female		10.55885	37.02716	2017.7	https://akvoflow-89.s3.amazonaws.com/images/c0ea83e1-d108-4e3e-9093-42a2eda53051.jpg
46	Amhara	West Gojjam	Bure zuriya	GIRMAW MELAK	Male	9460830829	10.64538	37.05155	1622.1	https://akvoflow-89.s3.amazonaws.com/images/f5d3e943-f595-4b6a-90da-6e651ea0f341.jpg
47	Amhara	West Gojjam	Bure zuriya	AMARE TESFA	Male		9.34462	38.72386	3550.4	https://akvoflow-89.s3.amazonaws.com/images/1c450bf4-e4cc-4146-bc0d-525bc3f200f4.jpg
48	Amhara	West Gojjam	Bure zuriya	WONDYFRAW MIRETIE	Male	922265108	10.73610	37.11637	2193.8	https://akvoflow-89.s3.amazonaws.com/images/19f5d2f4-4dcc-4d7d-8609-021699529c50.jpg
49	Amhara	West Gojjam	Bure zuriya	GETIE BIRESAW	Male		10.64484	37.04111	2010.6	https://akvoflow-89.s3.amazonaws.com/images/53c89b06-8f49-463f-ab7d-328b5b4d2c0e.jpg
50	Amhara	West Gojjam	Bure zuriya	BRHANIE WUDNEH	Male	913555365	10.75826	37.10836	2044.0	https://akvoflow-89.s3.amazonaws.com/images/84803214-ee39-423d-83a7-27996689e61e.jpg
51	Amhara	West Gojjam	Bure zuriya	MULUKEN DEGISEW	Female	918573254	10.98651	37.07877	2060.0	https://akvoflow-89.s3.amazonaws.com/images/1bfbf1ce-a163-430e-9169-be95e7be753f.jpg
52	Amhara	West Gojjam	Bure zuriya	HABTAMU BELAY	Male	928501852	10.65167	37.06983	2040.0	https://akvoflow-89.s3.amazonaws.com/images/d82c7f62-0b1b-4400-aa04-ec84ce70e579.jpg
53	Amhara	West Gojjam	Mecha	TECHANE WUBET	Male	932804268	11.48154	37.17581	1902.0	https://akvoflow-89.s3.amazonaws.com/images/dcb0c4db-5d6e-40d4-8deb-3630e8c67aea.jpg
54	Amhara	West Gojjam	Mecha	ADANE KINDE	Male		11.48603	37.15190	1886.0	https://akvoflow-89.s3.amazonaws.com/images/76b7bd94-8b07-4252-a25a-d4634ce58dd4.jpg
55	Amhara	West	Mecha	BAYEW GEBEY	Male		11.50282	37.13770	1898.0	https://akvoflow-89.s3.amazonaws.com/images/d4313844-

No.	Region	Zone	Woreda	User's Name	Sex	Telephone	Latitude	Longitude	Elev.	Picture of the respondent at the time of interview
		Gojjam								621c-4425-886b-febec6f176be.jpg
56	Amhara	West Gojjam	Mecha	MULAT ASIRE	Male	931779552	11.48514	37.19251	1913.0	https://akvoflow-89.s3.amazonaws.com/images/e017a8e7-a4a7-47c9-8de3-a3e629f7c94c.jpg
57	Amhara	West Gojjam	Mecha	ASABU TESEMA	Male	918309377	11.49462	37.15397	1769.0	https://akvoflow-89.s3.amazonaws.com/images/a46ef392-671e-424d-a96d-e8ad6e50bd49.jpg
58	Amhara	West Gojjam	Mecha	ZEMEN TILAHUN	Male	985895306	11.49936	37.14085	1963.0	https://akvoflow-89.s3.amazonaws.com/images/4cea37e6-c27c-40b8-860c-19479def8a35.jpg
59	Amhara	West Gojjam	Mecha	ADIGO SINISHAW	Male	978527654	11.51026	37.09673	1920.0	https://akvoflow-89.s3.amazonaws.com/images/509cbc11-1b4c-4b1e-b10c-4cd26e6d2db8.jpg
60	Amhara	West Gojjam	Mecha	ZELEKE MEKONEN	Male		11.50205	37.13670	1920.0	https://akvoflow-89.s3.amazonaws.com/images/47ed5f86-3ea9-4eea-aeca-8bfd49f09dcc.jpg
61	Amhara	West Gojjam	Mecha	YIRDAW TILAHUN	Male	965889495	11.50027	37.13419	1891.0	https://akvoflow-89.s3.amazonaws.com/images/75b3e211-3782-4564-a608-08bff867928e.jpg
62	Amhara	West Gojjam	Mecha	GEBRE ABEJE	Male		11.50100	37.13678	1891.0	https://akvoflow-89.s3.amazonaws.com/images/bf8f95c2-a124-4bd0-afab-89c67541a671.jpg
63	Amhara	West Gojjam	Mecha	ABAT CHALEW	Male		11.48528	37.18550	1732.0	https://akvoflow-89.s3.amazonaws.com/images/308f9f67-144a-4322-9f8a-69616aa200cf.jpg
64	Amhara	West Gojjam	Mecha	BELAY SIMNEH	Male	935860734	11.48201	37.15547	1865.0	https://akvoflow-89.s3.amazonaws.com/images/7431909e-4bea-424d-b350-cea7abb0b8d3.jpg
65	Amhara	West Gojjam	Mecha	MINALE BELAY	Male		11.48512	37.18754	1744.0	https://akvoflow-89.s3.amazonaws.com/images/ac6b3d25-d18f-4ff6-ae64-a38b59e42f1c.jpg
66	Amhara	West Gojjam	Mecha	DAMTIE KEFALE	Male		11.48657	37.16230	1925.0	https://akvoflow-89.s3.amazonaws.com/images/8e301f6b-7984-4aa5-8a82-e0b8b278ca47.jpg
67	Amhara	West Gojjam	Mecha	GEBRIE SIMINEH	Male	918539417	11.48836	37.17915	1874.0	https://akvoflow-89.s3.amazonaws.com/images/f1048828-1003-4a4f-a34c-652d4bc05d6e.jpg
68	Amhara	West Gojjam	Mecha	YESHANBEL KASIE	Male		11.48471	37.18692	1922.0	https://akvoflow-89.s3.amazonaws.com/images/ab86ea42-fc2a-41d5-9f47-8ce6aaaccb94.jpg
69	Amhara	West Gojjam	Mecha	SIMEGN TESEMA	Female		11.48342	37.15372	1901.0	https://akvoflow-89.s3.amazonaws.com/images/8b652568-72b8-4478-aaa3-118921ef8bc2.jpg
70	Amhara	West Gojjam	Mecha	GEDAMU ASIMARE	Male		11.48479	37.18570	1918.0	https://akvoflow-89.s3.amazonaws.com/images/7724afcb-4037-4fe2-9642-f9dbd71e2dfd.jpg
71	Amhara	West Gojjam	Mecha	DESIE/ENDALIE ZEFER	Male		11.48266	37.15332	1899.0	https://akvoflow-89.s3.amazonaws.com/images/a57641fe-7ca9-44ad-9cd5-4a3190eb9f50.jpg
72	Amhara	West Gojjam	Mecha	BILILGN WATIE	Male	948689737	11.48117	37.17562	1920.0	https://akvoflow-89.s3.amazonaws.com/images/3c1dbfce-b2a8-46d4-80d9-2e6628717187.jpg
73	Amhara	West Gojjam	Mecha	BERIE ALEMU	Male		11.48859	37.16628	1904.0	https://akvoflow-89.s3.amazonaws.com/images/b1276f2a-8e7f-4fd1-9a64-717952690201.jpg

No.	Region	Zone	Woreda	User's Name	Sex	Telephone	Latitude	Longitude	Elev.	Picture of the respondent at the time of interview
74	Amhara	West Gojjam	Mecha	AMILAKU ASIMARE	Male	918082076	11.48379	37.18297	1912.0	https://akvoflow-89.s3.amazonaws.com/images/54700cba-3ed5-411a-b94e-3a882bb459b2.jpg
75	Amhara	West Gojjam	Mecha	MISGANEW DEGIE	Male	955168376	11.41597	37.04802	1927.0	https://akvoflow-89.s3.amazonaws.com/images/9dfa2799-c908-4b68-9142-81ee54220b78.jpg
76	Amhara	West Gojjam	Mecha	TAZEBEW CHANE	Male		11.48926	37.16410	1834.0	https://akvoflow-89.s3.amazonaws.com/images/cccaf07a-8f06-480f-b53e-8a3c46e32219.jpg
77	Amhara	West Gojjam	Mecha	GIZACHEW BIYAZIN	Male	934643711	11.48303	37.15989	1972.0	https://akvoflow-89.s3.amazonaws.com/images/a3f3392b-666e-4320-92d4-513d45663569.jpg
78	Amhara	West Gojjam	Mecha	HABITAMU ADIS	Male	918133812	11.30536	37.03843	2026.0	https://akvoflow-89.s3.amazonaws.com/images/5974c3a9-9aaf-401e-9fa3-a4569ca81f07.jpg
79	Amhara	West Gojjam	Mecha	KESS/WOLDIE SEWUNET	Male	985246500	11.22155	37.08310	2111.0	https://akvoflow-89.s3.amazonaws.com/images/de926996-b11f-4abb-ae89-d7250547b3a3.jpg
80	Amhara	West Gojjam	Mecha	KETELE WONDALE	Male		11.48413	37.16206	1898.0	https://akvoflow-89.s3.amazonaws.com/images/1eaf7d2b-cec0-401d-b662-7c3705525e00.jpg
81	Amhara	West Gojjam	Mecha	YIZENGIE AMARE	Male		11.50336	37.13730	1877.0	https://akvoflow-89.s3.amazonaws.com/images/55e8d97b-2bc3-41cb-84b3-2a95a26ce1c1.jpg
82	Amhara	West Gojjam	Mecha	TEGEGNE FIKADIE	Male	948777087	11.49124	37.14668	2057.0	https://akvoflow-89.s3.amazonaws.com/images/c7f05148-16f2-45a9-af7f-6386dffbccf1.jpg
83	Amhara	West Gojjam	Mecha	WUBAYE YISIMAW	Male		11.14773	37.09072	2173.0	https://akvoflow-89.s3.amazonaws.com/images/1a4a6859-6947-483e-8741-72e2baed7a44.jpg
84	Amhara	West Gojjam	Mecha	YIHUNE MEKANET	Male	973758844	11.18406	37.06115	2098.0	https://akvoflow-89.s3.amazonaws.com/images/0cee9e6f-03bf-4e1c-9949-3001910f9fc3.jpg
85	Amhara	West Gojjam	Mecha	SEMIE GETIE	Male		11.48866	37.17707	1904.0	https://akvoflow-89.s3.amazonaws.com/images/f84bd474-40a4-409c-993c-4609b4f63ea2.jpg
86	Amhara	West Gojjam	Mecha	ZEMEN AMARE	Male		11.48351	37.17707	2088.0	https://akvoflow-89.s3.amazonaws.com/images/929eab43-27e2-460e-abda-79c7cbf650aa.jpg
87	Amhara	West Gojjam	Mecha	SEMIE BABIL	Male		11.48471	37.18297	1904.0	https://akvoflow-89.s3.amazonaws.com/images/bd6e59dc-3b4a-4c35-8472-9a4e63b272ff.jpg
88	Amhara	West Gojjam	Mecha	ALEMU NIBRRT	Male		11.50124	37.13542	1852.0	https://akvoflow-89.s3.amazonaws.com/images/ebf181b1-5648-4fd7-a7f7-46393fee27b8.jpg
89	Amhara	West Gojjam	Mecha	BAZEZEW LIJALEM	Male		11.57347	37.36436	69.9	https://akvoflow-89.s3.amazonaws.com/images/e3d60c9f-3e7c-4421-96ff-ddc2d6f0aa89.jpg
90	Amhara	West Gojjam	Mecha	TAFERE ATANAW	Male	963941381	11.50100	37.13678	1891.0	https://akvoflow-89.s3.amazonaws.com/images/9c29f5f6-bd19-4416-a86b-650c9fe0d8c7.jpg
91	Amhara	West Gojjam	Mecha	AMESHE DEGU	Male		11.14773	37.09072	2173.0	https://akvoflow-89.s3.amazonaws.com/images/c5557500-5d86-41e6-95b6-5f5f60259a4a.jpg
92	Amhara	West	Mecha	ALELIGN MOGES	Male		11.48836	37.17915	1874.0	https://akvoflow-89.s3.amazonaws.com/images/a4a2f477-

No.	Region	Zone	Woreda	User's Name	Sex	Telephone	Latitude	Longitude	Elev.	Picture of the respondent at the time of interview
		Gojjam								e6fc-41a5-b7f2-0c13cfd1cf31.jpg
93	Amhara	West Gojjam	Mecha	MITEK ENDALAMAW	Male	918598730	11.50282	37.13770	1898.0	https://akvoflow-89.s3.amazonaws.com/images/94544702-00f8-4cfe-b7d6-032a4eff5152.jpg
94	Amhara	North Wollo	Bugna	ADANE SISAY	Male		12.10247	38.86695	2000.2	https://akvoflow-89.s3.amazonaws.com/images/7132a79f-91f4-4288-baf3-fdd68c687d19.jpg
95	Amhara	North Wollo	Bugna	MOLA GELAW	Male		12.10836	38.85082	2016.4	https://akvoflow-89.s3.amazonaws.com/images/8c997bd7-f0b2-473f-9d02-490d752246ba.jpg
96	Amhara	North Wollo	Bugna	ZEMENE FEKADIE	Male		12.11235	38.87054	2123.1	https://akvoflow-89.s3.amazonaws.com/images/59736561-d112-4eb3-a66b-1bae95fe48be.jpg
97	Amhara	North Wollo	Bugna	ZEWUDU FENTIE	Male		12.15573	38.84045	2442.3	https://akvoflow-89.s3.amazonaws.com/images/17711a5c-2885-4058-81cb-1ff411163a8d.jpg
98	Amhara	North Wollo	Raya Kobo	ASSEFA NIGUS	Male	913942806	12.21427	39.66363	1472.7	https://akvoflow-89.s3.amazonaws.com/images/f85e9ac5-8a07-424f-bd40-ebe57bc6460b.jpg
99	Amhara	North Wollo	Raya Kobo	MOLLA MEKONEN	Male		12.21045	39.66350	1475.8	https://akvoflow-89.s3.amazonaws.com/images/26685d84-9ac3-47f8-b27a-e5824499d60d.jpg
100	Amhara	North Wollo	Raya Kobo	GEBRIE MERESA	Male		12.07768	39.62380	1472.4	https://akvoflow-89.s3.amazonaws.com/images/9240f097-ff10-4e42-ae34-d59f635f67a7.jpg
101	Amhara	North Wollo	Raya Kobo	BELAY MEKONEN	Male		12.07783	39.61952	1509.4	https://akvoflow-89.s3.amazonaws.com/images/102c93bc-b594-4e18-88f0-2931c82acc61.jpg
102	Amhara	North Wollo	Raya Kobo	ARAGIE ADANE	Male	919402989	12.07580	39.61812	1518.9	https://akvoflow-89.s3.amazonaws.com/images/975ab3f5-9cb8-484a-a97f-c9218b465687.jpg
103	Amhara	North Wollo	Raya Kobo	MULU MOKENEN	Female	919402989	12.06930	39.62565	1511.3	https://akvoflow-89.s3.amazonaws.com/images/c9b6e7e0-ba9b-4d74-b9e7-13530f83ed07.jpg
104	Amhara	North Wollo	Raya Kobo	TAREKE BELAY	Male	985267499	12.07569	39.61866	1404.5	https://akvoflow-89.s3.amazonaws.com/images/fc2149d0-4088-495d-bbc9-9b5e8c219ead.jpg
105	Amhara	North Wollo	Raya Kobo	ZINABIE ADMASIE	Male	923748745	12.07763	39.67185	1403.3	https://akvoflow-89.s3.amazonaws.com/images/cb50369f-7dc6-460e-b8bd-3b48ec47bcc1.jpg
106	Amhara	North Wollo	Raya Kobo	AKELE ASSFA	Male	914461701	12.07801	39.67757	1393.8	https://akvoflow-89.s3.amazonaws.com/images/fabdf4cc-4bc3-440b-b365-b1e67dea46e0.jpg
107	Amhara	North Wollo	Raya Kobo	BELAY GOBAZI	Male		12.07796	39.67756	1422.7	https://akvoflow-89.s3.amazonaws.com/images/241bfb5f-6d59-4598-a8be-ef9f72fca70b.jpg
108	Amhara	North Wollo	Raya Kobo	TESFAY TEKELE	Male	914669107	12.07889	39.68122	1466.6	https://akvoflow-89.s3.amazonaws.com/images/990386b2-094a-4d79-a7c4-08fa87cb8011.jpg
109	Amhara	North Wollo	Raya Kobo	EIBRHIM MOHAMED	Male	910912692	12.11278	39.69383	1574.8	https://akvoflow-89.s3.amazonaws.com/images/e00a2a39-2a73-4ce4-a7be-d249aa5bd06c.jpg
110	Amhara	North Wollo	Raya Kobo	HAMID ARBISE	Male		12.11237	39.69407	1356.0	https://akvoflow-89.s3.amazonaws.com/images/3b4e8a6a-7ac2-4029-ba5f-bab3daf150aa.jpg

No.	Region	Zone	Woreda	User's Name	Sex	Telephone	Latitude	Longitude	Elev.	Picture of the respondent at the time of interview
111	Oromia	East Wollega	Sibu Sire	LAMI GEMEDA	Male		9.04322	36.86832	1845.0	https://akvoflow-89.s3.amazonaws.com/images/735b52ba-b9a2-4d42-9668-24f1f40c2d91.jpg
112	Oromia	East Wollega	Sibu Sire	FANTA GUDEYA	Male	924404250	9.03791	36.86307	1822.0	https://akvoflow-89.s3.amazonaws.com/images/bb228ddc-6946-4ba3-8671-1175709a18f3.jpg
113	Oromia	East Wollega	Sibu Sire	YADESA GEBDA	Male		8.95747	36.85822	1513.0	https://akvoflow-89.s3.amazonaws.com/images/aff90043-4847-4ee7-b38e-9e00ae8233d4.jpg
114	Oromia	Jimma	Gomma	SIRBA MITIKU	Male	917265548	7.91112	36.69776	1505.4	https://akvoflow-89.s3.amazonaws.com/images/ac770642-bb5c-49b8-9aaf-968386c5411f.jpg
115	Oromia	Jimma	Gomma	SALI SHERIF	Male	917230258	7.92020	36.71978	1560.1	https://akvoflow-89.s3.amazonaws.com/images/cf8350fd-a00a-4c44-bc14-1d0d6bba7464.jpg
116	Oromia	Jimma	Gomma	SHARAFU ABA MACHA	Male	917104006	7.92056	36.72603	1603.4	https://akvoflow-89.s3.amazonaws.com/images/f32799c8-7665-4b40-81e1-88756ebdbcb3.jpg
117	Oromia	Jimma	Gomma	SHE ABBA BULGU	Male	925718213	7.92171	36.72009	1574.0	https://akvoflow-89.s3.amazonaws.com/images/69fe1683-dca1-48af-8988-894fea6ebb93.jpg
118	Oromia	Jimma	Gomma	ZAKIR FEDLU	Male	917805444	7.97008	36.70277	1863.8	https://akvoflow-89.s3.amazonaws.com/images/5664919e-2aa7-4bee-b951-ccdc61ad0c6f.jpg
119	Oromia	Jimma	Gomma	MAMED ABBA MECHA	Male	934264380	7.92991	36.70099	1575.4	https://akvoflow-89.s3.amazonaws.com/images/1f4e8f60-7616-4d2b-b276-896c54c56453.jpg
120	Oromia	Jimma	Gomma	NEGASH ABBA GOJAM	Male	917315503	7.86497	36.65517	1555.7	https://akvoflow-89.s3.amazonaws.com/images/27040cb9-1419-4a73-ad9d-c3edabfe1ae6.jpg
121	Oromia	Jimma	Gomma	JABAL ABBA FIXA	Male	917510317	7.83109	36.63973	1675.6	https://akvoflow-89.s3.amazonaws.com/images/c6b1ba3f-db3d-4c97-ad88-cf9cc0bdf340.jpg
122	Oromia	Jimma	Gomma	ADNAN ABA DURA	Male	917125028	7.89056	36.53624	1703.7	https://akvoflow-89.s3.amazonaws.com/images/24e59174-b805-4fbc-9c6d-332d3f83ac92.jpg
123	Oromia	Jimma	Gomma	MAHAMED ABA DEGA	Male	910794639	7.89167	36.53672	1713.4	https://akvoflow-89.s3.amazonaws.com/images/0a86914e-d0e2-4503-b08e-0b3624b0ba36.jpg
124	Oromia	Jimma	Gomma	JUNEDI ABBA MECHA	Male	913927171	7.88145	36.63335	1433.3	https://akvoflow-89.s3.amazonaws.com/images/cd3d1dd2-aea4-4afb-b774-8560ba397edd.jpg
125	Oromia	Jimma	Gomma	ABA NAGA ABA GOJAM	Male	917053833	7.91516	36.50652	1835.0	https://akvoflow-89.s3.amazonaws.com/images/bce8148b-f1bf-4ebb-8bf8-b06736449337.jpg
126	Oromia	Jimma	Gomma	UMAR ABA RAGO	Male	904069474	7.91660	36.50769	1824.2	https://akvoflow-89.s3.amazonaws.com/images/d4ed97b6-7375-45c4-9135-d32aee376478.jpg
127	Oromia	Jimma	Gomma	ZINABU ABA DAGA	Male	913293111	7.94090	36.51047	1726.1	https://akvoflow-89.s3.amazonaws.com/images/53b04445-f2f6-40b7-9ff7-928dcd630462.jpg
128	Oromia	Jimma	Gomma	TARFA EJERSO	Male		7.93152	36.51057	1783.9	https://akvoflow-89.s3.amazonaws.com/images/2d94e03e-ac29-41b2-8dc8-b6561a0ca4e3.jpg
129	Oromia	Jimma	Gomma	HAJAJI SH/ABDALLA	Male	963445851	7.94298	36.53078	1601.2	https://akvoflow-89.s3.amazonaws.com/images/49594e7b-

No.	Region	Zone	Woreda	User's Name	Sex	Telephone	Latitude	Longitude	Elev.	Picture of the respondent at the time of interview
										d112-4fd3-b8e8-de3a5ea85cd7.jpg
130	Oromia	Jimma	Gomma	A/TEMAM A/DIBA	Male	940266283	7.93891	36.53139	1641.6	https://akvoflow-89.s3.amazonaws.com/images/a7011e92-5167-47c2-8481-a1ec1e9d0c9e.jpg
131	Oromia	Jimma	Gomma	TADALE AYALEW	Male	917757346	7.94753	36.51918	1707.2	https://akvoflow-89.s3.amazonaws.com/images/e8e5a49f-d76c-4894-9acb-e2419eb99545.jpg
132	Oromia	Jimma	Gomma	KADIR HAJI	Male	917067853	7.91795	36.56212	1770.4	https://akvoflow-89.s3.amazonaws.com/images/f6ff8ec3-6832-4fbe-afc8-7a555b22fc34.jpg
133	Oromia	Jimma	Gomma	QASIMA ABA BULGU	Male	917202940	7.91978	36.56048	1737.8	https://akvoflow-89.s3.amazonaws.com/images/c38c014f-9d88-4386-9cd9-e526e34c1585.jpg
134	Oromia	Jimma	Kersa	ABA TEMAM ABA BULGU	Male	932760756	7.72877	37.09152	1800.0	https://akvoflow-89.s3.amazonaws.com/images/cbd91f37-8276-4d1b-85ff-a6e99e32c4b7.jpg
135	Oromia	Jimma	Kersa	ABAZINAB ABASAMBI	Male		7.76101	36.90324	2386.0	https://akvoflow-89.s3.amazonaws.com/images/4a3023d9-fdde-4bd4-8daf-75d186a3b467.jpg
136	Oromia	Jimma	Kersa	AMIN ABA TEMAM	Male	917782882	7.72846	37.09117	1801.0	https://akvoflow-89.s3.amazonaws.com/images/d8af7f8e-b120-4571-806e-21f4597acedc.jpg
137	Oromia	Jimma	Kersa	MAHAMAD ABAJEBAL	Male		7.74967	36.89394	2351.0	https://akvoflow-89.s3.amazonaws.com/images/f3a84857-c917-4e67-a065-dfd3fef1b8b1.jpg
138	Oromia	Jimma	Kersa	ABA JIHAD ABAFILBA	Male		7.62156	36.91028	1833.0	https://akvoflow-89.s3.amazonaws.com/images/a617777d-57b4-43b6-ac51-b6edf0b6818e.jpg
139	Oromia	Jimma	Kersa	AMIN ABAFOGI	Male		7.62207	36.91438	1784.0	https://akvoflow-89.s3.amazonaws.com/images/8a1e57f9-a5c6-42cd-915e-5614a9390784.jpg
140	Oromia	Jimma	Kersa	ABA RESHAD ABA GOJAM	Male		7.62548	36.91098	1882.0	https://akvoflow-89.s3.amazonaws.com/images/31208a90-5fc3-4ac7-9121-661f2bdda5cf.jpg
141	Oromia	Jimma	Kersa	ABABIYA ABA SAMBI	Male	949585408	7.76108	36.90188	2338.0	https://akvoflow-89.s3.amazonaws.com/images/3fc69a3f-edc0-4196-b408-e628b8d287f5.jpg
142	Oromia	Jimma	Kersa	NASIR ABANIGDI	Male		7.69354	36.97797	1785.0	https://akvoflow-89.s3.amazonaws.com/images/5775c8d0-a087-4c98-b231-ede708930042.jpg
143	Oromia	Jimma	Kersa	HAJI A/WARI A/MORKI	Male		7.83797	37.16586	2106.0	https://akvoflow-89.s3.amazonaws.com/images/654c6faf-b83d-4238-ba9a-04f1f339b4bb.jpg
144	Oromia	Jimma	Kersa	ABATEMAM ABAFOGI	Male		7.73148	37.14073	1720.0	https://akvoflow-89.s3.amazonaws.com/images/d2411b37-0c7a-4439-83c6-2fdbc0e33b7d.jpg
145	Oromia	Jimma	Kersa	HAJI KEDIR A/JOBIR	Male		7.85407	37.15508	2138.0	https://akvoflow-89.s3.amazonaws.com/images/c89077ed-e358-43b7-b36a-ebca094b33b5.jpg
146	Oromia	Jimma	Kersa	ABA FAJI ABA WARI	Male		7.70832	37.07761	1722.0	https://akvoflow-89.s3.amazonaws.com/images/325b232d-0474-4005-8b39-3f53bfe76edd.jpg
147	Oromia	Jimma	Kersa	ABAJEBEL ABAWARI	Male		7.70008	36.97756	1802.0	https://akvoflow-89.s3.amazonaws.com/images/5a34c7af-2067-43ab-ad70-80258649dfe4.jpg

No.	Region	Zone	Woreda	User's Name	Sex	Telephone	Latitude	Longitude	Elev.	Picture of the respondent at the time of interview
148	Oromia	Jimma	Kersa	ABDALLAHI ABAZINAB	Male		7.75967	36.90304	2323.0	https://akvoflow-89.s3.amazonaws.com/images/25bd12b8-a7cc-4c61-ba77-7f460cb91f1d.jpg
149	Oromia	Jimma	Kersa	SEFU ABADIGA	Male	960889781	7.75641	36.90193	2329.0	https://akvoflow-89.s3.amazonaws.com/images/d492f627-9af6-4f3a-9095-6ba3633505f7.jpg
150	Oromia	Jimma	Kersa	ABA OLI ABABULGU	Male		7.70264	36.96230	1815.0	https://akvoflow-89.s3.amazonaws.com/images/827b687f-9cc8-4952-b972-df9698218d43.jpg
151	Oromia	Jimma	Limu Kosa	NIGUSSIE DESSIM	Male	917327860	7.94690	36.84307	2018.1	https://akvoflow-89.s3.amazonaws.com/images/eadf9cd9-367e-4575-b2c7-d9edf19a3b5c.jpg
152	Oromia	Jimma	Limu Kosa	WORKE CHANIE	Male		8.01748	36.84997	1245.2	https://akvoflow-89.s3.amazonaws.com/images/829ea6c8-fc1a-432d-80fc-00ae199c9e03.jpg
153	Oromia	Jimma	Limu Kosa	ALI GOBA	Male	917248897	7.99990	36.84822	1990.7	https://akvoflow-89.s3.amazonaws.com/images/c2835b0e-d414-4d3b-ae8e-1b8e4d5e1c49.jpg
154	Oromia	Jimma	Limu Kosa	ZERIHUN ESHETU	Male	917015905	7.95348	36.84489	2019.0	https://akvoflow-89.s3.amazonaws.com/images/81800d0c-9ab7-4b54-a8b0-f198c60ff28d.jpg
155	Oromia	Jimma	Limu Kosa	JUNDI KEDIR	Male	917161866	7.99816	36.88267	1701.6	https://akvoflow-89.s3.amazonaws.com/images/51c3fe81-1592-4200-8111-c0f30c347d47.jpg
156	Oromia	Jimma	Limu Kosa	YAIKOB ABA BULGU	Male	917009073	8.06599	36.92600	1649.2	https://akvoflow-89.s3.amazonaws.com/images/7b01562e-8c23-4651-9fb4-76bd269e15ec.jpg
157	Oromia	Jimma	Limu Kosa	GEBEYEHU ASNAKE	Male	917259698	8.14880	36.97892	1714.7	https://akvoflow-89.s3.amazonaws.com/images/70e00088-c970-4076-bf8e-8102ae61b928.jpg
158	SNNP	Gedeo	Wonago	AMANUEL GETU	Male	916931559	6.31663	38.22496	1863.5	https://akvoflow-89.s3.amazonaws.com/images/d805c973-1ab4-4c01-bf4b-ecc9e4be6ed9.jpg
159	SNNP	Gedeo	Wonago	FANTU BONEYA	Male		6.33297	38.22661	1769.7	https://akvoflow-89.s3.amazonaws.com/images/7f0a2e8d-f337-499c-8ac9-31163114398c.jpg
160	SNNP	Kembata Tembaro	Angecha	TADES KEFATO	Male	910839647	7.34991	37.84430	2115.2	https://akvoflow-89.s3.amazonaws.com/images/1185956b-75e5-4985-b7a1-50ed381ddfa4.jpg
161	SNNP	Kembata Tembaro	Angecha	AMARECH MATHEWOS	Female		7.34579	37.86115	2306.0	https://akvoflow-89.s3.amazonaws.com/images/ff4faf37-9161-4b60-a586-aef238b33151.jpg
162	SNNP	Kembata Tembaro	Angecha	ALEMBO GODEBO	Female		7.46120	37.90981	158.6	https://akvoflow-89.s3.amazonaws.com/images/9d9bf63f-841d-46b5-a4d7-f6dc84490622.jpg
163	SNNP	Kembata Tembaro	Angecha	WOLDE ABO	Male		7.34527	37.86120	2368.1	https://akvoflow-89.s3.amazonaws.com/images/fddd0b4a-2253-4908-b19c-94e3916dc46e.jpg
164	SNNP	Kembata Tembaro	Angecha	ABREHAM LEAMANGO	Male		7.34539	37.95090	2235.0	https://akvoflow-89.s3.amazonaws.com/images/3aef6734-0154-4b0b-9f83-324d88a5623b.jpg
165	SNNP	Kembata Tembaro	Hadero	AYELCH CHEKEBO BIKE	Female	913646013	7.20945	37.63607	1565.9	https://akvoflow-89.s3.amazonaws.com/images/dfa9a241-d077-4d38-be1a-7b05a3e71cf5.jpg
166	SNNP	Kembata	Hadero	ASETER CHERINET	Female	916349037	7.20916	37.63243	1609.7	https://akvoflow-89.s3.amazonaws.com/images/61096385-

No.	Region	Zone	Woreda	User's Name	Sex	Telephone	Latitude	Longitude	Elev.	Picture of the respondent at the time of interview
		Tembaro								e6cb-4249-ba6e-0c6d28862dc0.jpg
167	SNNP	Kembata Tembaro	Hadero	BEKELE BATISO	Male		7.21089	37.63959	1527.4	https://akvoflow-89.s3.amazonaws.com/images/1eeb32f3-f104-4fed-8560-c82f8cc8d81b.jpg
168	SNNP	Kembata Tembaro	Hadero	DESELGN ABEBE	Male		7.24417	37.71217	1815.2	https://akvoflow-89.s3.amazonaws.com/images/f6b107a9-aac9-476d-9fc4-8f7587c595f3.jpg
169	SNNP	Kembata Tembaro	Hadero	ASERAT ASEFAW	Male		7.19208	37.68363	1632.8	https://akvoflow-89.s3.amazonaws.com/images/6e075643-00e1-4396-85e6-dca613c9136b.jpg
170	SNNP	Kembata Tembaro	Hadero	DEMISSE SHGUTE	Male	926083583	7.21623	37.61845	1566.0	https://akvoflow-89.s3.amazonaws.com/images/25a5247e-cd72-40d8-bf07-62b9a7d00dac.jpg
171	SNNP	Kembata Tembaro	Hadero	DESALEGN DEBENICHO	Male	925525693	7.22605	37.61895	1584.4	https://akvoflow-89.s3.amazonaws.com/images/36f9402f-6e11-4b20-8388-87c46a0f30c1.jpg
172	SNNP	Kembata Tembaro	Hadero	WORIKU WATARO	Male	929523677	7.22396	37.61583	1902.1	https://akvoflow-89.s3.amazonaws.com/images/e739b7b3-97c7-4860-8d10-4df9cb29d5d3.jpg
173	SNNP	Kembata Tembaro	Hadero	MELEKAM DENEKE	Female	916282696	7.18887	37.66390	1644.6	https://akvoflow-89.s3.amazonaws.com/images/5defd7a8-de94-473a-91bb-29b5a98ece85.jpg
174	SNNP	Kembata Tembaro	Hadero	TADESSE ELORE	Male		7.20370	37.61407	37.6	https://akvoflow-89.s3.amazonaws.com/images/aff31308-9e8a-4f32-90ac-e542d0fd8011.jpg
175	SNNP	Kembata Tembaro	Hadero	DAWIT BEYAMO	Male		7.20981	37.64589	1730.0	https://akvoflow-89.s3.amazonaws.com/images/424d509c-e62c-4680-b042-ec4465183a0b.jpg
176	SNNP	Kembata Tembaro	Hadero	KEBEDE ERGANO	Male		7.20370	37.95206	1794.0	https://akvoflow-89.s3.amazonaws.com/images/90451884-584c-4ec7-bbff-2c6e3465ec8b.jpg
177	SNNP	Kembata Tembaro	Hadero	DESALEGN DIGAMO	Male		7.21438	37.77999	1778.0	https://akvoflow-89.s3.amazonaws.com/images/c503b2d0-4287-4083-a04f-01c5b899a243.jpg
178	SNNP	Kembata Tembaro	Hadero	DESTA TADESSE	Male	925684172	7.20741	37.61215	1702.0	https://akvoflow-89.s3.amazonaws.com/images/93239fa0-b25d-43f8-a543-7e87aafa2247.jpg
179	SNNP	Kembata Tembaro	Hadero	MICHAEL DETEBO	Male		7.20156	37.95382	1695.0	https://akvoflow-89.s3.amazonaws.com/images/14e289a8-01c2-4c20-9f1d-c5fe4f65b197.jpg
180	SNNP	Kembata Tembaro	Hadero	MATHEWOS JABANGA	Male	923406926	7.21802	37.82035	1806.0	https://akvoflow-89.s3.amazonaws.com/images/369f377c-fa40-4078-9e1b-14582a32a783.jpg
181	SNNP	Kembata Tembaro	Hadero	MATHEWOS MADEBO	Male		7.20916	37.63243	1723.0	https://akvoflow-89.s3.amazonaws.com/images/7f094fb3-f493-4842-9561-cd97a35144af.jpg
182	SNNP	Kembata Tembaro	Hadero	YOHANES UKANSO	Male	916716367	7.21965	37.81896	1759.0	https://akvoflow-89.s3.amazonaws.com/images/4771f891-03ba-43b1-9eba-e179388c0fee.jpg
183	SNNP	Kembata Tembaro	Hadero	TEFERA TEDASA	Male	910149424	7.18600	38.08696	1670.0	https://akvoflow-89.s3.amazonaws.com/images/64482b77-d26c-4c78-974d-1314cc518c7c.jpg
184	SNNP	Kembata Tembaro	Hadero	TERAFA HERANO	Male	916282513	7.17902	37.83797	1492.0	https://akvoflow-89.s3.amazonaws.com/images/2c2b1f5a-7f75-443e-9996-63199b40354a.jpg

No.	Region	Zone	Woreda	User's Name	Sex	Telephone	Latitude	Longitude	Elev.	Picture of the respondent at the time of interview
185	SNNP	Kembata Tembaro	Hadero	SEBLEWORK CHERNAT	Female	913392906	7.18479	38.12486	1674.0	https://akvoflow-89.s3.amazonaws.com/images/3e563c45-7c45-4083-b97b-709a3f2cc287.jpg
186	SNNP	Kembata Tembaro	Hadero	WONJAMO MEGISO	Male	986097116	7.20507	37.74764	1744.0	https://akvoflow-89.s3.amazonaws.com/images/4e1c5235-cebd-442b-b0aa-0b4473b7525e.jpg
187	SNNP	Kembata Tembaro	Hadero	TESFAYE CHELO	Male		7.19419	37.76707	1656.0	https://akvoflow-89.s3.amazonaws.com/images/c5824c45-9857-46fe-b77c-49b3b9e428ec.jpg
188	SNNP	Kembata Tembaro	Hadero	TESHOME GENAMO	Male	984681036	7.19951	37.90289	1703.0	https://akvoflow-89.s3.amazonaws.com/images/157f4b26-6fa4-42fa-a0be-394271bb9490.jpg
189	SNNP	Kembata Tembaro	Hadero	AYENO GEDEBO	Male		7.18085	37.90662	1527.0	https://akvoflow-89.s3.amazonaws.com/images/0836a33a-dc43-4a9d-bbfb-2e543e1e753f.jpg
190	SNNP	Kembata Tembaro	Hadero	TESFAYE OKORE	Male		7.18125	37.92104	1534.0	https://akvoflow-89.s3.amazonaws.com/images/e7fd9b4e-f448-4b2c-98c0-d405f89276f0.jpg
191	SNNP	Kembata Tembaro	Kacha Bira	TADEWOS TIRORE	Male	916348575	7.91235	36.42150	1795.0	https://akvoflow-89.s3.amazonaws.com/images/1f173dc5-69b2-476d-9b8e-eb0d348285ef.jpg
192	SNNP	Kembata Tembaro	Kacha Bira	ALEMU ABEBE	Male		7.93720	36.35400	1799.0	https://akvoflow-89.s3.amazonaws.com/images/810abb89-1682-4a7f-a317-b270501ed18f.jpg
193	SNNP	Kembata Tembaro	Kacha Bira	TADELE TASIKO	Male	913083611	7.97770	36.72580	2001.0	https://akvoflow-89.s3.amazonaws.com/images/5cd90de2-4cb7-4dbf-9148-90c5dd75eb39.jpg
194	SNNP	Kembata Tembaro	Kacha Bira	ADMASU ARFICHO	Male		7.92927	36.49240	1820.0	https://akvoflow-89.s3.amazonaws.com/images/c10e42b6-34fc-4952-a705-18f34ed24382.jpg
195	SNNP	Kembata Tembaro	Kacha Bira	TINSAYE MEKEBO	Male	913779148	7.97783	36.73160	2004.0	https://akvoflow-89.s3.amazonaws.com/images/229af535-fd27-4977-a87a-5750e764b31f.jpg
196	SNNP	Kembata Tembaro	Kacha Bira	BIRHANU ERGATO	Female	913280600	7.92770	36.49770	1824.0	https://akvoflow-89.s3.amazonaws.com/images/2e3d9cf0-362d-4b3f-bbd0-35b78464bb39.jpg
197	SNNP	Kembata Tembaro	Kacha Bira	ABEBO ASHETO	Female	910665191	7.99775	36.88800	2090.0	https://akvoflow-89.s3.amazonaws.com/images/da2be9f3-b224-4d78-b950-158b8f136ada.jpg
198	SNNP	Kembata Tembaro	Kacha Bira	DELEBO WABELA	Male		7.95931	36.65250	1901.0	https://akvoflow-89.s3.amazonaws.com/images/9a60fe67-7560-45e2-af6c-0430ab490937.jpg
199	SNNP	Kembata Tembaro	Kacha Bira	TESFAYE LUDAGO	Male	939999500	7.92315	36.29460	1768.0	https://akvoflow-89.s3.amazonaws.com/images/9c25ed76-5cff-4423-bffd-a4d8b3cccd57.jpg
200	SNNP	Kembata Tembaro	Kacha Bira	AMARECH DANIEL	Female		7.92880	36.51820	1838.0	https://akvoflow-89.s3.amazonaws.com/images/98f6fdd1-81a7-46b0-860e-03495c04c9fa.jpg