**European Development Fund**
**For Ethiopia**

# Technical Evaluation of the Financing Agreement "Biogas Dissemination Scale-Up Project – National Biogas Programme of Ethiopia (NBPE+)"

*Final Report*

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*September 20, 2021*

This project is funded by
The European Union

A project implemented
by AETS

# *DELEGATION of the EUROPEAN UNION*

## Ethiopia

# Technical Evaluation of the Financing Agreement "Biogas Dissemination Scale-Up Project – National Biogas Programme of Ethiopia (NBPE+)"

## Contract N° 300014017 — SIEA-2018-2391

## FWC SIEA 2018 - Lot 2

## Infrastructure, sustainable growth and jobs

## EuropeAid/138778/DH/SER/Multi

## Final Report

## September 20, 2021


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# Table of Acronyms and Abbreviations

| | |
|---|---|
| ABPP | Africa Biogas Partnership Programme |
| AfSS | After-Sales Service |
| AIP | Alternative Implementation Partners |
| BCE | Bio-digester Construction Enterprise |
| BoA | Bureau of Agriculture |
| BoWIE | Bureau of Water, Irrigation and Energy |
| BUS | Biogas Users' Survey |
| CDM | Clean Development Mechanism |
| CI-Dev | World Bank's Clean Initiative for Development |
| CRGE | Climate Resilient Green Economy |
| CSC | Customer Support Centre |
| DBE | Development Bank of Ethiopia |
| DEVCO | European Commission Directorate-General for International Cooperation and Development |
| DP | Development Partner |
| EC | European Commission |
| EQ | Evaluation Question |
| EU | European Union |
| EUD | European Union Delegation |
| EUR or € | Euro |
| GHG | Greenhouse Gas |
| GoE | Government of Ethiopia |
| GTP | Growth and Transformation Plan |
| IL | Intervention Logic |
| INDC | Intended Nationally Determined Contribution |
| JC | Judgement Criteria |
| MFI | Micro-Financing Institution |
| MS | Member States |
| MoA | Ministry of Agriculture, former MoA |
| MoF | Ministry of Finance, former MoF |
| MoWIE | Ministry of Water, Irrigation and Energy |
| NBPCU | National Biogas Programme Coordination Unit |
| NBP-SC | National Biogas Programme – Steering Committee |
| NBPE | National Biogas Programme of Ethiopia |
| NBPE+ | National Biogas Dissemination Scale-Up Programme of Ethiopia |
| NDC | Nationally Determined Contributions |
| NGO | Non-Governmental Organisation |
| OECD/DAC | Organisation for Economic Co-operation and Development – Development Assistance Committee |
| PPP | Public Private Partnership |
| RBF | Results-Based Financing |
| RBPCU | Regional Biogas Programme Coordination Unit |
| RBP-SC | Regional Biogas Programme – Steering Committee |
| SDG | Sustainable Development Goal |
| SE4ALL | Sustainable Energy for All |
| SNPPR | Southern Nations, Nationalities & People's Region |
| SNV | Netherlands Development Organisation |

| | |
|---|---|
| TA | Technical Assistance |
| ToR | Terms of Reference |
| TVET | Technical and Vocational Education Training |
| UN | United Nations |
| UNFCCC | United Nations Framework Convention on Climate Change |
| WB | World Bank |

# 1. Introduction

Ethiopia's Climate Resilient Green Economy (CRGE) strategy emphasises the role of renewable energy for its Growth and Transformation Plan (GTP). GTP II (2015-2020)[1] advocates expanding electricity generation from renewable sources of energy and commits to expanding bio-based gaseous and liquid biomass energy and thereby reducing firewood consumption, deforestation and desertification. Renewable energy such as biogas is believed to support country's growth and reduce emission of greenhouse gases that cause climate change[2]. The GTP II has a target of installation of 31,400 bio-digesters in the country. In Ethiopia there are 14 million households with cattle of which 4 million households are technically eligible to bio-digester installation[3]. Biogas is an environmentally sustainable energy source, and its production serves as reducing firewood consumption, deforestation and desertification, indoor air pollution, provides clean energy and organic fertiliser (bio-slurry) and serves as a waste disposal method. Biogas contains 50–70% methane and 30–50% carbon dioxide and has a calorific value of 21–24 MJ/m$^3$. The average durability of bio-digesters is 20 years with a payback period of 1-2 years.

The National Biogas Programme of Ethiopia (NBPE), hosted by the Ministry of Water, Irrigation & Energy (MoWIE) has been implemented since 2009 as part of the Africa Biogas Partnership Programme (ABPP). Under the two phases of ABPP, in Ethiopia today known as NBPE-I (2009-2013) and NBPE-II (2014-2019, ended 31/03/2019), a total of 20,699 bio-digesters (NBPE-I: 8,161; NBPE-II: 12,538) have been installed in four regions: Amhara, Oromia, Southern Nations, Nationalities & People's (SNNP) Region and Tigray. Beneficiaries paid around 60% of total cost of a bio-digester, the remaining 40% being subsidised by the Ethiopian government and by donors as an investment incentive. The figure below shows the administrative configuration of Ethiopia, including the recently created Sidama region.

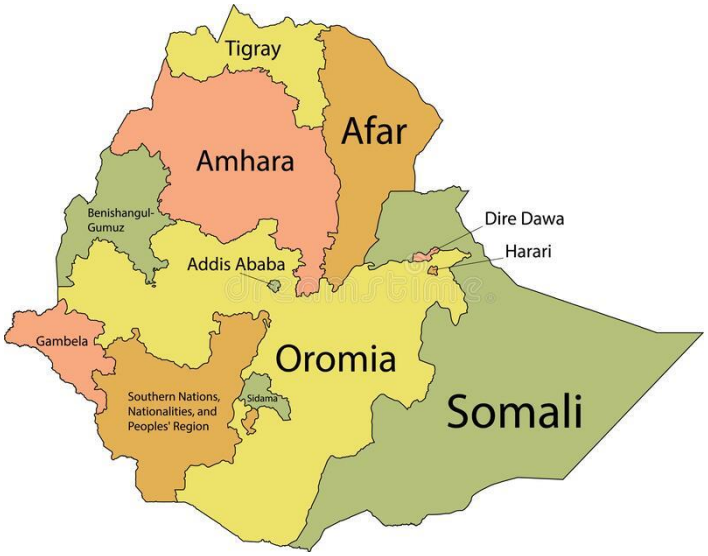



*Figure 1 - The country and regional states and city administration*[4]

1 Growth and Transformation Plan II, (2015-2020). GoE 2015.

2 CRGE (Climate-Resilient Green Economy). Ethiopia's Climate-Resilient Green Economy Strategy, The Path toSustainable Development. Ethiopia, 2011. Addis Ababa, Environment Protection Authority.

3 Technical potential for bio-digesters. SNV, June 2017.

4 https://www.google.com/search?q=regions+of+ethiopia+sidama&tbm=isch&ved=2ahUKEwjEleG7iIPzAhUSNRoKHWZJDw0Q2-cCegQIABAA&oq=regions+of+ethiopia+sidama&gs_lcp=CgNpbWcQAzoECAAQEzoGCAAQHhATOggIABAFEB4QE1DPP1jHUmClWWgAcAB4AIAB4AOIAYwWkgEFMy01LjKYAQCgAQGqAQtnd3Mtd2l6LWltZ7gBA8ABAQ&sclient=img&ei=__5CYYSaJ5LqaOaSvWg&bih=886&biw=1829#imgrc=6jqoaqGSGAZ6xM

The Biogas Dissemination Scale-Up Project (NBPE+) aims to extend the activities to four other regions: Afar, Benishangul-Gumuz, Gambella and Somali, in addition to the above-mentioned regions. NBPE+ was designed to scale up and expand the existing NBPE-II, which was supposed to end in March 2019 with 1.25 years of budget neutral extension, after the original 4 years plan of 2014 to 2017. NBPE+ targets the installation of 36,000 household and 40 larger size bio-digesters from April 12th 2017 to July 11th 2022 with a 63 months' implementation period. NBPE+ is being implemented as a Public Private Partnership (PPP) through the MoWIE, and the regional Energy Bureaus and agencies, involving the Woreda Energy Offices[5] and other relevant government actors at different levels. Further decentralisation of the programme implementation with Results-Based Financing (RBF) and performance contracts with Woredas are planned to be designed and implemented for improved performance of quality and accountability.

The investment incentives (subsidy) of NBPE+ have also been defined as 30-40% of the costs of a bio-digester for the first years of the programme, and a revision was planned in Year 3. The programme is co-funded by the European Union (EU) with € 20.85 million and by the Government of Ethiopia (GoE) with € 2 million. In three years' time, up to April 11th 2020, some 8,498 bio-digesters were installed from the target of 8,436, divided in 8,172 in the four original regions and 326 in the other four regions.

This evaluation aims at the technical evaluation of NBPE+ during the implementation period 12/04/2017 to 31/12/2020 in which was planned to install 12,416 household-based bio-digesters (4-10 $m^3$)[6], with an annual installation plan shown in Table 18 of this report.

The objective of this evaluation is the systematic and timely assessment of the NBPE+ programme financed by the EU, with the focus on the valuation of achievements, the quality and the results of the interventions with an increasing emphasis on result-oriented approaches and the contribution towards the implementation of the Sustainable Development Goals (SDGs).

From this perspective, the evaluation looked for evidence of result's achievement and tried to identify the factors driving or hindering progress. This evaluation covers the period from the beginning of the NBPE+, April 12th 2017 until December 31st 2020.

The evaluation was only asked to look at the first three objectives of the programme. Nevertheless, the analysis could not be done without touching some aspects that are related to the other two objectives.

## 1.1. Field Phase Methodology

The field phase methodology for this evaluation followed DEVCO (now INTPA)'s methodological guidelines for thematic and other complex evaluations[7], which is itself based on the Organisation for Economic Co-operation and Development / Development Assistance Committee (OECD/DAC) approach.

The sampling methodology was given in the Inception Report and is provided here as Annex III. For security reasons Benishangul-Gumuz and Tigray regions were excluded from the field visits. The sample therefore includes six programme regions: Afar, Amhara, Gambella, Oromia, SNNP and Somali and even in some of these regions the sample had to be slightly adjusted for security reasons.

5 Woreda is a fourth administrative unit also called district or county. Ethiopia's administrative structure is divided in to Regions, then to Zones, then to Woredas and then to Kebeles and finally to households.

6 Year 1 to 3 targets plus 50% of Year 4. NBPE+ Programme Implementation Agreement, May 2017.

7 http://capacity4dev.ec.europa.eu/evaluation_guidelines/

During the field phase, a mix of qualitative and quantitative data has been collected through interviews with relevant stakeholders, review of key documents reports as well as observations of bio-digesters.

The Field work entails:

- Meeting with the European Union Delegation (EUD) at the beginning of the field mission to discuss the desk analysis, key issues, evaluation approach, interview guides, etc.
- Refinement of interview guides as necessary following these discussions.
- Semi-structured interviews with all key relevant stakeholders in Addis Ababa (e.g. representatives of EU Member States, representatives of other development partners, representatives of key government federal and regional partner institutions such as the MoWIE, National Biogas Programme Coordination Unit (NBPCU) and Regional Biogas Programme Coordination Unit (RBPCU), the Ministry of Finance (MoF) and Ministry of Agriculture (MoA), NBPE+ Steering Committee members, Netherlands Development Organisation (SNV), bio-digester contractors, end-beneficiaries).
- Perform site visits, in the nine programme regions. Site visits have been conducted in sample Woredas. The following tasks have been carried out using appropriate methods and techniques:
  - Interview relevant regional and Woredas offices: RBPCU, bureaus/offices of energy, agriculture, finance, Micro-Financing Institutions (MFIs), private sector partners (bio-digester construction enterprises, masons, appliance manufacturers and suppliers).
  - Check the status of the regional implementation of the NBPE+ programme.
  - Interview bio-digester user households.
  - Quality of construction and functionality of domestic bio-digesters.
  - Check the conformity and quality of the digester database developed by the programme.
  - Bio-slurry production and application.
  - Affordability of biogas plants to users and access to finance.
  - Private Sector Development.
- Examine and assess the application of financial management manuals.
  - Financial flows associated to:
    - Investment incentives.
    - RBF mechanism.
    - Direct contributions of the Federal and regional governments.
    - Revenues from the households and institutions purchasing bio-digesters.
  - Opportunities for carbon credit revenue.
  - Check that there have been clear boundaries between the NBPE II and the NBPE+ programmes regarding bio-digester installation and finances – as mentioned in the Mid-Term Review and agreed by the Steering Committee of 9/6/2020.
- Checking and double-checking (with a variety of sources) of project assumptions, facts, figures, findings, praise, complaints, recommendations, etc., to ensure accuracy, relevance and usefulness.
- Formulation of findings.
- Discussion of these with the EUD at the end of the field mission.

Final analysis and reporting:

- Post-mission analysis and follow-up to fill any gaps in information and triangulation – discussion of findings with relevant stakeholders.
- Updating of indicators to fill gaps, adjust findings.
- Verification or discarding of hypotheses and conclusions.
- Preparing recommendations.
- Preparation of the Draft Report.
- Finalisation of the Report following receipt of comments.

The schedule of the field missions including the work of the team leader is shown in Annex I. A list of persons met is provided in Annex II.

## 1.2. Ranking of evidence

In answering the evaluation questions, the evidence obtained will be ranked according to the table below.

**Table 1 - Evidence ranking**

| Ranking of Evidence | Explanation of ranking of quality of evidence |
|---|---|
| Strong | The finding is consistently supported by a range of evidence sources, including documentary sources, quantitative analysis and qualitative evidence (i.e. there is very good triangulation); or the evidence sources, while not comprehensive, are of high quality and reliable to draw a conclusion (e.g. strong quantitative evidence with adequate sample sizes and no major data quality or reliability issues; or a wide range of reliable qualitative sources, across which there is good triangulation). |
| More than satisfactory | Evidence comprises multiple data sources (with good triangulation) of lesser quality, or the finding is supported by fewer data sources (limited triangulation) of decent quality, but that are perhaps more perception-based than factual. |
| Indicative but not conclusive | There is only one evidence source of good quality, and no triangulation with their sources of evidence. |
| Weak | There is no triangulation and / or evidence is limited to a low quality single source. |

*Source: Adapted from Independent evaluation of the UN system response to AIDS. June 2020.*

## 1.3. The NBPE+ and the SDGs

The overarching objective of the EU support to biogas in Ethiopia is linked to the SE4ALL initiative and the achievement of SDG7. The EU considers sustainable energy central to providing opportunities for inclusive, equitable and environmentally friendly economic growth and poverty eradication.

**Table 2 - The objectives of the NBPE+ and the SDGs**

| Overall objectives | SDGs |
|---|---|
| To improve the living standards of targeted farmers and their families, in the Ethiopian regions of Afar, Amhara, Benishangul-Gumuz, Gambella, Oromia, Southern Nations, Nationalities & People's Region (SNPPR), Somali and Tigray. | • Poverty eradication.<br>• Less use of traditional cooking fuels and therefore more availability of these fuels for the (very) poor.<br>• Good health and well-being. Biogas can improve the health of women (and children) who are most exposed to the dangers of wood smoke.<br>• Pollution control and waste management benefit all members of the community.<br>• Improvement of quality of life, especially for women and youth. Domestic biogas reduces the workload of women<br>• Gender equality and empowerment of women. Biogas can provide light that helps women and students with their study.<br>(SDG 1, 2, 3, 5, 7, 8) |

| | |
|---|---|
| To reduce the overexploitation of biomass cover in the 8 regions and to reduce Greenhouse Gas (GHG) emissions. | • Environmental and climate change.<br>• Access to affordable and clean energy.<br>• Application of bio-slurry increases soil fertility, and reduces the need for application of chemical fertiliser<br>(SDG 7, 13 and 15) |
| To develop 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. | • Sustainable inclusive growth.<br>• Construction and installation of biogas creates employment for landless rural people.<br>• Decent work and economic growth.<br>(SDG 1, 5, 7, 8 and 15) |

For the biogas programme as a whole, outcomes directly linked to SDGs are being realised:

- Increased access to affordable and reliable biogas energy promotes sustainable growth, improves the environment and combats climate change.
- Increased access to affordable and reliable biogas energy contributes to reducing environmental degradation of forests by lowering the demand for charcoal and firewood as well as lowering indoor air pollution from the burning of biomass. Greenhouse gas emissions are reduced by the use of biogas.
- Increased access to affordable and reliable biogas energy helps reduce poverty and has an immediate and well researched impact on the quality of life.
- Women and youth will especially benefit as they are the group that spend most time on collecting firewood and that suffer most from health hazards from indoor cooking using firewood, charcoal, and other forms of biomass, even dung.

## 1.4. The ToR and the organisation of the report

The overall objective of the project, described in the Terms of Reference (ToR) of this evaluation is:

*"To improve the living standards of farmers and their families, in the Ethiopian regions of Afar, Amhara, Benishangul-Gumuz, Gambella, 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 specific objectives of the programme are:

a. To provide 180,000 rural people with biogas as clean energy, mainly for cooking and bio-slurry as high value fertiliser from bio-digesters with investment incentives.
b. To improve affordability of bio-digesters and provide a pro-poor orientation towards female-headed and other disadvantaged families.
c. To expedite sector capacity development for a sustainable domestic bio-digester sector with private sector development and engagement of other partners to fill in the capacity gap.
d. To further improve the products, the quality and product options, including introduction of new bio-digesters for domestic and non-domestic purposes and appliances or accessories.
e. To further develop the institutional and policy framework for the domestic biogas sector.

It should be noted that the evaluation was only asked to analyse **the first three specific objectives** of the programme.

Chapter 2 provides the results of the field missions to Afar, Amhara, Gambella, Oromia, SNNP and Somali regions, where 295 households were visited and interviewed and the bio-digesters examined.

Chapter 3 provides a systematic answer to the evaluation questions that have been approved during the Inception Phase.

Chapter 4, based on the results described in the previous chapter findings, will present the macro-level conclusions and recommendations. Other types of recommendations are to be found also in the previous chapters.

# 2. The technical evaluation of the NBPE+

## 2.1. Introduction

In order to conduct the technical evaluation, households with bio-digesters that were constructed up to April 2020 were randomly selected from the SNV database. Field visits were organised for randomly selected households with bio-digesters in Afar, Amhara, Gambella, Oromia, Somali and SNNP (including Sidama) in May-June 2021, as shown in the table below.

**Table 3 - Household with bio-digesters selected from different zones of six regions**

| Region | Sample N= | Zone | Sample N= |
|---|---|---|---|
| Afar | 35 | Zone 1 | 35 |
| Amhara | 123 | Awi | 19 |
| | | East Gojjam | 71 |
| | | North Shoa | 30 |
| | | South Wello | 3 |
| Gambella | 25 | Anywaa | 21 |
| | | Gambella town | 4 |
| Oromia | 44 | Arsi | 16 |
| | | Jimma | 9 |
| | | North Shewa | 5 |
| | | West Arsi | 14 |
| SNNP (Southern Nations and Nationalities People including Sidama Region) | 33 | Gamo | 5 |
| | | Gurage | 5 |
| | | Kembata Tembaro | 6 |
| | | Sidama | 5 |
| | | Wolayita | 12 |
| Somali | 35 | Fafan | 35 |
| Total | 295 | | 295 |

## 2.2. Afar Region

### 2.2.1. Household characteristics

**Household Size**

The household size in sample households varies from two to 11 persons, the mean household size being 7.1 persons. About a quarter of the sample (26%) has eight household members. Households of 5 to 9 persons accounted for 84%.

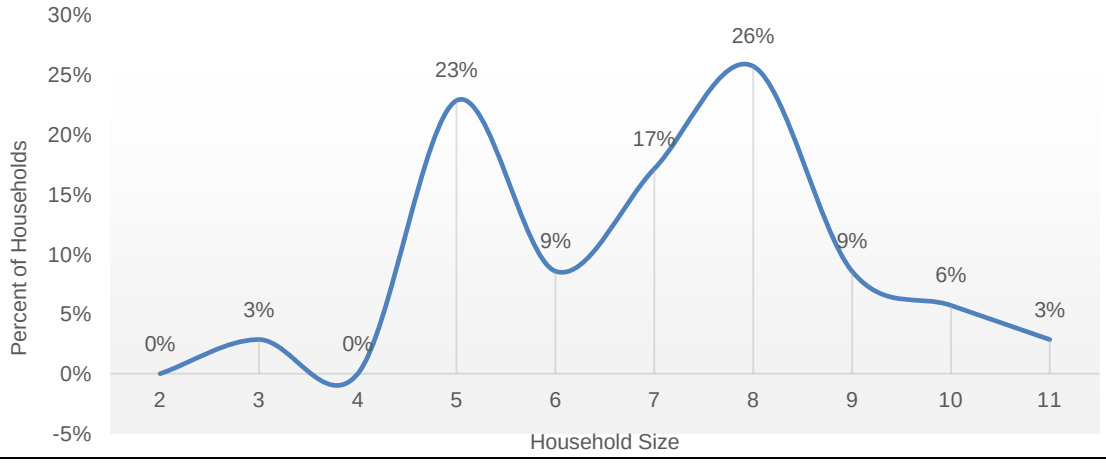



*Figure 2 - Distribution of Sample by Household Size in Afar Region*

**Characteristics of Head of Household**

Male-headed households accounted for 54% of the total sample households for 41%. The mean age of the head of the household is 42 years.

In terms of the distribution of the sample by educational level of the head of the household, we found that 51% were illiterate, 14% can read and write and the remaining 35% have formal education ranging from Grade 2 to a bachelor's degree, the majority being Grade 4 and Grade 5.

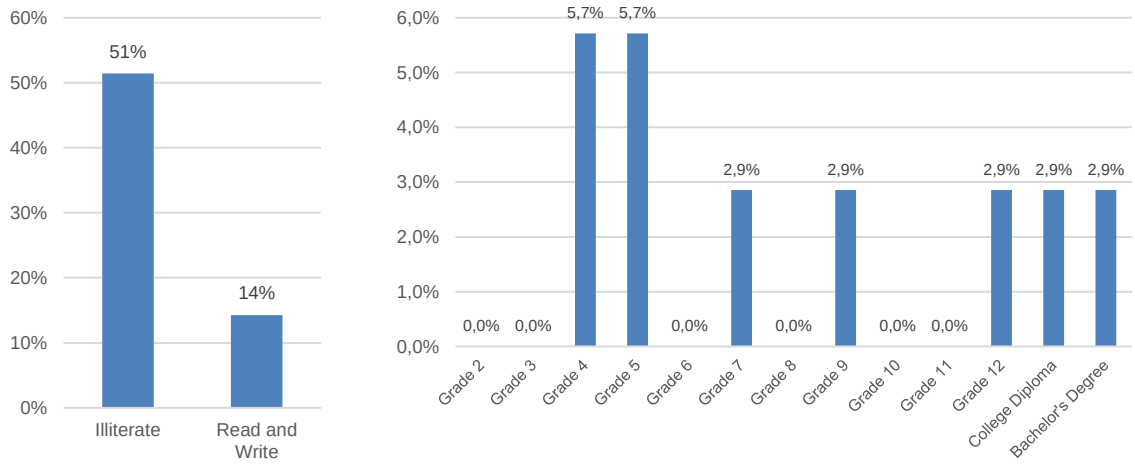



*Figure 3 - Distribution of Sample by Educational Level of Head of Household in Afar Region*

### 2.2.2. Reasons for installation of bio-digesters

User households were asked the most important reason for installation of bio-digesters. They all reported cooking fuel and almost half of the respondents said use of bio-slurry among the most important reasons. On the other hand, only 16% reported lighting as one of the important reasons. The lower percentage for lighting use is because most user households use solar lanterns.

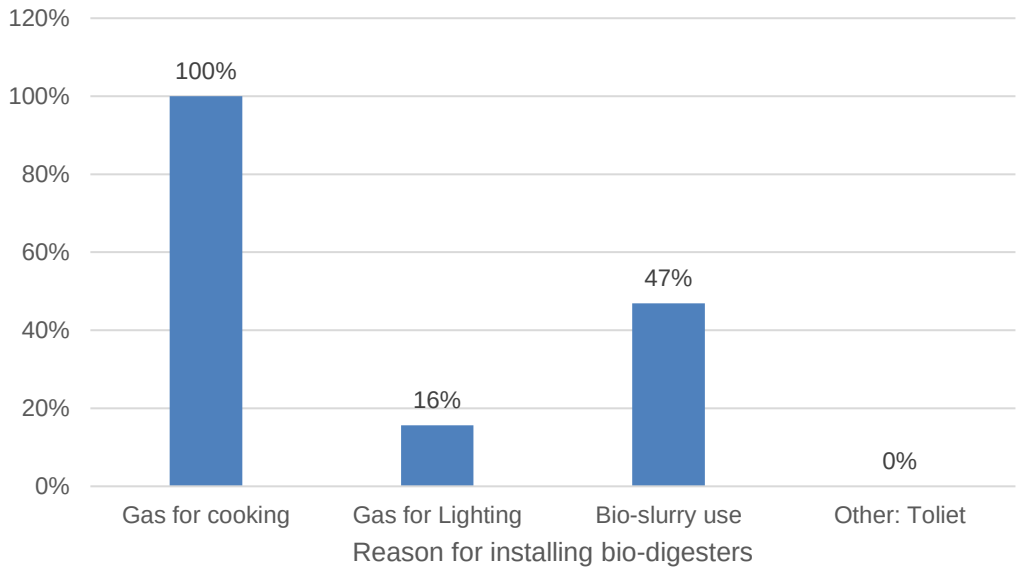



*Figure 4 - Use of bio-digesters in Afar Region*

### 2.2.3. Functionality of bio-digesters

The bio-digesters installed are based on established technical standards proven in several other countries. The technology is considered reliable, well-functioning, simple, durable and with low maintenance cost. A high-quality biogas plant needs minimum maintenance costs and can produce gas for at least 15–20 years without major problems and re-investments.

On the other hand, concerns are raised with regard of the functionality rates of bio-digesters. Non-functionality rate remains high. In Afar 62.5% of the bio-digesters were functional at the time of the survey. About 60% of the non-functional digesters were associated with insufficient dung for feeding mainly due to frequent cattle movement for pasture. The other important cause was lack of water and labour for feeding accounting for 28% and 9.4% for non-functionality of digesters, in their respective orders.

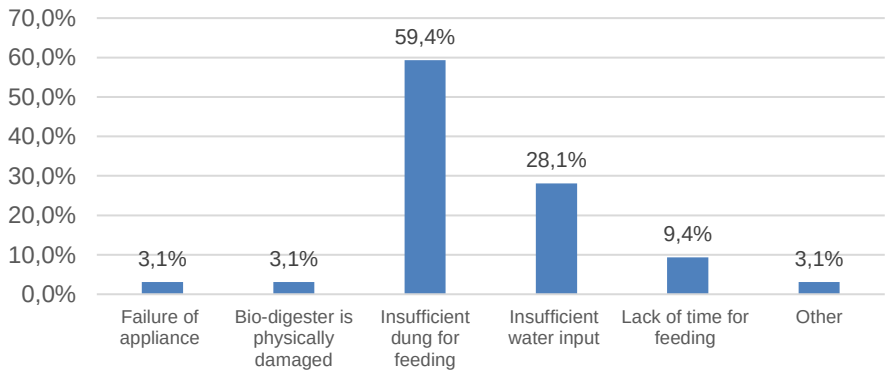


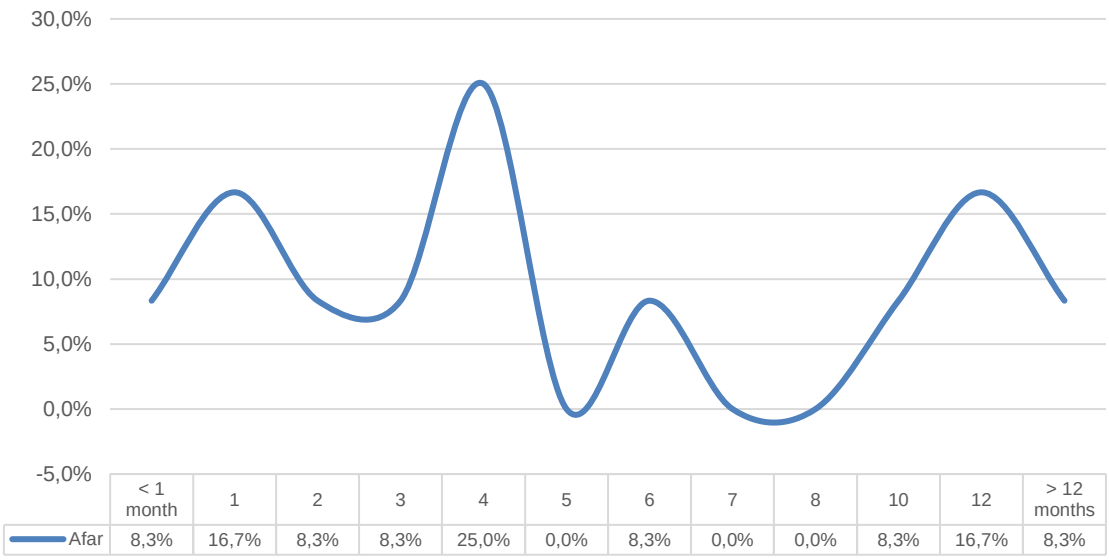

*Figure 5 - Causes of non-functioning of bio-digesters in Afar Region*

### 2.2.4. After-sales-service

The user households reported that there are significant delays in repair of non-functional bio-digesters by the masons/BCEs during the guarantee period. The average duration of non-functionality of the digesters in Afar region was 5.4 months (see Annex VI - Statistical Tables). About

25% of the non-functional digesters remained unrepaired for about 4 months and 17% each for a period of 1 month and 12 months.

Interviews with the RBPCU and Woreda experts as well as BCEs and masons reveal that the reasons for the delays in repair of non-functional plants were limited follow-up visits and by Woreda energy experts; insufficient mobility and budget for site-visits, as well as lack of replacement appliances in the market. Also, it was reported that the masons and BCEs tend to be reluctant to provide after-sale services as the amount withheld in the form of guarantee (about ETB 500) is too small to motivate them.




| | < 1 month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 10 | 12 | > 12 months |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Afar | 8,3% | 16,7% | 8,3% | 8,3% | 25,0% | 0,0% | 8,3% | 0,0% | 0,0% | 8,3% | 16,7% | 8,3% |

*Figure 6 - Distribution of non-functional bio-digesters by number of months in Afar Region*

### 2.2.5. Benefits of bio-digesters

A bio-digester is a quick impact intervention. According to the interviews with biogas user households, the impact of the bio-digesters can be observed in a number of areas including reduction on household expenditure on energy for cooking and lighting; firewood collection time saving; reduced cooking time; reduction on household expenditure on chemical fertiliser; increased crop yield; and improved health associated with reduction in household air pollution and improved sanitation and hygiene.

About 94% of bio-digester user households in Afar reported firewood savings associated with biogas use and 84% reported firewood collection time-savings. On the other hand, the impact of biogas use on household expenditure on cooking was minimal. This is because user households almost entirely relay on firewood collection to meet their cooking energy needs. In addition, we found that most user households use solar lanterns for lighting. The Regional Water, Mines and Energy Agency distributed the lanterns to households living in dwelling units with thatched roofs to minimize risks of fire accidents.

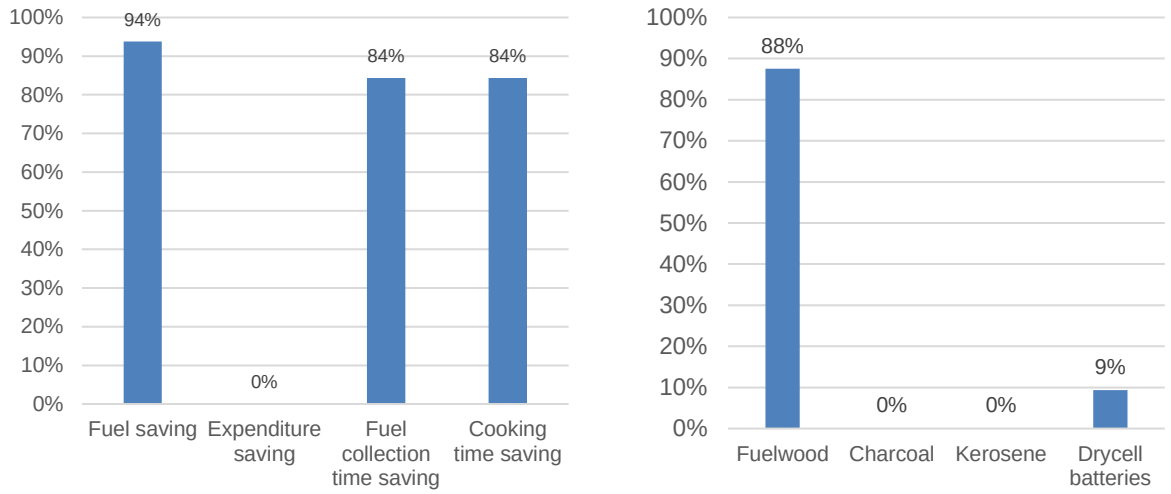



*Figure 7 - Benefits of biogas use (left) and Types of fuels displaced (right) in Afar Region*

### 2.2.6. Health impacts of biogas use

The use of biogas for cooking and lighting was associated with reduced Household Air Pollution (HAP) and related ailments. The sample user households reported that smoke levels were lower and those were in turn associated with reductions in eye irritation, respiratory illness, and incidence of fire burns.

About 88% of users reported reduction in eye irritation while 68% said fire injury associated with firewood cooking has been reduced. On the other hand, a high proportion of the biogas user households reported that they do not know the effects of using biogas on respiratory infections (66%) and on coughing (59%).

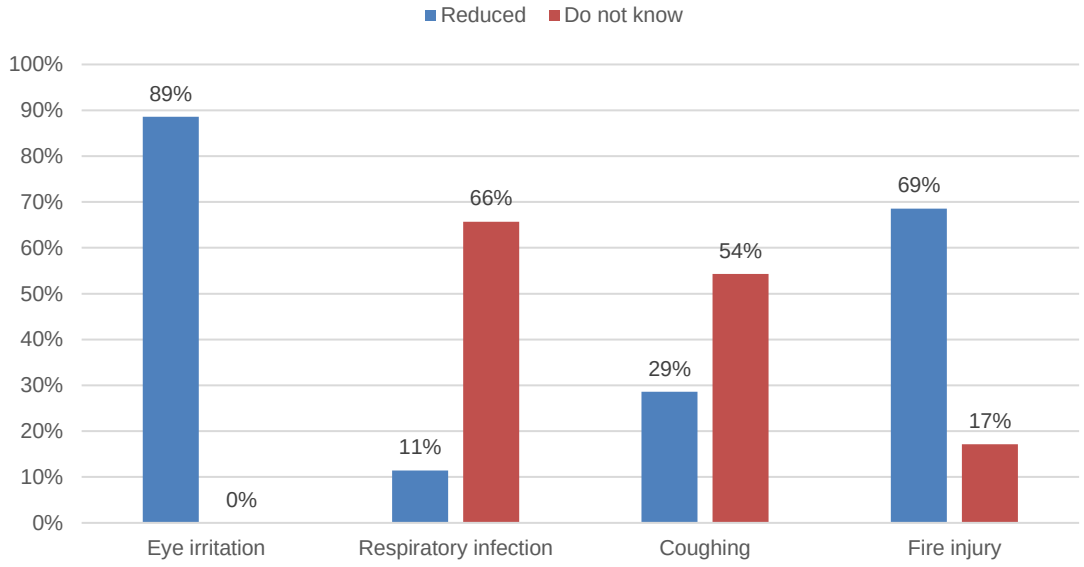



*Figure 8 - Health impacts of bio-digester use in Afar Region*

### 2.2.7. Bio-slurry management and application

About 60% of the bio-digester users in Afar apply bio-slurry on their farms. However, the quantity of bio-slurry produced per digester was unknown. The users generally do not measure the volume of bio-slurry production from their digesters. A 6m$^3$ bio-digesters requires 36-48 kg of cattle dung and

36-48 litres of water per day. According to SNV, a properly maintained 6m$^3$ can produce 30 to 35m$^3$ of bio-slurry per year. [8] This amount is sufficient to cultivate one hectare of farmland.

Asked how bio-slurry was applied, about two thirds of the households (67%) reported they apply it "as-it-is"; 17% apply it after drying; and 17% in the form of compost.

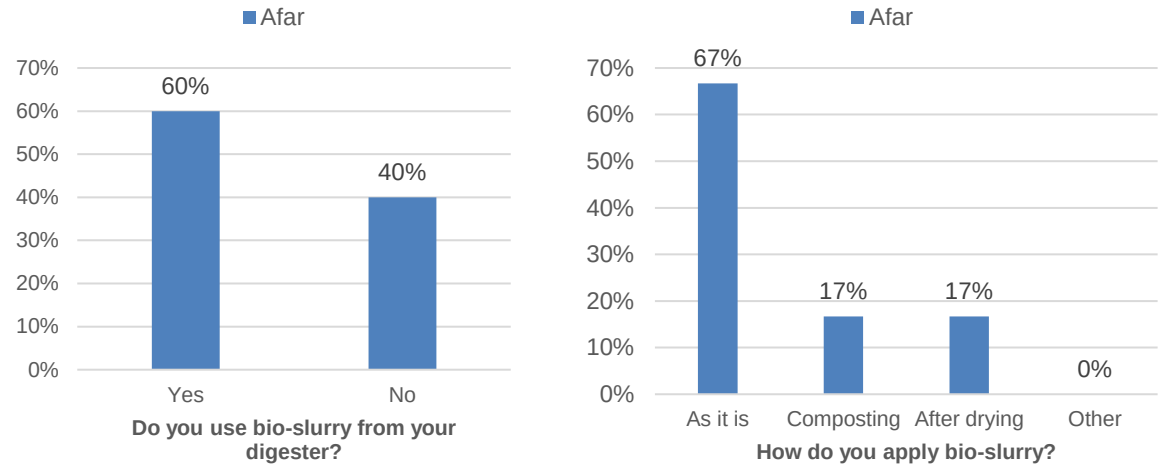



*Figure 9 - Use of bio-slurry by households (left) and How bio-slurry used (right) in Afar Region*

Bio-slurry application impact on saving of expenditure on chemical fertiliser

The application of bio-slurry has the potential to increase crop yield and reduce expenditure on chemical fertiliser. The use of the bio-slurry from bio-digesters reduces consumption of chemical fertiliser (Urea and DAP) and therefore expenditure savings.

In Afar region, user households reported the substitution of Urea and DAP with bio-slurry. The average quantity of Urea and DAP substituted was 45 kg and 65 kg per household per year, respectively. The average annual expenditure saving associated with the substitution of Urea and DAP with bio-slurry was ETB 1,300 (USD 29).

**Table 4 - Substitution of chemical fertiliser and expenditure savings in Afar region**

| | n= | Amount |
|---|---|---|
| Chemical Fertiliser substituted, Kg/HH/Year | | |
| Urea | 5 | 45 |
| DAP | 6 | 65 |
| Expenditure Saving, ETB/HH/Year | | |
| Urea | 5 | 722 |
| DAP | 4 | 719 |
| Total saving, ETB/HH/Year | | 1,297 |

Users' perception on changes in crop yield due to bio-slurry application

Although the impact of bio-slurry application on crop yield has not been measured, user households reported that application of liquid and composted form of bio-slurry resulted in incremental yield of major crops.

[8] Personal communications with SNV NBPE+ Programme Team Leader.

**Table 5 - Application of bio-slurry and Impact in crop yield in Afar Region**

| Crop Type | n= | Increased | Not yet known |
|---|---|---|---|
| Corn | 5 | 40% | 60% |
| Barely | 2 | 50% | 50% |
| Sorghum | 6 | 67% | 33% |
| Faba Beans | 1 | 0% | 100% |
| Vegetables | 4 | 50% | 50% |
| Fruits | 2 | 100% | 0% |
| Coffee | 1 | 100% | 0% |
| Animal Feed | 1 | 100% | 0% |
| Hinna | 1 | 100% | 0% |

Impact of bio-slurry on the incidences of diseases and pests

User farmers reported decrease in pests/diseases incidence with bio-slurry use. Since these are the mere perceptions of user farmers, no definite conclusion can be drawn without a focused R&D in this regard.

### 2.2.8. Challenges in the use of bio-digesters

User households were asked about any challenges associated with the operation bio-digesters. About 60% of the respondents in Afar stated there is none.

Lack of inputs in particular water shortage during dry season and during droughts and shortage of cattle dung were stated as major disadvantage. Water and dung shortage was reported as the main disadvantage by 19% and 13% of the respondents, respectively. The main problem with availability of dung is associated with the movement of cattle for pasture far away from residential areas. Another challenge reported was the lack of biogas stove for baking Injera (6%).

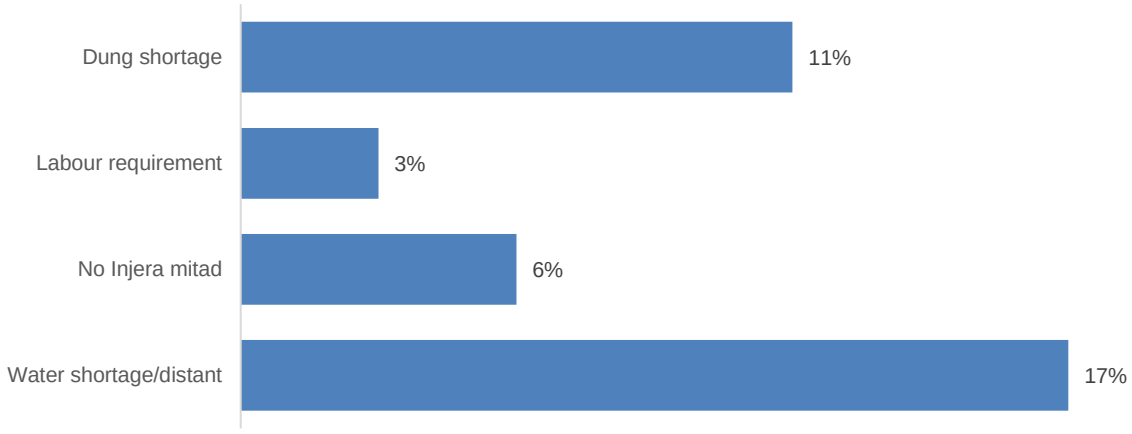



*Figure 10 – Challenges of Use of Bio-digesters in Afar Region*

### 2.2.9. Users' training

About 84% of the respondents in Afar reported training was provided during the initial feeding of the bio-digesters; 63% received training during plant completion; and 44% reported they received training on management of their plants operation. Only 13% of the user households reported they were given leaflets on the operation of their plants.

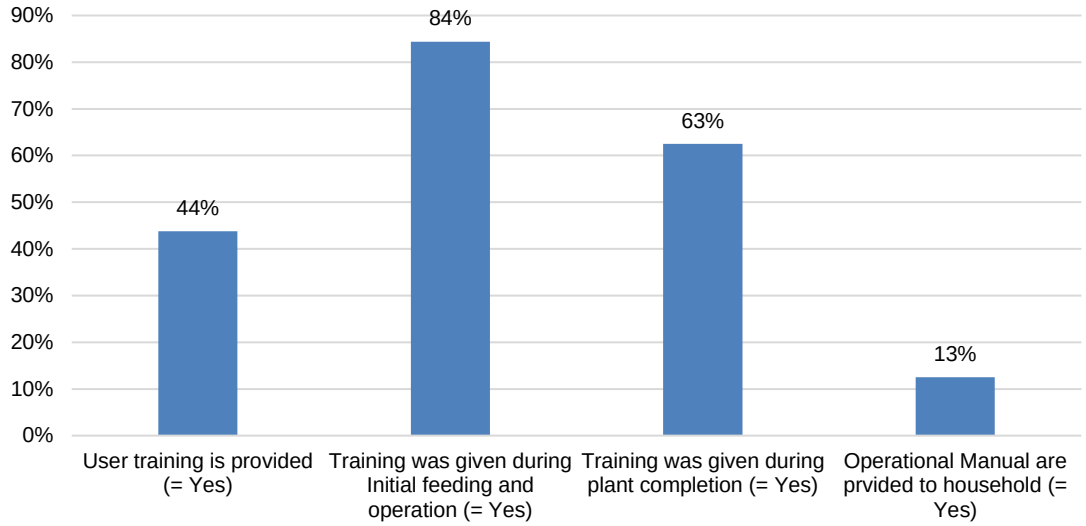



*Figure 11 – Users' Training in Afar Region*

### 2.2.10. Users' satisfaction

User households were asked (using a Likert scale) overall, to what extent were satisfied with their bio-digesters. About 88% stated that they are highly satisfied. About 3% in Afar stated they were unsatisfied. The reasons for high level of user satisfaction can be related to the various benefits of the bio-digesters (discussed in Sections 1.1.5 – 1.1.7).

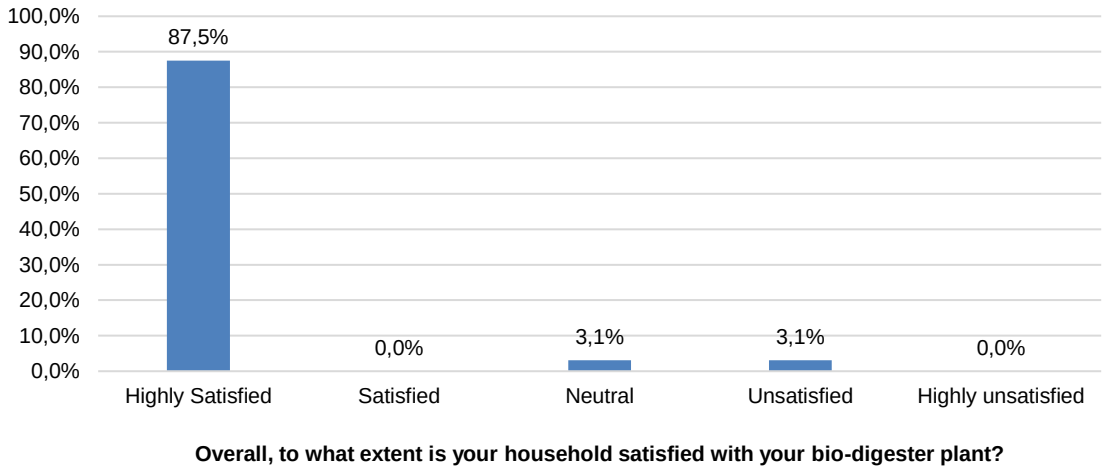



*Figure 12 – User Satisfaction in Afar Region*

### 2.2.11. User opinion on recommending to others to install bio-digesters

Bio-digester user households were asked whether they would recommend to others to install similar plants. An overwhelming majority of the respondents (91%) said they would recommend to others while 3% declined to respond to the question.

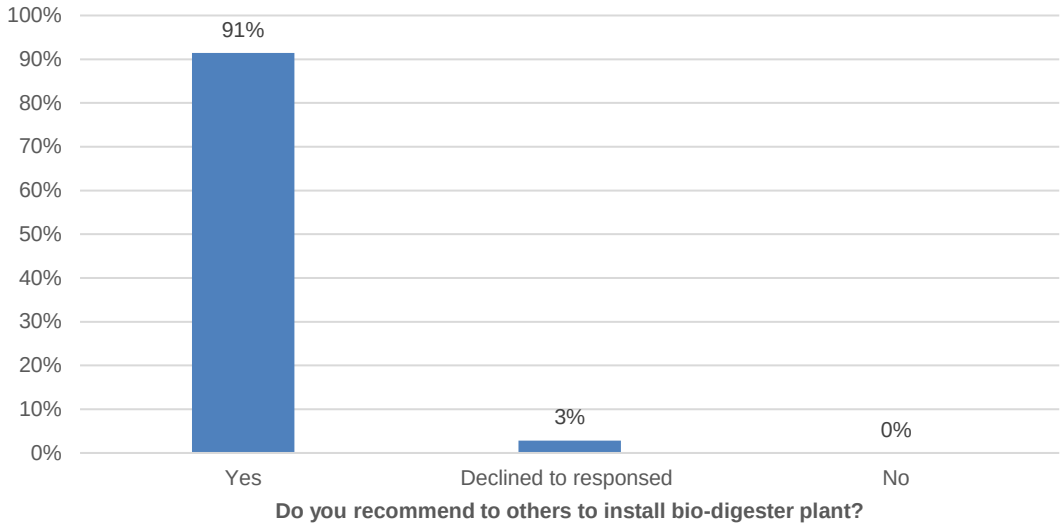



*Figure 13 - Users' opinion on recommending to others to install bio-digesters in Afar Region*

### 2.2.12. Key technical parameters sample bio-digesters

Overall, the construction of bio-digesters in Afar region was found to be of sound quality standards. About 94% of the construction sites were clean and the same percentage of the sites was exposed to sun.

While the quality of construction of the bio-digesters was generally of good quality, certain shortcomings were observed. It was observed that the top fillings of the bio-digesters were prone to erosion in about 30% in Afar region. Moreover, while the standard set by the Programme was to install two compost pits at each plant, one-fifth of the plants had one compost pit. It was observed that only 13% of the compost pits were protected against rain.

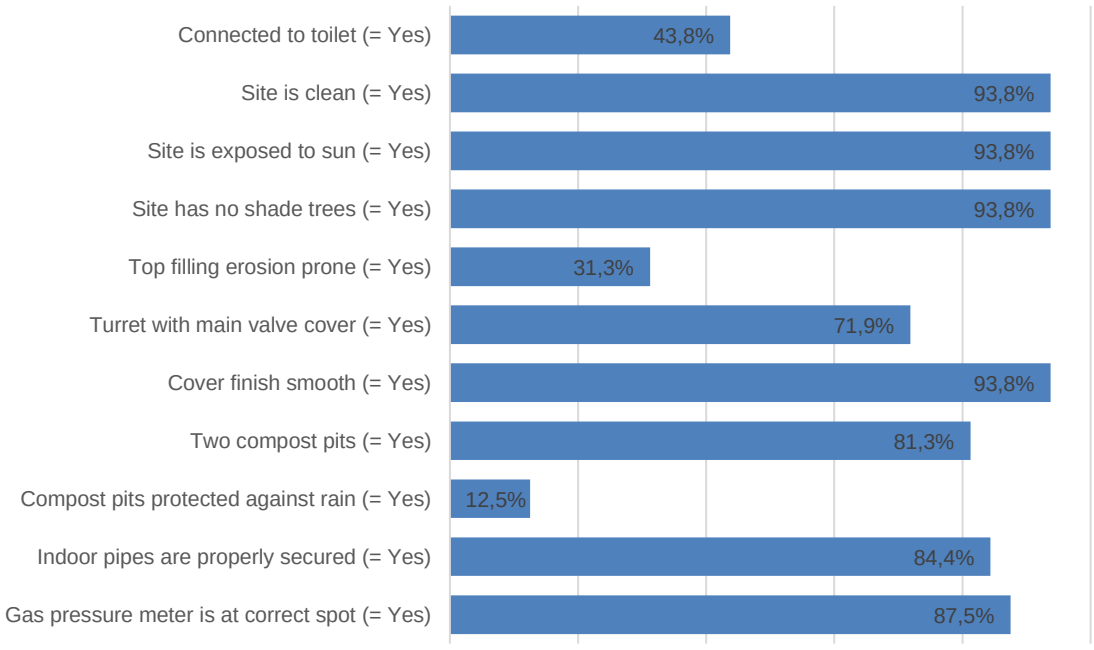



*Figure 14 - Bio-digester construction key technical parameters*

Similarly, it was observed shortcomings in the installation of gas pipes and gas pressure meters. Indoor gas pipelines were properly secured in about 85% of the households in Afar. Gas pressure meters were set at the correct spot in 88% of the sample households.

The above observations of the technical parameters were found to be inconsistent with the functionality rates of the bio-digesters. For instance, gas leakage was associated with poor quality of installation of gas pipes.

## 2.3. Amhara Region

The list of sampled and visited households is shown in Annex III. Some pictures taken in Amhara that illustrate some aspects mentioned in this chapter are shown in Annex IV.

### 2.3.1. Household characteristics

**Household Size**

The mean household size of the sample was 5.7 persons and varies from 2 to 10 persons. Households with 5 to 7 persons accounted for 60%. About 84% of the sample has a household size of 4 to 8 persons.

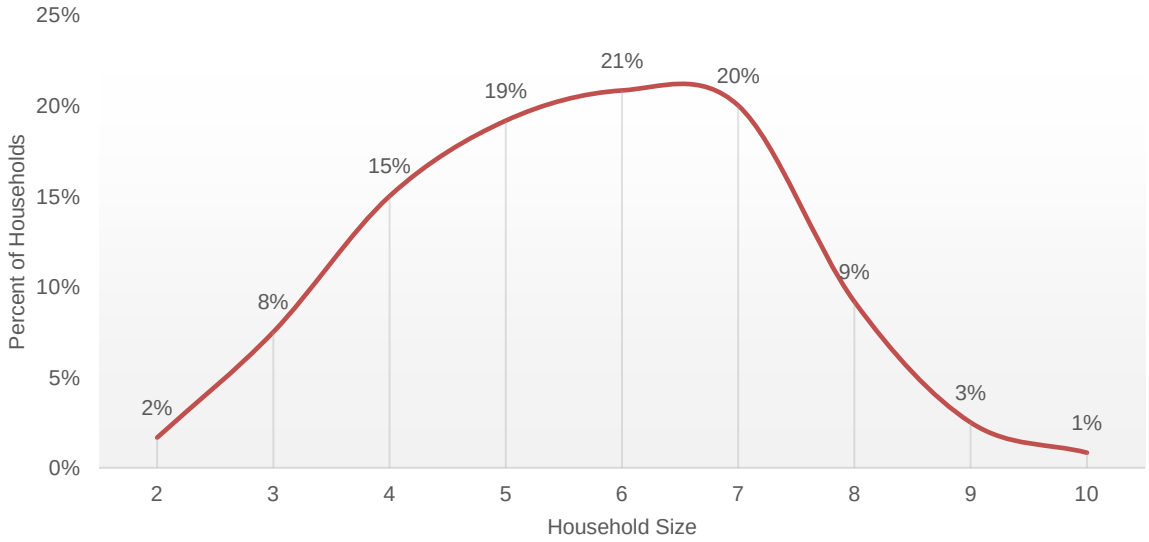



*Figure 15 – Distribution of Sample by Household Size in Amhara Region*

**Characteristics of Head of Household**

The majority of the bio-digester users are male-headed households (92%). The mean age of the head of the household is 42 years.

The distribution of the sample by educational level of the head of the household shows that 33% were illiterate while 34% can read and write. One-third of the sample has formal education ranging from Grade 2 to Grade10. The highest proportion of the heads of the households has Grade 5 and Grade 10, accounting for 5.8% each.

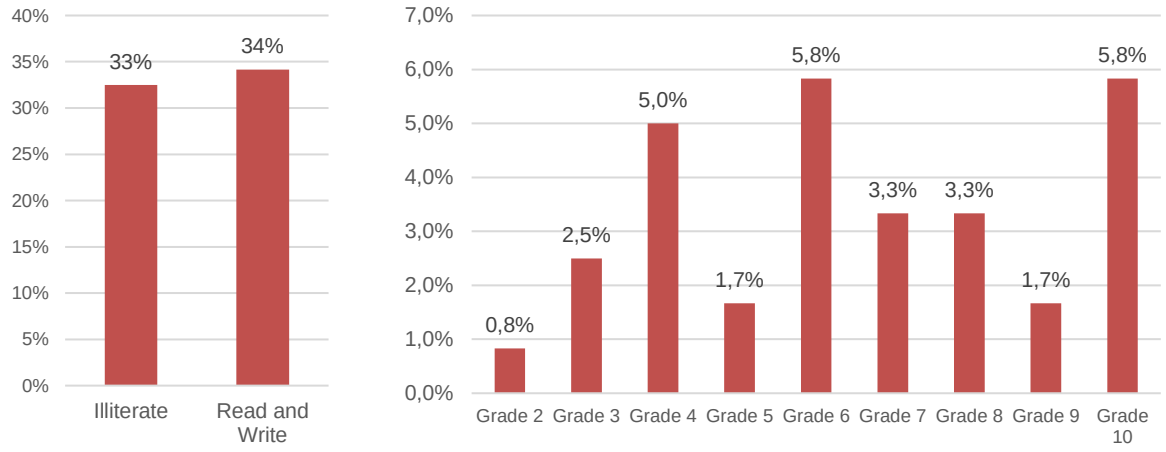



*Figure 16 – Distribution of Sample by Educational Level of Head of Household in Amhara Region*

### 2.3.2. Reasons for Installation of bio-digesters

Almost all user households (96%) in Amhara reported biogas for cooking as one of the main reasons for installing bio-digesters and 90% said biogas for lighting as one of the important reasons. About three quarters of users reported bio-slurry use as one of the main purposes for installing the bio-digesters.

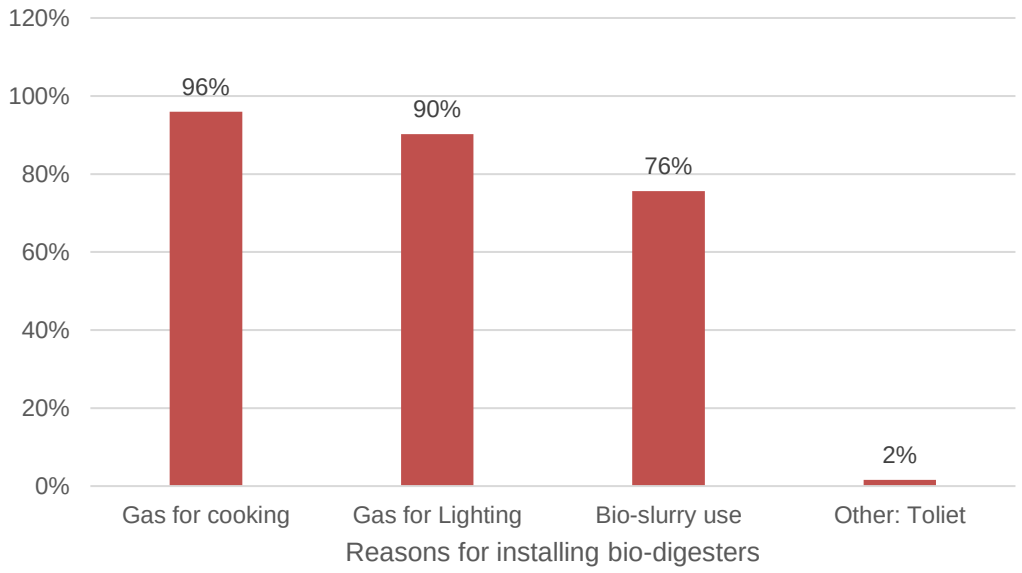



*Figure 17 - Use of bio-digesters in Afar and Amhara regions*

### 2.3.3. Functionality of bio-digesters

The bio-digesters installed are based on established technical standards proven in several other countries. The technology is considered reliable, well-functioning, simple, durable and with low maintenance cost. A high-quality biogas plant needs minimum maintenance costs and can produce gas for at least 15–20 years without major problems and re-investments.

On the other hand, concerns are raised with regard of the functionality rates of bio-digesters. In Amhara, only 72.5% of the digesters were functional (see Annex VI - Statistical Tables).

In Amhara the most important causes of non-functionality are insufficient cattle dung for feeding 13%, cracks in digesters and failure of appliances (such as broken pipes, shortage and low quality of accessories and appliances and poor workmanship) 12.2%; and lack of labour for feeding 12.2%.

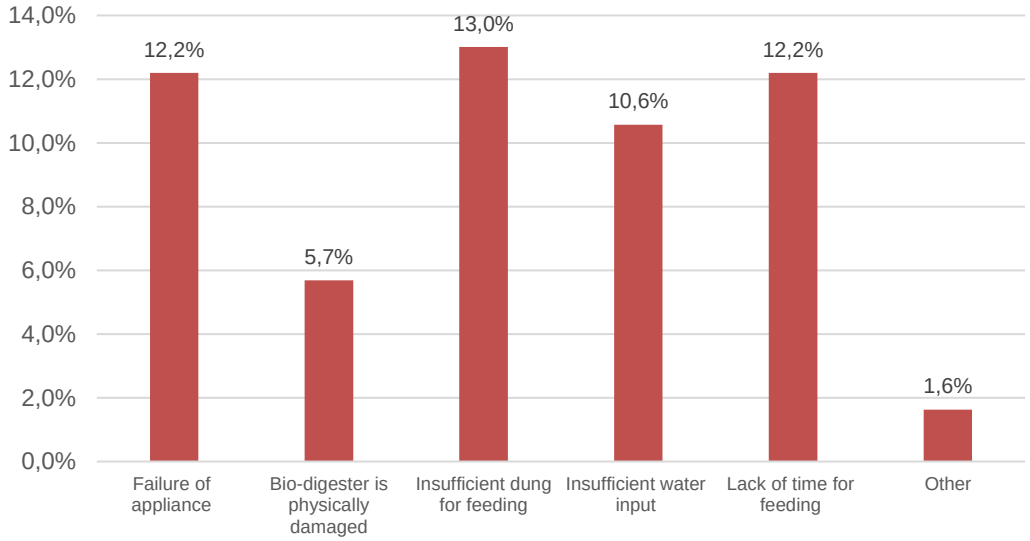



*Figure 18 - Causes of non-functioning of bio-digesters in Afar and Amhara regions*

### 2.3.4. After-sales-service

It was found that there are significant delays in repair of non-functional bio-digesters. The average duration of non-functionality of the digesters was 4.8 months (see Annex VI - Statistical Tables). About 18% of non-functional bio-digesters were not repaired for 2 months.

According to the Regional and Woreda energy experts the main reasons were weak monitoring and supervision by Woreda energy experts, lack of budget for repair and lack of appliances in the market.

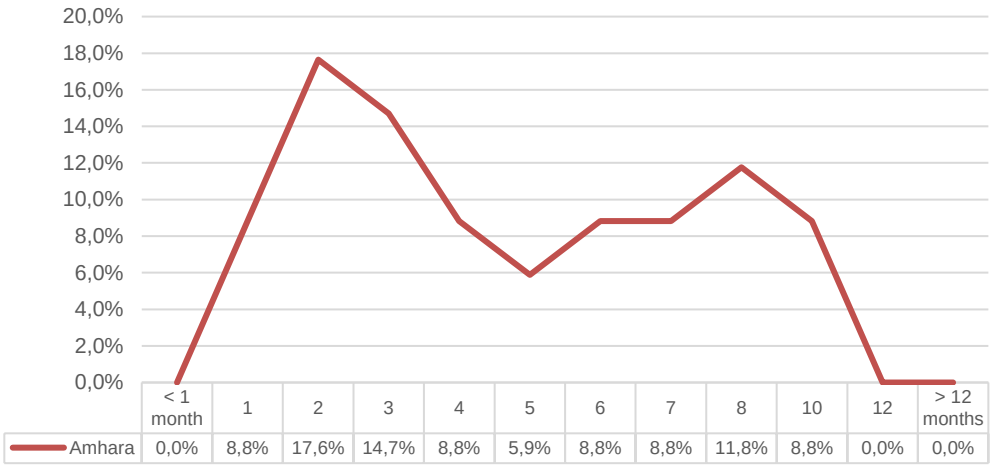



*Figure 19 - Distribution of non-functional bio-digesters by number of months*

### 2.3.5. Benefits of bio-digesters

The benefits of bio-digesters include reduction on household expenditure on energy for cooking and lighting, firewood collection time saving, reduced cooking time, reduction on household expenditure on chemical fertiliser, increased crop yield, and improved health associated with reduction in household air pollution and improved sanitation and hygiene.

About 94% of bio-digester user households in Amhara region reported firewood savings associated with biogas use and 95% of user households reported firewood collection and cooking time savings. In Amhara, 11% of the user households reported expenditure savings on cooking (charcoal and kerosene) and lighting (dry cell batteries).

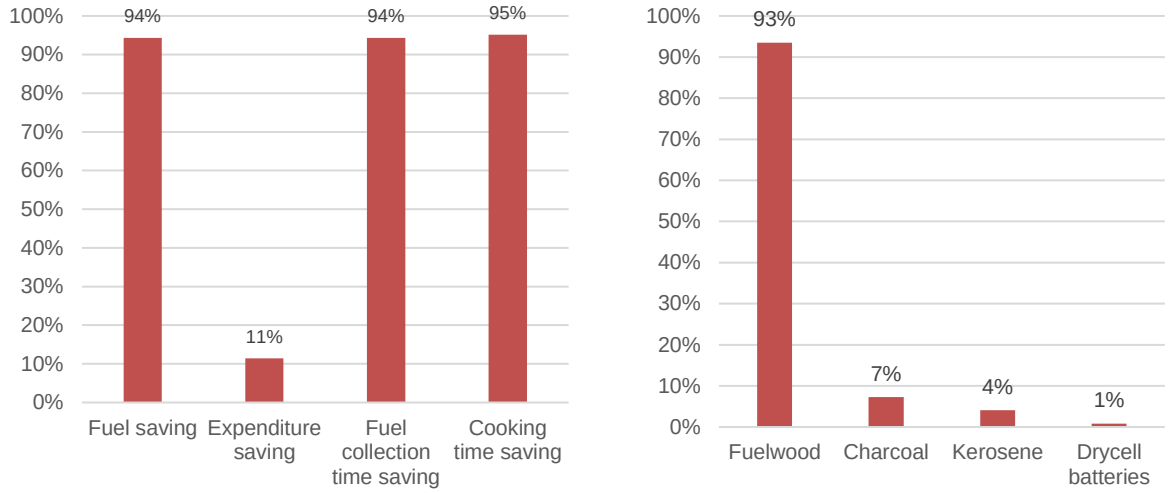



*Figure 20 - Benefits of biogas use (left) and Types of fuels displaced (right) in Amhara Region*

### 2.3.6. Health impacts of biogas use

The bio-digesters use for cooking and lighting were associated with reduced Household Air pollution and related ailments. The interviewed households reported that smoke levels were lower with the use of the biogas for cooking. The reductions in household air pollution contributed to the reductions of eye irritation, respiratory illness, and incidence of fire burns.

About 92% in Amhara reported reduction in eye irritation with biogas cooking as compared with firewood. Similarly, 79% in Amhara reported fire injury associated with firewood cooking has been reduced.

On the other hand, a high proportion of the biogas user households reported that they do not know the effects of using biogas on respiratory infections (76%) and on coughing (68%).

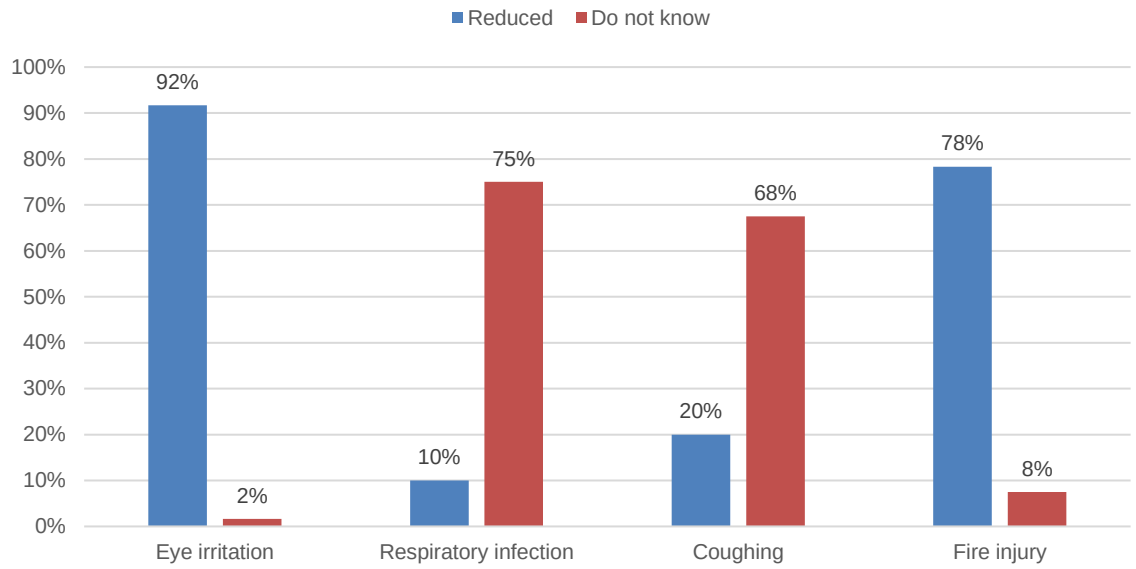



*Figure 21 - Health impacts of bio-digester use in Amhara Region*

### 2.3.7. Bio-slurry management and application

About 60% of the bio-digester users in Afar apply bio-slurry on their farms. However, it was found that the users do not take measurements of the quantity of bio-slurry produced and applied. A 6m$^3$ bio-digesters requires inputs of 36-48 kg of cattle dung and 36-48 litres of water per day. According to SNV, a properly maintained 6m$^3$ can produce 30 to 35m$^3$ of bio-slurry per year. [9] This amount is sufficient to cultivate one hectare of farmland.

Asked how bio-slurry was applied, about 63% reported they apply it "as-it-is"; 31% apply it after drying; and 6% apply it in the form of compost.

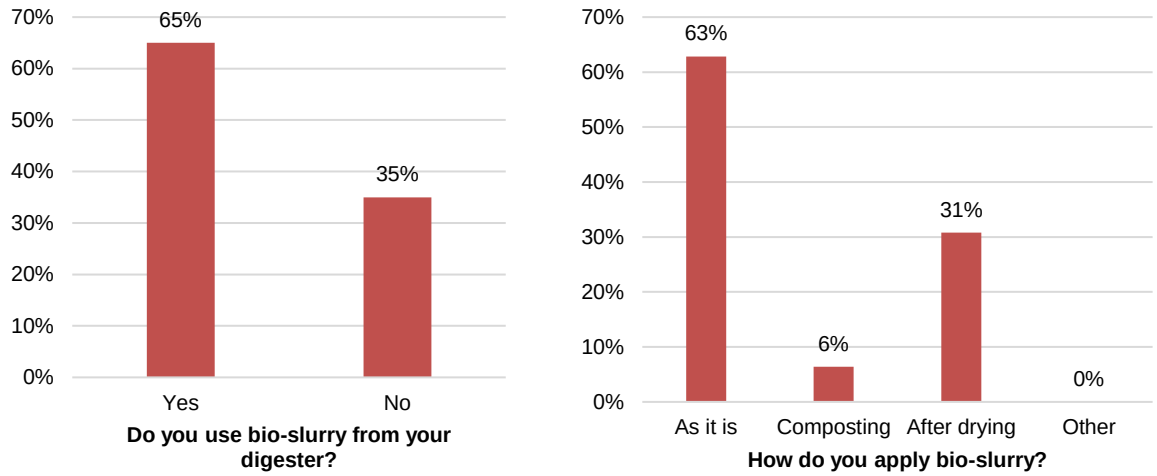



*Figure 22 - Use of bio-slurry in Amhara Region by households (left) and how bio-slurry used (right)*

Bio-slurry application impact on saving of expenditure on chemical fertiliser

[9] Personal communications with SNV NBPE+ Programme Team Leader.

The application of bio-slurry has the potential to increase crop yield and reduce expenditure on chemical fertiliser. The use of the bio-slurry from bio-digesters reduces consumption of chemical fertiliser (Urea and DAP) and therefore expenditure savings.

In Amhara region, user households reported the substitution of Urea and DAP with bio-slurry. The quantity of Urea and DAP substituted was 75 kg/HH/year and 73kg/HH/year, in their respective orders. The total household expenditure saving associated with the substitution of Urea and DAP with bio-slurry was ETB 2,200 (USD 49).

**Table 6 - Substitution of chemical fertiliser and expenditure savings Amhara Region**

| | n= | Amount |
|---|---|---|
| Chemical Fertiliser substituted, Kg/HH/Year | | |
| Urea | 24 | 75 |
| DAP | 32 | 73 |
| Expenditure Saving, ETB/HH/Year | | |
| Urea | 24 | 1,219 |
| DAP | 31 | 1,262 |
| Total saving, ETB/HH/Year | | 2,206 |

Users' perception on changes in crop yield due to bio-slurry application

Little attention has been given by the Programme in generating data regarding the influence of slurry use on the yield of crops and vegetables. When asked on any change in crop yield associated with bio-slurry application, most users reported increased in yield of major crops. For example, 80% or more reported increased yield of vegetables, fruits and wheat. A significant number of respondents said the effects of bio-slurry application on yield remains to be seen during the harvest season.

**Table 7 - Application of bio-slurry and Impact in crop yield in Amhara Region.**

| Crop Type | n= | Increased | Not yet known |
|---|---|---|---|
| Teff | 3 | 67% | 33% |
| Corn | 22 | 73% | 27% |
| Wheat | 20 | 80% | 20% |
| Barely | 8 | 50% | 50% |
| Sorghum | 9 | 56% | 44% |
| Faba Beans | 24 | 67% | 33% |
| Vegetables | 32 | 81% | 19% |
| Fruits | 6 | 83% | 17% |
| Coffee | 5 | 60% | 40% |
| Chat | 1 | 0% | 100% |
| Sugarcane | 1 | 100% | 0% |
| Hinna | 4 | 75% | 25% |

Impact of bio-slurry on the incidences of diseases and pests

User farmers reported decrease in pests/diseases incidence with bio-slurry use. Since these are the mere perceptions of user farmers, no definite conclusion can be drawn without a focused R&D in this regard.

### 2.3.8. Challenges of the use of bio-digesters

User households were asked about any disadvantages associated with bio-digester ownership and use. The majority of respondents (63%) stated there is none, just benefits.

Lack of inputs in particular water shortage during dry season and during droughts and shortage of cattle dung were stated as major disadvantage. Water shortage was reported by 10% while 8% reported dung shortage.

Other issues stated as a disadvantage of bio-digester include high labour requirement; biogas lamp replacement not available in market; gas output not adequate to meet household's daily cooking energy needs; lack of Injera Mitad (Injera baking stove); gas output not consistent, hand mixing of dung.

Other challenges cited include high labour requirement; unavailability of biogas lamp in the market; gas output is inadequate to meet household's daily cooking energy needs; lack of Injera Mitad (Injera baking stove); gas output not consistent, hand mixing of dung and water (lack of installation of a mixer), firewood collection easier than dung collection[10], flooding, and gas smell especially during dry season.

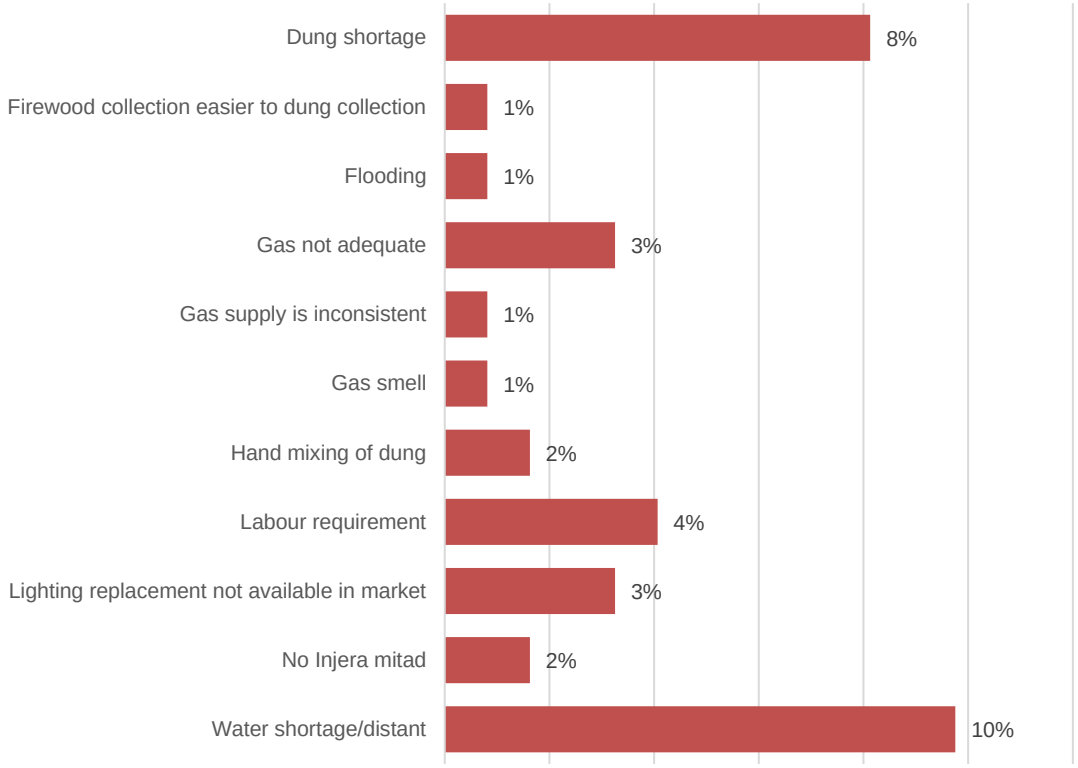



*Figure 23 – Challenges in use of Bio-digesters in Amhara Region*

### 2.3.9. Users' training

One of the causes of the high rate of the non-functionality rate of the bio-digesters is poor operation and management conditions for many installations. This in turn is attributed to inadequate user training and lack of operation guide including basic troubleshooting.

About 88% of user households in Amhara received post-construction orientation during the initial feeding of the bio-digesters, and 55% reported they received training on management of their plants operation. Only 25% in Amhara reported they were given leaflets on the operation of their plants.

[10] The respondent does not have cattle of his own. Collects cattle dung for the bio-digester. The respondent uses firewood from homestead plantations.

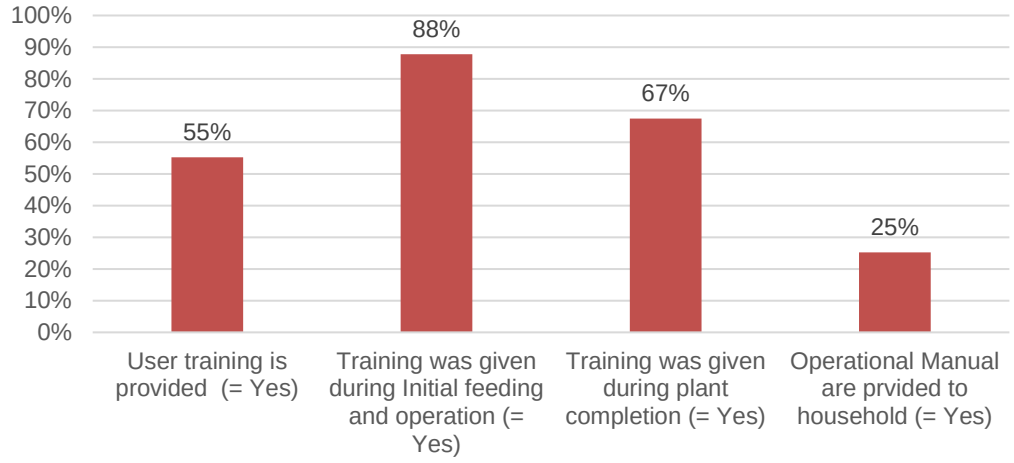



*Figure 24 – Users' Training in Amhara Region*

### 2.3.10. Uses' satisfaction

User households were asked (using a Likert scale) overall, to what extent were satisfied with their bio-digesters. About 76% in Amhara stated that they are highly satisfied. About 11% stated there were satisfied and 8% were neither satisfied nor unsatisfied (neutral). Only 2% of the respondents stated they were unsatisfied. The reasons for high level of user satisfaction can be related to the various benefits of the bio-digesters (discussed in Sections 2.1.5 – 2.1.7).

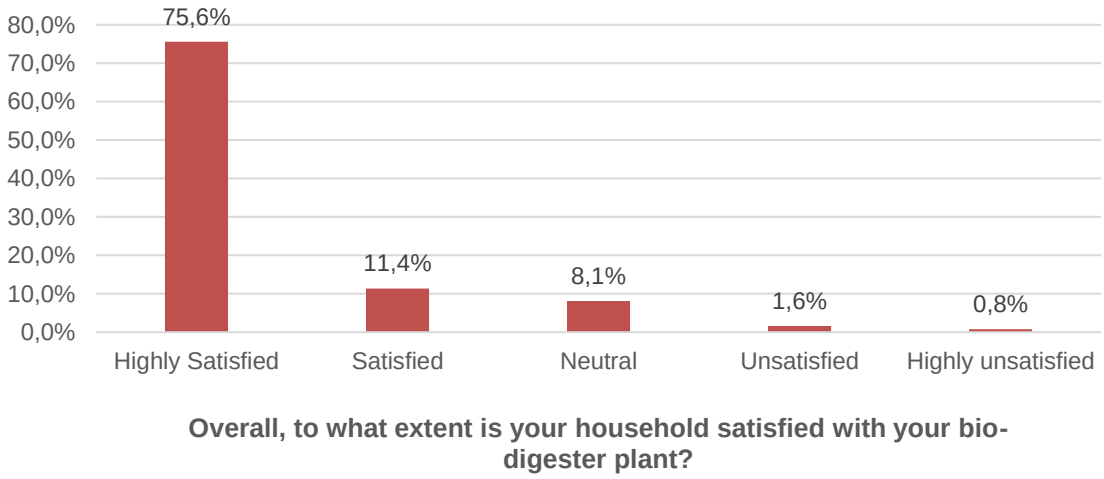



*Figure 25 – User Satisfaction in Amhara Region*

### 2.3.11. Users' opinion on recommending to others to install bio-digester

Bio-digester user households were asked whether they would recommend to others to install similar plants. An overwhelming majority of the respondents (95%) in Amhara stated they will recommend to others; and 1% each stated they would recommend only if their non-functional plants are repaired, if the household has sufficient labour to meet the daily feeding requirements.

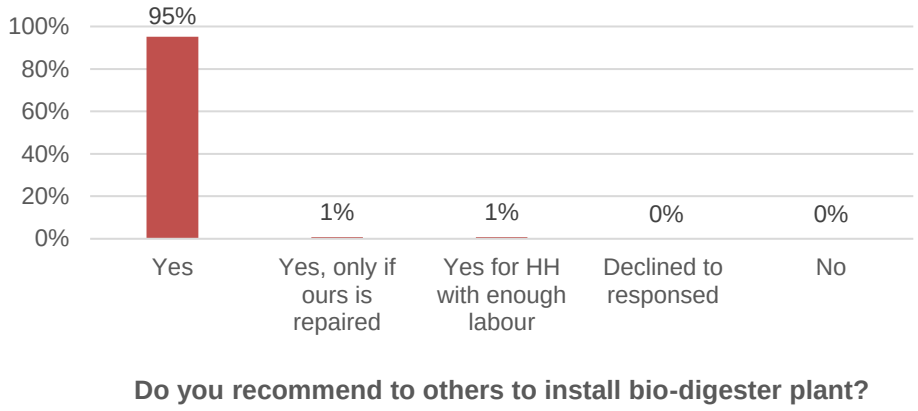



*Figure 26 - Users' opinion on recommending to others to install bio-digesters in Amhara Region*

### 2.3.12. Key technical parameters sample bio-digesters

Overall, the construction of bio-digesters in both Afar and Amhara regions were found to be of sound quality standards. About 97% of the construction sites were clean and 96% were exposed to sun. While the quality of construction of the bio-digesters was generally of good quality, certain shortcomings were observed.

It was observed that the top fillings of the bio-digesters were prone to erosion in about 30%. While the standard set by the Programme was to install two compost pits at each plant, about a quarter of the plants in Amhara had one compost pit. In addition, it was observed that only 23% of the compost pits were protected against rain.

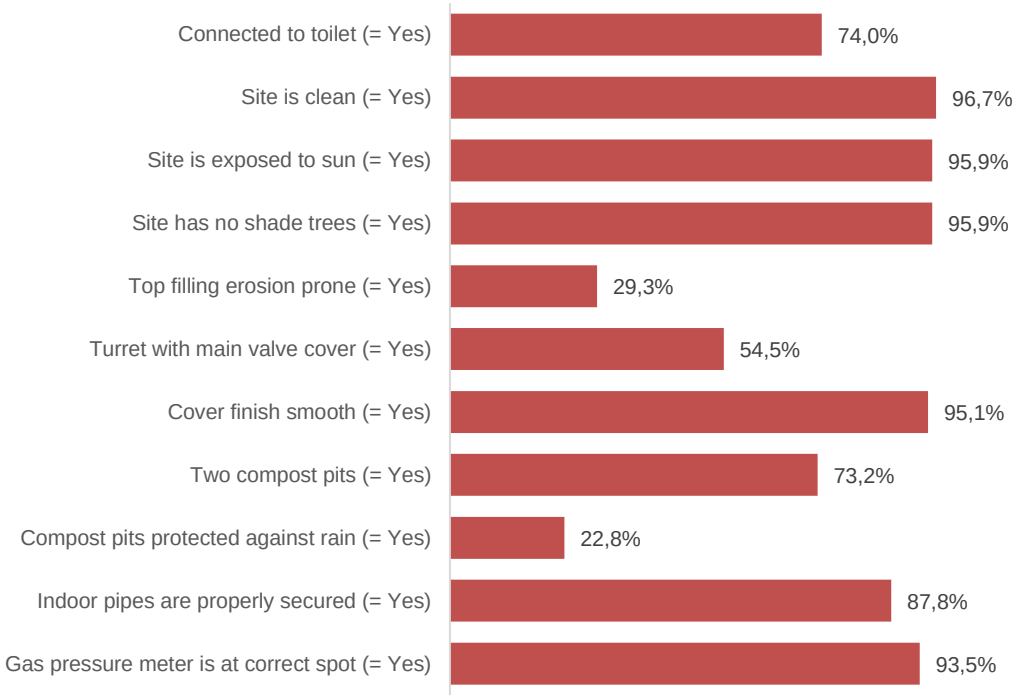



*Figure 27 - Bio-digester construction key technical parameters in Amhara Region*

Similarly, it was observed shortcomings in the installation of gas pipes and gas pressure meters. Indoor gas pipelines were properly secured in about 85% and 88% of the households in Afar and Amhara. Gas pressure meters were set at the correct spot in 88% in Afar and 94% in Amhara.

The above observations of the technical parameters were found to be inconsistent with the functionality rates of the bio-digesters. For instance, gas leakage was associated with poor quality of installation of gas pipes.

### 2.3.13. Implementation challenges

Interviews and discussions with RBPCU staff, energy experts at the regional, Zone and Woreda government structures, Biogas Construction Enterprises (BCEs) and masons, appliance manufacturers, and biogas users interviewed during the field missions pointed out the following implementation challenges:

a) Inadequate promotion and low level of demand creation:
- Lack of pre-financing for promotion and demand creation activities.
- Insufficient training of RBPCUs experts, regional, Zone and Woreda energy experts.
- Vacant positions in RBPCUs. The implementation of the Programme was highly affected by high turnover of experts at regional and Woreda levels.

b) Biogas investment incentive (subsidy) amount:
- The high inflation rate in Ethiopia has been accompanied with significant price increases of construction materials and wages.

c) Poor coordination of key partners:
- Complex programme implementation arrangement: multi-sectorial stakeholder at national, regional and Woreda level, number of implementation partners, geographic coverage.
- Low level of engagement of government agencies, particularly at Woreda level. In Amhara region, in addition to staffing biogas expert positions in each Woreda, the regional government allocates a matching fund of about 40%. The Afar regional Government has also allocated supplementary budget for the Programme.
- Poor inter-institutional coordination between energy office and agriculture.

d) High turnover of experts:
- The implementation of the Programme was highly affected by high turnover of experts at national, regional and Woreda levels.

e) Low motivation of Woreda energy experts:
- Poor organisational accountability.
- Lack of budget and transport for monitoring and supervision.
- Insufficient training of Woreda experts. The training areas may include bio-digester promotion and demand creation; bio-digester quality standards; site selection; bio-digester construction and supervision; operation and maintenance including troubleshooting; user training and monitoring and evaluation.

f) Private sector development.

The NBPE+ has rightly emphasised on market and private sector development thus enabling a vibrant market for bio-digesters including appliances and accessories manufacturing and supply. The private sector will ensure a reliable supply of services and systems that respond effectively to household demand. The successful implementation of the Programme has been challenged due to:

- **Low retention rate of biogas masons.** The main reasons of the low level of retention biogas masons are low payment rates; inaccessibility of biogas sites; delays in supply of construction materials (cement, sand and gravel) by beneficiary households; delays in

payment; and retention requirements but also low and geographically scattered demand. The biogas masons are reportedly attracted to relatively better paying and longer-term assignment in other construction works;

- Low capacity in technology research, development and dissemination (e.g., Injera Mitad and lighting appliances); and
- Low university-business linkage.

## 2.4. Gambella

In Gambella region (likewise in Oromia, SNNP and Somali regions) discussions were held about bio-digesters with the Regional Biogas Programme Coordination Unit, Bureau of Minerals and Energy Agency, Microfinance Institutions and Bureau of Regional Agriculture and masons. There were interviews with the bio-digester households owners during which different types of questions were asked at household level, such as the household characteristics and the performance of bio-digesters energy and bio-slurry. The status of the bio-digesters was also observed.

The qualitative data was summarised and narrated, while quantitative data was analysed by descriptive statistics and logistic regression. An inferential statistic "*t-test*" was used to determine the significant difference between the means of the two groups of the performing and non-performing bio-digesters, with restriction or degree of freedom (df=N-1) and significance at 5% probability level.

### 2.4.1. Quality of construction

In Gambella region (likewise in Oromia, SNNP and Somali regions) discussions were held about bio-digesters with the Regional Biogas Programme Coordination Unit, Bureau of Minerals and Energy Agency, Microfinance Institutions and Bureau of Regional Agriculture and masons. There were interviews with the bio-digester households owners during which different types of questions were asked at household level, such as the household characteristics and the performance of bio-digesters energy and bio-slurry. The status of the bio-digesters was also observed.

The qualitative data was summarised and narrated, while quantitative data was analysed by descriptive statistics and logistic regression. An inferential statistic "*t-test*" was used to determine the significant difference between the means of the two groups of the performing and non-performing bio-digesters, with restriction or degree of freedom (df=N-1) and significance at 5% probability level.

### 2.4.2. Purpose for which bio-digesters were installed

In Gambella, about 92.3% of the households installed bio-digester for cooking purpose and 15.4% for bio-slurry supply. The regional energy office was the main agent who promoted bio-digester technology where people are gathered. The number of people who use biogas for light was few because of the availability of electricity. The number of people who planned for bio-slurry was also low because of the few experience in agricultural practice.

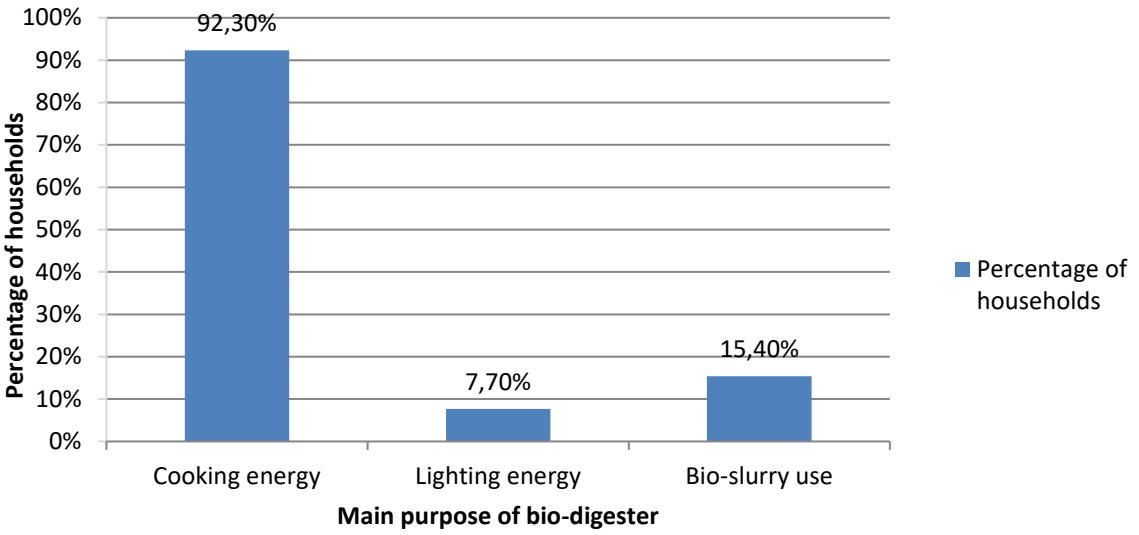



*Figure 28 - Use of bio-digesters in Gambella region*

### 2.4.3. Functionality of bio-digesters

In Gambella, it was difficult to determine the functionality rate of bio-digesters because the construction of 48% of the sampled bio-digesters was not completed. The regional coordinator of biogas responded as the uncompleted bio-digesters to be completed in short period of time. Delayed construction such as uncovered domes and poor feeding were the major problems for their functionality. Moreover, households had no problem with firewood as energy source. The cattle number was decreasing through time because of cattle disease or death, which also decreases the availability of dung. The ownership of bio-digesters in Gambella was not clear because the households did manage the bio-digester as expected. The overall functionality during the study period (May 2021) was 77% out of the completed 13 bio-digesters, which varied among the studied Woredas as shown in the table below. Four did not exist at all, although they were registered in the database.

**Table 8 - Functionality levels bio-digesters in Gambella Woredas**

| | | Functioning | Not functioning | Total number |
|---|---|---|---|---|
| Sampled Woredas in Gambella | Abobo | 67.0 | 33.0 | 9 |
| | Abol | 100.0 | 0.0 | 1 |
| | Gambella town | 100.0 | 0.0 | 2 |
| | Gambella Zuria | 100.0 | 0.0 | 1 |
| Total average percentage | | 77.0 | 23.0 | 100 |
| Total number | | 10.0 | 3.0 | 13 |

The functionality rate without notable problem was low, however minor and major functionality problems without system problem were seasonally corrective such as no proper feeding because of loss of livestock (local thieves) than can be replaced and no sufficient feed and distant water sources in dry season. The permanent problem for non-functionality were no proper feeding because of cattle death (33.3%) and delayed construction, and no proper feeding any more (66.7%). The lack of sufficient feed was also due to the prevailing dry season, in which the local people usually take their livestock away from the residential areas in pastoral mode life. The size of all sampled households bio-digester was 6m$^3$ and there was no complain on the size or the functionality. The biogas lamps were not working when the stoves were being used, because of insufficient share of power.

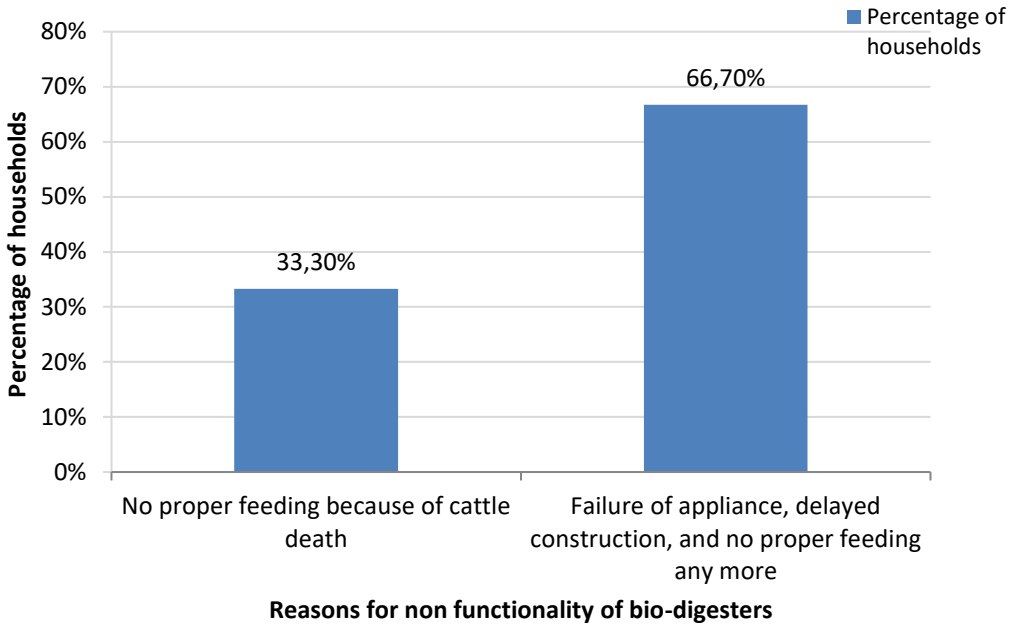



*Figure 29 - Reasons for non-functionality of bio-digesters in Gambella.*

Abandoned construction of simple excavation only!

*Figure 30 - Bio-digester agreed and put in database but not done, abandoned construction after simple excavation.* Gambella Gambella Town_ Gambella Town_ Tut Tongyiek_ GM AB 20 Year 3_2020 (Left) and Gambellla Anywaa_ Gambella Zuria_ Abol Kir_ Agwa Gilo_ GM AB 15 _Year 3 2020_(right)

### 2.4.4. Quality of after-sales service

There were some after-sales services in Gambella but, because of lack of transport, the masons were not able to reach the households' bio-digesters regularly. The masons have no special budget to maintain bio-digesters. Although there is an already allocated budget for after-sales-service, the budget is either not sufficient to take care of the bio-digester. After –sales –service is not a onetime activity as it requires repeated and frequent travel and material costs. The bio-digesters were highly scattered and the distance between the residential places of masons and the bio-digester construction areas were large and inaccessible.

The households that faced problems with their bio-digesters had difficulties in communicating with the biogas experts because there was no Woreda and Zone level energy administration. The few region level staff could not reply to the all the questions raised by the households. On the other hand, the region level experts were aiming at quantity rather than quality, as the funding was based on the number of bio-digesters constructed regardless of their functionality. Moreover, there is lack of

budget for maintenance of damaged bio-digesters but new budget is allocated annually for new installation. For example, turret cover dismantled was not maintained and then susceptible to dome pipe breakage as shown in the figure below. The after sales service delays up to 24 months to solve problems created on bio-digesters as shown in Figure below.

*Figure 31 - Dismantled turret cover.*
(Gambella_Anywaa _Abobo _Mender 8 GM AB 8 Year 3_2019 Deneke Tesfaye)

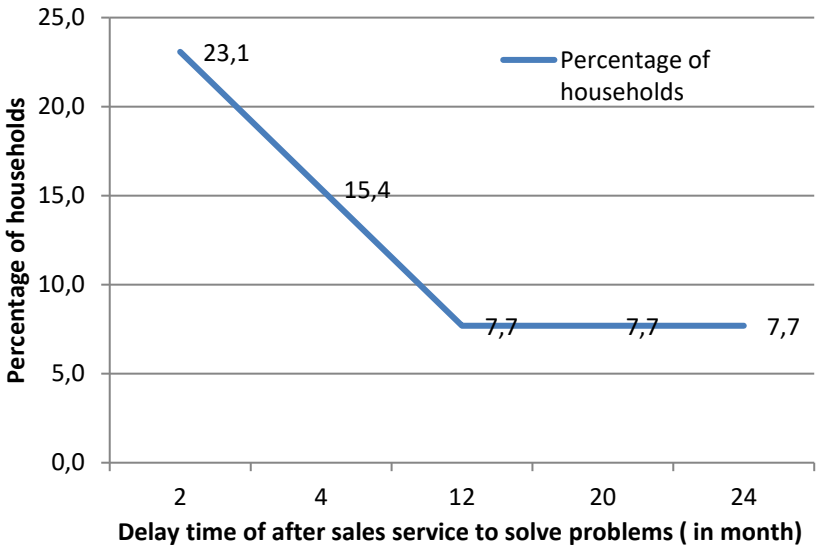



*Figure 32 - The delay time of maintenance required in after sales service for bio-digesters*

### 2.4.5. Benefits of biogas

The benefits of bio-digester technology are diverse. Especially, the cooking benefit of biogas is highly appreciated because it saves time of cooking when compared with firewood.

Bio-digesters are not only sources of energy and bio-slurry, but they also improve the health condition of people affected by firewood smoke and reduce expenditure and save time used for firewood collection and utilisation, reduce the amount chemical fertiliser and improve the productivity of crops. The proper use of biogas could save 11.0 to 43.0% in hot season and 12.0 to 46.0% in cold season the amount of woodfuel utilised that varied significantly among households. In hot season firewood is easily obtained so that less biogas is used but in cold season firewood is not easily obtained so that more biogas is used. The bio-digesters were installed in households that have water source points that take a walking distance ranging from 1.5 to 5.5 minutes and a monthly income of ETB 15,850 to ETB 20,303. The contribution of biogas to households in continuously functioning bio-digesters was greater than the non- functioning. In functioning bio-digesters, the contribution of

biogas in consumption of wood saving ranged from 37.5% to 42.5%. About 75% of the households stated that the use of biogas saved 50% of the amount and time wood fuel collection and utilisation.

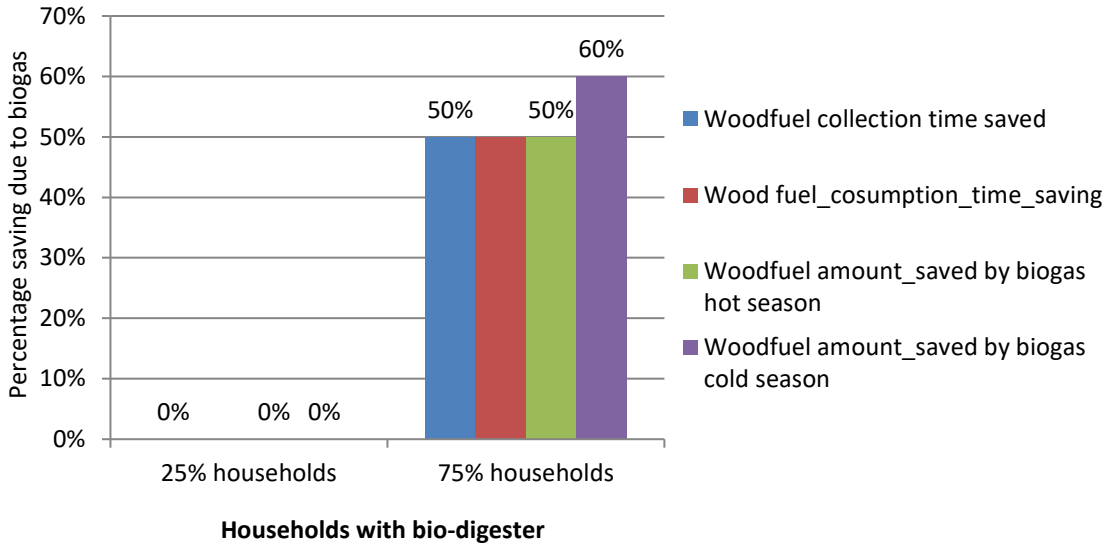



*Figure 33 - Wood fuel amount and time saving due to biogas utilisation in Gambella*

### 2.4.6. Health impacts of biogas

About 61.5% of the households responded that they perceived health benefits of biogas by reducing eye infection, respiratory diseases, cough, and fire related injury. However, 23.1% of the households perceived no health benefits of biogas.

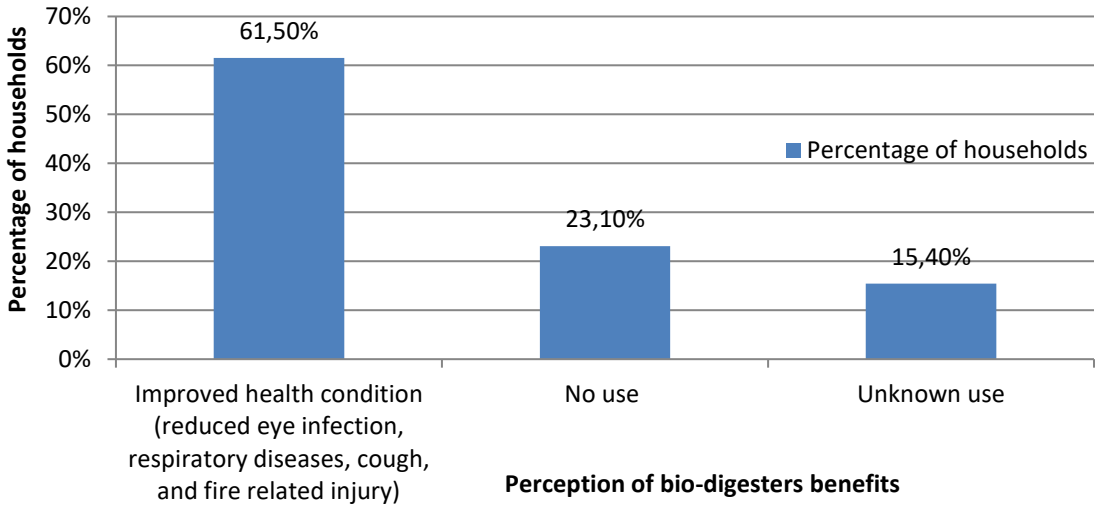



*Figure 34 - Perception of households on health impacts of bio-digesters in Gambella*

### 2.4.7. Bio-slurry management and application

There was no recognised use of bio-slurry in Gambella because of the poor experience of applying bio-slurry to agricultural land. The demand for bio-slurry was very low because the subsistence farmers had fertile soils. There was also a poor extension service and a lack of awareness in promoting bio-slurry for agriculture. Households in urban areas who constructed bio-digesters faced the problem of disposing the bio-slurry, because the households situated in urban areas had no

agricultural land. As shown in the figure below about 69.2% of the households' bio-slurry was not utilised. In 15.4% of the households, bio-slurry was used for maize production.

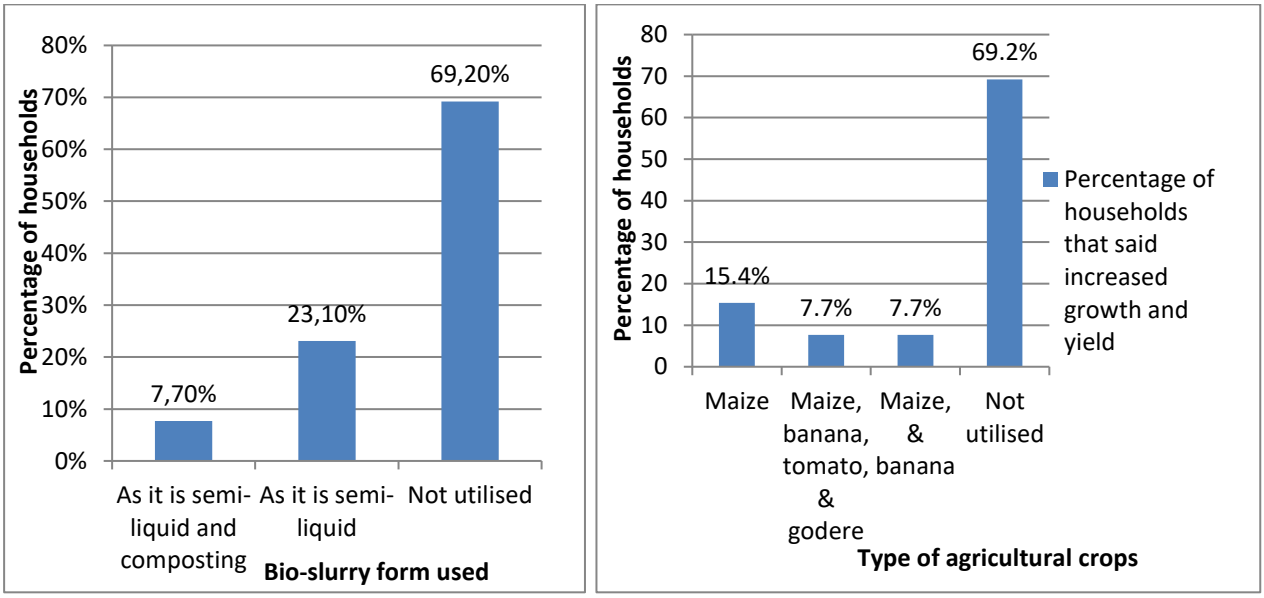



*Figure 35 - Bio-slurry utilisation form and crop types used in Gambella*

A discussion held at Gambella Bureau of Agriculture (BoA) revealed the possibility of creating demand for bio-slurry if there is possibility of a continuous supply of bio-slurry. There was one household that occasionally used bio-slurry (see figure below).

Gambella BoA stated that its staff members were trained in bio-digester and bio-slurry at national level in Adama in 2005. However, the application of bio-slurry on soil and improvement of soil fertility was not well taken by some stakeholders. There was no continuous provision of training and no ownership of bio-slurry. The lack of institutional ownership of bio-slurry was caused by the insufficient supply of bio-slurry and the low awareness level of farmers. Scanty production of bio-slurry at different scattered places did not attract the interest of neither farmers nor agricultural professionals in Gambella BoA. Better production of bio-slurry requires better feeding of livestock and bio-digester, which also includes working with livestock sectors. The soil fertility improvement department of the Gambella BoA has no financial support to run any bio-slurry activities. Nevertheless, the bureau has a great interest to work on bio-slurry with any organisations that want to work collaboratively.

*Figure 36 - Bio-slurry used for maize and banana farm.*
(Gambella_ Anywaa_ Abobo_ Mender 7_ GM AB 2_ Year 3_2019_ Tesfaye Ayemo)

### 2.4.8. Limitations in the use of bio-digesters as disadvantage

About 30.8% the households with bio-digesters perceived that bio-digesters had no challenges' or limitations. However, some 23.1% of the households perceived that there is unpleasant odour during mixing dung with water and during utilising the biogas in stoves.

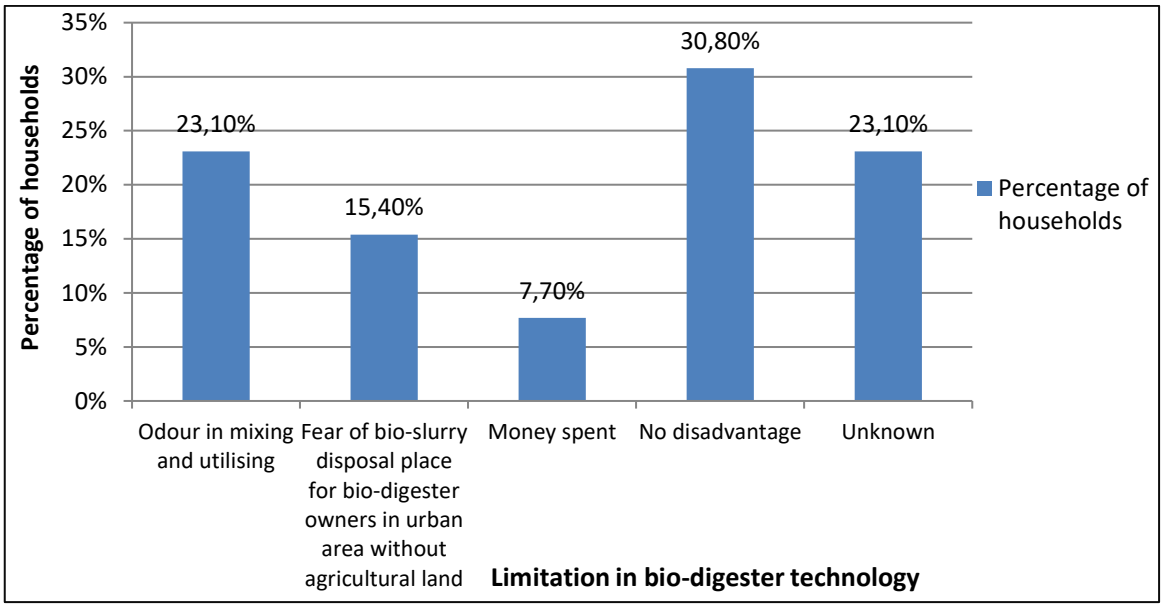



*Figure 37 - Limitations in the installation and use of bio-digester in Gambella*

### 2.4.9. Users' training

All the bio-digester users were trained about how to use and feed the bio-digester. However, all of them were not provided with user manual and they lack reference material as show in table below. Moreover, the great interest of households on bio-digester technology motivated them to finance the necessary costs without any credit as shown in the figure below. On the other hand, those poor households were not able to install the bio-digester as responded by the regional biogas coordinators.

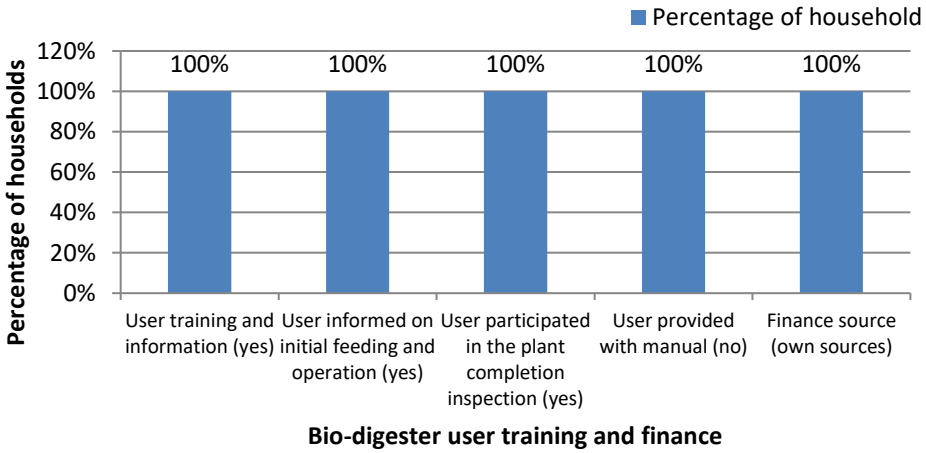



*Figure 38 - Training of bio-digester user households in Gambella*

### 2.4.10. Users' satisfaction

From the completed bio-digesters, the households expressed different levels of satisfaction. Those 30.8% of the households with well-functioning bio-digesters were highly satisfied but with poorly functioning 15.4% of the households were highly unsatisfied as shown in the figure below.

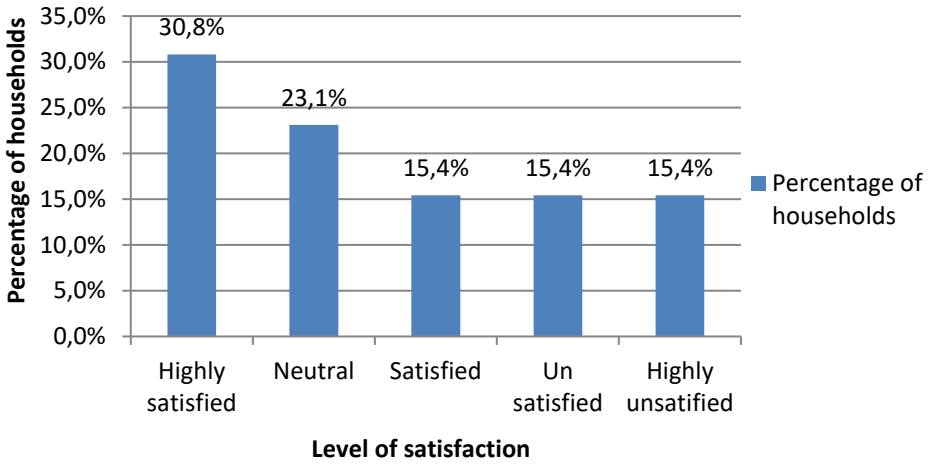



*Figure 39 Level of satisfaction of bio-digester Users in Gambella*

### 2.4.11. Users' opinion on recommending to others to install bio-digester

About 69.2% of the households recommended the wider distribution of bio-digesters; whereas 15.4% of the households did not recommend the use of the technology, while 15.4% of the households had no clear view of bio-digester technology as shown in the figure below.

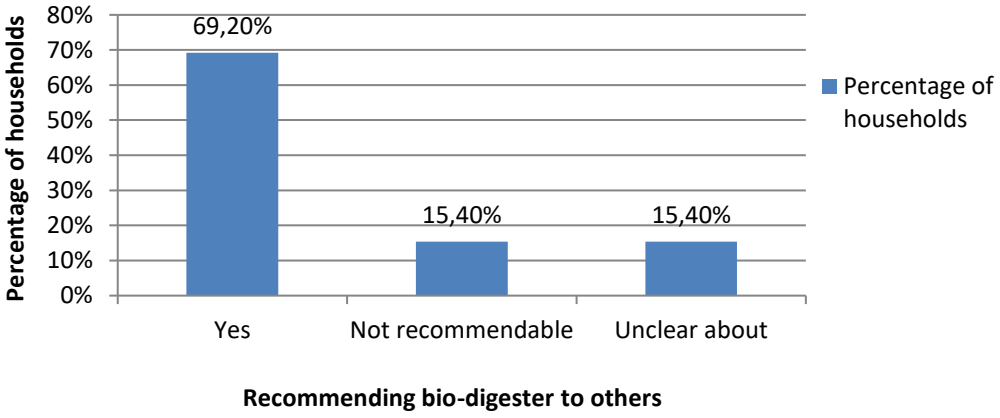



*Figure 40 - Users' opinion on recommending bio-digester to other in Gambella*

### 2.4.12. Key technical parameters for the bio-digesters construction

The quality of construction of bio-digesters in Gambella was based on the manuals and standards. However, it was compromised because of material supply deficiency (e.g., low amount of cement during concrete making). The dimensional characteristics of the construction were also at recommended level. Toilet inlet was constructed together with the bio-digester but in 84.6% of the households the toilet was not utilized. Some households are using toilets already constructed in another place within the residential area. About 53.8% of the households' bio-digesters had only one bio-slurry pit and 7.7% had none at all.

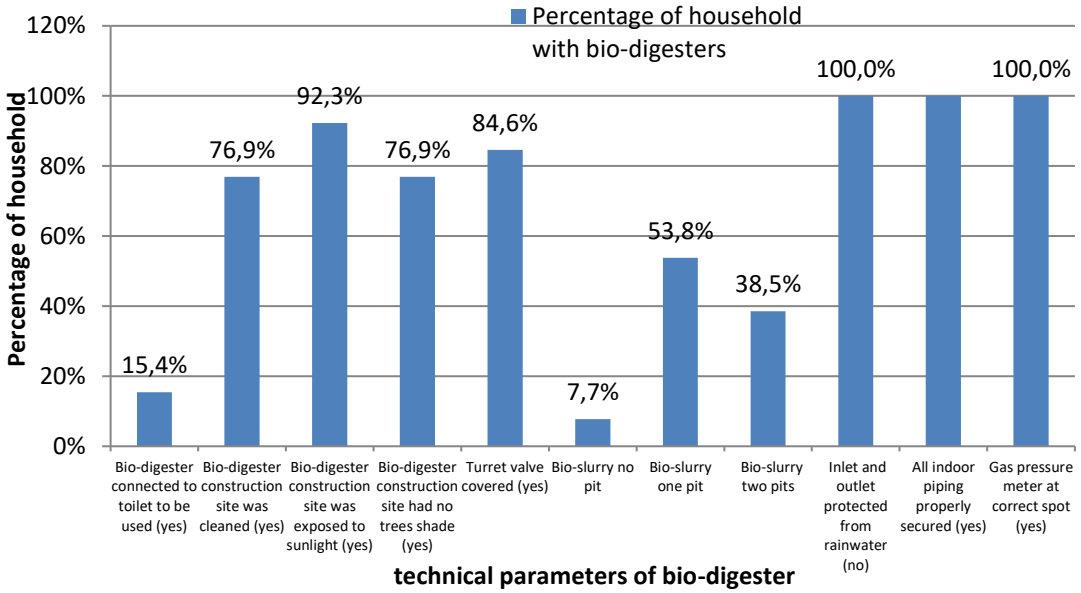



*Figure 41 - Observations on key technical parameters household bio-digester construction*

As shown in the table below, out of the 25 registered and sampled bio-digesters, eight had no completed construction and four were not existing/ not constructed on the households' compound, were one is constructed and registered within the old Sinidu model but different name of person who constructed in pilot activity of "fast track" bio-digester construction, another one was backfilled by the owner after his cattle was stolen, one was backfilled by the owner because of delay of mason and loss of purchased cement and the fourth was unknown.

Some households were highly disappointed with the biogas programme either because the masons delayed the construction, or they were not properly trained, or they would just have the user excavate the soil excavated but would not continue the construction. In the case of some households, that were informed to prepare construction materials, like cement and sand, the delay of masons resulted in loss or (expiration) of cement. The masons were also discouraged by insufficient material supply, lack of transport and security issues.

**Table 9 - Complete and incomplete construction of bio-digesters in Gambella**

| Number of completed bio-digesters | Number of uncompleted bio-digesters | Number of agreed and put in database but not done/not existing bio-digesters | Total sampled |
|---|---|---|---|
| 13 | 8 | 4 | 25 |

The poorly trained/untrained masons were one of the main causes for incompleteness of bio-digesters in Gambella. In the picture below, there is an incomplete bio-digester on which three masons worked at different times. They all put the blame one on another and as a result the construction got delayed for more than one year and created a conflict with households.

*Figure 42 - Incomplete bio-digester under construction for over one year.*
(Gambella_ Anywaa_ Gambella Zuria_ Gambella Town_ GM AB 24_ Year 3_2020_ David Omo Okori)

### 2.4.13. Implementation challenges

(a) Low rate of promotion
Poor extension service and the low rate of promotion also reduced the expansion of bio-digester technology. The Gambella Energy and Mineral Agency informed that there were many higher officials (like the finance departments) who do not even know "what biogas is"[11]. There is lack of awareness of higher officials and farmers about bio-digester technology.

Some households perceived some disadvantages of biogas such as odour and lack of bio-slurry disposal place.

The presence of firewood, the lack of pasture grass and water in dry season and the livestock disease, reduced the utilisation of bio-digester technology in Gambella. Moreover, all the surveyed households were electrified, so the use of biogas for lighting was reduced.
(b) Lack of linkage with agricultural sector.
(c) In urban areas direct use of dung is preferable, because bio-slurry is not combustible and can only be used for agricultural land fertilisation.
(d) Lack of coordination in livestock sector to alleviate cattle disease and death.
(e) Lack of budget and transport services.
(f) High rate of government staff turnover.
(g) Lack of sufficient number of well-trained masons.
(h) Lack of users' experience
The study revealed that in Gambella, there was little experience on utilising bio-digester technologies. The communication between the biogas coordination offices, households and masons was very poor and insufficient. The bio-digester was considered as if it belongs to some external property and not properly owned. The presence of sufficient firewood also impacted the low motivation of learning about bio-digester technology. There was also lack of agricultural crop cultivation experience to use bio-slurry.
(i) Lack of Zone and Woreda level administrative structure
There was no administrative structure of energy at Woreda and zone level in Gambella. As a result it was difficult to that allow proper after-sales-service.

[11] Interview at Gambella Energy and Mineral Agency.

### 2.4.14. Sex and age characteristics of bio-digester users

From the completed bio-digesters 23.1% were owned by female household heads and 76.9% were by male household heads. The age group ranged from 28 to 52 years and the highest percentage of the owners, about 30.8% (7.7% female and 23.1% male) was 40 years old with mean age of 39.1 years as shown in the following figure and the detailed lists are given in Annex VI. The dependence (binary logistic regression) of functionality of bio-digesters on household characteristics like sex, age, education level, and number of livestock and distance of fetching water was not significant for functional and non-functional bio-digesters. The average number of persons in a household was seven.

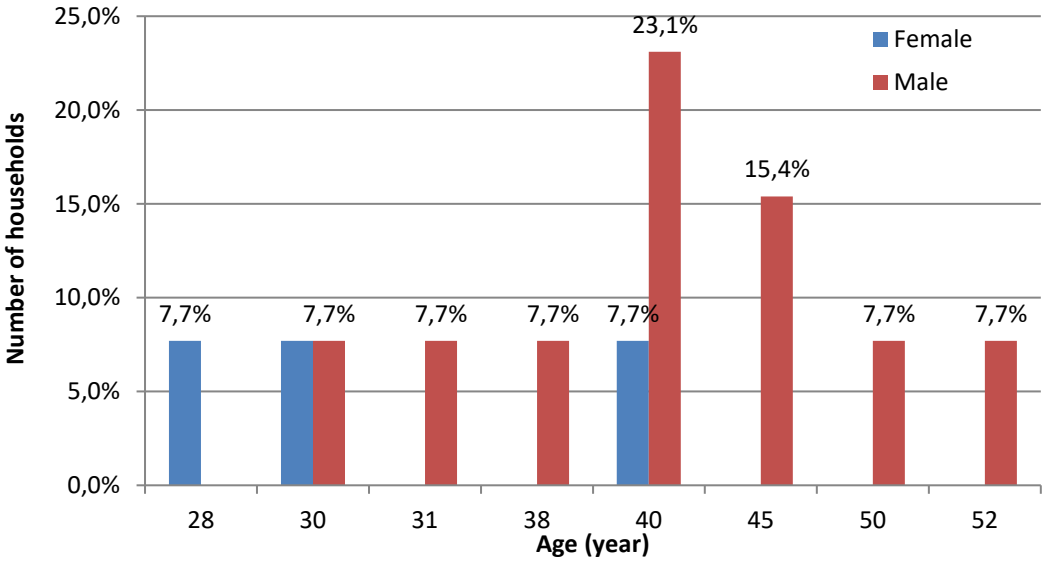



*Figure 43 - Age and sex distribution household bio-digester users in Gambella*

### 2.4.15. Recommendations

There should be further awareness creation at different levels of local people including higher officials, traders and farmers about bio-digester technology.

More training should be given about how to use the energy and bio-slurry to household bio-digester owners.
The role of biogas on reducing deforestation should be informed in detail to the local people because the presence of firewood had been reducing the interest in biogas.

The different sectors of Gambella for example, livestock, crop and forestry should be coordinated to implement bio-digester technology so as get a win-win situation, which reduce cattle death, reduce deforestation and improve crop productivity. Moreover, in dry season dung and water shortage should be solved by coordinated efforts of different representative sectors.

More masons should be trained from the local residential people instead of searching masons from the other areas so as to reduce the turnover of masons.

Forms of providing credit should be started, so that the local people that have cattle can install bio-digester.

Since there was no administrative structure of energy at Woreda and zone level, the rate of construction was reduced in Gambella, then the structure should be in place so that the proper after-sales-service could also be provided.

## 2.5. Oromia

### 2.5.1. Purpose for which bio-digesters were installed

In Oromia, the main purpose constructing bio-digester was to supply energy that account 100% for cooking and 90.9% for light supply. The toilet connection also reduced the cost of the usual toilet construction, which is deep well and then about 20.5% of the households' purpose was toilet connection as shown in the following figure.

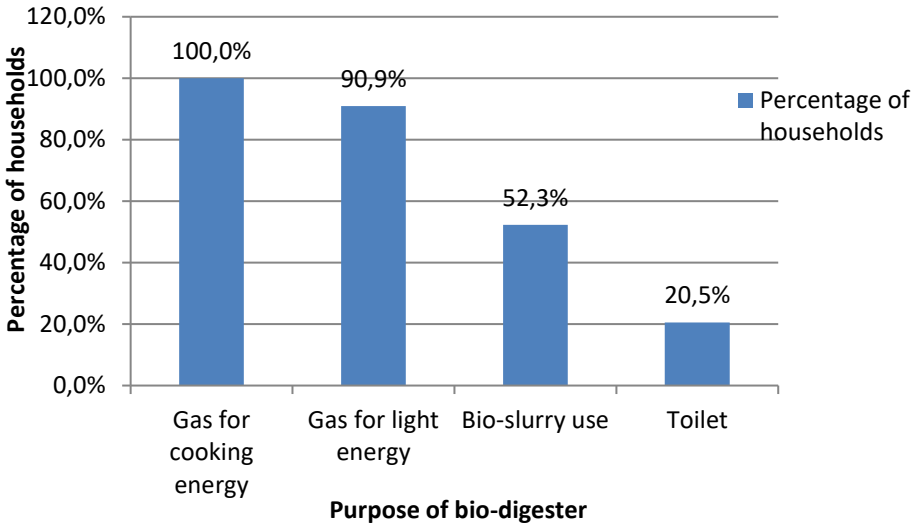



*Figure 44 - Purpose bio-digester installation in Oromia*

*Figure 45 - The use of biogas stoves for cooking*
(Oromia Arsi Munesa_ D/Ashe_ Year 3_ Mar_2020_ Chaltu Deme)

### 2.5.2. Functionality of bio-digesters

In Oromia, the functionality of the bio-digesters varied from Woreda to Woreda depending on the accessibility of water. The functionality at Woreda level was given in the following table and the overall average functionality of the region found to be 75% based on the recently provided definition of functionality, that minor and seasonal problems on bio-digester were accepted as functioning.

**Table 10 - Functionality levels of bio-digesters in Oromia Woredas**

| | | Functioning percentage | No functioning bio-digesters | Total |
|---|---|---|---|---|
| Sampled Woredas in Oromia | Abichu | 100 | 0 | 3 |
| | Bele Ges | 100 | 0 | 3 |
| | Dodola | 88 | 13 | 8 |
| | Gera | 43 | 57 | 7 |
| | Grar Jarso | 100 | 0 | 2 |
| | Gumay | 100 | 0 | 2 |
| | Kofale | 33 | 67 | 3 |
| | Lode Het | 100 | 0 | 2 |
| | Munesa | 100 | 0 | 2 |
| | Seru | 50 | 50 | 2 |
| | Shirka | 100 | 0 | 5 |
| | Tiyo | 50 | 50 | 2 |
| | Wondo | 33 | 67 | 3 |
| Total mean percentage | | 75 | 25 | 100 |
| Total number | | 33 | 11 | 44 |

The reasons for non-functionality of bio-digesters were diverse. The lack of spare parts such as appliances, fittings, and the lack of transport service played roles in functionality. For example, the lack of dung during four dry months accounted 11%, turret valve damage with gas leakage accounted 5% and total dismantle bio-digesters accounted 5% of the non-functionality, see table below (Table 2.4.2a). The sizes of 6.8% of the sampled households' bio-digester were 4m$^3$, 79.5% were 6m$^3$ and 13.6% were 8m$^3$. The household were not complaining about the effect of size on functionality. The Woreda energy experts explained that the bio-digesters of all the sizes were performing well and what matters is the amount and frequency of feeding dung. The biogas lamps were not working when the stove was being utilised because of insufficient share of power. One household head stated that even the 8m$^3$ bio-digester was not sufficient for the Injera (local bread) baking stoves. These observations require further investigation of Injera baking stoves.

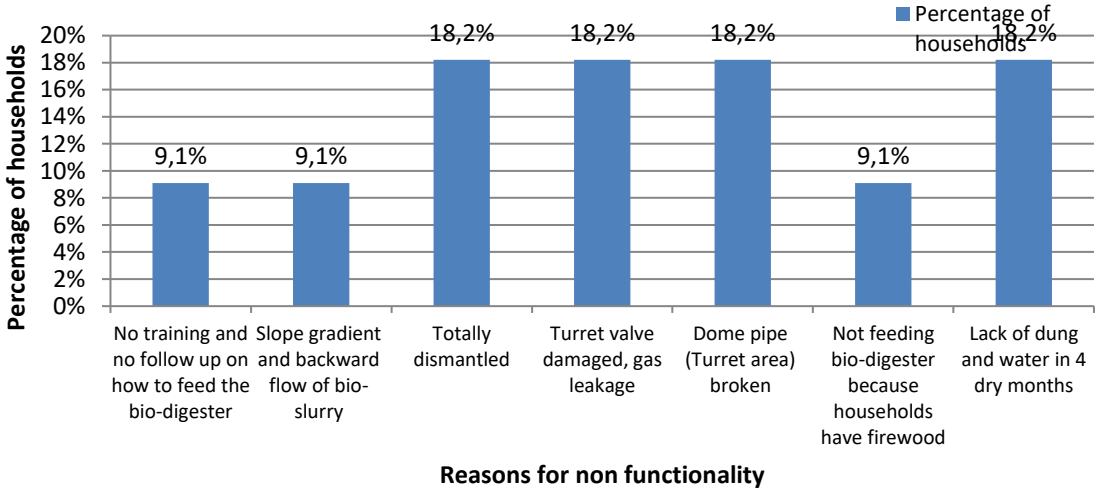



*Figure 46 - Reasons for non-functionality of bio-digesters in Oromia*

### 2.5.3. Quality of after-sales service

The after-sales service in Oromia was assumed to continue for two years. However, the lack of transport service, accessories, welding, fittings, pipes, the shortage of water and dung in dry season led to the abandonment of bio-digesters and made the quality of the after-sales service very low. As

a result, some bio-digesters were dismantled, the drainage was forgotten, and stove valves were removed.


*Figure 47 - Dismantled (left) and un-utilised bio-digesters (right).*
(Oromia_ Jimma_ Gera_ Boge Dedo_ Year 1_2017_ Shemsu A/Mecha) (left) (Oromia_ West Arsi_ Wondo_ B/Gugisa_ Year 2_ Aug_2018 Jemal Kasim) (right)


*Figure 48 - Dismantled dome pipe (left) and forgotten drainage of bio-digester (right).*
Oromia_ Jimma_ Gera_ Bore Gogo_ Year 1_2017_ A/Reya A/Mecha (left), Oromia_ Jimma_ Gumay_ G/Dege_ Year 3_ Nov_2019_ Idris A/Sura (rigt)

### 2.5.4. Benefits of bio-digesters

The benefits of bio-digesters in Oromia include energy supply, sanitation, and bio-slurry as organic fertiliser. The users had a good experience of utilising biogas and bio-slurry.

The households were utilising 295.9 kg of woodfuel (charcoal and firewood) per month. The bio-digesters were installed in households that have water source places which are at a walking distance ranging from 6.8 to 24.5 minutes, finding water was difficult in dry season. The proper use of biogas could save 42.0 to 51.0% in hot season and 55 to 66.0% in cold season on the amount of woodfuel utilised. In some individual households, the energy from biogas totally replaced charcoal and 42 to 66% of both charcoal and firewood. Since the biogas saved 48% of the time required for woodfuel collection and consumption, and saved 47 to 61% of the total amount wood on average, the local people are highly interested and the demand for bio-digesters is increasing year after year. The use biogas reduced over 50% of the time of collection and consumption of wood fuel as shown in the following figure.

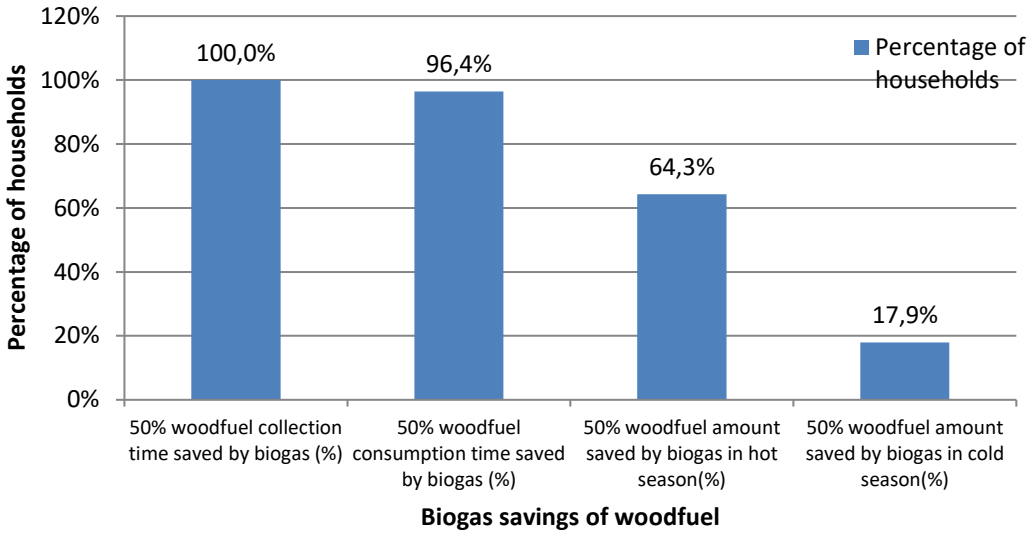



*Figure 49 Wood fuel amount and time saving due to bio-digester utilisation in Oromia*

### 2.5.5. Health impacts of biogas

Households that use biogas for cooking perceived that their health condition was improved because of reduced eye infection, respiratory diseases, cough, and fire related injury caused by firewood burning. Accordingly, about 95.5% of the households' perceived reduction in health impacts and all of households stated the sanitation from dung wastes in the residential areas as shown in the figure below.

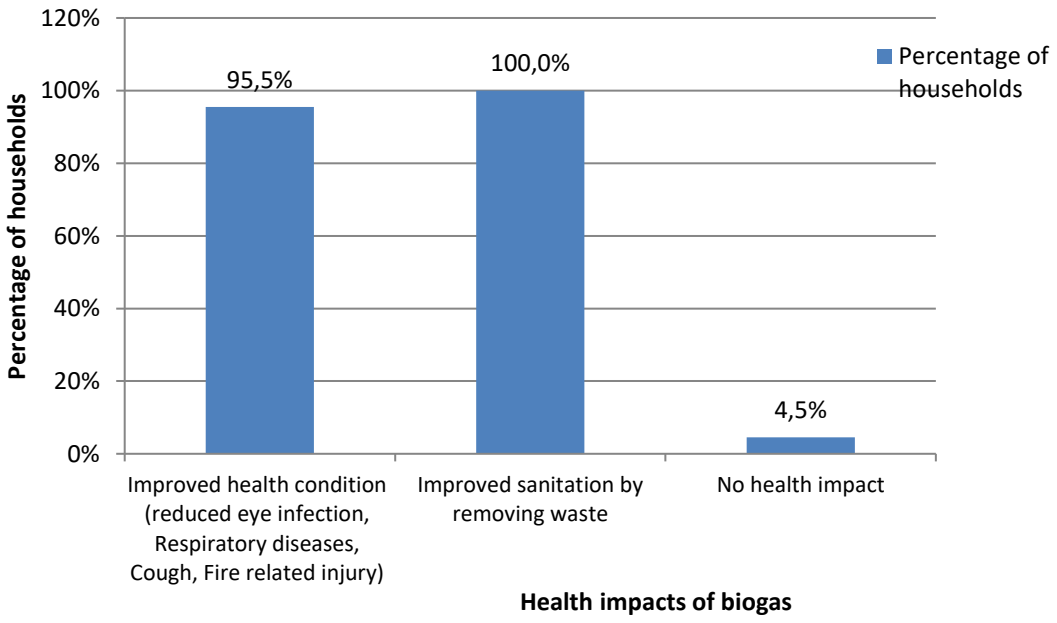



*Figure 50 - Perception of households on health impacts of bio-digester technology in Oromia*

### 2.5.6. Bio-slurry management and application

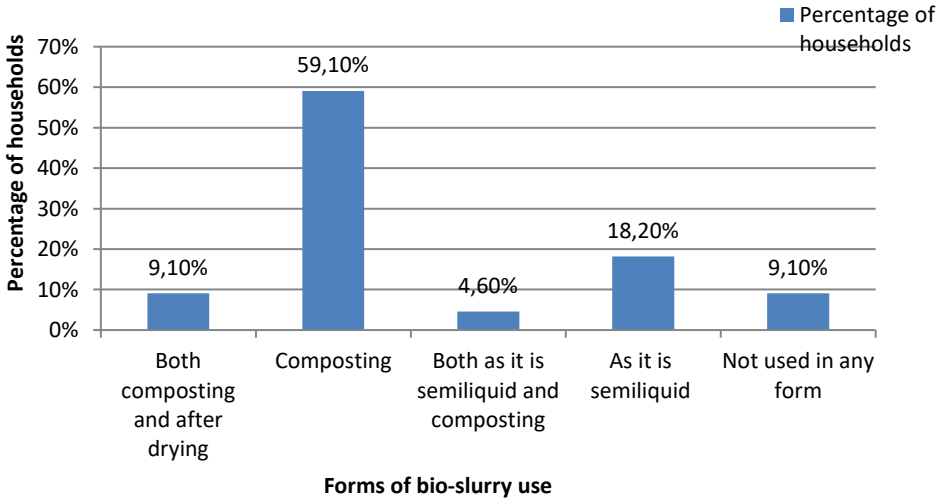
Bio-slurry was well utilised in most parts of the region for different agricultural crops. Bio-slurry was mostly used in the form of composting (59.1%) for maize, wheat, onion, barley and cabbage (18.2%) as shown below.

*Figure 51 - Bio-slurry utilised for growing horticultural crops.*
(Oromia_ Arsi_ Munesa_ D/Ashe_ Year 3_ Mar_2020_ Birhanu Habte)

Some households faced difficulty of disposing bio-slurry in North Showa urban areas because their agriculture land was far from the residential area.

*Figure 52 - Accumulation of bio-slurry around the bio-digester*
(Oromia_ North Shewa_Grar Jarso_Kotche Year 3_ Jul_2019_Tariku Hailu)

In some 59.1% of the households bio-slurry was used by composting with other organic residues and grasses while 18.2% were using bio-slurry as it is semi liquid. About 18.2% of the households stated the use of bio-slurry increased the growth and yield of wheat, onion, barley, cabbage, and maize as shown in the following figure.



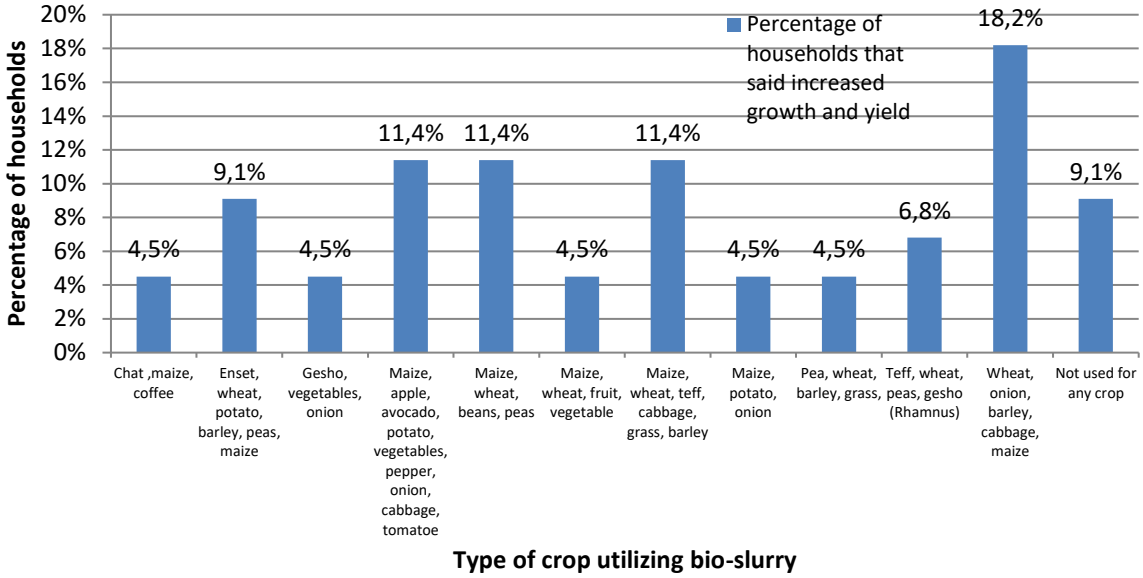



*Figure 53 - Bio-slurry utilisation forms and crop types used by households in Oromia*

The field observation showed the use of bio-slurry for fattening livestock. That is by using bio-slurry the growth of pasture grass was highly increased. Households stated that bio-slurry was better than chemical fertiliser in improving soil fertility and crop yield quality and quantity.

### 2.5.7. Limitations in the use of bio-digesters as disadvantage

There were difficulties of getting water in the dry season in Woredas like Dodola. The effort to dig deep water wells was very low as the information from local administrators. In fact, there were some households that use deep water wells in water deficit areas, which could be good lessons for other bio-digester owners who complain about water shortage. In some households, the toilet constructed was left without usage because of lack of proper follow up and lack of proper promotion to use toilet connection. Some households had a toilet constructed with bio-digester without being interested in using it.

The responses of household interviews revealed that, the presence of bio-digesters did not address any side effects on 90.9% of the sampled households, but 6.8% of the households stated that the money spent affected their household planning and 2.3% blamed the incorrect place of bio-digester construction in the residential area. About 25% of the households stated the difficulty of searching water in dry season as shown in the following figure.

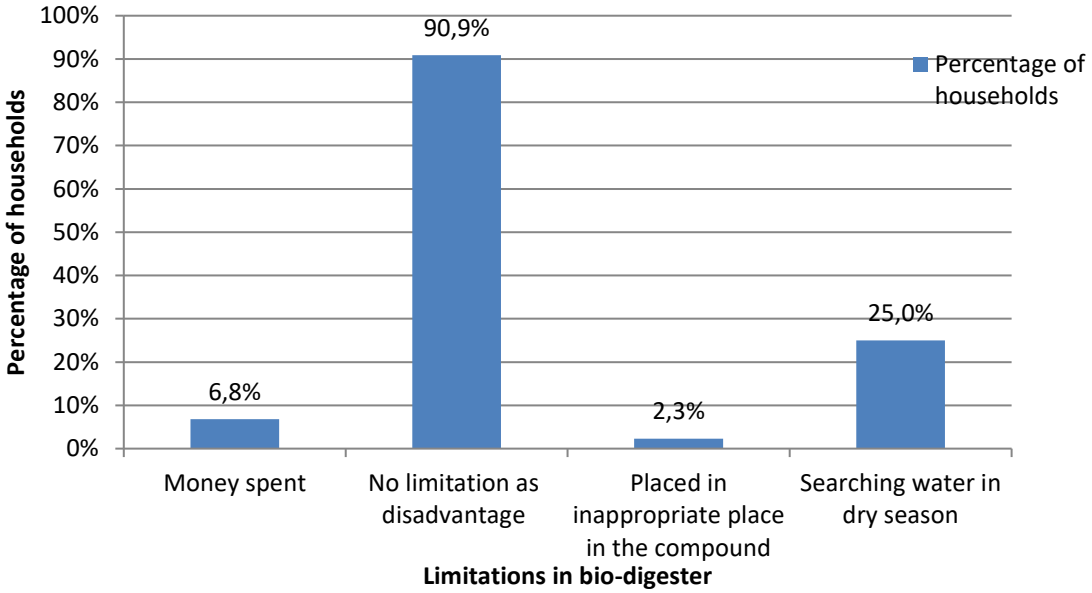



*Figure 54 - Limitations in the installation and use of bio-digester in Oromia*

### 2.5.8. Users' training and finance sources

Most about 97.7% of the bio-digester user households were trained about the way feeding and using bio-digester. However, all the households had no user manual.

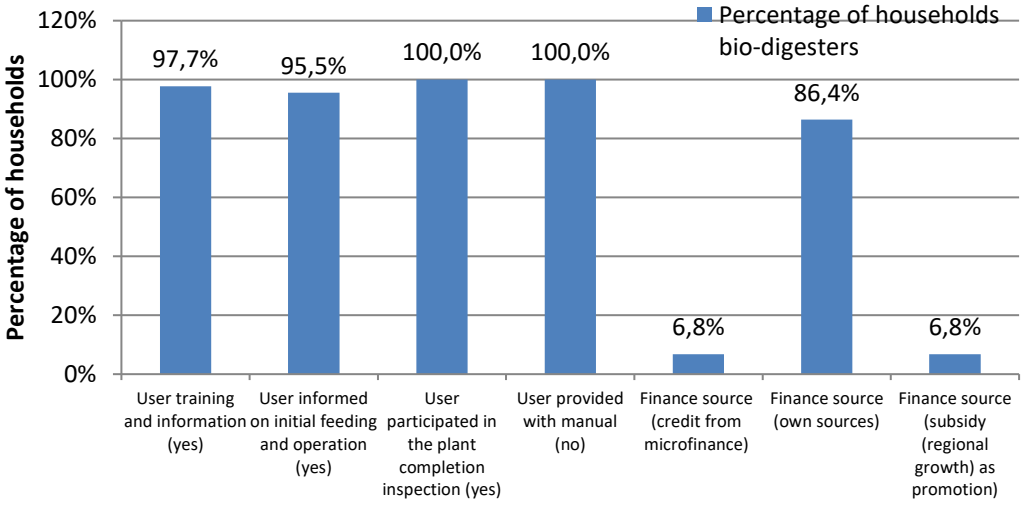



*Figure 55 - Training and finance sources of bio-digester user households in Oromia*

### 2.5.9. Users' satisfaction

Households with continuously functioning bio-digesters about 43.2% were highly satisfied, while those with non-functioning bio-digesters about 25% were highly unsatisfied as shown in the figure below. The unsatisfied households were either totally left the bio-digester or complain for solution to the energy experts.

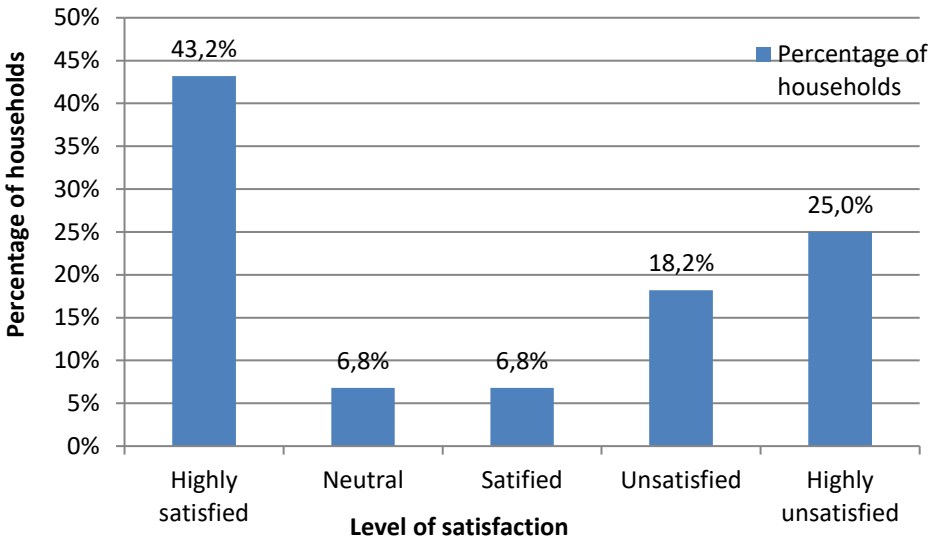



*Figure 56 - Level of satisfaction of bio-digester Users in Oromia*

In addition to the biogas, the households were utilising non-biomass energy sources including electricity (45.4%) and solar home lighting systems (54.5%). These energy sources could have an effect towards the utilisation of biogas, because they reduce the importance of the biogas. However, the electric supply was not sufficient, sometimes power cut and expensive so that the presence of biogas could reduce cost. The presence of cattle and agricultural land also motivate to install bio-digester technology and to use the high value fertiliser, bio-slurry.

**Table 11 - Other non- biomass sources of energy in households in Oromia**

| Sources of energy | Percentage of households |
|---|---|
| Battery | 4.5 |
| Electricity | 45.4 |
| Kerosene | 2.3 |
| Solar | 54.5 |
| **Total** | **100.0** |

### 2.5.10. Users' opinion on recommending to others to install bio-digesters

About 72.8% of the households recommended the wider distribution of bio-digesters; whereas 22.7% of the households recommend the use of the technology after solving the current problem of maintenance issue, as shown in the figure below.

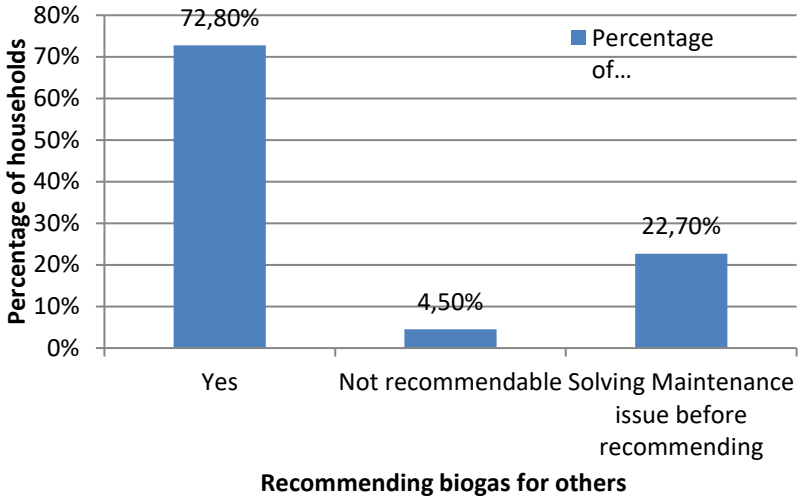



*Figure 57 - Users' opinion on recommending bio-digester to other in Oromia*

### 2.5.11. Key technical parameters for the bio-digesters construction

In Oromia, the quality of construction was based on the standards set by manuals and built by experienced masons. However, most of the digesters code is not listed or not registered, either totally covered by concrete. Even codes available in the site were not registered in the database. In some cases, toilet was constructed but not utilised. About 79.5% of the households with bio-digesters were connected to a toilet, and that connection reduced the cost of constructing toilet which could have been costly in the absence of bio-digester. About 93.2% the bio-digesters had no protection from rainwater entering to inlet and outlet as shown in the table below.

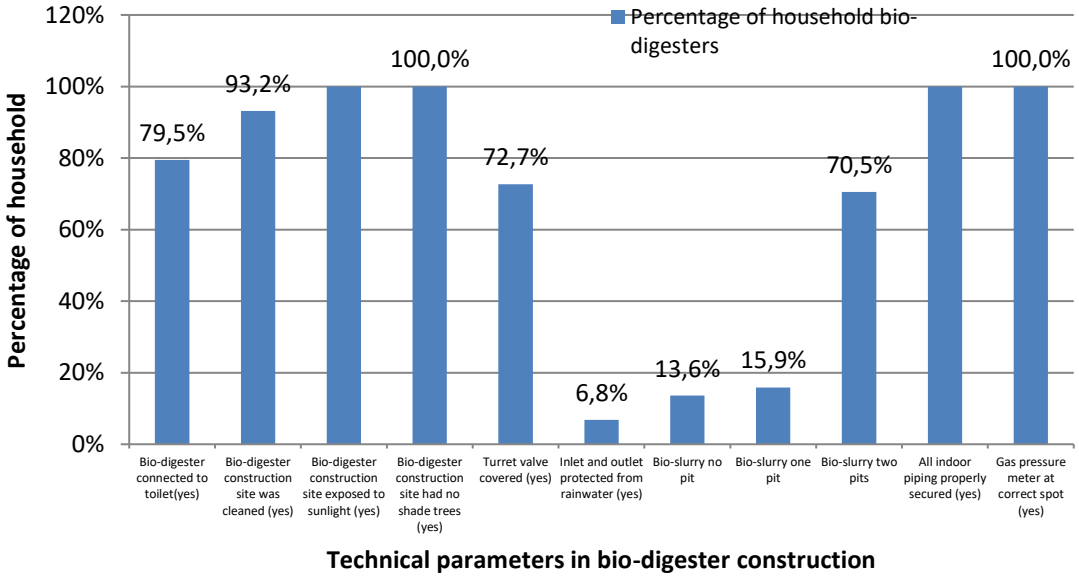



*Figure 58 - Observations on household key technical parameters of bio-digester construction in Oromia*

### 2.5.12. Implementation challenges

In Oromia, there different types of problems that hinder the full functioning of bio-digesters:

- Lack of budget and transport service for monitoring and follow up in urban areas.
- Lack of training, and demonstration to farmers, and low after-sales-service.

- Lack of trained bio-digester energy experts at Woreda level.
- Lack of accessories, pipes and other materials required for maintenance.
- Lack of trained masons and drop out of masons.
- Lack of focus on biogas by bureau of water and energy because of skewed focus on water.
- Lack of willingness of farmers to repay credits from microfinance institutions.
- The lack of pasture grass and water in dry season.

### 2.5.13. Sex and age characteristics of bio-digester users

From the bio-digester owners, 18.2% were female and 36% were male household heads. The age category ranged from 32 to 70 years with mean of 45.1 years, which attained the highest proportion of 11.4%. The average number of persons in a household was ranging from 6.6 to 7.9. On average, the size of households that installed bio-digesters was 7.27 with an educational level of class 3 to 7.The livestock number of households was also close to 7, which was sufficient for biogas generation as shown in Annex VI.

It was known that household characteristics like sex, age, education level, and number of livestock and distance of fetching water affect the functionality of bio-digesters. However, the dependence of functionality of bio-digesters on those characteristics was not mathematically related in binary logistic regression at different significant level. The most significant household characteristics were the educational level (educated households had bio-digesters functioning very well or at least better than those with a lower/missing education). Therefore, with the same distance of water point or even more, and the same number of people in a household, the functionality of bio-digesters depends on commitment of the persons in a household.

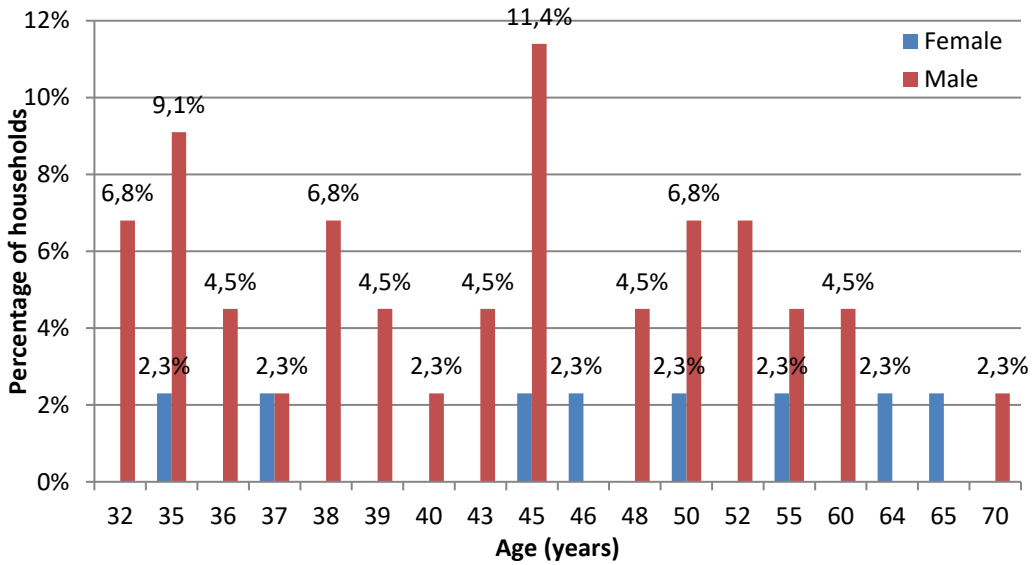



*Figure 59 – Age and sex distribution household bio-digester users in Oromia*

### 2.5.14. Recommendations

- There should be coordinated efforts of agricultural sector, energy sector and forest sectors to solve the problem of budget and transport service for bio-digester technology activities.
- Training and demonstration of bio-digester technology activities should be done to bio-digester owners and masons at different time interval for example every year.

- There should be means of hiring and maintaining trained bio-digester energy experts and masons at Woreda level.
- There should provision of accessories, pipes and other materials required for maintenance of bio-digesters.
- Motivating credit accesses and encouraging the willingness of farmers to repay credits taken from microfinance institutions.
- Encouraging deep water well in areas where there is shortage of pasture grass and water in dry season.

## 2.6. Southern Nations Nationalities People (SNNP)

### 2.6.1. Purpose for which bio-digesters were installed

In SNNP, the main purpose constructing bio-digester was to supply energy that account 100% for cooking and 71.4% for light supply. The toilet connection also reduced the cost of the usual toilet construction, which is deep well and then about 57.1% of the households' purpose was toilet connection as shown in the following figure.

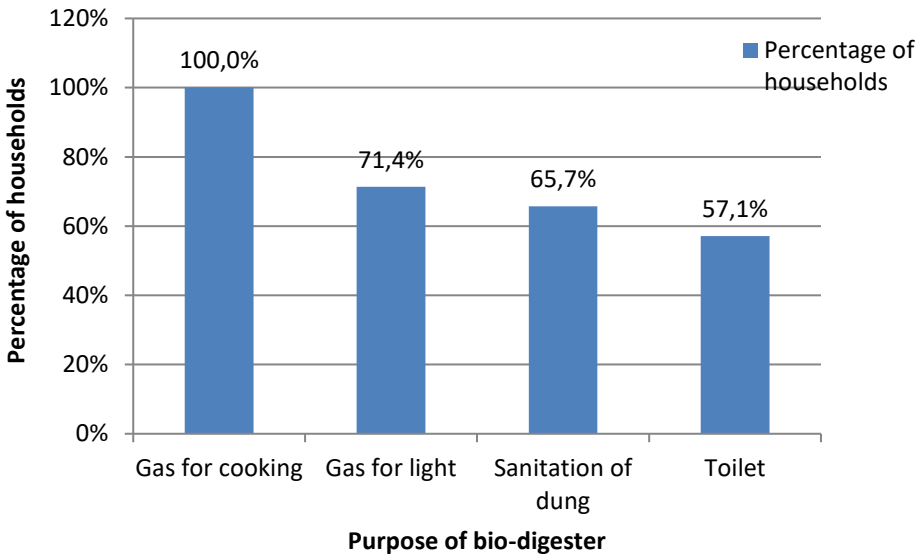



*Figure 60 - Purpose bio-digester installation in SNNP*

### 2.6.2. Functionality of bio-digesters

In SNNP, the functionality of the bio-digesters was 69.7% by considering functional the bio-digesters that faced shortage of dung and water during the dry season. The continuous functionality of bio-digesters was affected by insufficient dung and water availability, as responded by 50% of the households. The functionality was also different among Woredas as shown in the following table.

**Table 12 - Functionality levels of bio-digesters in SNNP Woredas**

| | | Percentage of functioning bio-digesters | Percentage of non-functioning bio-digesters | Total number |
|---|---|---|---|---|
| Sampled Woredas in SNNP | Arba Minch Zuriya | 0.0 | 100 | 1 |
| | Boloso Sore | 100.0 | 0 | 4 |
| | Damot Pulasa | 100.0 | 0 | 2 |

| | | | | |
|---|---|---|---|---|
| | Enamor | 100.0 | 0 | 2 |
| | Ezha | 66.7 | 33 | 3 |
| | Hadaro Tunto | 100.0 | 0 | 2 |
| | Kedida Gamela | 75.0 | 25 | 4 |
| | Kucha | 0.0 | 100 | 2 |
| | Mirab Abaya | 50.0 | 50 | 2 |
| | Offa | 66.7 | 33 | 6 |
| | Shebedino | 50.0 | 50 | 2 |
| | Wondo Genet | 66.7 | 33 | 3 |
| Total percentage | | 69.7 | 30.3 | 100 |
| Total number | | 23 | 10 | 33 |

The other reasons attributed to the poor functionality of bio-digesters were the lack of labour to mix dung (10%) and inappropriate site selection (20%).

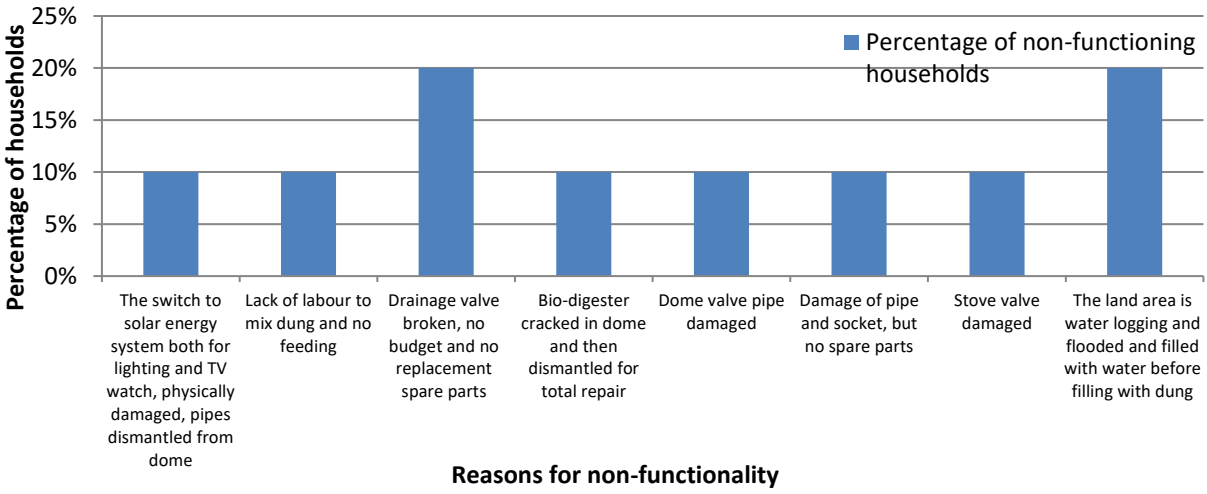



*Figure 61 - Reasons for non-functionality of bio-digesters in SNNP*

### 2.6.3. Quality of after-sales service

The efforts in after-sales service were very low because of lack of spare parts, fittings and accessories but also lack of transport service. As a result, different types of damages persist such as breakage in drainage and broken dome pipe.


*Figure 62 - Damages in bio-digester that persist in the absence of after-sales service*

(SNNPR_ Gamo_ M/Abaya_ Ankober_ SN+ HOPE 63_ Year 3_ June,2019_ Wegaso Dea (left)); (SNNPR_ Gamo_ Kucha_ Shochora_4629_ Year 2_ 2019_ Wzo Merega Tuma right))

There was poor follow up and then some of the connected toilet pipes were not utilised, about 54.5% of the turret and all the inlets and outlets were not covered as shown in the figure below. In response to the poor follow-up and the poor functioning of bio-digesters in the region, the regional government planned to alleviate the shortage of transport service in the 2021/2022 fiscal year by allocating ETB 15 M (€ 300 k) to purchase 50 motorcycles, as indicated by the SNNP regional biogas coordination unit head.

*Figure 63 - Poor finishing in bio-digester, turret not covered and unutilised toilet*
(SNNPR_ Wolayita_ Boloso sore_ Arka 02_4940_ Year 3_ March,2020_ Dereje Wogaso)

### 2.6.4. Benefits of bio-digesters

Bio-digesters have many benefits in SNNP including energy supply, sanitation, and waste disposal, bio-slurry as organic fertiliser, income generation and insect pest protection. The users had a good experience of utilising biogas and bio-slurry and established biogas village in Wondo Genet Woreda. The average number of persons in a household was ranging from 6.5 to 8.0 and they would utilise 238.0 kg of woodfuel (charcoal and firewood) per month. The proper use of biogas could save 25.0 to 41.0% in hot season and 31.0 to 50.0% in cold season on the amount of woodfuel utilised. Biogas would also reduce over 30% the time and the money for the wood collection. Biogas saved 50% of woodfuel collection, and consumption time in hot and cold season as responded by all households of bio-digester owners as shown in the figure below.

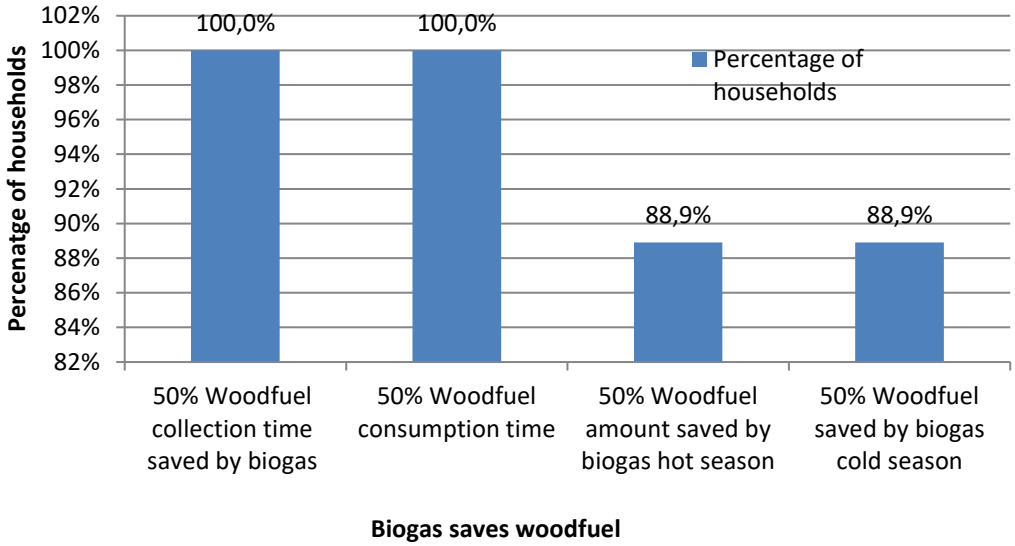



*Figure 64 - Wood fuel amount and time saving due to biogas utilisation in SNNP*

### 2.6.5. Health impacts of biogas

About 75.8% of the households responded that biogas has beneficial effect on health such as reducing eye infection, cough, respiratory diseases, fire related injury when compared with firewood burning. All households' appreciated the sanitation and waste disposal role of bio-digesters.

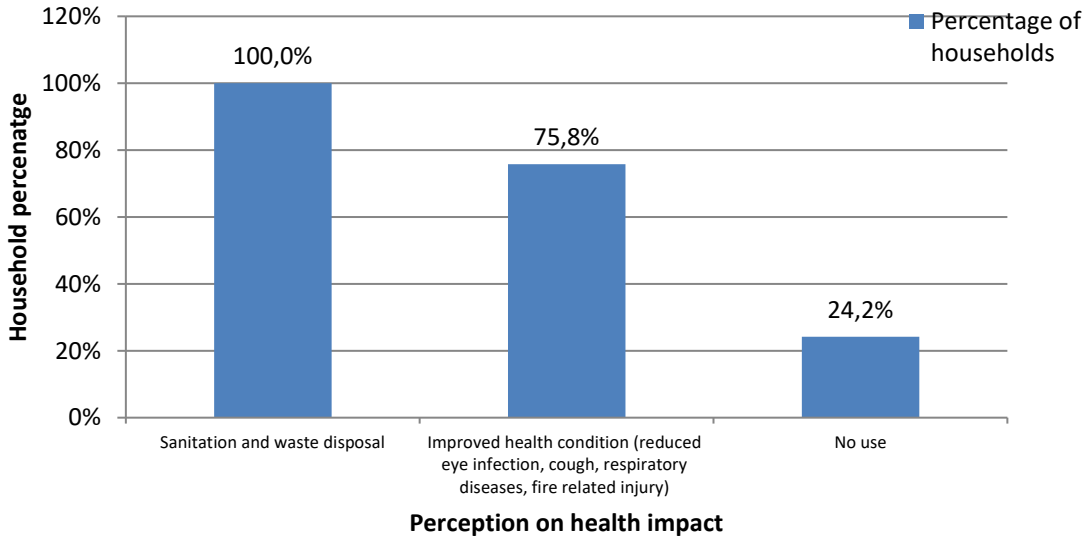



*Figure 65 - Perception of households on health impacts of bio-digester technology in SNNP*

### 2.6.6. Bio-slurry management and application

In SNNP bio-slurry was used at the households' farm and sold in local markets, see figure below. Therefore, it is promising that the use of bio-digester technology can easily be scaled up by the bio-slurry benefits in addition to the energy benefit. Bio-slurry was used for the growth of pasture grass (livestock feed) so as to increase the yield of livestock and for home garden and field food crops. However, bio-slurry pits were not shaded in all samples.

*Figure 66 - Home garden enriched by bio-slurry directly (left) and packed dry bio-slurry for sale (right).*
(SNNPR_ Wolayita_ Offa_ Okoto sere_7_ Year 2_ 2019_ Etagegnew Wogaso (left)); (SNNPR_ Sidama_ Wondo Genet_ Wesha_4346_ Year 1_2018_ Debalke Alemayehu)(right)

The effect of bio-slurry on the growth of maize and grass was easily detected by the green colour. Bio-slurry applied areas became deep green colour, while light green colour was observed in unapplied areas. Bio-slurry favoured unusual growth of pasture grass in dry season.

*Figure 67 - Bio-slurry unusually favoured dry season grass in Kedida Gamela, SNNP*
(SNNPR_ Kembata Tembaro_ Kedida Gamela_ Abonsa_4725_ Year 2_2019_ Tesfaye Walano)

In households, that accounts about 30.3% of the sample; bio-slurry was used by composting, but in 15.2% of the households' bio-slurry was used as it is semi-liquid. Composting was used for annual crops like maize and wheat, while the semiliquid bio-slurry was used for false banana (enset plant) and other perennial crops. Accordingly, 18.2% of the household were using the bio-slurry for maize production, 9.1% for sugar cane, chat, banana, coffee, and enset plant and 27.3% of the households were not utilising the bio-slurry in any form as shown in the figure below.

In a nutshell, the role of bio-slurry in improving plant growth and soil fertility was highly appreciated by farmers. However, the number of users remains very low. It would be very important and beneficial to promote these few cases to the wider society, for better impact.

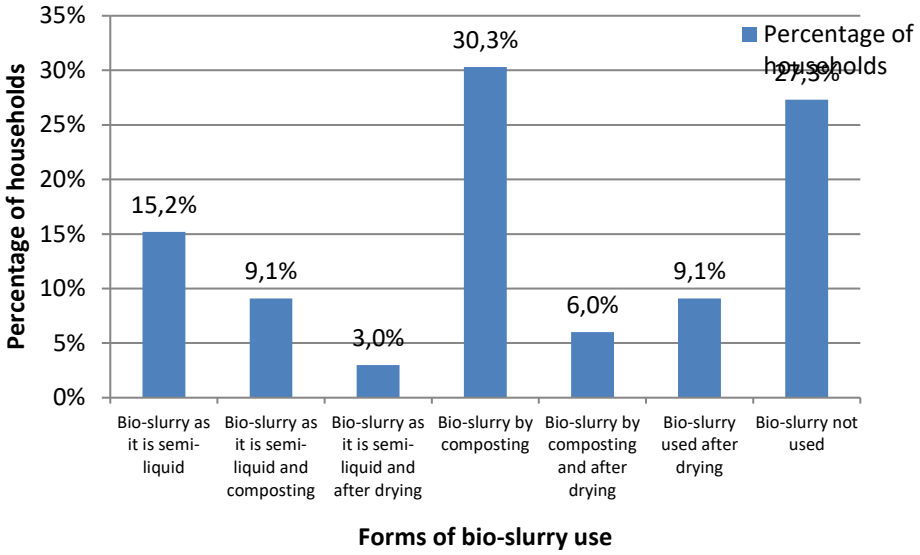



*Figure 68 - Bio-slurry form used in SNNP*

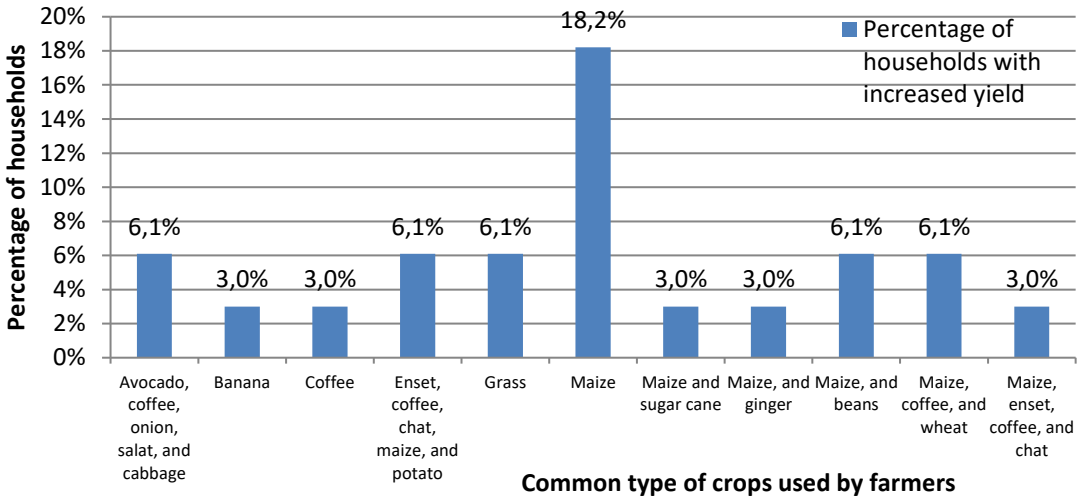



*Figure 69 - Common crop types grown by bio-slurry application in farmers of SNNP*

### 2.6.7. Challenges' or limitations in the use of bio-digesters as disadvantage

From the households that installed bio-digesters, 97% feel no disadvantage, where the remaining 3% stated that the installation had taken the place of their fertile land that could have been used to grow food crops. Those household who took credit, about 54.5%, to install bio-digester faced difficulty to return the payment on time.

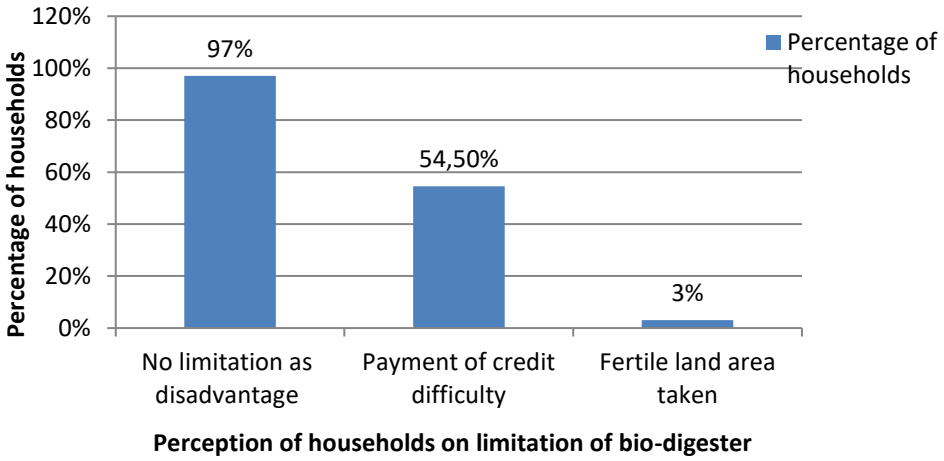



*Figure 70 - Limitations in the installation and use of bio-digester in SNNP*

### 2.6.8. Users' training and finance

In SNNP, about 97.0% of the bio-digester user households were trained about the way of feeding and using bio-digester. However, all the households had no user manual. The finance sources for installing the bio-digester was from own sources (45.5%) and from government and private sectors credit organization (54.5%).

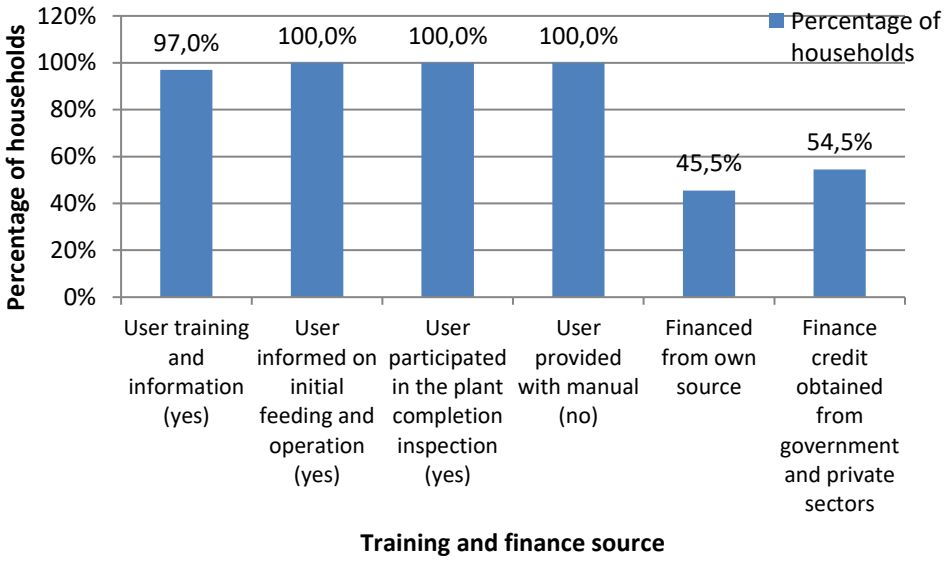



*Figure 71 - Training and finance sources of bio-digester user households in SNNP*

### 2.6.9. Users' satisfaction

Households with continuously functioning bio-digesters about 27.3% were highly satisfied, while those with non-functioning bio-digesters about 33.3% were highly unsatisfied as shown in the figure below. The unsatisfied households were planning to get other energy sources like solar home lighting systems.

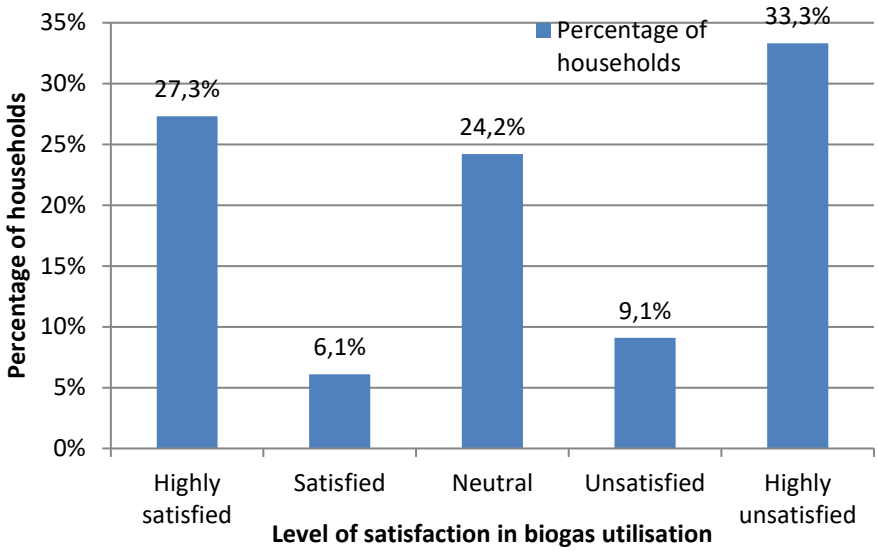



*Figure 72 - Level of satisfaction of bio-digester Users in SNNP*

In addition to the bio-digesters constructed for biogas energy, there were other non-biomass energy sources used by the households in SNNP. About 57.6% the households had solar home lighting system and 45.4% had electricity as shown in the figure below.

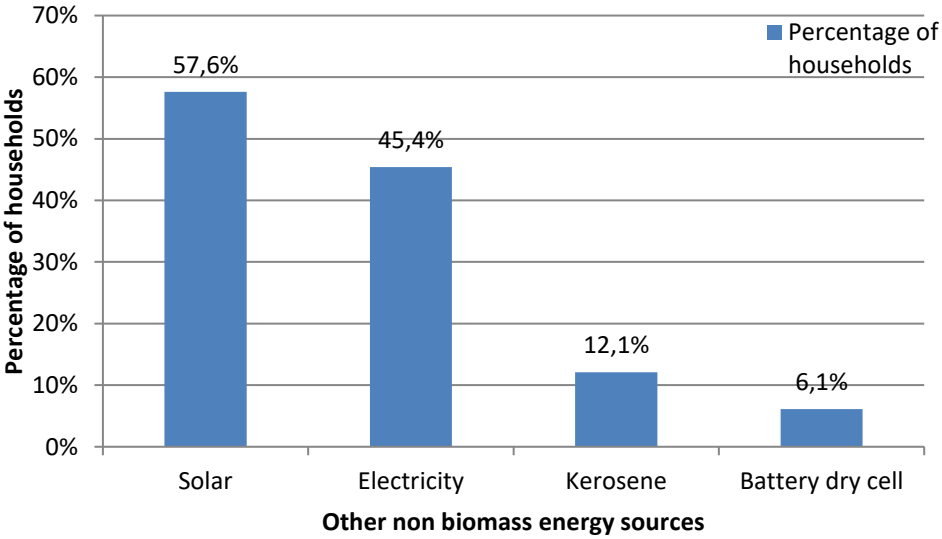



*Figure 73 - Other non -biomass energy sources in households, in SNNP*

### 2.6.10. Users' opinion on recommending to others to install bio-digesters

About 78.8% of the households recommended the wider distribution of bio-digesters; whereas 11.2% of the households recommend the use of the technology after solving the current problem of maintenance issue, as shown in the figure below.

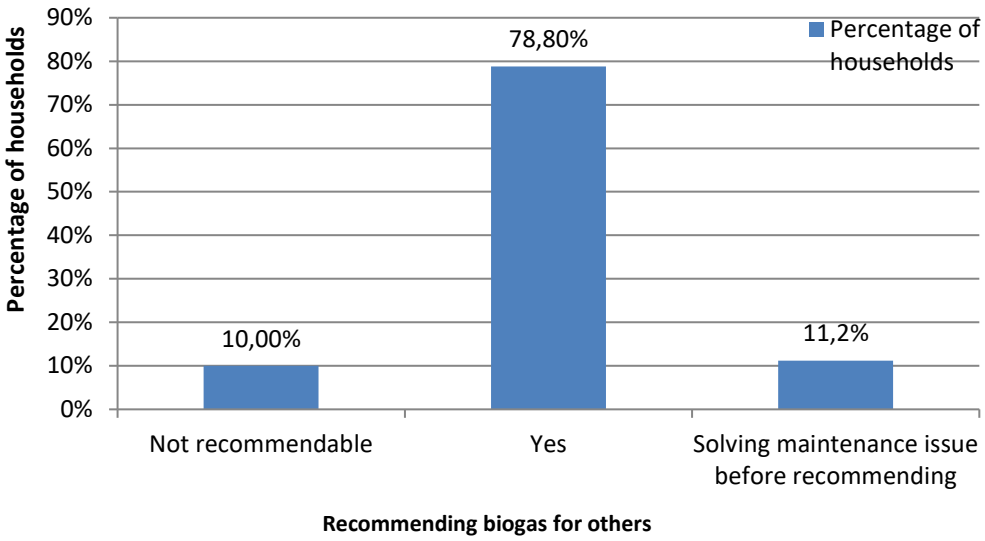



*Figure 74 - Users' opinion on recommending bio-digester to other in SNNP*

### 2.6.11. Key technical parameters for the bio-digesters construction

In SNNP, the construction of household bio-digesters was made based on standards (Fig. 22). However, in 54.5% of the digesters the turret valve was not covered, which increases its susceptibility to damage. The inlet and outlet of the bio-digesters was not shaded and not protected from rainwater in 93.9% of the households, see table below. The sizes of 90.1% of the sampled households' bio-digester were $6m^3$, and 9.1% were $8m^3$.

*Figure 75 - Well-constructed bio-digesters with toilet connected but not used*
(SNNPR_ Wolayita_ Boloso sore_ Wurmuma_ Sn-hope-284_ Year 3_2019_ Dawit Gua)

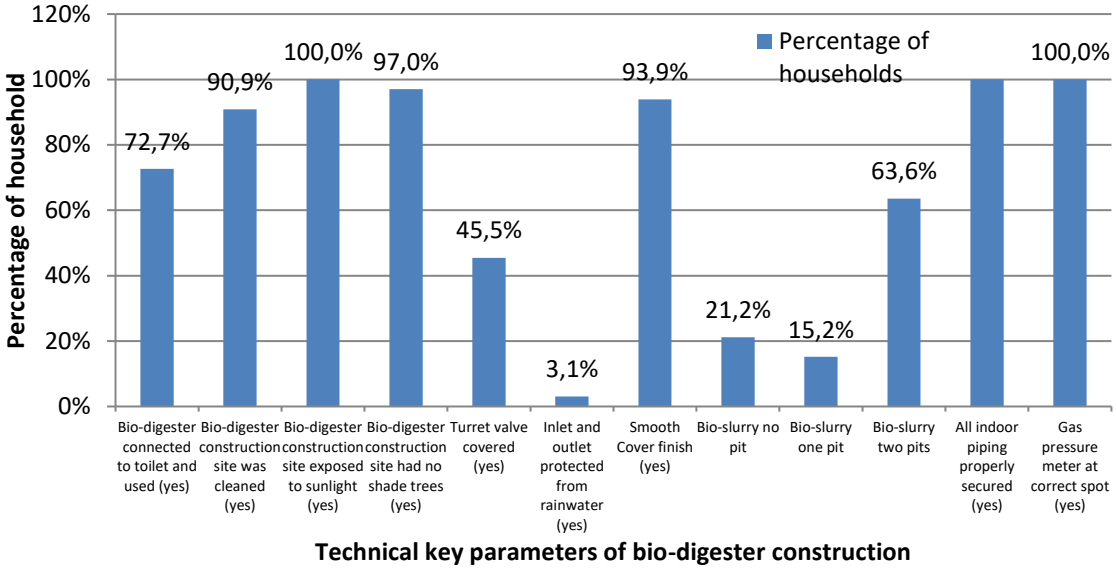



*Figure 76 - Observations on household technical key parameters of bio-digester construction*

The above observations were made on the samples of 33 completed bio-digesters.

### 2.6.12. Implementation challenges

In SNNP, bio-digesters installation and functionality was limited by untrained masons, and poor feeding, lack of transport, lack of local appliances, fittings and accessories, which specifically were:-

- Shortage of livestock due to disease or due to drought that reduce livestock feed intern reducing the amount of dung.
- Lack of livestock feed, pasture grass and water.
- Lack or shortage of labour.
- Lack of budget and transport service.
- Lack of participation of local administration and political bodies.
- Lack of training to households and supervisors.
- High rate of turnover of government staff, trained masons and energy experts.
- Lack of commitment of government microfinance institute like OMO microfinance to provide credit.
- Lack of willingness by farmers to repay credits from microfinance institutions.
- Lack of focus on biogas by bureau of water and energy because of skewed focus on water.

### 2.6.13. Sex and age characteristics of bio-digester users

In SNNP, the households that installed bio-digester were 21.2% female and 78.8% male. The age range was 22 to 65 years old with mean of 41.4years as shown in Annex VI.

The bio-digesters were installed in households that have water source points that take a walking distance ranging from 3.4 to 10.2 minutes and monthly income of ETB 19,823 to ETB 20,903.
In SNNP, functional bio-digester households had greater number of livestock (cattle and oxen), closer water source points, and better monthly cash income than the non-functional bio-digesters.

Although, the functionality bio-digesters varied with the household characteristics, there was no significant relation. That is the dependence of (binary logistic regression) functionality or non-functionality of bio-digesters on household characteristics like sex, age, education level, and number of livestock and distance of fetching water was not significant statistically. Therefore, the functionality of bio-digesters depends on the commitment and ownership of households.

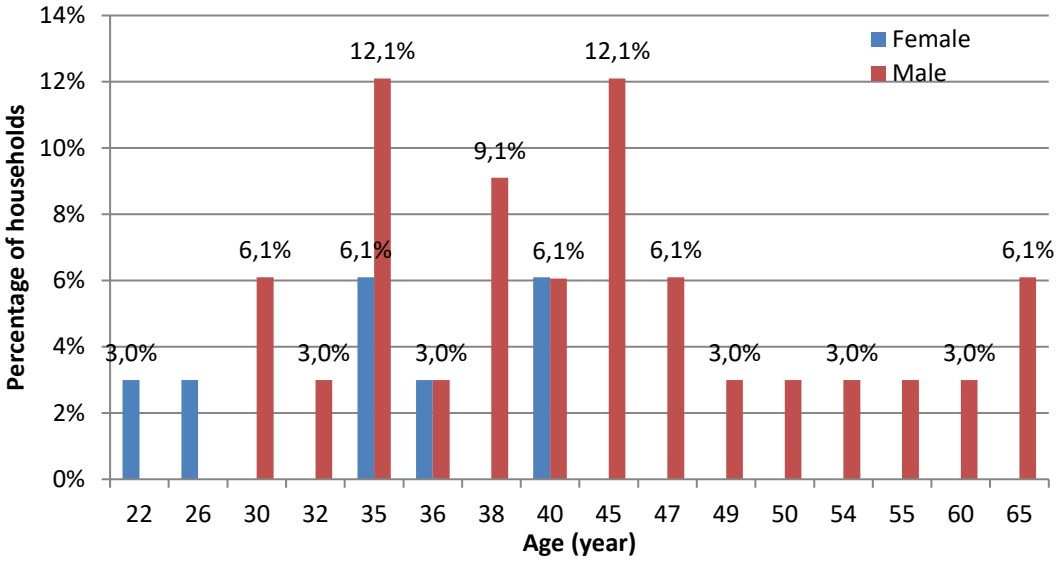



*Figure 77 - Sex and age distribution of household bio-digester owners in SNNP*

### 2.6.14. Recommendations

In SNNP, the bio-digesters users were highly appreciating the energy and the fertiliser value of bio-digester technology. Although, the bio-digester technology is not easily affordable in terms of time and money, the households using it saved wood consumption up to 50-60% and fertiliser expenditure by 50-100%. The experiences were not widely replicated, therefore, local experts and development agents need to be encouraged to scale-up the few experiences located in limited households.

- There should be coordinated efforts of agricultural sectors, livestock, and crop and forestry in order to strengthen the biogas generation of households.
- Livestock diseases should be solved at Federal level
- Modern livestock feeding and deep water well generation should be started so as to make the biogas sector sustainable
- Dung mixer should be disseminated in order to reduce the shortage of labour.
- Woreda level budget and transport service should be solved by purchasing motor cycles instead of big vehicles.
- Additional awareness creation should be done to local administrators and political bodies.
- Regular training should be done for supervisors and energy experts on biogas.
- Incentives should be created to government staff, trained masons and energy experts so as to reduce turnover.
- Biogas users association should be created so as to make the sector self-sustaining.

## 2.7. Somali

### 2.7.1. Purpose for which bio-digesters were installed

Households with bio-digesters had experience in using biogas. Use of the bio-digester technology was mainly for cooking purpose. Since the rural areas of Somali region was devoid of any vegetation for firewood, but endowed with many livestock, bio-digester technology is convenient. The local people were also highly interested in installing an additional bio-digester on their own source of financing. In Somali region, the main purpose constructing bio-digester was to supply energy that account 100% for cooking and 91.2% for light supply as shown in the following figure.

The regional government committed and supplied dung mixer and solar home lighting system as a promotion of bio-digester technology. The biogas light lamps were installed in all households, but they are not functioning. As a result, all the households with bio-digesters owned solar home lighting system, which was subsidised from the regional energy office.

*Figure 78 - Dung mixer locally manufactured in Somali region used in Owbarre Woreda.*

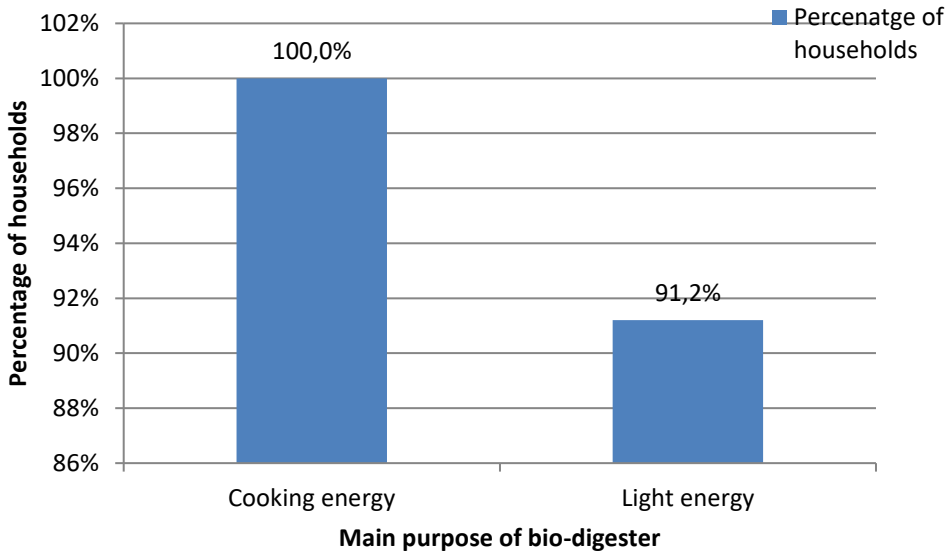



*Figure 79 - Purpose bio-digester installation in SNNP*

### 2.7.2. Functionality of bio-digesters

Functioning bio-digesters are highly needed in the Somali region, because there was no alternative source of energy for cooking. The bio-digesters found to function without notable problem were using harvested and stored rainwater. Although the field survey was conducted during the dry season when there was high scarcity of water, an average 73.5% of the sampled bio-digesters were functioning, which varied among Woredas.

**Table 13 - Functionality levels of bio-digesters in Somali Woredas**

| | | Functioning percentage | Not functioning percentage | Total number |
|---|---|---|---|---|
| Sampled Woredas in Somali | Gursum | 55.6 | 44.4 | 9 |
| | Owbarre | 76.5 | 23.5 | 17 |
| | Shabeley | 66.7 | 33.3 | 3 |
| | Tulli-guled | 100.0 | 0.0 | 5 |
| Total average percentage | | 73.5 | 26.5 | 100 |
| Total number | | 25 | 9 | 34 |

The sizes of 51.4% of the sampled households' bio-digester were 6 $m^3$, and 48.6% were 8 $m^3$. There were no complaints on the size for their functionality, because the functionality and power obtained was independent of size. However, it was generally said that the 8$m^3$ bio-digester was better for injera. There was no injera stove at all in the samples surveyed.

*Figure 80 - Rainwater harvesting structure for dry season storage to be used for bio-digester in Owbarre Woreda*

In addition to the shortage of water, there were other reasons for non-functionality of bio-digesters including pipe line cracked and gas leakage (11.1%) and stove valve damage (22.2%), as shown in the table below.

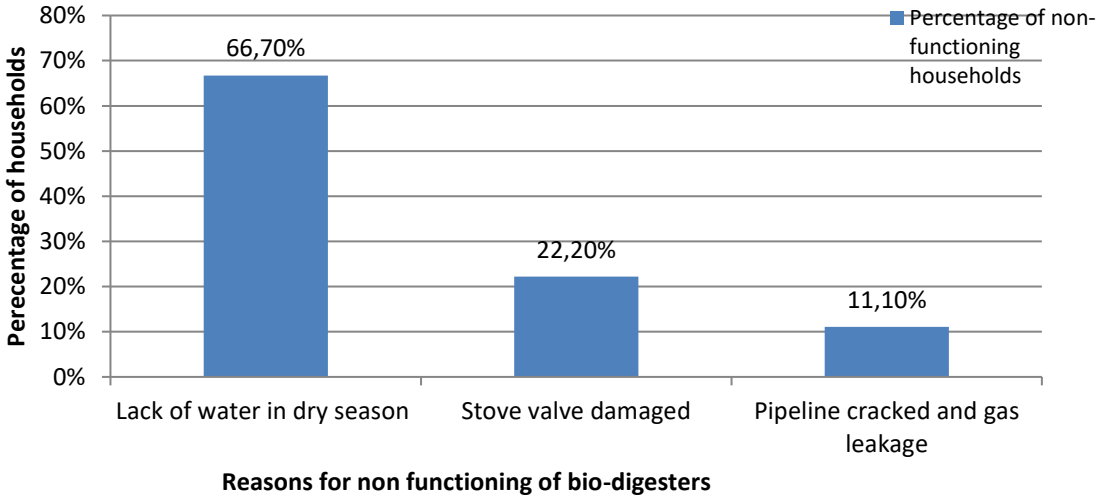



*Figure 81 - Functionality and reasons for non-functionality of bio-digesters in Somali*

The bio-digester technology is highly important in areas where there are no other cooking energy sources, like firewood. In Somali region, the lack of firewood triggered households to store rainwater for their biogas. The rural people of Somali region highly appreciated the biogas cooking system, which they did not know before. On the other hand, pre-urban areas that are electrified had given less attention to the bio-digester technology. The bio-digester was poorly functioning in areas where there is electricity within the Somali region. In all bio-digesters, the toilet pipes were not installed because of the culture of the local people to exclude human excreta.

The functionality of bio-digesters depends on:

- The availability of feedstock and water.

- The correct proportion of water and dung.
- The frequent use or abandonment of the digester.
- Clogging in the pipes, or gas leakage in the pipes.
- Incorrect alignment of pipes, and/or defects in the dome.

During dry season, there is lack of sufficient dung and water, therefore, it is difficult to consider equal level of performance of bio-digesters in rainy and dry seasons. The functionality of bio-digesters reported in this evaluation was minimal because the survey took place during the dry season.

### 2.7.3. Quality of after-sales service

The quality after-sales service in Somali region was very poor because of shortage of masons, drop-out of masons and turnover of government staff. There was no Zone and Woreda level energy sector administration and that reduced the after-sales service. The households responded that no one was replying for the problems encountered in their bio-digester.

### 2.7.4. Benefits of bio-digester

Characteristics of household with completed bio-digesters showed that the s technology saved 44 to 55% of woodfuel collection and consumption time and saved 41 to 67% of the amount of woodfuel consumption, the highest being in cold season and the lowest in hot season.

The average number of persons in a household is ranging from 8.9 to 10.3 that utilise 214.8 kg of woodfuel (charcoal and firewood) per month.

The proper use of biogas could save 41.0 to 53.0% in hot season and 52.0 to 67.0% in cold season on the amount of woodfuel utilised. The bio-digesters were installed in households that have water source points that take a walking distance ranging from 40.7 to 72.9 minutes. About 50% of the households responded that biogas saved 50% Woodfuel collection time and 50% Woodfuel consumption time as shown in the figure below.

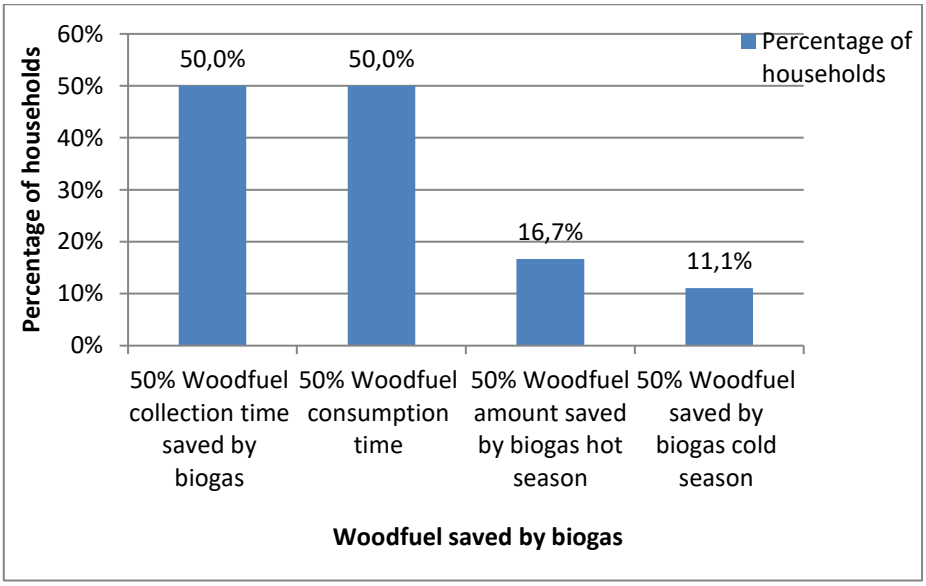



*Figure 82 - Wood fuel amount and time saving due to biogas utilisation in Somali*

### 2.7.5. Health impacts of biogas

Construction of bio-digesters had additional benefits like health condition improvement (in comparison to the firewood smoke). On the other hand, 73.5% of the households stated that biogas

had improved the health condition including reducing eye infection, respiratory diseases, cough, and fire related injury.

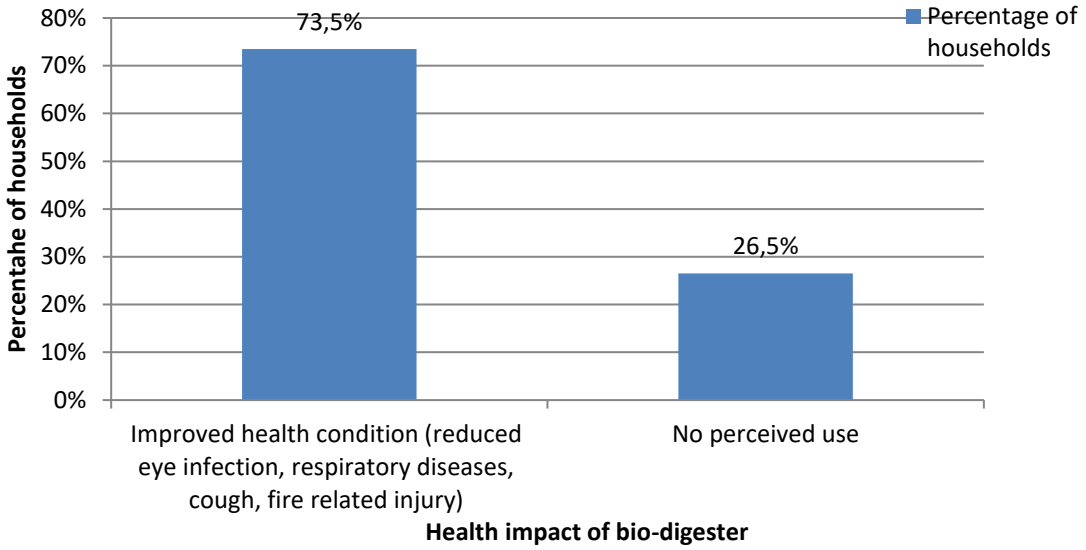



*Figure 83 - Perception of households on health impacts of bio-digester technology in Somali*

### 2.7.6. Bio-slurry management and application

In Somali region, the bio-slurry was not well utilised because crop cultivation was not widely practiced. Most of the bio-slurry produced was freely flowing even without pits. As stated in the table below, about 50% of the bio-digesters had no bio-slurry pit at all.

*Figure 84 - Unused bio-slurry (left) and freely flowing bio-slurry (right).*
(Somali_ Fanfan_ Gursum_ Degahle_ SOAB58_ Year 2_2018_ Ilyas Somane (left)); (Somali_ Fanfan_ Owbarre_ Ged-gedlac_158_ Year 3_2019_ Ahmed shugri dhidar (right))

In Somali region, about 91.2% of the households were using the bio-slurry occasionally after drying (Table 22) for agricultural crops like maize and wheat (61.8%), while 8.8% were not using it at all. As can be seen from the above figures, most time of the year the bio-slurry was left without being utilized. The households had not experienced in using the bio-slurry because of the limited agricultural practice, and the newly introduced bio-digester technology. That is the absence of agricultural activity showed as the bio-slurry was not utilised especially in dry season.

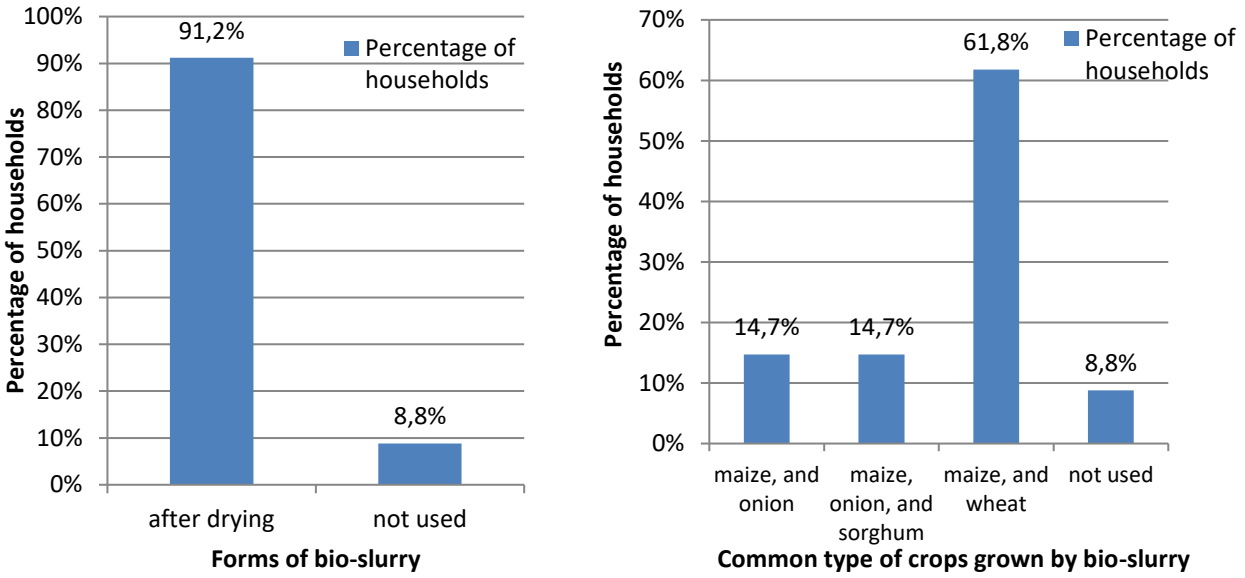



*Figure 85 - Forms of bio-slurry and type of agricultural crops grown by bio-slurry*

### 2.7.7. Limitations in the use of bio-digesters as disadvantage

During the discussions with the households, it was found that 11.8% consider that there was no disadvantage in construction of bio-digesters. However, the other 11.8% of the households stated, as they missed their expectation of getting energy and 8.8% stated as the construction was expensive and became a household financial burden. The highest disadvantage stated by 61.8% of the households was the scarce water taken for bio-digesters dung mixing.

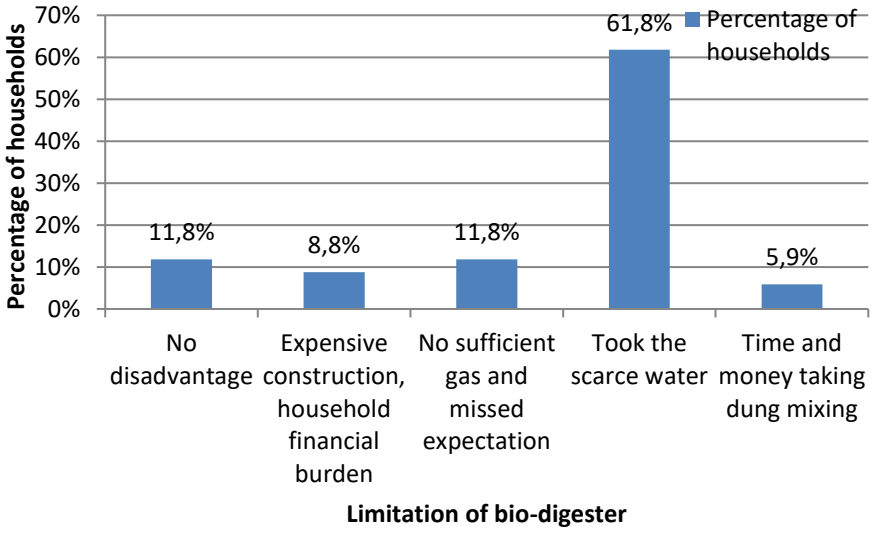



*Figure 86 - Limitation as disadvantage of bio-digester installation in Somali*

### 2.7.8. Users' training

In Somali, all bio-digester user households were trained about the way of feeding and using bio-digester. However, all the households were not provided user manual. The finance sources for installing all the bio-digester was from own sources as shown in figure below.

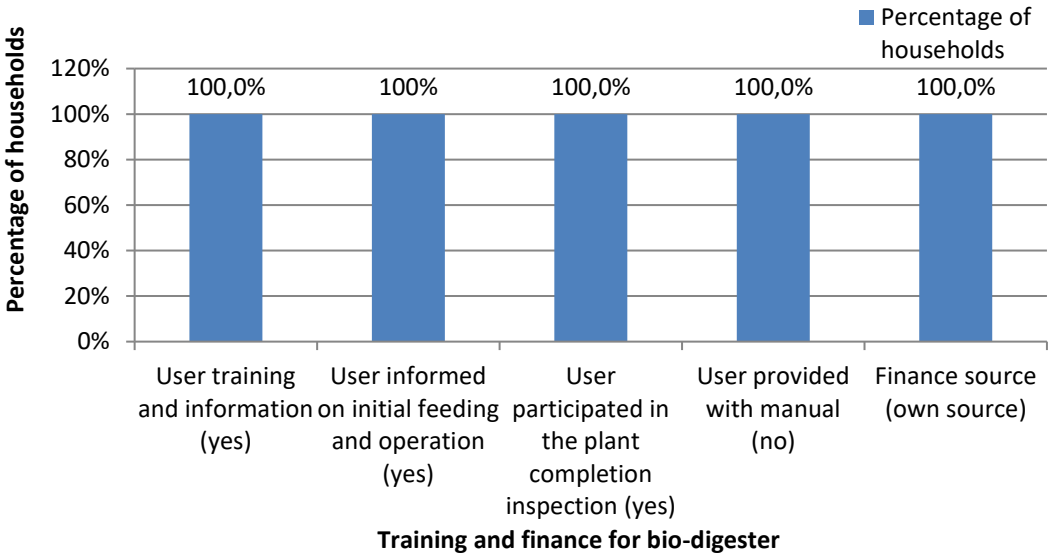



*Figure 87 - Training and finance sources of bio-digester user households in Somali*

### 2.7.9. Users' satisfaction

Households with continuously functioning bio-digesters about 44.1% were highly satisfied, while those with non-functioning bio-digesters about 17.6% were highly unsatisfied as shown in the figure below. The unsatisfied households were creating conflict with regional energy coordinators, developed mistrust and did not want provide any information**.**

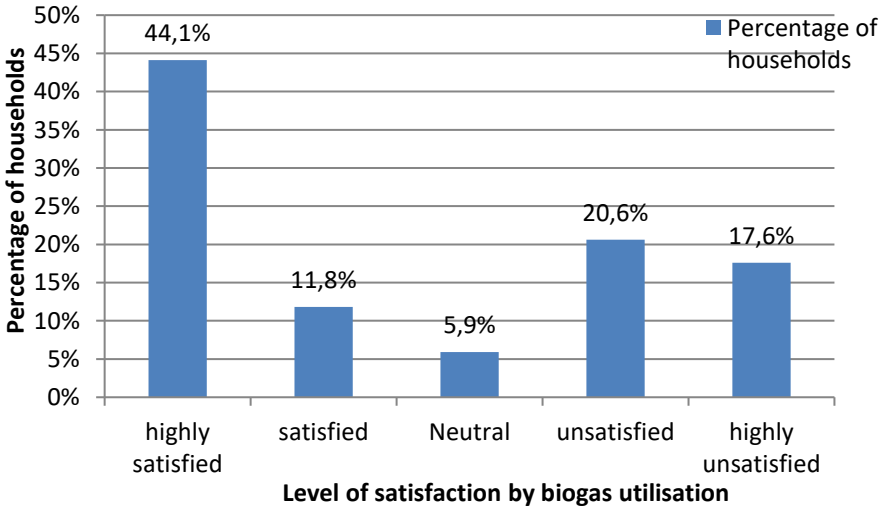



*Figure 88 - Level of satisfaction of bio-digester users in Somali*

The household that installed bio-digesters had additional sources of non-biomass energy including 94.1% who had subsidised solar home lighting systems and 32.4% had electric energy from the central grid. There was no information about the use of kerosene in the sampled households.

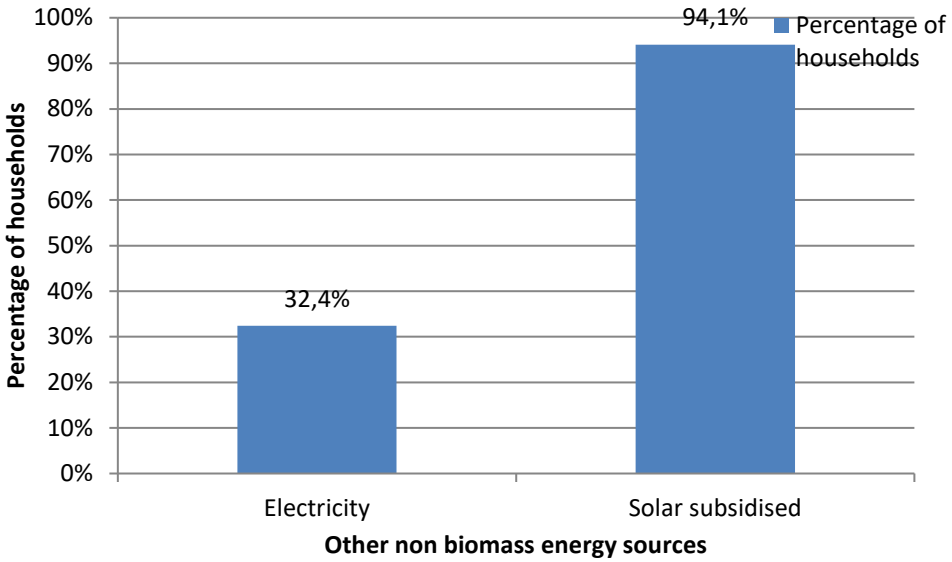



*Figure 89 - Other non-biomass sources of household energy*

### 2.7.10. Users' opinion on recommending to others to install bio-digesters

In Somali region, about 73.5% of the households recommended the wider distribution of bio-digesters; whereas 8.8% of the households recommend the use of the technology after solving the current problem of maintenance issue, as shown in the figure below.

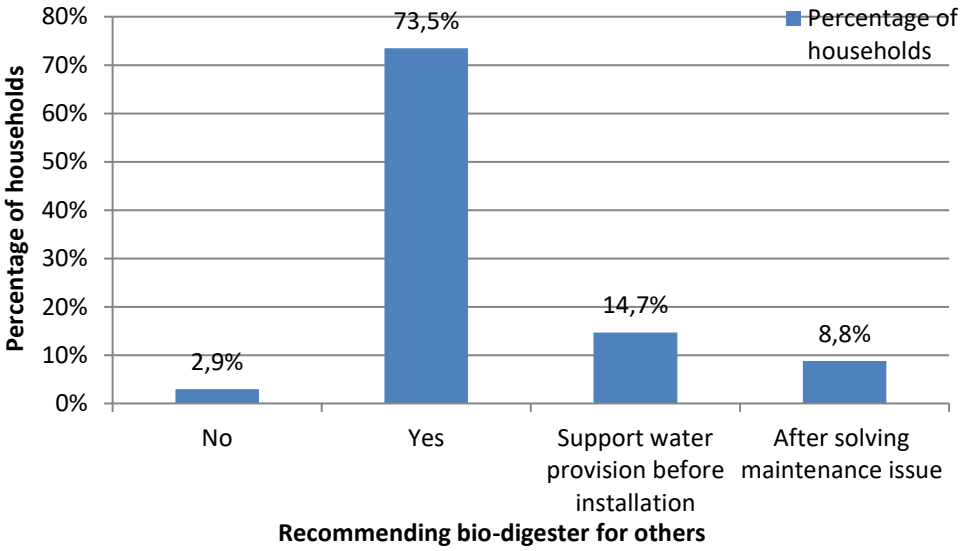



*Figure 90 - Users' opinion on recommending bio-digester to other in Somali*

### 2.7.11. Key technical parameters for the bio-digesters construction

In Somali region, the quality of construction was based on standards. However, households complained about the untrained and delayed masons that caused low quality of construction, because of the non-functioning bio-digester after filling with dung that require repeated corrections. There were levelled sites selected to construct Sinidu that made the bio-digesters susceptible to flooding and physical damage. For example, Pipes were exposed to fluctuating temperature and physical damage.

*Figure 91 - Exposed pipes (left) and flat outlet (right) of bio-digesters*
(Somali_ Fanfan_ Owbarre_ Lafa-ise/subusha_125_ Year 3_2019_ Abdi ahmed yusuf (left));(Somali_ Fanfan_ Gursum_ Degahle_ SOAB16_ Year 2_2018_ Deeqa Doof (right))

Cement shortage is reflected on the construction of unsmoothed inlet and outlet, which can easily break down. The outlet level is higher than what it should be which is a construction critical error, because it can cause slurry to enter the pipes.

*Figure 92 - Unsmoothed and high opening of the outlet of bio-digester*
(Somali_ Fanfan_ Owbarre_ Lafa-ise/harqurux_101_ Year 3_2019_ Hirsi burale farah)

In Somali, the site used for the construction of all bio-digesters was clean. In all sampled households, the toilet pipe was not constructed at all to be used with bio-digester inlet because of the culture of the people that exclude contact of livestock with human excreta. There is a lack of awareness on the chemistry of biogas, as removal of methane and carbon monoxide eliminates the toxicity. In all bio-digesters, the inlet and outlet were not protected from rainwater. Moreover, 2.9% of the bio-digesters turret valve was not covered and half of the bio-digesters had no bio-slurry pit at all.

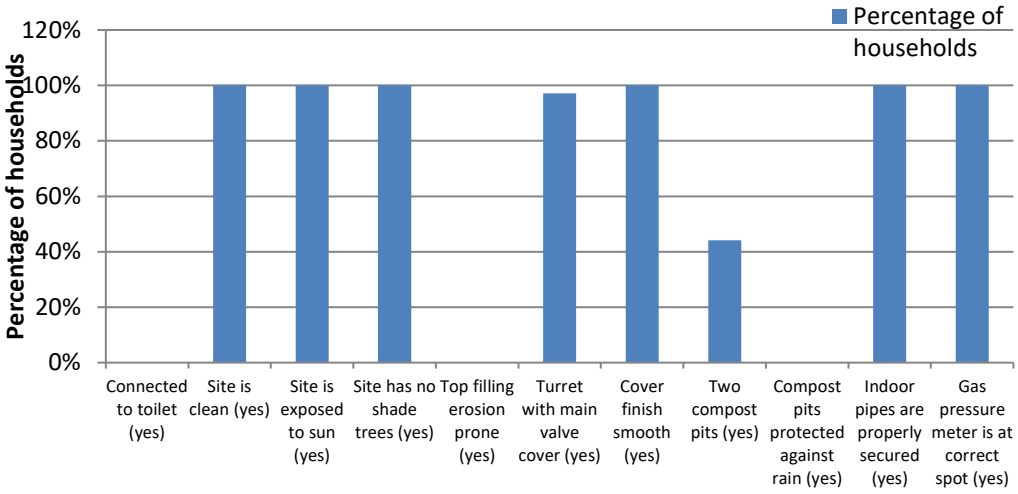



*Figure 93 - The key technical parameters in construction of bio-digesters in Somali*

The above observations were made on the samples of 34 completed bio-digesters.

### 2.7.12. Implementation challenges

In Somali regions bio-digester installation faced different types of problems that hinder the full functioning of bio-digesters:

- The lack of pasture grass and water in dry season reduced the utilisation of bio-digester technology in Somali.
- Lack of agricultural crop cultivation experience to use bio-slurry.
- Lack of Zone and Woreda level administrative structure that allow proper after-sales service.
- Lack of budget and transport services.
- Unclear implementation of NPBE+ project on the allocation of fund.
- High rate of government staff turnover.

### 2.7.13. Sex and age characteristics of bio-digester users

In SNNP, the households that installed bio-digester were 11.8% female and 88.2% male. The age range was 25 to 70 years old with mean of 40.3 years, although dominated by the age of 35 years male about 14.7% as shown in the figure below and in Annex VI.

The dependence of (binary logistic regression) functionality of bio-digesters on household characteristics like sex, age, education level, and number of livestock and distance of fetching water was not significant statistically. We conclude that the functionality of bio-digesters depends on the commitment, ownership and lack of alternative energy sources of households. Hence, it is important to create awareness and training to use bio-digester technology before and after installing the bio-digesters.

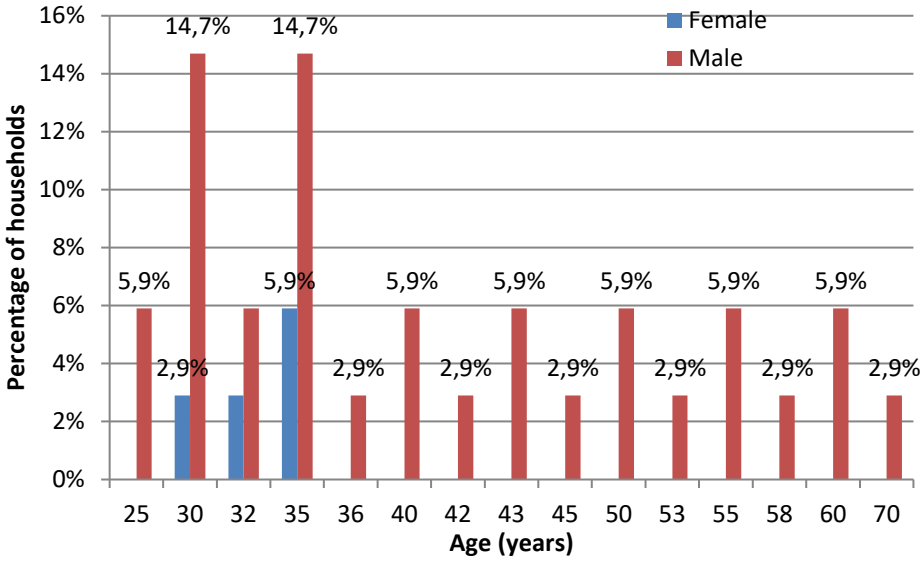



*Figure 94 – Age and sex distribution household bio-digester users in Somali*

### 2.7.14. Recommendations

- There should be improvement of pasture grass feed for livestock and water in dry season so as to promote the utilisation of bio-digester technology in Somali.
- There is ample land for crop cultivation and bio-slurry production should be used to promote crop cultivation.
- There should be Zone and Woreda level administrative structure that allow proper after-sales service.
- There should be mean of motivating local energy staffs, and masons through administrative political attention that reduce government staff turnover.
- Since bio-slurry is not combustible, it can only be applied to agricultural crops because it is a high value organic fertiliser. Therefore, if there would be a wide use of bio-slurry, there could be a possibility of creating agricultural sustainability of the pastoral and mobile people of Somali region.
- Biogas light lamps were installed but were not utilised and replaced with subsidy with solar lamps. Therefore, it would be better to exclude the biogas lamps from the beginning of the installation, in order to reduce the overall incurred costs. Household heads that were running trading activities in Somali had less time to feed the digester. Therefore, the bio-digester functioned better and should most appropriate be used for households with livestock-crop income earning system.

## 2.8. Conclusions and recommendations for all regions

The functionality of bio-digesters varied amongst the regions and amongst the households because of technical failure and availability of feedstock. Their functionality depends on: (i) the availability of feedstock and water, (ii) the correct proportion of water and dung, (iii) the frequent use or abandonment of the digester, (iv) clogging of the pipes, or gas leakage in the pipes, (v) incorrect alignment of pipes, and/or (vi) defects in the dome. Based on the revised SNV definition of functionality of bio-digesters, the average functionality of bio-digesters by including minor problems was 77% in Gambella from 13 completely constructed bio-digesters, 75% in Oromia from 44 bio-digesters, 69.7% in SNNP from 33 bio-digesters and 73.5% in Somali from 34 bio-digesters.

In Gambella, Oromia and SNNP toilets were installed and the pipes connected, but some of them were not utilised. Therefore, a prior agreement with households should be required before installing

toilet connection, to save unnecessary cost. In Somali the toilet pipes were not installed with bio-digesters, but separate toilets were constructed in another place within the residential area. Moreover, in Somali, biogas light lamps were installed but none were utilised and have been replaced by solar lamps. Therefore, it is recommended to exclude the biogas light lamps from the beginning of the installation in order to avoid unnecessary costs.

Households' heads that were running mining activity in Gambella and trading activity in Somali, Oromia, and SNNP had no sufficient time to feed the digester. Therefore, households with livestock-crop income earning system were most appropriate for bio-digester to function.

During dry season there is lack of sufficient dung and water in all studied regions, therefore, since it is unrealistic to consider equal level of performance of bio-digesters in rainy and dry seasons, the functionality of bio-digesters reported in this evaluation is assumed to be the minimum.

In Gambella, the use of biogas saved 11.0% of the amount of wood fuel utilised in the hot season to 46.0% in the cold season. However, about 23.1% of the households perceived that biogas has unpleasant odour during mixing dung with water and during utilising the gas in stoves.

In Oromia, the local people developed good experience of using biogas and bio-slurry. However, there was a difficulty of getting water in dry season. There were some households that use deep water wells in water deficit areas, which could be a good lesson and advise for other bio-digester owners who complain about water shortage.

In SNNP bio-slurry composting was used for annual crops like maize and wheat, while the semi-liquid bio-slurry was used for enset plant and other perennial crops. Bio-digester technology was not easily affordable in terms of money and time. However, the households using the technology, saved wood by 50-60% and fertiliser expenditure by 50-100% at individual household level. The experiences were not widely replicated, therefore, local experts and development agents need to be encouraged to promote and scale up these few experiences.

In Somali region, the after-sales service quality was very poor because of shortage of masons, resignation of masons and turnover of government staff. The absence of Zone and Woreda as the coordination structure of energy offices in Somali and Gambella reduced the after-sales service. Dung mixer and solar home lighting system provided to bio-digester owner household in Somali region were good lessons to alleviate the problem of labour required in bio-digester feeding, and the problem of breakage of the glass of biogas lamps, respectively.

Overall, the functionality of bio-digesters was not related to the household characteristics like sex, age, education level, and number of livestock, but it rather depends on the commitment, ownership and lack of alternative energy sources of households. Households with many livestock may not use the bio-digester, if they are not committed to get energy from biogas. Hence, it is important to regularly create awareness and training to use bio-digester technology before and after installing the bio-digesters.

The construction of bio-digesters in most cases was government driven and external fund oriented, which reduced the households commitment and ownership of the technology. Hence, the future role of government should be technical training of households, development agents, energy experts and creating links between the technical staff and the household owners and developing true Public Private Partnership. The credit and individual organisations together with masons and BCEs should be enabled to install bio-digesters as the bio-digester construction enterprises. In remaining period of NBPE+, great attention should be given to maintenance and enabling the functioning of the already constructed bio-digesters. The increasing price of cement and the frequent need of training of masons, require alternative type of bio-digesters like prefabricated plastic ones, created preferably by national or continental factories.

Some recommendations for all regions:

1 Support the Regional Governments to develop region-specific bio-digester sector Strategy.

2 Refresher training of RBPCU experts as well as relevant government experts: energy, agriculture. The programme should provide training on:
- Bio-digester promotion and demand creation;
- Bio-digester quality standards;
- Site selection and bio-digester construction and supervision;
- Bio-digester operation and maintenance including troubleshooting;
- Monitoring and Evaluation.

3 Training of BCEs and masons. The quality of the primary services (construction and after-delivery service) will be key to the success of the Programme. To ensure a high level of service quality, the programme should make a significant investment in training and retaining of bio-digester masons and supervisors.

4 Outsourcing of quality inspection services to independent quality supervision (certain bio-digester construction companies could be contracted for quality inspection and not engaged in digester construction). The primary responsibility for quality control rests with the contractor (i.e., BCE or mason). However, an independent quality assurance may be needed as the masons or BCEs should not certify the bio-digesters they constructed. Currently, the quality assurance is done by the Woreda experts. So, instead of relying solely on the Woreda experts (and in some cases there are no biogas experts) this function could be contracted to independent BCEs by the RBPCU.

5 Enhance mobility – supply motorbikes and vehicles for new and existing regions.

6 Per-diem for monitoring and supervision of bio-digester construction by regional/ Zone/ Woredas experts.

7 Additional financing towards promotion and demand creation activities as current RBF amount is insufficient

8 Publication and dissemination of good practices.

9 Research grant for biogas appliances and accessories such as improved Injera Mitad.

10 Support the Ministry of Agriculture and the regional bureaus of agriculture for development of bio-slurry promotional materials to be used by agriculture extension workers.

11 Develop slurry extension model that is helpful to promote bio-digesters. The model shall provide detailed guidance on coordination of slurry extension and promotion; training of agricultural development agents and energy experts on slurry extension and promotion, production of bio-slurry extension and promotion materials; and financial and economic analysis of bio-slurry.

# 3. Answers to the evaluation questions

## 3.1. EQ1 – Strategic Relevance

**EQ1 - To what extent has the EU biogas cooperation responded to the evolving energy needs of Ethiopia and of the end-users and is aligned to the wider EU and global development agenda?**

Rationale: To be sustainable and lead to impact, outcomes must be delivered in response to developing partner country needs and priorities. In Ethiopia the NBPE+ is especially relevant since the launch of the Sustainable Energy for All (SE4ALL), the adoption in September 2015 of the SDGs and with the entry into force in November 2016 of the Paris Agreement on Climate Change. Ethiopia has also prepared the Intended Nationally Determined Contribution (INDC) – and, upon their ratification of the Paris Agreement – the Nationally Determined Contribution (NDC) which have had crucial importance for sustainable energy and therefore for the NBPE+. These changes have facilitated a shift from a focus on fossil-based generation capacity and power infrastructure to access to modern energy, also via local and off-grid solutions, and to increasing focus on renewable energy and energy efficiency. In this highly dynamic context, EQ1 seeks to understand to what extent EU support to the NBPE+ has been strategically relevant in addressing Ethiopian needs and aligned to the country's priorities; how effective partner/beneficiary involvement and ownership has been in design and implementation; and how the EU intervention is aligned to the broader global development agenda and were coherent with relevant EU development policies.

This has led to the following Judgemental Criteria (JC):
JC 1.1 - Degree of alignment to national energy objectives, strategies, plans, and programmes.
JC 1.2 - Degree of country involvement in and ownership of programme design and implementation.
JC 1.3 - Degree to which the biogas sector support is aligned with the wider global development agenda.
JC 1.4 - Degree to which the programme purpose and its objectives (outcome-level) are still valid and consistent with/supportive of the government needs.

Link with OECD/DAC evaluation criteria: EQ1 particularly addresses relevance (i.e., were the right challenges and opportunities addressed).

Link with 3Cs: EQ1 relates closely to all three Cs, i.e., coherence (policy coherence with partner country and internally among many different types of EU interventions in the country), complementarity (with initiatives supported by EU member states); and coordination (how effectively the NBPE+ initiative is/was coordinated with activities supported by other development actors at the country or regional and local implementation levels).

Link with IL: The EQ relates to the Intervention Logic (IL) intended outcomes as well as assumptions from outputs to outcomes. The EQ also relates to impact in its assessment of programme and project design and implementation results.

**Box 1 - Summary answer to EQ1**

1. There is strong evidence that NBPE+ support is aligned to national and regional objectives, strategies, plans, and programmes. There is also strong evidence that the NBPE+ is relevant for the users.

2. There is more than satisfactory evidence of the country involvement in and ownership of design and implementation. The quality of the evidence is strong.

3. Overall, there is strong evidence that the NBPE+ support was aligned to the wider global development agenda and was EU policy coherent. The evidence for this was strong for SDG7 but weaker for the Paris Agreement on Climate Change.

4. There is strong evidence that the programme purpose and objectives are still valid and consistent with government needs.

**Conclusion:** The EU biogas cooperation responds to the evolving energy needs of Ethiopia and of the end-users and is aligned to the wider EU and global development agenda.

### 3.1.1. JC 1.1 - Degree of alignment to national and regional energy objectives, strategies, plans, and programmes.

**Indicators:**
I.1.1.1 – Evidence of analysis that indicates the presence of a sound and credible national sector framework of policies, strategies, programmes and institutional structures and procedures with which to align.
I.1.1.2 – Intervention is aligned where the national sector framework was sound.
I.1.1.3 – The EU applied an appropriate intervention strategy where the national sector framework was not sufficiently in place.

I.1.1.1 – Evidence of analysis that indicates the presence of a sound and credible national sector framework of policies, strategies, programmes and institutional structures and procedures with which to align.

The EU cooperation with the public sector in Ethiopia was backed by analysis of government policies, plans, and programmes. For most of the public sector-oriented initiatives, analysis was undertaken of the relevant national/regional sector framework of policies, strategies, programmes, institutional structures and procedures with which the cooperation should align.

In December 2011, Ethiopia launched its Climate Resilient Green Economy (CRGE) Strategy[12]. The objective of CRGE strategy is for the country to achieve middle-income status by 2030 through climate-resilient and green economy development. The green economy strategy has prioritised two programmes that could help to develop sustainable forestry and reduce firewood demand. One of the strategies relevant to the biogas programme aims to "Reduce demand for firewood via the dissemination and usage of fuel-efficient stoves and/or alternative-fuel cooking and baking techniques (such as electric, LPG, or biogas stoves[13]) leading to reduced forest degradation" (p. 24). The CRGE strategy builds on a series of progressive development strategies that have begun to link economic growth, poverty reduction and sustainability.

According to CRGE core assumptions for abatement initiatives, biogas stoves will have an abatement leverage of 2.3 million metric tons of carbon dioxide equivalent ($MtCO_2e$). Furthermore, the bio-slurry (which is the co-product of biogas) enhances agricultural productivity and encourages organic farming.

The Draft Ethiopian National Energy Policy 2012[14] had a policy objective to enhance diverse and efficient bio-energy production, and mentioned among others the following Policy Instruments: to promote improved bio-energy conversion technologies including agro-industrial waste for thermal and power applications, biogas from urban, livestock and poultry waste.

Under the policy objective to ensure bio-energy supply security mentioned the following Policy Instruments: (i) promote modern cattle raising for better biogas production, and (ii) promote the construction and effective utilisation of bio-digesters.

12 CRGE – Climate Resilient Green Economy: Green Economy Strategy 2011-2025, GoE, September 2011.
13 It is meant bio-digesters and its accessories, which include stoves.
14 Ethiopian National Energy Policy (2nd draft). Ministry of Water and Energy, February 2013.

The Biomass Energy Strategy of Ethiopia[15] drafted in 2013 envisions a sustainable biomass energy "used for the socio-economic and environmental benefit of the Ethiopian people" (p. 31). It also recognises that biomass energy will be used over the coming decades, and therefore, it is essential to increase sustainability to strengthen the development of rural areas and to secure income for local people. Although the strategy does not directly mention biogas programme, its objective 3 and result 3.3 pertain to the biogas programme. Objective 3 reads "Rural and Urban Households and small biomass energy consuming enterprises use fuel efficient technologies" whereas result 3.3 refers to "Substitution of dung and agricultural residues by other renewable fuels" (p. 64).

The Ethiopian governmental policies are not targeted but supportive of bio-digester sector development. The Growth and Transformation Plan (GTP I[16] and II[17]) and the CRGE strategy emphasise the role of renewable energy to support the country's ambitious development plans and goals.

The GTP II (2015-2020) had a target of installation of 31,400 bio-digesters in the country. The NBPE+ is implemented through the government structures and is supporting the country in line with its policies, strategies, plans and programmes.

The National Electrification Programme[18] was launched in 2017 to strategically shift focus from infrastructure development to delivery of adequate, reliable, and affordable electricity services by 2025. The credit line provided by the World Bank (WB) through the Development Bank of Ethiopia (DBE) is also meant to finance bio-digesters.

Therefore, there is evidence that the intervention was aligned where the national sector framework was sound. Even though the sector framework is sound and based in several policies and strategies that promote the sustainability of the sector, there is not yet a policy that fully supports the biogas sector intervention and especially the development of a private sector market.

I.1.1.2 – Intervention is aligned where the national sector framework was sound.

For the biogas sector initiative there is evidence of an appropriate intervention strategy when the sector and policy framework was inadequate. In fact, the EU support in the biogas sector was targeted at addressing the identified weakness in the NBPE II future sustainability. Without the NBPE+ the biogas sector would most likely start collapsing at the end of 2020.

In the programme design, it is also defined that one of the roles of the NBPE+ Steering Committee is to ensure that the NBPE+ is implemented in line with the government's policy on renewable energy, rural energy, rural development, livestock and agriculture development, employment creation and poverty reduction[19].

The NBPE+ programme is implemented through the government structures and is therefore directly supporting the country in line with its policies, strategies, plans and programmes.

I.1.1.3 – The EU applied an appropriate intervention strategy where the national sector framework was not sufficiently in place.

Bio-digesters have multiple benefits for households. The benefit of using biogas for cooking is very much appreciated by the users, as it saves time in collecting firewood, which is becoming increasingly scarce (even though this does not apply for all intervention areas of the NBPE+) and

15 Biomass Energy Strategy of Ethiopia, EUEI PDF, December 23, 2013.
16 Growth and Transformation Plan I, (2010-2015). GoE, 2010.
17 Growth and Transformation Plan II, (2015-2020). GoE 2015.
18 Ethiopia's energy sector transformation, ESMAP, November 2019
19 NBPE+ Programme Implementation Agreement, May 2017.

improves the health condition of the household's members, especially women and children who are in this way not exposed to harmful smoke.

Biogas lamps are still promoted by the programme and useful in many places, but solar photovoltaic lamps are becoming increasingly cheap and reliable, so this benefit from the biogas programme is losing relevance (also because biogas lamps are very fragile and the mantle is very brittle and almost impossible to be found in most areas of the country).

Bio-slurry and bio-compost are now actively being promoted by NBPE+ for different agricultural uses. Bio-compost production is arguably the best way to recycle nutrients. Today, almost all bio-digesters have double compost pits in order to fill the one pit while the other is completing the 2-3 months decomposition period. According to the NBPE a 6 $m^3$ bio-digester may produce around 27 tonnes of bio-compost per year, which would be sufficient for fertilising 3 hectares of land. Some farmers may also make an income by selling bio-slurry or bio-compost.

The EUD Action Fiche[20] similarly reflected evidence of analysis of national/regional sector framework with which to align, as part of the detailed rationale for the intervention.

**Conclusion**: **the JC is validated**. There is strong evidence that NBPE+ support is aligned to national and regional objectives, strategies, plans, and programmes. There is also strong evidence that the NBPE+ is relevant for the users.

### 3.1.2. JC 1.2 – Degree of country involvement in and ownership of programme design and implementation.

**Indicators:**
I.1.2.1 – Evidence of effective dialogue in programming, preparation and implementation processes.
I.1.2.2 – Evidence of consultative processes for effective country involvement in preparation process and implementation.
I.1.2.3 – Evidence of financial contribution of national/regional institutions to the implementation of interventions.

I.1.2.1 – Evidence of effective dialogue in programming, preparation and implementation processes.

The process of programming EU cooperation was constructive. For the NBPE+ there is evidence of effective dialogue with partners in programming, preparation, and implementation processes. To come to the Action Document and the Financing Agreement between the GoE and the EUD, extensive meetings were held between the partners involved. The decision to add 4 new regions to the programme had already been taken by the GoE before the programming begun.

I.1.2.2 – Evidence of consultative processes for effective country involvement in preparation process and implementation.

There is evidence of consultative processes for effective country involvement. The EUD is involved in the Energy Sector Development Partners Forum where at the highest level donors coordinate their interventions with the government. The most important related to the NBPE+ are the Sector Working Groups which bring together the Government and Development Partners (DPs) at the sector level to discuss and address sectorial policy and programme issues. These sector groups play a critical role to ensure the effectiveness of development cooperation by safeguarding that aid is fully aligned to sectorial plans and strategies, thus ensuring the ability of the national plan to deliver results. So, via the EUD the NBPE+ is involved in the discussions of these coordination mechanisms and platforms which contribute to an increased coordination at policy level.

[20] NBPE+ Description of the Action, Final. January 15, 2016.

Recently the Development Assistance Group committee approved the proposal submitted by the EU and Norway for a new working group named "Climate Resilient Green Economy (CRGE) Forum" which aims to serve as a discussion platform to promote the exchange of information and facilitate dialogue and programmatic efforts in relation to the CRGE. The forum is also relevant for informing and guiding future efforts such as the GTP III. The position and design of the CRGE Forum allows it to play a critical role in ensuring the effectiveness of development cooperation within the CRGE sector.

I.1.2.3 – Evidence of financial contribution of national/regional institutions to the implementation of interventions.

As was the case of the NBPE II, NBPE+ is implemented as a PPP through MoWIE and the regional Energy Bureaus or Agencies, involving the Woreda Energy Offices and other relevant government actors at different levels. This ensures national ownership and commitment to realise the programme objectives at all levels, with good possibility of mainstreaming or institutionalisation of the programme with the national structures, for continuity and sustainability.

The NBPE+ has a financial contribution by the country thereby indicating ownership. The GoE contributes with 25% of the user's subsidy[21] and, overall, the GoE contributes with 8.75% of the total programme costs[22]. There are also contributions from the regional governments to the programme which indicate the commitment and ownership of the programme at local level. For example, Amhara contributes yearly with ETB 10 M (€ 200 k), Oromia with ETB 11 M (€ 220 k)[23] and Gambella with ETB 200,000 (€ 4 k)[24].

**Conclusion: the JC is validated**. There is evidence of the country involvement in and ownership of design and implementation. The quality of the evidence is strong.

### 3.1.3. JC 1.3 - Degree to which the biogas sector support is aligned with the wider global development agenda.

**Indicators:**
I.1.3.1 – Intervention is coherent with relevant EU development policies.
I.1.3.2 – Alignment of support with SDGs.
I.1.3.3 – Alignment of the EU programme objectives with country INDCs/NDCs and Paris Agreement implementation.

I.1.3.1 – Intervention is coherent with relevant EU development policies.

There is strong evidence that the NBPE+ intervention was coherent with relevant EU development policies. There is strong evidence of alignment to the EU Agenda for Change and other key EU policy documents. Further discussion in EQ6.

I.1.3.2 – Alignment of support with SDGs.

There is evidence that the NBPE+ initiative is strongly aligned to SDG7. Interventions from 2015 and later also made reference to SDG7 and – to a limited degree also to other SDGs notwithstanding the EU perspective on sustainable energy as a broader enabler of social and economic development and not narrowly as a "sector" focused only on SDG7. The NBPE+ activity generally does not make

[21] NBPE+ Description of the Action, Final. January 15, 2016.
[22] Personal communication from the financial department of SNV. 18 May 2021.
[23] Interview with Mr. Temeshen Tefera, National Programme Manager (NBPCU), 19 May 2021.
[24] Interview with Mr. Mesfin, Gambella Regional Biogas Programme Coordinator (RBPCU), 28 May 2021.

reference to the use of information it gathers in the Global Tracking Framework[25], a major initiative led by the World Bank and IEA with some 20 international partners aimed at providing countries and the international community with a global dashboard to register progress on energy access and renewable energy. Thus, the results frameworks of EU cooperation could have been even further aligned to these goals and associated indicators.

I.1.3.3 – Alignment of the EU programme objectives with country INDCs/NDCs and Paris Agreement implementation.

There is evidence that the NBPE+ is aligned to the implementation of the Paris Agreement on climate change. The NBPE+ is fully aligned with the second Growth and Transformation Plan (GTP II, 2015-2020) and this GTP II provided the main elements of Ethiopia's INDC (presented at the United Nations Framework Convention on Climate Change's (UNFCCC) 21st Conference of Parties/COP21 in Paris, December 2015), including a clear and ambitious target of reducing Greenhouse Gas (GHG) emissions by 64% in 2030 compared to a business-as-usual scenario. Ethiopia ratified the Paris Agreement in March 2017, thereby converting its INDC to its NDC with GHG emission reduction targets for 2030. Ethiopia is one of the leading least-developed countries in the international climate change arena and key European Union (EU) ally in the Paris Agreement process.

However, references to the Paris Declaration on Climate Change and the NDCs were more limited than might have been expected in most of the key NBPE+ documents.

**Conclusion: the JC is validated**. Overall, there is evidence that the NBPE+ support was aligned to the wider global development agenda and was EU policy coherent. The evidence for this was strong for SDG7, but weaker for the Paris Agreement on Climate Change.

### 3.1.4. JC 1.4 - Degree to which the programme purpose and its objectives (outcome-level) are still valid and consistent with/supportive of the government needs.

**Indicators:**
I.1.4.1 – Is the EU action still necessary?
I.1.4.2 – Are the objectives still valid?

I.1.4.1 – Is the EU action still necessary?

The overall objective of achieving a sustainable private-sector led bio-digester market is still not achieved. It is also unlikely that these objectives will be achieved until the end of the NBPE+. This issue is further analysed in EQ7 and EQ8. The action is still necessary.

I.1.4.2 – Are the objectives still valid?

It is doubtful whether the objectives of creating a private-sector led bio-digester programme in the new regions is realistic. In these regions, without strong support from the government, the bio-digester programme will likely collapse - for example, zone and level energy experts were not established because it has not achieved a critical mass, and it is also doubtful that this critical mass can ever be achieved, see further discussion in EQ3, EQ4 and EQ6. The objectives are still valid.

**Conclusion: the JC is validated**. The programme purpose and objectives are still valid and consistent with government needs.

[25] IEA, IRENA, UNSD, World Bank, WHO. 2021. Tracking SDG 7: The Energy Progress Report. World Bank, Washington DC.

## 3.2. EQ2 - Coherence

**EQ2 - To what extent have the policy dialogue and networks established led to synergies with other development partners and has the GoE adopted and implemented policy and sector reforms that create an enabling environment for biogas development?**

Rationale: The enabling environment is key to unlocking public and private sector resources and triggering civil society initiatives for sustainable energy solutions and in this case for the establishment of a biogas sector. EQ2 evaluates to what extent EUD policy dialogue related to the establishment and implementation of the NBPE+ have resulted in increased commitment to enabling policies by decision makers, improved policy environments, and policy making capacity i.e., the capacity to review progress and make policy changes when necessary.

The Judgement Criteria examine the extent to which EU support addressed the right issues, which actually influenced Ethiopia's policies, and led to reforms creating, reinforcing and enabling the environment for the biogas sector. This has indicated the following areas for JCs:
JC 2.1 – Degree to which the EU promoted an appropriate and viable policy agenda and sound policy messages.
JC 2.2 – Degree to which there is evidence of actual commitment to and adoption of enabling policies and regulatory reforms.

Coverage: EQ2 covers only the policies that can influence positively or negatively the NBPE+.

Link with OECD/DAC evaluation criteria: EQ2 is linked to coherence (i.e. was it the right policy agenda that resonated with Ethiopian needs and priorities and thus formed the basis for effective policy dialogue); effectiveness (i.e. whether it has worked in practice - did the Ethiopia government and stakeholders take it up, did they respond and make reforms and were the reforms showing signs of working); sustainability (to what extent has the design and implementation of EU cooperation contributed to increased ownership and long-term capability of Ethiopia to sustain the development outcomes); and emerging evidence of impact (to what extent was EU cooperation designed to be pro-poor, gender sensitive, environment friendly and pro-sustainable growth, will likely achieve those goals).

Link with 3Cs: EQ2 particularly relates to coherence (i.e., to what extent are policy objectives of the NBPE+ mutually supportive of other EUD country initiatives and how well were they aligned to Ethiopian policy priorities); complementarity (with initiatives supported by EU member states); and policy coordination (with support from other development partners at country level).

Link with IL: EQ2 particularly focuses on outcomes and design for intended impact.

Note: There are important linkages between EQ1 Strategic Relevance and the present EQ2 Coherence. The strategic relevance - i.e. whether the right challenges and opportunities were addressed in EU's cooperation in Ethiopia - is closely linked to the issue of policy relevance, i.e. whether the EU focused on the right policy agenda that resonated with Ethiopian country needs and priorities and thus formed the basis for effective policy dialogue and policy effectiveness, i.e. the degree to which partners responded and made reforms and whether reforms showed signs of working; the latter issues are addressed in EQ2.

**Box 2 - Summary answer to EQ2.**

1. There is strong evidence that EU promoted via the NBPE+ an appropriate and viable policy agenda and sound policy messages in its dialogue with and support to Ethiopia.

2. There is no evidence that the NBPE+ strongly influenced the policy framework. Whether not translated into policy, the MoA has shown commitment to adopt bio-slurry as part of its

activities. The EUD could have benefited from more use of available and emerging tools for measuring the progress and success of the NBPE+ in influencing renewable energy policy and interventions.

**Conclusion**: The policy dialogue and networks established led to synergies with other development partners and promoted sound and viable policy messages, but the GoE has not adopted and implemented policy and sector reforms that create an enabling environment for biogas development.

### 3.2.1. JC 2.1 - Degree to which the EU promoted an appropriate and viable policy agenda and sound policy messages.

**Indicators:**
I.2.1.1 – Evidence that the EU biogas support addressed the key sustainable energy issues in the Ethiopian context and took account of support by other development partners.
I.2.1.2 – Policy messages were targeted at enabling improved access to modern affordable and clean energy.

I.2.1.1 – Evidence that the EU biogas support addressed the key sustainable energy issues in the Ethiopian context and took account of support by other development partners.

The GoE approved a new national development strategy (CRGE, mentioned before) that was closely observed by and discussed with DPs and was commented by bilateral partners under the coordination of Energy Sector Development Partners Forum in which the EUD also participates, thus providing evidence that the EU was aware of the initiatives and took account of support by other DPs.

The policy messages promoted by the NBPE+ emphasised social, economic and environmental dimensions of sustainability and focused on enabling private sector participation. The NBPE+ promotes **by design** investments and activities in the following areas: (i) improving the life of women and girls; (ii) productive (agricultural) use of bio-slurry; (iii) inclusive pro-poor activities; and (iv) innovative solutions in terms of organisation, financing or delivery of energy services. Thus, the EU biogas support addressed key sustainable energy issues in Ethiopia and took account of support by other development partners.

I.2.1.2 – Policy messages were targeted at enabling improved access to modern affordable and clean energy.

The NBPE+ developed and communicated policy messages aimed at enabling improved access to modern affordable clean cooking with biogas (such as the need for a national bio-digester policy, the evidence of the benefits of the use of bio-slurry for increased agricultural productivity, the need for the NBPE+ to be better recognised and embedded in the regional institutions). This was facilitated by the references in the Action Document to EU's Agenda for Change and other policy documents and guidelines that align to the goals of SE4ALL and the later SDG7.

**Conclusion: the JC is validated**. There is strong evidence that EU via the NBPE+ promoted an appropriate and viable policy agenda and sound policy messages in its dialogue with and support to Ethiopia.

### 3.2.2. JC 2.2 – Degree to which there is evidence of actual commitment to and adoption of enabling policies and regulatory reforms.

**Indicators:**

I.2.2.1 – Evidence that the key issues in the EU policy dialogue related to bio-digester dissemination are addressed in national and regional enabling policy frameworks.
I.2.2.2 – Evidence that Ethiopia has committed actions to identify, address and remove policy barriers for the biogas sector through national legislation, strategic development/investment plans, and local regulatory frameworks.
I.2.2.3 – The extent to which the policies and reforms supported/inspired by the NBPE+ and then adopted and implemented have brought about the intended results in practice.

I.2.2.1 - Evidence that the key issues in the EU policy dialogue related to bio-digester dissemination are addressed in national and regional enabling policy frameworks.

The programme gets high level oversight and guidance through the Steering Committee at the federal and regional levels, which provide multi-stakeholder platforms for coordination and oversight through endorsement of the annual plans and reports (federal level) for discussion of issues and agendas and for guidance to the programme implementation in policy and other strategic matters[26].

Key issues raised in EU policy dialogue related to the NBPE+ were not addressed in national and regional enabling policy frameworks. As found in EQ1 (I.1.1.1 and other indicators) the NBPE+ was ***designed*** so they were relevant to and aligned with key policy issues in national enabling policy frameworks. Here under EQ2, it is assessed how the EU then through policy dialogue in the context of the NBPE+ influenced the GoE to further address these key issues in national and regional policy frameworks. After ten years of NBPE I and II and 3 years of the NBPE+ there is still no national or regional policy related to the creation of a bio-digester market. Sustainable energy might not always be a local priority (road access, water, and health often tended to take priority). This underlines the importance of policy engagement at the sub-national level, particularly in a federal country like Ethiopia where regional governments have an important role in sustainable energy development, but where development partners' policy dialogue has often focused on the federal level. Nevertheless, there is an enabling environment, the GoE and most regional governments are very positive about the importance of the programme for its development agenda.

I.2.2.2 – Evidence that Ethiopia has committed actions to identify, address and remove policy barriers for the biogas sector through national legislation, strategic development/investment plans and local regulatory frameworks.

The efforts from the NBPE+ to have a policy dialogue mechanism and policy framework for in place, to provide policy guidance and linkage to the programme and raise issues to national policy related to the biogas sector, were at the end of the third year of the programme still not successful[27].

There is, so far, weak evidence that policies and reforms supported by the EU via the NBPE+ have brought the intended results in practice. As noted above, there is not much information on the level of commitment to policies and reforms promoted by the EU, but there is even less evidence on the extent to which policy and reforms promoted by the EU have had the intended results. Out of the four target areas for SDG7 (access, efficiency, renewables, international cooperation), access to clean cooking is the most often overlooked by policy makers. In the latest edition of the World Bank's Regulatory Indicators for Sustainable Energy index, policy frameworks for SDG7.1.2 – universal access to clean fuels and technologies for cooking by 2030 – were evaluated. Ethiopia is one of the top 20 countries with access-deficit for clean cooking (2015 –19 average). The sustainability of the NBPE+ activities could be enhanced when not only capacity issues but also enabling policy issues were the focus of the GoE enhancing the already existing conducive policy environment.

I.2.2.3 - The extent to which the policies and reforms supported/inspired by the NBPE+ and then adopted and implemented have brought about the intended results in practice.

26 Final NBPE+ Description of the Action, January 15, 2016.
27 Interim Narrative Report Year 3 - Period: April 12, 2019 to April 11, 2020. SNV.

The NBPE+ via SNV influenced the government's position on bio-slurry mainstreaming, so that Ethiopia gives due attention for promoting organic fertilisers to transform its agriculture. The MoA was brought on-board of the National Biogas Programme Steering Committee about 4 years ago. In its capacity as the technical assistance provider during NBPE II, SNV developed the bio-slurry promotion and mainstreaming modality involving stakeholders and shared cases on the uses and benefits of bio-slurry. This effort has significantly contributed to awareness raising on bio-slurry as high value organic fertiliser in the agriculture sector. Recognising the importance of bio-slurry as organic fertiliser, the State Minister of MoA, issued a letter (in Aramaic, March 2017) acknowledging the efforts made by SNV and urged the four former biogas programme regional bureaus of agriculture and natural resources to promote bio-slurry as an organic fertiliser for improved soil fertility management[28]. However, the implementation lacks budget and capacitated staff, due to the high turnover. There are not many policies that have been adopted or influenced by the NBPE+, except the inclusion of bio-digester targets in the GTP I and II.

The EUD could have (or via the NBPE+) used concrete tools to monitor the outcomes of the policy dialogue, such as the SE4ALL tool the Global Tracking Framework[29]. This would be a way for the EUD to confidently and critically analyse progress and take up controversial issues with actors at country level.

**Conclusion: the JC is not validated**. There is no evidence that the NBPE+ strongly influenced the policy framework. While not translated into policy the MoA has shown commitment to adopt bio-slurry as part of its activities. The EUD could have benefited from more use of available and emerging tools for measuring the progress and success of the NBPE+ in influencing renewable energy policy and interventions.

[28] Interim Narrative Report Year1 - Period: April 12, 2017 to April 11, 2018. SNV.

[29] IEA, IRENA, UNSD, WB, WHO. 2021. Tracking SDG 7: The Energy Progress Report. World Bank, Washington DC.

## 3.3. EQ3 - Effectiveness

**EQ3 - To what extent are the objectives being met? Or in other words is the NBPE+ doing the right things, and what is not doing that should be done or not enough?**

Rationale: This question includes a review of the determining factors/key actions that influence the achievement (or non-achievement) at local, regional and national level (but also at policy, institutional and financial level) against set targets and commitments. When doing so, a key element will be to assess the roles, skills and incentive structures of key stakeholders at all government levels, technical assistance and financing organisations as well as their ability to coordinate and complement each other.
This question addresses also the choices made for programme implementation: are they the right things to do, are they enough or what should be done to achieve the objectives of the programme.

This has led to the following JCs:
JC 3.1 - Have the programme choices made during design and implementation (including whether the technical cooperation approach is well selected and managed) been such that they lead in an effective way to the achievements of the results and outputs?
JC 3.2 - Degree to which the technical Assistance (TA) provided by SNV has followed EU strategy for capacity development.
JC 3.3 - Have the results/outputs that have been formulated at the beginning of the programme been achieved?
JC 3.4 - Degree to which EU technical assistance has led to an increased capacity in key selected partner institutions.
JC 3.5 - Degree to which TA has supported the mainstreaming of cross-cutting concerns.

Note: During the field phase of the technical evaluation it was found that the original JC 3.3 was too narrowly defined and that a more overarching judgement was missing, because it is not only the technical cooperation approach that is relevant for the effectiveness of the programme, but also whether the right choices been made during programme design and implementation. It has now been included here, as the first judgement criteria JC 3.1, as it sets in fact the context for the other JCs.

Link with OECD/DAC evaluation criteria: The EQ addresses aspects of relevance (there is need for it, is demand-led and contributes to programmatic and country objectives); effectiveness (what is the evidence that results are being achieved); efficiency (is the kind of TA adequate); outcome (the degree to which the TA is enabling reforms and contributes to reduce barriers to sustainable energy and energy access).

Link with 3Cs: The EQ is also linked to coherence among the EU interventions and also with coordination and complementarity as there are many funds and similar instruments being supported by other donors.

Link with the European Consensus on Development of cross-cutting issues (Article 101): The EQ is also linked with one of the ToR demands, namely on gender issues, and in steering policy reforms and project implementation towards incorporation of environmental considerations and a pro-poor design.

Link with IL: The EQ focuses on the logical links related to how TA provided to train and capacitate staff and institutions, leads to improved sector institutional performance and good governance, and either directly or indirectly to public and/or private investments (outputs) and to the sustainable and access energy goals (outcomes).

**Box 3 - Summary answer to EQ3.**

1. The programme has not done the right choices by paying for the programmatic support to the new regions. The institutional organisation of the NBPE+ is the one possible with the kind of technology used, but no alternative ideas have been sufficiently examined. The choice of the implementation through a PPP is the right one, but no true PPP exists. The bio-digester promotion might be well designed but there are indications that the promotion at the user level is not what should be done (weak evidence). The technology choice for the "brick-and-mortar" model is made on "automatic pilot" and alternatives have not been sufficiently considered. The quality of the evidence is strong.

2. The TA activities clearly followed the EU strategy for capacity development, i.e., responded to the needs, were partner owned, were results oriented and partly achieved those results. The results were partly achieved because of the incapacity of the new regions to deliver the proposed results and because of the effects of COVID-19 pandemic for most of 2020. The quality of the evidence is strong.

3. The objectives have not (yet) been achieved. Partly because of programme choices, partly because of external factors, and partly because the quality of what is being delivered may jeopardise the outcomes of the programme. The quality of the evidence is strong.

4. The TA has strengthened the enabling environment at sector level and the EU support has strengthened the skills of core personnel and where relevant the structure and functional organisation of the key partner institutions. The sustainability of the TA interventions due to the high turnover of government staff may not be achieved. There are also serious concerns about the quality of some of the outputs delivered. Private sector participation is a high priority of the NBPE+, but here also there no guaranty of sustainability. The quality of the evidence is more than satisfactory.

5. The TA showed that they take gender and environmental issues seriously in consideration, during the design and the implementation, although, in the case of gender, there is little success. The TA has not contributed to steering policy reforms / project implementation towards a pro-poor purpose. The quality of the evidence was more than satisfactory.

**Conclusion**: The objectives are not being fully met, partly because of the regional choices for implementation, partly because of the kind of technology used. There is weak evidence that external factors may have influenced negatively the performance of the programme. The TA clearly follows the EU strategy for capacity development, but there are serious concerns about the sustainability of these efforts. There are as well serious issues with the quality of some outputs being delivered. Even though crosscutting issues are taken very seriously by the programme, there is little progress in gender mainstreaming and a biogas programme is not the right pro-poor approach and not effective to pursue.

### 3.3.1. JC 3.1 – Have the programme choices made during design and implementation (including whether the technical cooperation approach is well managed and selected) been such that they lead in an effective way to the achievements of the results and outputs?

**Indicators:**

I.3.1.1 – Is the choice of the new regions effective to achieve NBPE+ outcomes?
I.3.1.2 – Is the institutional organisation of the NBPE+ a benefit or a hindrance for achieving the objectives of the programme?
I.3.1.3 – Is the choice for the implementation through a PPP what is really happening in practice?
I.3.1.4 – Is the bio-digester promotion addressing the right issues?

I.3.1.5 – Is the technical choice for a "brick-and-mortar" model the right choice? Are there alternatives?

I.3.1.1 – Is the choice of the new regions effective to achieve NBPE+ outcomes?

**The choice of the new regions is, from the point of view of geographic inclusion,** understandable and from the principle of equity and also of "leave no one behind". The question here is being the programme resources limited and not infinite is it an effective choice? The answer is no.

More than equity or leave no one behind, this is a political decision that from the perspective of programme effectiveness and efficiency (this will be analysed in more detail in EQ4) is not justifiable as all objectives of the NBPE+ could be met at much lower cost by concentrating in the formerly existing regions. One simply has to consider the potential for bio-digesters in the new regions to see that this choice is not sensible.

The estimation of the total amount in Ethiopia of households with cattle is 14 million. The total amount of households (excluding cities) with 4 or more heads of cattle is 5.95 million. When taking into account water availability, in the minimum case, only 22.9% of the households with more than 4 heads of cattle would be eligible to install a bio-digester. In the case of maximum water availability this would be 68.2%.

**Table 14 – Technical potential for bio-digester dissemination in Ethiopia[30].**

| Region | Total households with 4 and above heads of cattle | Technical Potential (Discounted depending on water availability) | | Existing Regions |
|---|---|---|---|---|
| | | Minimum (Rural access to safe water=23%) | Maximum (National water coverage = 68.45%) | |
| Afar | 65,792 | 15,132 | 45,034 | |
| Amhara | 1,663,170 | 382,529 | 1,138,440 | 1,138,440 |
| Benishangul-Gumuz | 53,530 | 12,312 | 36,641 | |
| Gambella | 16,842 | 3,874 | 11,528 | |
| Oromia | 2,467,361 | 567,493 | 1,688,908 | 1,688,908 |
| SNNP | 1,164,894 | 267,926 | 797,370 | 797,370 |
| Somali | 58,357 | 13,422 | 39,945 | |
| Tigray | 436,231 | 100,333 | 298,600 | 298,600 |
| Ethiopia | 5,948,567 | 1,363,020 | 4,056,467 | 3,923,318 |

The table above shows that the technical potential for bio-digester dissemination **for the new regions is only 3.28%** of the total national technical potential (maximum scenario). How is it justifiable, that these programme regions absorb a large amount of programme budget as compared to the existing regions? We consider that this is a misapplication of resources (more in EQ4).

Furthermore, this decision of the GoE has never been consensual. As soon as NBPE+ started implementation, a question was raised at the federal level by the MoF on the feasibility and practicality of the programme in the new regions[31]. The extension was also not consensual at programme level. SNV has called the attention to the low bio-digester potential of the new regions and the consequent dilution of programme resources. The programme management (at the time HIVOS) was not in agreement either. A quotation from a WB report[32]:

**"Conflicting aims of lead implementer**: During the course of programme implementation, the ABPP and the MoWIE discovered they had different aims and approaches. Whereas the ABPP

30 Technical potential for bio-digesters. SNV, June 2017.

31 Annual Operational Plan and Budget for Year 3 – Period 12 April, 2019 to 11 April, 2020. SNV

32 The power of dung - Lessons learned from on-farm bio-digester programs in Africa. ESMAP, WB, 2019 (page 52).

prefers a market-based approach, selecting those regions and households with the highest potential for biogas (i.e., "low-hanging fruits," or households with access to credit/those that can afford a bio-digester), the government prefers a poverty reduction and equity approach. Therefore a compromise had to be sought for the geographical focus of the program. The ABPP wanted to focus activities on a smaller number of Woredas, while the government wanted to increase the geographical focus to enable all rural households to benefit from biogas. However, funds, infrastructure, and resources remained the same. This turned into a large challenge for effective and efficient programme implementation."

From the point of view of the GoE and to keep geographic cohesion and the equity principle, the GoE cannot exclude these regions from participating in the programme. But this is a political decision and from a programmatic point of view, not an effective use of resources. If the GoE wants to continue to support these regions, then all programme costs should be provided by the national and regional governments. The RBF and subsidies to bio-digesters to be equitable should come from the NBPE+ programme likewise the continuation of technical assistance from SNV.

I.3.1.2 - Is the institutional organisation of the NBPE+ **a benefit or a hindrance** for achieving the objectives of the programme?

The organisation of the NBPE+ (and of the former phases of the NBPE) is very complex due to several factors:

- The several layers of administrative divisions in Ethiopia (Federal, Regional, Zone, Woreda), which naturally follows from the huge size of the country. This means that the structure of programme functions is replicated at almost all levels. The question is whether the choices to have all functions at all levels are efficient (to be answered in EQ4). This large organisational set-up is a consequence of the type of technology used but does not necessarily need to be so.
- Due to the nature of the technology, a large involvement of the public institutions is needed. The question is, does it need to be so? The answer is no, and there are regions (like Amhara) that are already trying to simplify the institutional set-up.

In the Grant Agreement, of which the Description of the Action[33] is the final document, along with the budget, the basic idea was to replicate the structure of the existing/larger regions, to the new regions. However, an **option was mentioned**, in case there was a need due to potential and unreasonable demands from the new regions. With all the effort and time spent in repeated discussions, it ultimately went the usual way, which is working with the regional government institutional structures. The alternative option would have been engaging Non-Governmental Organisations (NGOs), etc. This alternative might not have been feasible and would pose doubts on national ownership and sustainability. However, one cannot say that this option has been seriously considered. The Alternative Implementation Partners (AIP) idea that is mentioned in several documents, such as the EUD Description of the Action, has been in the meanwhile dropped and is nowhere to be found and no one has given a reasonable explanation for this.

So, the answer to this indicator is a difficult one, it cannot be said that the institutional set-up is a hindrance, but certainly measures need to be taken to streamline the flows of money, knowledge and control.

I.3.1.3 - Is the choice for the implementation through a PPP what is really happening in practice?

NBPE+ is designed and being implemented as a PPP where actors from the public sector, mainly ministries and regional agencies work in partnership with the private sector. However, a close analysis of the real situation on the ground shows that the **P** from Public is huge and that the **P** from Private is very small and that there is no **P**artnership, because a partnership can only develop

[33] Final NBPE+ Description of the Action, January 15, 2016.

between equals which is not the case with the private sector, still completely dependent on the government for orders and for payments.

The creation of a private bio-digester market has been, from the very beginning of the NBPE, an objective and it is there already for more than 10 years. However, we still find in recent documents of the NBPE+ the sentence "**As the development of the private sector is at infant stage**"[34]. There are very few regions (where Amhara is the strongest example) where there are some signs of bio-digester private sector development, yet there is the question whether these efforts will be sustainable with all limitations inherent to the bio-digester market. The analysis of the private sector involvement will be developed in EQ6.

### I.3.1.4 - Is the bio-digester promotion addressing the right issues?

During the field visits, it has been surprising to find that some biogas' users at the least problem that causes the bio-digester to malfunction or stop functioning, kind of accept it as a fate. Many of the problems where very simply to be solved but the farmers did not dare to take action and/or did not call the Woreda officer or the Customer Service Centre (it is true that most of them did not have any of these phone numbers, either because they never had or because they lost them, this issue will be dealt in EQ5).

If biogas users show so little interest in the functioning of the bio-digesters, it can be a sign that they don't perceive the benefits of the technology and/or that these benefits have not been correctly explained to them, and that is an issue of the promotion strategy used and/or the inability of masons and Woreda officials to correctly and truthfully explain the benefits of the technology.

This issue will be more thoroughly dealt with in EQ5, JC 5.6. However, here some of the points of concern related to the way the bio-digester technology is being promoted are given:

- The biogas lamp is part of the promotion of the bio-digesters and many users appreciate the benefits of having light, even if they have been connected to the national grid as the grid often is unavailable. However, the biogas lamp is and has been, in all countries where the bio-digester technology is being promoted, a serious weak point of the benefits of the technology. The mantle of the lamp breaks easily, it cannot be bought on the local market and is often unavailable at Woreda level. During field visits, many of these lamps were not functioning (see Chapter 2).
- It cannot be generalised to the whole country, but in many Zones (like in Amhara, Gambella and some Zones in Oromia and SNNP) wood availability is not a problem, wood is grown sustainably and is all around homes, therefore available with little effort. This means that the promotional aspect that biogas saves time in the collection of wood is no longer true, in this case it might even increase the burden on the household (the women) in the collection of water for the bio-digester. Also, the avoided GHG emissions in this case are reduced which has implications for the amount of carbon credits to be obtained. Anyhow, all the other benefits of the technology still remain.
- That the Injera stove cannot be used with bio-digesters smaller[35] than 8 $m^3$ might not be correctly explained to the users and this can lead to frustration with the technology and therefore people being more prone to abandon it at the least problem.
- The quantity of land that can be fertilised using bio-slurry might not be clear to the users, creating too large expectations.

An answer to this indicator cannot be given with absolute certainty, the promotion materials are correct, but it all depends on how the promotion is done.

I.3.1.5 - Is the **technical choice** for a "brick-and-mortar" model the right choice?

[34] Interim Narrative Report Year 3 (Period: April 12, 2019 to April 11, 2020). SNV, July 2020.

[35] The majority of the bio-digesters installed are smaller than 8 $m^3$, but this is not a choice of the NBPE+ the size of the bio-digester is limited by the amount of dung available and by the amount of energy needed for cooking.

The "brick-and mortar" technology has been there for a long time, proved to be reliable and has a long lifetime of at least 20 years (when correctly and skilfully constructed). When the NBPE started back in 2009 there were very few alternatives to this model (certainly there were other models already developed but none of them had as many advantages as the "brick-and-mortar" model). However, at the beginning of the NBPE+ there were already serious alternatives on the market, but understandably the programme chose to continue to what they already knew. The situation changed dramatically and now there are other models on the market that are sold by thousands, proved reliable, and claim to produce more biogas (which can only be explained by having less leakage). The situation in Kenya is an example with a number of companies having slightly different models (but all based on the plastic bag concept or pressure moulded plastic).

The advantages are:

- The companies installing these models only rely on their own skilled workers, so no need for training as these companies train their own people.
- Some companies are offering a 10-year warranty on their product so no need for Quality Control, such a company doesn't want to lose the costumer and doesn't want to get the bad publicity of the bio-digester not working. The quality control is done "off-factory" like any other commercial product, such as a television. Their skilled in-house labourers guaranty the quality of the installation.
- Some of these companies are offering their own line of credit in a kind of "pay-as-you-go" system, is doubtful however that they would offer the same service in Ethiopia.
- They have their own customer service centre to accommodate their customers' needs and complaints.
- These installations could be the solution for the problems encountered by the "brick-and-mortar" technology with the so-called "black cotton soil", as they only require little digging (which also has the advantage that they require less effort from the users to excavate the pit).
- In case the installation has been bought with access to a credit line, the installation can almost totally be repossessed. So, in this case the need for collateral would be less.
- A team of two people can install 2 bio-digesters per day.

Some disadvantages are:

- This technology provides much less local employment. However, the cost of the employment provided by the "brick-and-mortar" model is huge and one can argue if this is the most effective way of creating employment.
- A larger percentage of the technology will have to be imported, at least so long the market for this technology has not gained enough momentum.
- Some of these new bio-digesters are more expensive to build than the "brick-and-mortar" alternative. However, when one looks at the total programme costs to install a "brick-and-mortar" model, the new technologies are by far much cheaper.
- The promotion of the technology in a country like Ethiopia, where farmers have no access to mass media, might still be dependent from local government structures, which makes it difficult if the "brick-and-mortar" model would continue to be promoted by the NBPE+, as it most likely will.
- These bio-digesters are imported so there is the problem of the availability of sufficient FOREX. Some of these companies are large enough to import the bio-digesters with their own capital, but they would require that FOREX is available to export the revenues to pay them back.

In case these models are accepted by the NBPE+ (SNV is already in contact and testing some of these models, which one can understand, but SNV should look much more to the overwhelming positive experience with some of these models that are being marketed elsewhere), these new models should have the same benefits as the "brick-and-mortar" technology, i.e., RBF incentives (adapted to the way it is promoted) and subsidy (it is questionable whether the GoE would be willing to provide its part of the subsidy, but if this would be the case it would be based on a misconception

because the subsidy is not to increase the profit of those companies but as is the case with the existing models to lower the costs to the user).

Another key issue in this case would be to allow that these new technologies would have the same tax benefits (such as a waiver on import taxes) as those foreseen in the policy and legislation for other renewable energy technologies such as solar lamps and PV systems.

The consequences for the programme structure of these new technologies are huge and change completely roles and responsibilities. Before this is analysed, a simple question: does the GoE or regional governments go to peoples' houses to control whether a television they bought is working properly? Evidently not. What would then be the roles of the existing NBPE+ actors in a new set-up with this kind of new technologies:

- **NBPCU**: Assuring that the GoE provides the tax benefits for these imported renewable energy technologies, further no substantial role. The flow of funds for RBF and subsidies could in principle be provided at national level directly to the companies installing the new bio-digesters, based on a monthly invoice, with a-posteriori control at Woreda level. The system of setting targets per region does not apply here, a private company goes where the market is and the government has no role in telling them how many systems they should build, **this would be a truly private sector bio-digester market**.
- **RBPCU**: no role whatsoever. No target setting per region for these technologies.
- **Zone**: limited to a functionality check on a random sample percentage of the installed new technologies immediately after they start functioning, one year and 5 years after installation, this to guarantee that the subsidy is correctly used and to protect the users. To discourage misbehaviour of these private companies, a penalty system could be introduced that would force the companies to give back the subsidy on the same percentage of the installations found non-functioning.
- **Woreda**: based on the existing RBF the Woreda officials would spot potential users. Here obviously a conflict of interest will exist in choosing the technology, but, as it is already being used in some regions, a tender procedure could be used in case a cluster approach is followed. There is no need to quality control either during construction or after installation is completed. This would obviously result in resistance because of losing their RBF for these activities.
- **SNV**: there is no need for technical assistance or mason training or Bio-digester Construction Enterprise (BCE) capacity development and business skills training, among others. The need for promotion material and strategies is still there and the promotion and technical assistance and training for the use of bio-slurry would still be relevant. Subsidies and RBF would go directly to the private company, in order to lower the selling price of the technology.
- **Masons and BCEs**: out of business with these new systems, could seek employment with the new companies.

In EQ4 an analysis of the programme costs will be made, in this case it would be possible to assess how much the programme savings would be.

The answer to this judgement criterion is that the programme is not doing the right things when it comes to the choice of the technology, or is being too slow in introducing new technologies.

**Conclusion: the JC is not validated**. The programme has not done the right choices by paying for the programmatic support to the new regions. The institutional organisation of the NBPE+ is the one possible with the kind of technology used, but no alternative ideas have been sufficiently examined. The choice of the implementation through a PPP is the right one, but no true PPP exists. The bio-digester promotion might be well designed, but there are indications that the promotion at the user level is not what should be done (more than satisfactory evidence). The technology choice for the "brick-and-mortar" model is made on "automatic pilot" and alternatives have not been sufficiently considered.

### 3.3.2. JC 3.2 – Degree to which TA provided by SNV has followed EU strategy for capacity development[36]

**Indicators:**
I.3.2.1 – Evidence that the type of TA was adequate for addressing the identified need.
I.3.2.2 – Is the organisational setup of the NBPE+ appropriate, where can improvements be achieved?
I.3.2.3 – Evidence that the TA was well managed at all stages from response to demand of ToR, delivery of support, reporting and monitoring.
I.3.2.4 – Is the NBPE+ embarking on the correct activities and in line with the Programme Implementation Document?
I.3.2.5 – Was the work schedule set out at the beginning of the programme realistic?

The EU has developed a number of strategic principles to guide capacity development of partners and institutions. This JC will assess whether these guidelines and principles (technical cooperation that is demand-led, partner owned and results orientated and clearly directed towards one of 4 main purposes i.e., policy and expert advice; project preparation; project implementation; capacity development) have been followed in the design and implementation of capacity development efforts.

I.3.2.1 – Evidence that the type of TA was adequate for addressing the identified need.

Under NBPE+, SNV is responsible for the overall programme management, including the fund management and for the technical assistance, which includes some direct implementation of the activities like studies, piloting innovations, and standardisation, etc. together with MoWIE and others.

The many activities developed during programme implementation follow the most usual path for developing a bio-digester private market: awareness creation, promotion, demonstration of the technology, partners' training, removing financial barriers either by providing subsidies to the user or by facilitating access to user finance, quality control and monitoring, etc. These activities were adequate for the identified needs and have been discussed and approved by the Steering Committee of the programme.

I.3.2.2 – Is the organisational setup of the NBPE+ appropriate, where can improvements be achieved?

As discussed under JC 3.1, the organisational set-up of the NBPE+ is appropriate taking into consideration the technology being promoted and the federal structure of the country, although there was often no Zone or Woreda level energy organisational set-up in the new regions. The possibility to engage other implementing partners (AIPs idea mentioned in the Action Document) than the GoE structures has not been sufficiently explored when extending the programme to the new regions, in this case a typical "business-as-usual" approach has been followed. AIPs are institutions such as NGOs which are capable of taking up large part of the programme responsibilities in a short period of time, but for temporary period through a RBF modality. A report mentions[37]: "*There are no AIPs found in any of regions as per the programme definition for AIP. However, there are non-governmental organisations, cooperatives, unions, and Community Service Organisations who are making a contribution to the dissemination of bio-digester technology. The participation of these institutions is limited and not continuous in most cases. The main reasons mentioned by respondents are lack of capacity and failure to clearly state the roles of these actors. This has left RBPCUs and Woreda as the only public sector implementing partners for the programme at the regional and local levels*." However, it is questionable if the proposed new structure would be feasible and accepted by the GoE.

[36] Analysis is based on the guiding principles of the "Reforming Technical Cooperation and Project Implementation Units for External Aid provided by the European Commission - A Backbone Strategy - July 2008".
[37] NBPE+ Programme Baseline Study. Report by Sak Business and Personal Development PLC. May 2018.

I.3.2.3 – Evidence that the TA was well managed at all stages from response to demand of ToR, delivery of support, reporting and monitoring.

SNV has extensive experience in managing biogas programmes and has a core team of experienced bio-digester experts with a clear management structure and commitment to the job. The activities described in all annual reports are the correct ones to be implemented and the programme has shown large flexibility to respond to challenges. For example, an alternative way of contacting people and keeping people motivated has been the increased use of social media, which has reached a large audience among the programme and government staff and local organisations.

SNV has developed a large number of documents to guide the programme implementation, such as frameworks, manuals, guidelines, tools, and strategies. For example the Private Sector Development Framework (2016)[38], and a supplement[39] to that document under NBPE+, Implementation Partners Guidelines[40], bio-slurry promotion and mainstreaming guidelines, guidelines/manuals for training, promotion, after-sale service, etc.

The quality control of the bio-digesters has not been as it was foreseen in the first 2 years of the programme, and has suffered some drawbacks in 2020, due to the COVID-19 pandemic. Nonetheless, in the third year of implementation a total of 6,224 (82 % of the planned target) of the bio-digesters installed in year 1 and 2 were visited for the purpose of quality monitoring by RBPCUs, SNV and NBPCU. In this regard, 100 % quality check by Woredas happened. However, there have been limitations to cover the 10 % quality check by RBPCU and 5 % by SNV/NBPCU[41]. As functionality of bio-digesters is at the heart of the programme, a lot of efforts and initiatives were exercised in year three.

After-Sales Service (AfSS) is also not operating as it should, and this was also evident from the observations of the field missions. This is also recognised by the programme management[42]: "*Though providing AfSS has paramount importance to improve functionality rate, the activity is not well practiced by RBPCUs. In the reporting period, AfSS was provided only for 260 (Tigray – 240 and Oromia – 20) bio-digesters. The AfSS was provided by respective masons and payment is released for the guarantee period. This is a very poor AfSS record that needs immediate action in the upcoming year*."

I.3.2.4 - Is the NBPE+ embarking on the correct activities and in line with the Programme Implementation Document?

SNV is following the outcomes, outputs and activities indicated in the Action Document and reporting annually on the achievements of the programme. It promoted the cooperation and **linkage** with community based organisations such as micro finance institutions, cooperatives, local government bodies, development partners and private sectors. These included:

- Networking and partnership created with MoA, BoA, research institutes and universities (Mekele, Hawassa etc.) on bio-slurry and bio-slurry extension.
- NBPE+ has addressed the private sector needs and weaknesses by providing of business development services to strengthen business management skills, proper book-keeping, develop business plans, sharing of experiences and scaling up the good practices of successful companies, developing the appliance and spare parts supply chain, and linking of private sector

38 National Framework for Private Sector Development under Public-Private Partnership (PPP) in Ethiopian Biogas Sector. Approved by NBP-SC. NBPEII, January 2016.

39 Biogas Dissemination Scale-Up Programme (NBPE+) - Strategy for Private Sector Development (Supplementary Plan), SNV, no date.

40 Implementation Partner Guidelines. SNV, December 2018.

41 Interim Narrative Report Year 3 - Period: April 12, 2019 to April 11, 2020. SNV.

42 Interim Narrative Report Year 3 - Period: April 12, 2019 to April 11, 2020. SNV (page 15).

support with on-going programs such as Entrepreneurship Development Centre, regional rural job creation and micro and small enterprise development agencies.
- Cooperation and linkage created with development partners like GIZ, and other projects implemented under SNV.
- SNV has started to pilot a cluster/market hub approach in promotion of bio-digesters through the engagement of cooperatives.

Awareness creation events on promoting the bio-digester technology and of bio-slurry use among partners and rural community through construction of demonstration bio-digesters, arranging awareness raising campaigns and experience sharing visits were planned to be undertaken.

Trainings on installation of bio-digester to selected local masons and supervisors on the new design SINIDU 2008 (new cost-effective design), for ensuring quality from the beginning and achieving the targets. However, trained masons, new and experienced ones, are either leaving the programme and their villages to move to urban centres for better wages and better life or are sticking to agriculture and/or other rural activities in their own villages. There are (in 2020) around 137 registered BCEs in the business, with 274 masons, including 17 females. Additional 482 individual masons are in business. However, the total trained masons since 2009 is 2,784, which gives a very low mason retention rate of 27% (cumulative)[43].

Another activity is the promotion of increased access to credit through capacity development and partnership strengthening of MFIs. The programme is also trying to improve gender balance by developing guidelines and providing training to institutions and increase pro-poor orientation by developing a smaller bio-digester.

I.3.2.5 - Was the work schedule set out at the beginning of the programme realistic?

The work schedule (as translated in the number of bio-digesters to be installed, as this number directly influences the number and intensity of all other programme activities) set out at the beginning of the programme was realistic for the previous existing regions, but not realistic for the new regions: (i) the potential for bio-digester dissemination in the new regions is much more limited as discussed under I.3.1.1, and (ii) even though the programme as a whole had many years of experience in Ethiopia, to replicate the structures and to train government staff and masons in sufficient quantity has not been realistically forecasted. The lack of capacity of partners in the new regions to absorb the training and to implement activities (due to budget limitations, lack of staff, lack of sufficiently qualified staff, lack of transport, etc.) was also not properly considered.

**Conclusion: the JC is validated.** The TA activities clearly followed the EU strategy for capacity development, i.e., responded to the needs, were partner owned, were results oriented and partly achieved those results. The results were partly achieved because of the incapacity of the new regions to deliver the proposed results and because of the effects of COVID-19 pandemic for most of 2020. The quality of the evidence is strong.

### 3.3.3. JC 3.3 – Have the results/outputs that have been formulated at the beginning of the programme been achieved?

**Indicators:**
I.3.3.1 – To what extent have external conditions been an obstacle for implementation of the programme and how has the programme management been able to address these?
I.3.3.2 – What is the quality of the results/outputs?
I.3.3.3 – What were the major factors influencing the achievement or non-achievement of the objectives?

[43] SNV Presentation on Bio-digester Technology & the Programme. April 2021.

I.3.3.1 – To what extent have external conditions been an obstacle for implementation of the programme and how has the programme management been able to address these?

The programme may have been impacted in its activities by the emergence of the COVID-19 pandemic. Comparing the bio-digester construction figures between 2019 and 2020 and only for Q2 to Q4 (when the impact of the pandemic was the strongest), in the previous existing regions Oromia actually had more construction and Amhara had a decline of 28%. The decrease in bio-digester construction was the largest in the SNNP region and in Tigray, but at least in the last region this was due to insecurity and the war situation. In the new regions and for the same period is difficult to have any firm conclusions, because one deals with very small numbers, but actually the bio-digester construction increased by more than 50%, except for Beninshangul/Gumuz where the decline in bio-digester construction was dramatic (security issues?). The fact that the evaluation field mission had sometimes to change the sample due to security reasons is also an indication of the external factors that may have influenced the NBPE+ performance (weak evidence).

Another external factor that may have impacted the results is the (un)availability of cement which has affected the construction of bio-digesters for the past year.

Both COVID-19 and security are aspects that the programme management tried to cope with, by for example intensifying communication with stakeholders, but there is little else what could be reasonably done. Implementation of monitoring and secondary quality control work by the NBPCU and SNV has also been more difficult (they have to undertake at regional level a 5% quality control of the installations and conduct monitoring of the activities and outputs and fund flow at Regional, Zone and Woreda level).

I.3.3.2 - What is the quality of the results/outputs?

The main result of the programme is the bio-digester installation. The field missions, data from the Customer Support Centre (CSC), data from the Biogas Users' Surveys (BUS), the NBPE+ baseline survey and some independent studies[44] show with varying percentages that the functionality rate is quite low. Even if one takes the highest estimations, the functionality rate is dismally low. This affects negatively the reputation of the programme and is a disincentive for new users to invest in the technology, besides making it almost impossible to set-up any credible financing arrangement for the user.

Trainings have been provided to masons, but from observations one can also see that while the training itself might be good, the low retention rate means that constantly un-experienced masons are entering the programme and constructing bio-digesters, with the ensuing proven poor performance. These trained masons get some experience in constructing bio-digesters but soon find better paid opportunities in the building construction sector. That these poor constructed bio-digesters get approved by the quality control checks done by Woreda staff, also signifies that their training is not functioning properly.

The programme has developed and distributed high quality promotional materials such as posters and leaflets to bio-digester construction enterprises and masons as well as to local partners such as Woreda staff. The promotional messages highlight the benefits of bio-digesters and that they should be selected in such a way that could address users' priorities and perspectives. However, the field missions indicate that in many cases both the energy needs assessment as the assessment of the number of animals available is not properly done, which often leads to underperformance of the bio-digester and/or to their abandonment because they don't meet the aspirations of the user, which partly are caused by the wrong promotion messages passed to them.

[44] Biogas Plant Distribution for Rural Household Sustainable Energy Supply in Africa. Tewelde Gebre Berhe, Rahwa Gebre Tesfahuney, Grmanesh Abreha Desta & Lemlem Semungus Mekonnen (2017). Energy and Policy Research, 4:1, 10-20, DOI: 10.1080/23815639.2017.1280432

The quality of the bio-slurry promotion is good, but still not sufficient to inform the users. The AfSS is either not being provided as the field missions found or not being done properly: complaints about non-functionality are often not being addressed with sufficient attention, users often have no idea of the function of the water drain and sometimes even do not know where it is located, slurry pits are almost never covered and users have no idea that this should be done and of the benefits in terms of higher fertiliser quality of doing that, toilets are not being used and apparently little is done to inform users of the benefits of using them.

All the above aspects are more extensively discussed and analysed in EQ5.

I.3.3.3 – What were the major factors influencing the achievement or non-achievement of the objectives?

As mentioned elsewhere the *by design* not so realistic numbers of bio-digesters to be constructed in the new regions. High turn-over of government staff at all levels of programme implementation, leading to training to be constantly provided and to new people with no experience at all entering the biogas sector. Another reason is the lack of appetite of construction companies to deliver services in the biogas sector, with few exceptions in a number of regions (Amhara, Oromia). The high rate of abandonment of the programme by masons, leading to a waste of resources, because new masons must be constantly trained and therefore are not sufficiently skilled in the bio-digester construction.

**Conclusion: the JC is not validated.** The objectives have not (yet) been achieved. Partly because of programme choices, partly because of external factors, and partly because the quality of what is being delivered may jeopardise the outcomes of the programme.

### 3.3.4. JC 3.4 - Degree to which EU technical assistance has led to an increased capacity in key selected partner institutions

**Indicators:**
I.3.4.1 – Evidence that the EU support has strengthened the enabling environment at sector level for key partner institutions.
I.3.4.2 – Evidence that the EU support has strengthened the skills of core personnel and where relevant the structure and functional organisation of the key partner institutions.
I.3.4.3 – Evidence that the TA has contributed to longer term sustainability of the institutions and activities that they carry out.

The development of capacity at key selected partner institutions is a crucial part of EU support This criterion looks at whether capacity has been built at the sector enabling environment and at the institutional level (in terms of systems, functional structures) and individual level (skills) and, whether as a result the institutions are more able to sustain their activities and the projects they are engaged with.

I.3.4.1 – Evidence that the EU support has strengthened the enabling environment at sector level for key partner institutions.

The TA through SNV has provided training at all levels of government from the federal to regional, zone and Woreda levels. MoWIE/NBPCU and 8 Regions/RBPCU have a total of 111 trained programme staff[45], also Zones/Woredas/Kebeles are engaged through the Partner Engagement Guidelines and also trained.

45 SNV Presentation on Bio-digester Technology & the Programme. April 2021.

The EU technical assistance has strengthened the enabling environment at sector level for key partner institutions.

I.3.4.2 – Evidence that the EU support has strengthened the skills of core personnel and where relevant the structure and functional organisation of the key partner institutions.

The NBPE+ has strengthened the skills of core personnel, a large quantity of training and workshops has been implemented to reinforce the knowledge and skills about the several aspects of the biogas sector, such as, promotion, bio-digester construction, AfSS, quality control, bio-slurry utilisation, credit provision to users, etc.

The structure and functional organisation of the NBPCU and of the RBPCUs have been directly set-up and paid by the programme so in general they have well-trained and skilled staff. The staff of the key partner institutions, such as Government staff of the MoWIE at regional level, Zone and Woreda staff and staff of the MFIs that provide credit to biogas users has been more difficult to influence and strengthen, because their functions are only in a very small fraction dedicated to the biogas programme. All of them however, suffer from high turn-over of staff, which limits the efficiency of the training provided.

I.3.4.3 – Evidence that the TA has contributed to longer term sustainability of the institutions and activities that they carry out.

The European Parliament Committee on Budgetary Control in its Special Report on the Energy Facility support for Renewable Energy in East Africa[46] mentioned unfavourable circumstances and insufficient local capacities, which compromised the extent to which policy interventions carried out by the projects were taken up and implemented. This certainly applies for Ethiopia and the NBPE+ is strongly addressing this issue, although progress is hampered by constant changes in staff at federal, regional, Zone and Woreda level and by the low retention of trained masons.

So, sustainability in terms of capacity building has not been assured because there will be the need for a continuous stream of new resources to every time train unskilled people.

**Conclusion**: t**he JC is partly validated.** The TA has strengthened the enabling environment at sector level and the EU support has strengthened the skills of core personnel and where relevant the structure and functional organisation of the key partner institutions. There are also serious concerns about the quality of some of the outputs delivered. The sustainability of the TA interventions due to the high turnover of government staff may not be achieved. Private sector participation is a high priority of the NBPE+, but there also is no guaranty of sustainability.

### 3.3.5. JC 3.5 - Degree to which TA has supported the mainstreaming of cross-cutting concerns

Capacity development through technical cooperation provides an opportunity whereby the EU can support the capacity of partners to ensure that design and implementation is gender sensitive, that the environment is not negatively affected and that it pursues inclusive and pro-poor results. Cross-cutting issues are also analysed in other parts of this evaluation, but here one looks at it from the perspective of effectiveness.

**Indicators:**
I.3.5.1 – Evidence that TA has been active in supporting incorporation of gender issues.

[46] European Parliament Committee on Budgetary Control. ECA Special Report on "EU Energy Facility support for renewable energy in East Africa" (2015).

I.3.5.2 – Evidence that the TA has contributed to incorporation of environmental considerations in policy reforms and programme implementation.
I.3.5.3 – Evidence that the TA has contributed to steering policy reforms / programme implementation towards a pro-poor design.

I.3.5.1 – Evidence that TA has been active in supporting incorporation of gender issues.

TA has been active in supporting incorporation of gender issues by design, however there was still little evidence of results. A study[47] commissioned by the NBPE had the following findings:

- Biogas market supply side was working on market based system, competitive and open recruitment as well as no special consideration for engagement of women.
- Engagement of women professionals in biogas programme units of four main regions was found to be very minimal.
- RBPCUs where women were engaged (few in number) their role is also limited in supportive roles like secretary and store keeper.
- There was no special provision to encourage female practitioners in the biogas programme.
- Recruitment of trainee masons was open for both sexes and there was nothing exclusive about them in all regions.
- Programme units did not put any mechanism to enlist female masons in the biogas programme.
- Number of BCE owners found in the study was mostly male. Only few reported they had female members.

The TA has been active in trying to involve women at all levels of programme first by developing the above mentioned study and by discussing it with the implementation partners, but it has no control of how staff is hired in government, the programme cannot force companies to have female masons even when encouraged to do that. The NBPE+ can try but it cannot change deep engraved cultural and social patterns related to the role of women. So, the effectiveness of this support is limited.

I.3.5.2 – Evidence that the TA has contributed to incorporation of environmental considerations in policy reforms and programme implementation.

The programme has contributed to the incorporation of biogas if not in the policy at least in the recognition by federal and regional government staff of it as being a renewable solution for the problem of cooking with firewood. Bio-digester targets have been incorporated in the GTP I and II. The use of bio-slurry instead of chemical fertiliser has clear environmental benefits and its use has been recognised and is being promoted by the MoA. So, the TA has contributed to a raised awareness of the positive environmental impacts of the use of biogas and environmental aspects are included in project implementation.

I.3.5.3 – Evidence that the TA has contributed to steering policy reforms / programme implementation towards a pro-poor design.

Even though *by design* the programme as the objective to contribute to steering policy reforms / project implementation towards a pro-poor objective, there is no evidence that this is achieved. The programme is developing a smaller bio-digester model to try to cater to farmer households with fewer heads of cattle, this is very positive, but the real poor will never be reached because they don't have (enough) cattle and it is unlikely that targeted financial lending will reach them, because the Micro-Financing Institutions (MFIs) do not consider these groups to be credit worth. Therefore, only relatively rich farmers can install bio-digesters, so in this respect this objective is not effective / achievable.

**Conclusion: the JC is partly validated.** The TA showed that they take gender issues and environmental considerations seriously in design and implementation, although in the case of gender

[47] Gender mainstreaming and social inclusion baseline and strategy formulation study report. NBPE+, April 2018.

with little success. The TA has not contributed to steering policy reforms / project implementation towards a pro-poor purpose. The quality of the evidence was more than satisfactory.

## 3.4. EQ4 – Efficiency

**EQ4: To what extent are the EU resources allocated used efficiently, in other words is the NBPE+ doing things right?**

Rationale: EU commitment to the SE4All initiative, achieving SDGs and the Paris Agreement has called for an increased focus on energy and resources allocated to the sector. The key question of EQ4 is how efficiently the EU resources are managed by the NBPE+ partners. This has led to the following JCs:
JC 4.1 Degree to which EUD efficiently mobilised capacity (i.e., financial and human resources) to strengthen the biogas sector development.
JC 4.2. Degree to which the support through grant funding has achieved, demonstrated and lead to a replication of pro-poor, pro-environment, pro-growth and pro-gender benefits.
JC 4.3 Degree to which the programme funding was sustainable.

Coverage: The question considers aspects across all parts of the intervention (policy support, capacity development, and investments).

Link with OECD/DAC evaluation criteria: The EQ addresses the efficiency (extent to which outputs have been delivered relative to the costs of intervention).

Link with 3Cs: EQ4 relates to coordination and complementarity of EU sustainable energy cooperation instruments and implementation modalities (because poor coordination leads to duplication and inefficiency).

Link with IL: EQ4 focuses on whether adequate resources (time, capacity, knowledge and funds available) are allocated efficiently to deliver the planned outputs and outcome, and partly addresses sustainability of the intervention (only limited to the efficient use of resources).

**Box 4 – Summary answer to EQ4.**

1. Most of the indicators show that the programme resources are not being used efficiently. The largest inefficiency, also because it has the biggest impact on the financial resources of the NBPE+ is the inclusion of the new regions in the programme. "Leave no one behind" is very expensive from a programmatic point of view. If the programme resources (not the subsidy and the RBF because these are proportional to the number of installed plants) would be used in other regions one could provide in a more efficient way more bio-digesters to more people, so from the point of view of development and of climate change this would be a much more efficient use of resources. The JC is for the most part not validated and the evidence is strong.

2. The programme removed barriers, an additional number of households benefits from the technology, the gender benefits are real and the programme leads to a reduction of GHG. However, the programme is not innovative, the number of households that benefit from the technology is lagging behind the target, and the programme is not pro-poor or inclusive. The evidence varies between more than satisfactory and strong.

3. The programme funding was sustainable by design, there was sufficient attention given to operation and maintenance and sustainability issues, the programme was intended to provide effective skills transfer and other support needed for continuous operation, a quality control system has been set-up but is not operating correctly and again by design, the benefits of the programme would still be delivered after completion. The evidence is strong.

**Conclusion:** the EU resources allocated are not being used efficiently and the programme is not doing things right. The programme has removed barriers for bio-digesters dissemination, the gender benefits are real and the programme leads to a reduction of GHG, but the programme is not pro-poor or inclusive. By design it has been given enough attention to sustainability.

### 3.4.1. JC 4.1 - Degree to which EUD efficiently mobilised capacity (i.e. financial and human resources) to strengthen the biogas sector development.

**Indicators:**
I.4.1.1 – Evidence that the resources and scale of EU policy dialogue support to reforms were in proportion to the results achieved to date.
I.4.1.2 – Have inputs been provided on time and in the desired quality by stakeholders involved in the programme?
I.4.1.3 – Evidence of whether the results of the programme justify the costs.
I.4.1.4 – Are programme resources managed and monitored in a transparent and accountable manner?
I.4.1.5 – Evidence of the separation and right attribution of costs between NBPE II and NBPE+.
I.4.1.6 – Are the costs of the national / regional implementing partners justified in face of the results obtained?
I.4.1.7 – Are envisaged outputs achieved within the estimated cost / budget at the beginning of the programme?
I.4.1.8 – Is the programme implementation approach flexible to adapt to changing needs?

I.4.1.1 – Evidence that the resources and scale of EU policy dialogue support to reforms were in proportion to the results achieved to date.

The amount of resources provided by the EU to the NBPE+ programme has led to progress in the policy dialogue around the benefits for the country of biogas utilisation as a renewable resource. However, at national level there is still little indication of the huge EU financial and human outlay in national policies related to biogas (see EQ1 and EQ2), with some objectives and goals defined in

the past (GTP I and II), but little in terms of legislation or regulation. At the regional level, some regions have recognised the importance of biogas utilisation to meet many of their environmental and social objectives and are allocating resources to the programme (see EQ1). The quantitative results in terms of achieving the targets planned have been partly achieved, despite the challenges posed by COVID-19 pandemic and with huge regional differences, but the qualitative results in terms of functionality of the bio-digesters, quality control and after-sales service and meeting the objectives of a private sector led biogas market are far from being met (see EQ3). So in this regard the results achieved to date are not in proportion to the resources inputted in the programme.

I.4.1.2 - Have inputs been provided on time and in the desired quality by stakeholders involved in the programme?

There are essentially three stakeholders in the programme: the government institutions at national and regional level, SNV providing programme financial and technical management and the private sector.

Concerning the government institutions at national level the inputs have been generally provided on time, even though due to the turn-over of staff the quality of the provided assistance to the regional programmes varies considerably[48]. At regional level and considering the amount of staff involved and the disappointing low quality of construction in many areas, one can conclude that at least in controlling the quality of construction that there have been not enough or timely or qualitative interventions. Here too the turn-over of staff is high which requires the inefficient use of resources in training new staff. At Woreda level, the results also give a mixed picture, the quality of the achievements depends on the training and experience of the Woreda officials and here too the turn-over is high. Another important factor is the motivation and engagement of the Woreda official that even when the circumstances are equal they deliver outstanding results by their commitment to the programme. In this regard, one can also question the efficiency of the former decision to allocate 2 cars per region when most of the work needs to be done at Woreda level where transportation is a problem. A pool of motorbikes at regional level that are allocated on a rotation basis to Woredas in order to be able to perform the promotion and quality control functions could have been much more efficient.

Concerning the provision of inputs by SNV and after the decision to allow the transfer of funds directly to the regions the evaluation team did not receive any criticisms about delayed transfer of funds. The NBPE+ budget is structured in the following way:

1. RBF - Programme functions for financing programme support activities and investment incentives to the users. For now, the RBF for the programme support activities is also as per installation. This system can be further improved in coming years, to reflect the qualitative aspects as well.
2. Non-Result Based Financing (Non-RBF) - Administrative functions including human resource and office costs; purchase of equipment and vehicles, improving access to credit (as a structural investment), etc.

The overall fund flow for the RBF as well as program support activities and non-RBF funds has been changed and now flows directly to the regional programme coordination units, which greatly improved the efficiency and timely disbursement.

Concerning the technical inputs, SNV has been alert and pro-active in developing and organising all kind of trainings and workshops at regional and national level, as can be seen in their Narrative Yearly reports to the EUD.

Concerning the private sector the picture is mixed and highly dependent on the region they operate. Mostly the acquisition of the clients is done by the Woreda officers and when requested to tender

[48] Interviews with regional staff of some RBPCUs.

the BCEs generally respond adequately. A different aspect is that often the farmers have to wait for some time before construction is completed, mostly –that is the formal reason- because of the lack of sand or cement and even delay because masons do not show after the construction materials have been procured. Concerning the quality of what is delivered, here again the results depend very much on the region but generally the indicators are worrying, see EQ5.

The first Interim Narrative Report of SNV to the EUD already summarised some of the challenges the programme faced, and even though some of these aspects have recently been improved, many are still relevant: *"In the reporting period, the programme faced some unexpected challenges related to government organisational set-up not reaching to the community level, high turnover of trained Woreda staff, low awareness, low commitment and accountability of zones and Woreda officials for bio-digester promotion, etc. Some of these problems got aggravated due to new political developments in the country. These challenges combined with an under-developed private sector, lack of imported appliances in the market, high drop-outs of masons referring the low payment rates, in some regions, did make meeting the target quite a challenge and SNV had to make intensive interventions, on the ground, to expedite implementation activities.*[49]*"* One can question here if these are "unexpected challenges" or inherent to the programme set-up because this analysis appears after 8 years of implementation of the NBPE I and II, and also is relevant for NBPE+.

Indicator I.4.1.2 provides a mixed picture of the programme, generally the inputs are provided on time but the quality of what is delivered offers scope for much improvement.

I.4.1.3 – Evidence of whether the results of the programme justify the costs.

Concerning whether the results of the programme justify the costs, one can look at it from different perspectives, but two aspects are important: the quality of construction, which is of uttermost importance for the reputation of the programme and to create a sustainable bio-digester market and the costs of the programme per bio-digester. The quality of construction which is reflected in the functionality rate of the bio-digesters is reason for concern, this aspect is analysed in more detail in EQ5.

Concerning the programmatic costs, one always starts with very high costs at the beginning when everything has to be set-up, training of programme officers and masons has to be provided, the technology is not known to the beneficiaries and the number of bio-digesters constructed is very low. One expects that along the years the programmatic costs decrease with the establishment of a sustainable private sector market. The analysis along the years is a difficult one in Ethiopia, because of large variations of the exchange rate and because the scope of programme has changed.

The programme efficiency can be measured by the costs that are borne by the programme and have to be externally financed, per bio-digester installed. One benchmark set by the ABPP in 2009 was to reach at the end of the programme period (2012) a total of programme costs and subsidies of € 450 per bio-digester[50].

**Table 15 - Cost efficiency of the programme (in Euro)[51]**

| | 2009 *(4)* | 2010 | 2011 |
|---|---|---|---|
| Household cost per bio-digester | 3,415 | 366 | 297 |
| Subsidy cost per bio-digester (1) | 2,277 | 258 | 212 |
| Total investment cost per bio-digester | 5,692 | 624 | 509 |
| | | | |
| Programme activity cost per bio-digester (2) | 17,763 | 792 | 463 |

49 Interim Narrative Report Year 1. Period: April 12, 2017 to April 11, 2018. SNV.

50 Mid-Term Review of the National Biogas Programme Ethiopia. Final Report, November 2011.

51 Mid-Term Review of the National Biogas Programme Ethiopia. Final Report, November 2011.

| | | | |
|---|---|---|---|
| Technical assistance cost per bio-digester (3) | 9,800 | 742 | 235 |
| Total cost per bio-digester | 33,255 | 2,157 | 1,208 |

*(4) The costs in Euro for 2009 must have been calculated using a bizarre exchange rate[52] as the costs for the household and the subsidy in ETB did not vary much from 2009 to 2010. Obviously that the programme costs per bio-digester for that year must have been high as it could be expected but the amounts shown are completely off-limits.*

As it can be seen from the table above the costs (1+2+3) were decreasing: 2010 = € 1,792; 2011 = € 910. However, the comparison with the present cost is difficult because the exchange rates of the ETB fluctuate but generally the ETB is depreciating against the EUR, and to be totally exact the inflation rates should also be considered. If one discards 2009 because it is typically a start year of the programme in the country where all support structures have to be installed and people trained (and as mentioned above something strange has happened in the conversion from ETB to EUR), one could using only the exchange rates make the following extrapolation[53]:

2010: EUR 1,792 * 19 ETB/EUR / 40 ETB/EUR = EUR 851
2011: EUR 910 * 23.6 ETB/EUR / 40 ETB/EUR = EUR 537

The above shows that the total programme costs per bio-digester if extrapolated would be for 2010 € 851, and for 2011 € 537.

If one compares now the above costs with the NBPE+ programme costs very little progress has been made towards a more efficient and thereby a more sustainable programme, see table below.

**Table 16 – NBPE+ programme costs by bio-digester (EUR)**

| | Year 1 | Year 2 | Year 3 | Year 4 *(1)* |
|---|---|---|---|---|
| Total programme costs | 1,407,927 | 2,506,427 | 3,700,878 | 2,270,717 |
| Number of constructed bio-digesters | 1,100 | 2,003 | 5,395 | 2,408 |
| Programme costs per bio-digester | 1,280 | 1,251 | 686 | 943 |

*(1) Year 4 Q1-Q3.*

Two things should however be considered: (i) one is the price inflation that has taken place but that would mostly affects the investment cost of the bio-digester, so there are other factors impacting the programme costs such as, increased level of salaries paid and incentives given, and (ii) in Year 3 there was a very positive trend to an acceptable cost per bio-digester, which however has not continued in Year 4, but one would most likely have to accept that here this number has been negatively influenced by the COVID-19 pandemic, which limited tremendously any activity in the country and also construction activities.

A very interesting comparison in terms of efficient use of resources is to compare the costs per bio-digester between the previous programme regions and the new ones, see table below.

**Table 17 - Regional programme costs[54]**

| Region | Year 1 | Year 2 | Year 3 | Year 4 till Dec | Total |
|---|---|---|---|---|---|
| Amhara | 232,315 | 209,729 | 767,966 | 587,156 | 1,797,166 |
| Cost per bio-digester | 396 | 214 | 265 | 422 | |
| Oromia | 67,651 | 155,886 | 432,884 | 186,357 | 842,777 |
| Cost per bio-digester | 413 | 443 | 432 | 358 | |
| SNNP | 46,184 | 121,859 | 263,603 | 166,037 | 597,683 |
| Cost per bio-digester | 457 | 592 | 513 | 1,122 | |

[52] In 2009 the average exchange rate was € 1 = 16.17 but fluctuated a lot, and in 2010 was € 1 = 19, but in this year there is also a gap of some months in the data, showing that something unusual was happening.

[53] https://www.exchangerates.org.uk/EUR-ETB-spot-exchange-rates-history-2010.html

[54] Consolidated expenses of partner (Excel file). SNV, May 2021.

| | | | | | |
|---|---|---|---|---|---|
| Tigray | 98,308 | 123,322 | 259,799 | 161,405 | 642,835 |
| Cost per bio-digester | 447 | 320 | 341 | 656 | |
| Afar | | 65,635 | 98,077 | 57,737 | 221,450 |
| Cost per bio-digester | (1) | 6,564 | 1,923 | 2,749 | |
| Bem/Gumuz | 16,677 | 99,659 | 82,867 | 43,419 | 242,622 |
| Cost per bio-digester | 1,042 | 3,691 | 1,011 | 8,684 | |
| Gambella | | 64,079 | 66,511 | 39,605 | 170,194 |
| Cost per bio-digester | (1) | 21,360 | 3,023 | 5,658 | |
| Somali | | 83,356 | 89,742 | 65,430 | 238,527 |
| Cost per bio-digester | 0 (2) | 2,194 | 1,381 | 991 | |

*(1) - No costs and no construction.*
*(2) - Somali region in Year 1 had no costs but had construction.*

As one can see the programme costs of the new regions fall outside any reasonable and acceptable range. One could argue that the first year everything had to be set-up, which is true, even though there were already 8 years of programme implementation in the country, so one would assume that the lessons learned would be easily implemented at lower costs, but that is not the case. It is not the case even in Year 4 of implementation so one should vigorously argue about the sense of implementing the programme in these regions, especially when as shown in EQ3 the potential for further dissemination is very low in these regions. As also discussed in EQ3 the decision to implement the programme is a purely political one that as little to do with equity and "leave-no-one-behind" because if the resources were used in the regions with more potential, more people would have benefitted from the programme.

Another interesting aspect is the amount of GoE contribution to the NBPE+ as compared with NBPE II. In the SNV report NBPE Programme Implementation Document 2014 is written that the user contributed with 60% of the bio-digester costs and the GoE with 40%. So this means that the totality of the subsidy came from the GoE. The ABPP fund was only for the rest of the programme expenses. The GoE contribution to the NBPE+ was over 50% of the total NBPE II expenses. In one of the meetings[55] with financial officers of SNV it was mentioned that the actual contribution to the NBPE+ was around 8.75% of the total costs (there are some contributions at regional level to the programme that are not included in this percentage). It obviously does not make the programme more or less efficient where the money is coming from, but the former high contribution of the GoE to the programme would make it more sustainable. But, strictly from the point of view of the use of EU resources it would make their use more efficient.

So, the answer to indicator I.4.1.3 of whether the results of the programme justify the costs is mixed, being heavily negatively impacted by the decision to extend the programme to the new regions. Also the costs per bio-digester show no real tendency to decrease with the caveat that the COVID-19 might have impacted negatively these costs. It anyway is far from the benchmark defined at the beginning of the NBPE in 2009 (total of programme costs and subsidies of € 450 per bio-digester) and also much higher than similar programmes in Asia with the same amount of years of implementation.

I.4.1.4 – Are programme resources managed and monitored in a transparent and accountable manner?

The programme resources are managed by SNV that makes available funding to MoWIE and to the RBPCUs for the implementation of the NBPE+ regular activities, as agreed and detailed in the Annual Operational Plans and Budgets that are approved by the EUD and by the NBPE+ Steering Committee. SNV keeps the EUD funds in a separate bank account, and there is no indication from any source that the funds are not well managed.

[55] May 18, 2021

The monitoring and evaluation system is developed based on the Logical Framework (LogFrame) of the programme, as it is included in the Description of the Action[56]. Based on that, regular monitoring and evaluation of the activities progress are conducted accordingly, across all the programme implementation levels. The following are the major activities under monitoring and evaluation:

- Baseline and biogas user surveys have been conducted that lead to updating indicators based on the survey report.
- Effective data collection and analysis approaches such as online monitoring systems by using smart phones and the CSC.
- Implementation of reliable and unique coding for each plant and verification system to avoid duplication.
- Ensuring regular evaluation of activities and progress reporting by all.
- Overall programme performance monitoring and guidance of the programme on strategic and policy issues, including based on the decisions of the National Biogas Programme Steering Committee.

The funding includes EUR 2 million budgeted provided directly by the GoE to support part of the subsidy costs. The details are attached as annexes to the Operating Plans and Budgets and form the basis for expenditure, accounting and auditing. These funds according to information provided by interviews of people of the NBPCU and RBPCU, are regularly and truly disbursed.

Concluding, the programme resources are managed and monitored in a transparent and accountable manner.

I.4.1.5 – Evidence of the separation and right attribution of costs between NBPE II and NBPE+.

The challenge of separating costs and programme activities is even higher, because the programme under ABPP had a budget neutral extension for 15 months (till May 2019). To avoid geographical over-lapping with NBPE Phase II (under ABPP), the installation of NBPE+ bio-digesters in the 4 previously existing regions takes place in separate Woredas with clear construction date mentioned and a unique digester coding system that differentiates the installations under the two separate programmes. In the 4 new regions, since there was no programme before, the installation started in selected Woredas from year 1 under the new programme.

SNV also continued providing TA with the one advisor under ABPP budget until the end of 2018. The costs of the ABPP SNV TA have not been reflected in the budgets and the time allocation is kept separately. However, while designing the TA plan under NBPE+, it was done in alignment with TA under ABPP.

SNV also keeps the funds from the two sources in separate bank accounts and the costs and expenses are audited.

So the evidence shows that there is a separation and right attribution of costs between NBPE II and NBPE+.

I.4.1.6 – Are the costs of the national / regional implementing partners justified in face of the results obtained?

The costs of the regional implementing parties have already been discussed under I.4.1.3 and at least concerning the new regions these costs are not justifiable in face of the results.

The costs of the NBPCU and Steering Committee are more difficult to justify or decline, because this would require using contra-factual evidence. The structure of the staff in the NBPCU is very heavy,

[56] NBPE+ Programme Implementation Agreement, May 2017.

with some functions like the biogas engineers being doubtful to justify. First, the staff places have been frequently vacant and the programme still functions without them, although the RBPCUs often complain about the little technical support they get from the NBPCU, second, most of its functions are provided by SNV and this support is generally appreciated by the RBPCUs. The function of the National Programme Coordinator is fully justifiable, maybe a financial manager and less support staff, but for the rest the functions should be decentralised or outsourced.

One good example of outsourcing of functions is the Customer Support Centre, which works very efficiently and provides an enormous quantity of feedback data for the programme (which is not being adequately used, but more of that in EQ5). Even a financial manager at national level could be easily replaced by a direct line of responsibility and accountability from the programme financial managers at regional level to the Ministry of Finance, either or not via the regional bureaus of finance.

Also the costs of these government structures are related to the dissemination approach of the "brick-and-mortar" technology. A truly private sector market with "off-the-shelf" technologies would remove the need for most of these functions.

The answer to the indicator whether the costs of the national / regional implementing partners are justified in face of the results obtained is mixed.

I.4.1.7 - Are envisaged outputs achieved within the estimated cost/budget at the beginning of the programme?

There are many outputs that were to be achieved by the programme, but one key output is the number of bio-digesters to be installed by the programme (total 36,000). The table shows the forecasted numbers.

**Table 18 – Number of planned bio-digesters per year and region[57].**

| | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 (3 months) | Total |
|---|---|---|---|---|---|---|---|
| Afar | 160 | 240 | 360 | 540 | 810 | 352 | 2,462 |
| Benishangul | 140 | 210 | 315 | 473 | 709 | 308 | 2,154 |
| Gambela | 60 | 90 | 135 | 203 | 304 | 130 | 921 |
| Somali | 160 | 240 | 360 | 540 | 810 | 352 | 2,462 |
| Sub-total | 520 | 780 | 1,170 | 1,755 | 2,633 | 1,142 | 8,000 |
| | | | | | | | |
| Amhara | 170 | 255 | 1,202 | 1,803 | 2,704 | 1,169 | 7,303 |
| Oromia | 210 | 315 | 1,485 | 2,227 | 3,341 | 1,449 | 9,026 |
| SNNPR | 140 | 210 | 990 | 1,485 | 2,227 | 959 | 6,010 |
| Tigray | - | - | 990 | 1,485 | 2,227 | 959 | 5,660 |
| Sub-total | 520 | 780 | 4,666 | 6,999 | 10,499 | 4,536 | 28,000 |
| | | | | | | | |
| TOTAL | 1,040 | 1,560 | 5,836 | 8,754 | 13,131 | 5,678 | 36,000 |

*Interim Narrative Report Year 1 - Period: April 12th 2017 to April 11th 2018*

NBPE+ in its first year plan had targeted to install 1,040 household size bio-digesters in eight regions. Accordingly, 1,100 (106%) bio-digesters were installed in year one. However, in reality 520 bio-digesters were planned to be installed in the previously existing regions and 1,072 were effectively installed. Of the 520 bio-digesters planned to be installed in the new regions only 28 were installed.

Thus, the major achievements of the programme in the first year are: 5,500 people (estimated 50 % female) got access to affordable and modern energy, 3,300 tonnes of annual $CO_2$-equivalent emission reduced, 5,225 tonnes of firewood saved and 77 people (Female – 8) gained new direct employment among other achievements. As the reporting period is year one of the programme,

57 NBPE+ Programme Implementation Agreement, May 2017.

much emphasis was given for preparatory activities, coordination unit establishments, development of tools and guidelines and etc. In total € 1,407,927 (72.21 % of the budget) was utilised in the reporting period.

*Interim Narrative Report Year 2 - Period: April 12, 2018 to April 11, 2019*
NBPE+ in its year two plan had targeted to install 2,000 household bio-digesters in eight regions (the target has been increased by the Steering Committee following instructions of the MoWIE). A total of 2,003 (100%) domestic bio-digesters were installed in year two in 205 Woredas of eight regions. NBPE+ was implemented in parallel with the on-going NBPE Phase II that came to an end in March 2019. Again, the majority of the bio-digesters were installed in the previously existing regions (1,925) with a dismally low number of bio-digesters installed in the new regions (78).

The major achievements of the programme in the reporting period are; 10,015 people (50 % female) got access to affordable and modern energy, 6,009 tonnes of annual $CO_2$-equivalent emission reduced, 9,514 tonnes of firewood saved and 264 people (Female – 37) gained employment opportunity. In addition, two larger size bio-digesters (80 $m^3$ and 60 $m^3$) were in final stage of installation in Sululta and Sebeta towns of Oromia region, respectively. A total of 108 bio-digester construction enterprises, 12 MFIs, 19 cooperatives and 17 appliance/accessories manufacturers were engaged in the programme.

In the reporting period, a total of € 2,506,427 was utilised with a depletion rate of about 97.64% against the total year 2 budget of € 2,566,987 (including SNV overhead cost) for installation of target of 2,000 household bio-digesters and piloting 10 larger size bio-digesters.

*Interim Narrative Report Year 3 - Period: April 12, 2019 to April 11, 2020*
NBPE+ in its year three Annual Operational Plan and Budget, had targeted to install 6,600 household bio-digesters in eight regions. Accordingly, 5,395 (82%) household bio-digesters were installed in year three in 367 Woredas of the eight regions. Once again, the majority of the bio-digesters were installed in the previously existing regions (5,175) with a dismally low number of bio-digesters installed in the new regions (220).

The major achievements of the programme in the reporting period are; 39,437 rural people (18,883 - females) got access to affordable and modern energy, 25,764 tonnes of annual $CO_2$-equivalent emission reduced, 25,626 tonnes of firewood saved and 378 people (females – 38) gained direct employment opportunity. In addition, two larger size bio-digesters (80 $m^3$ and 60 $m^3$) were installed in Sululta and Sebeta towns of Oromia region, respectively. A total of 1 importer, 34 appliance manufacturers, 111 bio-digester construction enterprises, 663 individual masons, 14 MFIs and 19 cooperatives were engaged in the programme.

In the reporting period, a total of € 3,700,878 was utilised, which is a depletion rate of about 82.14 % against the total year 3 budget of € 4,505,422. The low depletion has to do with lower progress compared to the target of 6,600 household bio-digester installations, an inspirational target.

The Interim Narrative Reports for year 1 to 3 show that with some adjustments that have been explained there, that the many outputs have been achieved within the cost/budget, but that the target installation numbers were not achieved in Year 3, and not achieved at all for all years in the new regions. For year 4 the number of bio-digesters installed in the first 3 quarters was low (2,309 in previously existing regions and 99 in new regions) as compared to the target, but those months should not be considered normal due to the COVID-19 pandemic.

Concluding the envisaged outputs were achieved within the estimated cost/budget at the beginning of the programme, but the numerical target is lagging behind, most notoriously in the new regions (see Annex VI).

I.4.1.8 - Is the programme implementation approach flexible to adapt to changing needs?

The programme has shown flexibility in adapting to new situations (COVID-19) and needs, for example starting business development activities with the private sector, using social media to keep staff and partners up to date, and biogas and bio-slurry promotion held through regional electronic and print media in regional languages. This helped the programme to be known among rural communities and other stakeholders. Less flexibility has been shown in introducing new technologies into the programme, even though this possibility is being examined (see EQ3 and 5).

The programme implementation approach has been in general flexible to adapt to changing needs.

**Conclusion: the JC is not validated.** Most of the indicators show that the programme resources are not being used efficiently. The largest inefficiency also because it has the biggest impact on the financial resources of the NBPE+ is the inclusion of the new regions in the programme. "Leave no one behind" is very expensive from a programmatic point of view. If the programme resources (not the subsidy and the RBF because these are proportional to the number of installed plants) would be used in other regions one could provide in a more efficient way more bio-digesters to more people, so from the point of view of development and of climate change this would be a much more efficient use of resources. The JC is for the most part not validated and the evidence is strong.

### 3.4.2. JC 4.2 - Degree to which the support through grant funding has achieved, demonstrated and lead to a replication of pro-poor, pro-environment, pro-growth and pro-gender benefits.

**Indicators:**
I.4.2.1 – Evidence that the grants removed barriers and have demonstrated innovative institutional, management and technical alternatives.
I.4.2.2 – Additional number of households with access to biogas.
I.4.2.3 – Evidence from observation of additional gender related benefits e.g. (i) increase of the number of women owning and benefitting from improved access to energy; (ii) decreased burden of wood and water collection arising from improved access to energy.
I.4.2.4 – Evidence that the programme design and implementation are inclusive and pro-poor.
I.4.2.5 – Reduction of greenhouse gasses.

I.4.2.1 – Evidence that the grants removed barriers and have demonstrated innovative institutional, management and technical alternatives.

Without the EUD grant to this programme the NBPE+ would not have been possible, so in that sense it removed the most important barrier, the need for funds and that the potential achievements of the programme are in this way made possible. However, the programme has not reduced the direct transaction costs in the sense that the institutional set-up has not been innovated (the question is whether that was possible) as compared to the previous phases of the NBPE. Moreover the supporting structures from the side of the government have been enlarged and the contribution of the GoE has been reduced as compared with the previous phase of the programme, 8.75% in average now as compared with 50%[58] in NBPE II. So, in conclusion the grants removed barriers but were not innovative.

I.4.2.2 – Additional number of households with access to biogas.

The existence of the programme which is financed by the EUD and the GoE make it possible that an additional number of households have access to biogas, up to December 2020, 10,906 households. Worrisome is the fact that with 2 years and a quarter of the programme to go, the

[58] Interviews with SNV staff.

programme will most likely not meet its target of constructing 36,000 bio-digesters. So, this indicator is not a positive one.

I.4.2.3 – Evidence from observation of additional gender related benefits e.g. (i) increase of the number of women owning and benefitting from improved access to energy; (ii) decreased burden of wood and water collection arising from improved access to energy.

Related to women owning the bio-digester installations the programme has given attention to this aspect among other by developing a gender mainstreaming strategy[59] and promoting it among implementation partners. The programme cannot however, disregard neither change traditional societal patterns related to the position of women in the Ethiopian society. The programme has also given some attention and encouraged the participation of women in the programme, not only as users but also as entrepreneurs and technicians. Nevertheless even when the ownership pattern of the bio-digesters is predominantly male-oriented, the greatest beneficiaries of the technology are the women as it decreases the burden of collecting firewood (even though on the other hand it increases the time spent to collect water, this is especially important in arid regions and in regions where firewood is not that scarce). Another not minor benefit is the fact that by using biogas women are less exposed to harmful smoke that causes lung and eye problems as it is widely documented in the literature. So, this indicator is validated as it also has been documented by our field mission and by users' surveys.

I.4.2.4 – Evidence that the programme design and implementation are inclusive and pro-poor.

Concerning the evidence that the programme design and implementation are inclusive and pro-poor, one should be clear: a biogas programme is not the best option to provide cooking energy for really poor people[60]. To start with, really poor people do not own cows or they own insufficient quantities to feed even the smallest bio-digester. So, even with the best intentions in design and implementation, poor people will not be able to own a bio-digester. And, in this regard there is no credit provision that can solve this fundamental issue (the same applies for gender mainstreaming). The SNV technicians are trying to partly solve this problem by introducing a smaller bio-digester (2.5 $m^3$). Still these farmers will most likely not be able to finance a bio-digester and specific lines of credit will also not solve it. The solution would be to keep the same amount of subsidy for these smaller plants so that they would become virtually free. However, these farmers do not have smaller families, so their need for firewood will not decrease substantially, and this could lead to the abandonment of the bio-digester at the least problem. A real solution for these really poor farmers (poor people in general) would be the promotion of improved cookstoves, including a very efficient injera biomass stove already being marketed, and a solar lantern. So, by the very nature of the technological solution the NBPE+ is not pro-poor or inclusive.

I.4.2.5 – Reduction of greenhouse gasses.

The programme when it substitutes unsustainably harvested firewood leads to a large reduction of the emission of GHG. However, as the field missions have observed, many bio-digesters have been installed in areas where wood was not scarce neither seemingly grown in an unsustainable way. In this case the GHG emissions reduction would be much less, see table below.. The use of a biogas lamp also leads to a modest reduction of GHG, however most biogas lamps in the sampled households were not working. The use of the high-quality bio-slurry also reduces the need for chemical fertiliser, whose production is a large source of GHG. So this indicator is validated.

[59] NBPE+ Gender mainstreaming and social inclusion baseline and strategy formulation study. By Sak Business and Personal Development PLC, April 2018.

[60] One could also debate whether the people who have just sufficient animals to feed a small bio-digester (4 $m^3$) are by all accepted definitions of poverty not falling within the classification of poor people.

**Table 19 - Indicate data on availability of firewood**

| Region | Sample N= | Zone | Firewood availability |
|---|---|---|---|
| Afar | 35 | Zone 1 | Moderate. Farmers harvest firewood from homestead plantations as well as from the invasive tree Prosopis juliflora. The Zone is one of the main charcoal producing areas. |
| Amhara | 123 | Awi | Moderate. Farmers harvest firewood from homestead plantations. |
| | | East Gojjam | Moderate. Farmers harvest firewood from homestead plantations |
| | | North Shoa | Low. Eucalyptus is the most commonly grown tree and main source of round wood and firewood. Farming households use dung cake for cooking and baking. |
| | | South Wello | Low. |
| Gambella | 25 | Anywaa | Firewood available |
| | | Gambella town | Not available |
| Oromia | 44 | Arsi | Not available |
| | | Jimma | Firewood available |
| | | North Shewa | Firewood available |
| | | West Arsi | Firewood available |
| SNNP (including Sidama Region) | 33 | Gamo | Firewood not available |
| | | Gurage | Firewood available |
| | | Kembata Tembaro | Firewood available |
| | | Sidama | Not available |
| | | Wolayita | Firewood available |
| Somali | 35 | Fafan | Not available |

**Conclusion: the JC is partly validated.** The programme removed barriers, an additional number of households benefited from the technology, the gender benefits are real and the programme leads to a reduction of GHG. However, the programme is not innovative, the number of households that benefit from the technology is lagging behind the target, and the programme is not pro-poor or inclusive. The evidence varies between more than satisfactory and strong.

### 3.4.3. JC 4.3 - Degree to which the programme funding was sustainable.

This judgment criterion is forward looking and is not the same as in EQ6 which is an assessment of 3.5 years programme implementation, thus both forward and backward looking.

**Indicators:**
I.4.3.1 – Evidence that the programme design included sufficient attention to operation and maintenance and sustainability issues.
I.4.3.2 – Evidence that the programme provided effective skills transfer and other support needed for continuous operation (e.g., to cost recovery systems).
I.4.3.3 – Evidence that a quality control system has been set-up and is operating correctly.
I.4.3.4 – Evidence that the benefits of the programme will still be delivered after completion.

I.4.3.1 – Evidence that the programme design included sufficient attention to operation and maintenance and sustainability issues.

The programme design and according to the objective / outcome of installing 36,000 bio-digesters mentioned as a concrete output that "the functionality of the bio-digesters are improved to reach the target of minimum 95% functionality for ensured actual impact in people's lives and the environment.[61]". As indicators / intermediate outputs / activities it mentioned:

- Improve frameworks, tools/techniques and capacities for quality for improved functionality.
- Undertake quality assurance and monitoring of promotion, construction and after-sales service in the field for newly installed and others that are under pre-paid after-sales service and or warranty period.
- Maintain and operate a computerised database system with a CSC as is established under NBPE II.
- Collect periodic users' feedback to improve performance and to measure the socioeconomic impacts in the users' lives and the environmental and other economic impacts.

There is enough evidence that by design the NBPE+ included sufficient attention to operation and maintenance and sustainability issues (this is not saying that it actually happened as planned, that is analysed in several other EQs).

I.4.3.2 – Evidence that the programme provided effective skills transfer and other support needed for continuous operation (e.g., to cost recovery systems).

The programme document states as an objective / outcome that "Sector capacity development expedited for a sustainable domestic bio-digester sector with private sector development and engagement of other partners to fill in the capacity gap." As a concrete output is mentioned "Private sector capacity developed for faster and sustainable bio-digester market creation in rural areas, in line with and full implementation of the NBPE National Framework on Private Sector Development." As indicators / intermediate outputs / activities it mentioned:

- Train rural youths and encourage/support for formalised private sector development for sustained market development.
- Support formalised BCE and other biogas enterprises with Business Development Services for development of their business plans, access to credit, etc.
- Encourage/support other existing or new enterprises to take up or add bio-digester construction, manufacturing, supply of appliances/accessories, etc. to complete the intra-sector private sector development effort.
- Support and license capable BCEs and other enterprises for promotion, construction, after-sales services including spare parts and for manufacture and supply adequate and quality accessories and appliances.
- Support the private sector for establishment and operationalisation of private sector associations or their chapters, to work as professional platform, including for capacity development and other private sector interests.

Not mentioned above is that by design the programme also intended to provide capacity building to the government institutions at national, regional, zone and Woreda level to be able to support the bio-digester dissemination efforts, as indicated by Outcome 5: "National institutional and policy framework for the sector exist embedded in the overall national planning and development framework, and with a sectorial vision."

The investment incentives have also been defined as 30-40% of the costs of a bio-digester for the first years of the programme, and a revision was planned in Year 3. So, by design the programme was intended to provide effective skills transfer and other support needed for continuous operation.

I.4.3.3 – Evidence that a quality control system has been set-up and is operating correctly.

[61] NBPE+ Description of the Action, Final. January 15, 2016.

As mentioned before one of the indicators of the first objectives was to: "Undertake quality assurance and monitoring of promotion, construction and after-sales service in the field for newly installed and others that are under pre-paid after-sales service and or warranty period.

The conclusion is that a quality control system has been set-up (the answer of whether it is operating correctly is given under EQ3, EQ5).

I.4.3.4 – Evidence that the benefits of the programme will still be delivered after completion.

Concerning the evidence that the benefits of the programme will still be delivered after completion is a very forward looking question and at least by design that was the intention of the NBPE+ (training and skills development of masons, BCEs, MFIs, government officers and setting up a quality control system, enabling the creation of a bio-digester private sector, etc.). This question can be more accurately answered under EQ6.

**Conclusion: the JC is validated.** The programme funding was sustainable by design, there was sufficient attention given to operation and maintenance and sustainability issues, the programme was intended to provide effective skills transfer and other support needed for continuous operation, a quality control system has been set-up but is not operating correctly and again by design, the benefits of the programme would be still delivered after completion.

## 3.5. EQ5 – Technical evaluation

**EQ 5 - To what extent are the bio-digesters operating as expected and therefore fulfilling the needs of the users, what is the technical quality of construction, what is their functionality rate, what can be improved and what needs to be changed?**

Rationale: Well-functioning bio-digesters, meaning that they are skilfully constructed and correctly operated and maintained will provide for many decades the many benefits of this technology to users, environment and country. On the other hand, poorly constructed and/or badly operated bio-digesters will fail to deliver those benefits with the consequent reputation damage to the technology and programme, the abandonment of the installation and often the loan repayment default. This has led to the following questions:
JC 5.1 Is the bio-digester design adequate and is being built according to technical specifications.
JC 5.2 Degree to which the bio-digesters are functioning adequately.
JC 5.3 Assessment of the quality of construction.
JC 5.4 Use of bio-slurry.
JC 5.5 Adequacy of Quality Control.
JC 5.6 Are the bio-digesters meeting the needs of the users.

Links with OECD/DAC evaluation criteria: This question addresses effectiveness and efficiency and is linked to impact and sustainability.

Link with IL: EQ5 focusses on whether the resources made available are being / have been used in such a way that the programme delivers the outputs and outcomes that was designed for.

**Box 5 – Summary answer to EQ5.**

1. The bio-digester design is adequate for the conditions of the country, but other designs should be promoted in the future. There have been adaptations of the design to accommodate to regional differences. The training provided to masons / BCE seems adequate, but there are other factors that influence the quality of construction. There are substantial differences in the quality of construction between regions, Zones and Woredas. The quality of the evidence is strong.

2. The bio-digesters are not functioning adequately, the rates of non-functionality are very high, the minimum acceptable rate of functionality to create confidence in the technology and not damage the reputation of the programme should be above 95%. The quality of construction and the improper training of the users is a main cause of non-functionality. The quality of after-sales services is well below of what should be acceptable. The quality of the evidence is strong.

3. Most installation were constructed according to dimensions with minor problems but in general poor plastering, not all components were properly installed, especially the turrets and pipes which could lead to unsafe situations and is an important reason for non-functionality. Water drains were mostly available. Two slurry pits were the norm as was the norm that they were not covered to protect them from sunlight. The quality of the evidence is more than satisfactory.

4. Users are using bio-slurry, but there regional differences some regions have little or no use for bio-slurry. The training of users on the use of bio-slurry is in almost all regions inadequate and they are not provided with instruction materials. When used bio-slurry is highly appreciated. The quality of the evidence is strong.

5. The quality control is adequate for the technology being used, but overly complex and expensive, as compared with "off-the-shelf" technologies. Quality control has not been functioning well, as can be deduced from the high rate of non-functionality. The quality of the evidence is strong.

6. Users of well-functioning bio-digesters are generally satisfied and are aware of the benefits in terms of monetary savings and health. Not being able to bake Injera ranks high in the dissatisfaction of the users, but this aspect is probably more related to wrong promotion as it should be clear that certain bio-digester sizes do not produce sufficient energy to bake Injera. Users are generally not aware of the existence of the CSC, some have contacted the CSC with complaints with not apparent follow-up. Users are in general not well trained in the feeding and maintenance of the bio-digesters. The quality of the evidence is strong.

**Conclusion:** The bio-digesters design is adequate but other types of technology should be introduced. There are large percentages of bio-digesters not operating as expected, but when they operate well they fulfil the needs of the users and the users are generally satisfied. The quality control is not functioning well as can be de deducted from the high rates of non-functionality but depending on the type of non-functionality this can also be the consequence of inadequate after-sales service. Training of the users in feeding and maintenance of the bio-digesters needs to be improved.

### 3.5.1. JC 5.1 - Is the bio-digester design adequate and is being built according to technical specifications.

**Indicators:**
I.5.1.1 – Is the bio-digester design adequate for the conditions of the country?
I.5.1.2 – Would regional differences require a different design?
I.5.1.3 – Is the training provided to masons / BCEs adequate?
I.5.1.4 – Are there substantial differences in the quality of construction between regions?

I.5.1.1 – Is the bio-digester design adequate for the conditions of the country?

The bio-digester "brick-and-mortar" design used in Ethiopia is a proven model that has been used with slightly adaptations in most countries where there are large biogas programmes. In Ethiopia the design has also been adapted, especially to save on the quantities of cement and iron rods, in order

to lower its price. The original design of the flat-top outlet with slabs is now become a dome-shaped outlet in the so-called Sinidu 2010 model.

However, as indicated in EQ3 the "brick-and-mortar" model might not be the best model for Ethiopia, considering the geographic and socio-economic conditions of the country. SNV indicates that it has been trying to approach companies that successfully installed tenths of thousands of plastic/flexi bag digesters in Kenya and they are not willing to work in Ethiopia due to the complexity of the system – meaning political interference- and difficulties to accesses hard currency easily. This is then something that the NBPE+ could influence at national level if there was political will. This political will might not be there due to the fact that this would have as a consequence that a true private sector bio-digester market would have to be accepted with a minimal intervention of the government.

Looking from the socio-economic perspective SNV is developing a smaller model -2.5 $m^3$- that could serve the poorer farmers with less cattle. However, due to the fact that poor farmers do not necessarily have smaller families and therefore need the same quantities of firewood and the fact that this model will not be suitable to bake Injera, one could ask the question if improved cookstoves and the efficient Injera stove being developed in the country would not be a better and much more affordable solution.

Not a design question but more a cultural cooking habit, SNV from the very beginning of the NBPE is promoting the Injera stove.

I.5.1.2 - Would regional differences require a different design?

There are parts of Ethiopia where the "black cotton soil" problem occurs that leads to variations in the pressure the surrounding soil exerts on the bio-digesters leading to cracks and misalignment of the structure. SNV has successfully developed a so-called "black cotton soil" bio-digester model, a variation of the original Sinidu 2010 model

There are also large parts of the country that suffer from drastic shortages of water during large part of the year. This would require a bio-digester model that uses less water. In other countries a so-called "solid-state" bio-digester has been developed, and the model has been piloted in Ethiopia under the ABPP in former phases of the NBPE. The design is ready for introduction on a large-scale.

I.5.1.3 - Is the training provided to masons / BCEs adequate?

SNV has developed training manuals and theoretical and on-the-job training is provided regularly. One can only assess the adequacy of the training by looking at the results. These are mixed, there are masons that deliver excellent work and that are masons that don't, so the different results may not indicate that the quality of training is not adequate, but that it also depends on the individual skills and motivation. Another problem is that even if adequately trained a mason needs some time and practice to excel, however, due to the low rate of retention, the skills of bio-digester masons do not mature.

NBPE+ is encouraging that masons get organised in BCEs and provide organisation, administrative training, in general called business development services, and there is no indication that this training is not adequate.

I.5.1.4 - Are there substantial differences in the quality of construction between regions?

Yes, not only between regions but also between Zones and even between Woredas in the same Zone. This has to do with many factors, like difficulties in transport in extensive areas, but most boils down to the motivation of the concerned officers of the Zone and Woreda, as there are excellent examples of high quality of construction and timely provision of after-sales services in Woredas that are similar to others where the quality of construction is very poor.

Regional differences are analysed in Chapter II and are also evident in the JC 5.2 below.

**Conclusion: the JC is validated.** The bio-digester design is adequate for the conditions of the country, but some other designs should be promoted in the future. There have been adaptations of the design to accommodate to regional differences. The training provided to masons / BCE seems adequate, but there are other factors that influence the quality of construction. There are substantial differences in the quality of construction between regions, Zones and Woredas.

### 3.5.2. JC 5.2 - Degree to which the bio-digesters are functioning adequately.

**Indicators:**
I.5.2.1 – Functionality rates per region.
I.5.2.2 – What influences functionality in the different regions?
I.5.2.3 – Is there an adequate response to users' complaints about malfunctioning?
I.5.2.4 – Long delay between complaint and repair due to the lack of accessories and appliances.
I.5.2.5 – Malfunction due to quality of construction.
I.5.2.6 – Malfunction due to mismatch between resources (dung, water, time) and cooking needs.
I.5.2.7 – Malfunctioning due to improper training of users.

Functionally of a bio-digester can be impacted by four different factors:

1. Quality of construction and of after-sales service.
2. Users' ability to properly feed the bio-digester.
3. Users' interest and willingness to feed the bio-digester.
4. Lack of insufficient cattle due to death or theft or family composition changed or family moved away to another area.

The first 3 factors can in decreasing order be influenced by the NBPE+. The last factor falls outside of the scope that can be attributed to how much the programme can foresee or influence.

I.5.2.1 - Functionality rates per region.

There are many sources that provide data about the functionality of the bio-digesters. First some data will be summarised, before presenting the summary of the evaluation itself.

The SNV Interim report Year 2[62] shows that the national average functionality rate is 79% (30% functioning without significant problem, 22% functioning with minor problems and 27% are functioning with major problems) and 21% of the plants are found totally not functional for reasons like not being fed, houses abandoned, cattle sold off, lack of water and sometimes technical problems including lack of after-sale service. Specific to NBPE+, the functionality rate of bio-digesters in the intervention Woredas, namely Wolkayit and Raya Kobo Woredas that were included through random sampling in BUS 2019 is 87%.

The SNV Interim report Year 3 shows that functionality rate for all Ethiopia is 79% of the bio-digesters functioning and only for the NBPE+ that number is 87%. In the NBPE+ Woredas, 40% functioned without notable problems, 20% with minor problems, 27% with major problems and 13% were non-functional[63]. Data in both SNV reports does not agree with evaluation findings, neither with the CSC reports. It should be however noted that a user reporting non-functionality to the CSC can be for very minor problems, but what really is important is that this is an indication that the user is not satisfied.

[62] Interim Narrative Report Year 2 - Period: April 12, 2018 to April 11, 2019. SNV.
[63] Interim Narrative Report Year 3 - Period: April 12, 2019 to April 11, 2020. SNV.

The CSC established in 2018 under MoWIE, but outsourced to a private company with ABPP support, started piloting a remote data collection and entry system, by means of telephone interviews with users. CSC is the service provided to customers before, during and after purchasing and using the biogas. The team handled a total of 1,505 users, out of which, 1,130 were reachable contacts. From these reachable users[64]:

- 56% (628) of the bio-digesters are working well.
- 39% (440) users perceived that their digesters are not working due to reasons associated with feeding, accessories, water shortage and other problems.
- 5% (55) are working but less gas production.
- 1% (7) are reported as having no bio-digester.

This information fairly agrees with the evaluation findings.

The reasons given to the CSC for the bio-digester not working were:

1. Under construction.
2. Being fed.
3. Shortage of water, dung.
4. Broken pipe.
5. Personal reasons.
6. Less quantity of materials.
7. Not being trained.

Another source of information is the NBPE+ baseline study[65] that gives information up to the first year of the NBPE+, for the original four programme regions.

**Table 20 - Functionality of bio-digesters according to different studies**

| Region | BUS report (2015) | PAV report (2015/16) | Inventory (2017) | Baseline study (2018) |
|---|---|---|---|---|
| Amhara | 88% | 90% | 45% | 50% |
| Oromia | 72% | - | 60% | 57% |
| Tigray | 66% | 51% | 51% | 57% |
| SNNPR | 78% | 48% | 51% | 50 % |

Also there is information provided by the Biogas Users' Surveys (BUS) along the years[66]. In general the conclusions of the BUS surveys about functionality are much more optimistic than the finding of the CSC or the findings of other studies (compare for example the year 2018 in both tables), including this evaluation, see table below.

**Table 21 – Functionality rates according to several BUS surveys**

| Region | BUS (2015) | BUS (2018) | BUS (2019) |
|---|---|---|---|
| Amhara | 88% | 81% | 73% |
| Oromia | 72% | 72% | 81% |
| SNNP | 78% | 90% | 81% |
| Tigray | 66% | 65% | 83% |
| Average | 76% | 77% | 79% |

## Afar

According to the CSC (all info from the CSC from the same reference as indicated above), the functionality rates in Afar were as indicated in the table below.

**Table 22 – Functionality rates in Afar according to the CSC.**

[64] Customer Support Centre - Yearly report April 19 – April 20. Techno Brain.

[65] NBPE+ Programme Baseline Study. Report by Sak Business and Personal Development PLC. May 2018.

[66] Biogas Users' Survey 2019. SNV, 2019.

| Description | Number | Percentage |
|---|---|---|
| Complete Survey - No Bio-digester | - | - |
| Complete Survey - Bio-digester not working | 5 | 56% |
| Complete Survey - Bio-digester working but less gas than expected | - | - |
| Complete Survey – Bio-digester working well | 4 | 44% |
| Total reachable | 9 | 100% |

This evaluation indicates a functionality rate in Afar of 62.5% of the bio-digesters, higher than the CSC percentages.

## Amhara

**Table 23 – Functionality rates in Amhara according to the CSC**

| Description | Number | Percentage |
|---|---|---|
| Complete Survey - No Bio-digester | 6 | 2% |
| Complete Survey - Bio-digester not working | 158 | 43% |
| Complete Survey - Bio-digester working but less gas than expected | 21 | 6% |
| Complete Survey – Bio-digester working well | 181 | 49% |
| Total reachable | 9 | 100% |

This evaluation indicates a functionality rate in Amhara of 72.5% of the bio-digesters, higher than the CSC percentages. The CSC reporting of 6 bio-digesters not being constructed is caused by a mistake by Woreda technicians who have reported the not-completed digesters. The respondents were trying to state their dissatisfaction because the bio-digester construction was not completed at the time of the CSC call.

## Benishangul-Gumuz

**Table 24 – Functionality rates in Benishangul-Gumuz according to the CSC**

| Description | Number | Percentage |
|---|---|---|
| Complete Survey - No Bio-digester | 1 | 6% |
| Complete Survey - Bio-digester not working | 3 | 19% |
| Complete Survey - Bio-digester working but less gas than expected | 1 | 6% |
| Complete Survey – Bio-digester working well | 11 | 69% |
| Total reachable | 16 | 100% |

This region was not part of the evaluation.

## Gambella

CSC had no data on Gambella, because of the low numbers of constructed bio-digesters, which makes the probability of reaching users very low. Under this evaluation 25 bio-digesters were sampled and visited, of which 19% were working and 81% not working. An incredible high non-functionality rate.

## Oromia

**Table 25 – Functionality rates in Oromia according to the CSC**

| Description | Number | Percentage |
|---|---|---|
| Complete Survey - No Bio-digester | - | - |
| Complete Survey - Bio-digester not working | 57 | 44% |
| Complete Survey - Bio-digester working but less gas than expected | 3 | 2% |
| Complete Survey – Bio-digester working well | 69 | 53% |
| Total reachable | 129 | 99% |

Under this evaluation 44 bio-digesters were sampled and visited. The average functionality rate was about 63.4% in the dry period studied, which in some areas was with high scarcity of water. This percentage is higher than the one of the CSC.

## SNNP

**Table 26 – Functionality rates in SNNP according to the CSC**

| Description | Number | Percentage |
|---|---|---|
| Complete Survey - No Bio-digester | - | - |
| Complete Survey - Bio-digester not working | 67 | 39% |
| Complete Survey - Bio-digester working but less gas than expected | 12 | 7% |
| Complete Survey – Bio-digester working well | 94 | 54% |
| Total reachable | 173 | 100% |

Under this evaluation 33 bio-digesters were sampled and visited. The functionality of the bio-digesters was low about 27.3% because the survey was conducted in the dry season where there was no sufficient dung and water as responded by 50% of the households. This might explain the big difference in functionality (54%) with CSC, but any case in both the non-functionality is very high.

## Somali

**Table 27 – Functionality rates in Somali according to the CSC**

| Description | Number | Percentage |
|---|---|---|
| Complete Survey - No Bio-digester | - | - |
| Complete Survey - Bio-digester not working | 11 | 73% |
| Complete Survey - Bio-digester working but less gas than expected | - | - |
| Complete Survey – Bio-digester working well | 4 | 27% |
| Total reachable | 15 | 100% |

Under this evaluation 35 bio-digesters were sampled and visited. On average, 52.9% of the sampled bio-digesters were functioning during the survey period. This is a higher percentage than found by the CSC but both are still very low.

## Tigray

**Table 28 – Functionality rates in Tigray according to the CSC**

| Description | Number | Percentage |
|---|---|---|
| Complete Survey - No Bio-digester | - | - |
| Complete Survey - Bio-digester not working | 139 | 33% |
| Complete Survey - Bio-digester working but less gas than expected | 18 | 4% |
| Complete Survey – Bio-digester working well | 265 | 63% |
| Total reachable | 422 | 100% |

For security reasons the evaluation did not visit any bio-digesters in Tigray. As comparison a study[67] from 2017 (thus from the time of the NBPE II) was used that examined 180 bio-digesters in the four districts of the region with a higher number of bio-digesters (Hintalo Wajirat, Ofla, Kilte Awlaelo, and Enderta), with a total of 2,202 bio-digesters. According to the Tigray Region Biogas Programme Coordination Office, there were more than 3,600 bio-digesters in Tigray at the time.

The most essential finding of the study is that 58.1% of the installed bio-digesters were found to be non-operational. This was due to incomplete installation, technical problems, and limited supervision.

[67] Biogas Plant Distribution for Rural Household Sustainable Energy Supply in Africa. Tewelde Gebre Berhe, Rahwa Gebre Tesfahuney, Grmanesh Abreha Desta & Lemlem Semungus Mekonnen (2017). Energy and Policy Research, 4:1, 10-20, DOI: 10.1080/23815639.2017.1280432.

Therefore taking the CSC percentage, it seems that the functionality has improved in recent years, but is still quite low.

I.5.2.2 – What influences functionality in the different regions?

The NBPE+ Baseline study[68] indicates the following reasons for non-functionality and this evaluation did not come with substantially different conclusions.

**Table 29 - Causes of non-functionality and their percentage share in major programme regions**

| Region | Causes for non-functionality problems in percentage | | | | |
|---|---|---|---|---|---|
| | Feeding problems | Technical problems | Water supply | Spare part accessories /appliances | Other |
| Tigray | 40% | 36% | 4% | 12% | 8% |
| Amhara | 24% | 53% | - | 13% | 10% |
| Oromia | 25% | 47% | 10% | 9% | 9% |
| SNNPR | 41% | 43% | - | - | 16% |

Noteworthy is the fact that 2 of the reasons that are directly under the influence of the programme (Technical problems and Spare part accessories / appliances) are responsible for the high rate of non-functionality. Another reason that can be partly directly attributed to the programme is "Feeding problems", which could be caused by among others deficient training of the users. But certainly all of them are caused by a deficient after-sales service.

In the following the numbers were established by this evaluation:

In Afar about 60% of the non-functional digesters were associated with insufficient dung for feeding mainly due to frequent cattle movement for pasture. The other important cause was lack of water and labour for feeding accounted for 28% and non-functionality of bio-digesters accounted for 9.4%.

In Amhara the most important causes of non-functionality are insufficient cattle dung for feeding 13%, failure of appliances (such as cracks in digesters, broken pipes, shortage and low quality of accessories and appliances and poor workmanship) 12.2% and lack of labour for feeding 12.2%.

In the Gambella region the observed low rate of functionality was attributed to different reasons including lack of sufficient feed and distant water sources (20%), and delayed construction (8%). The lack of sufficient feed was also because of the prevailing dry season, in which the local people usually take their livestock away from the residential areas in pastoral mode life.

In the Oromia region the reasons for non-functionality of bio-digesters were diverse. The lack of spare parts such as appliances, fittings, and the lack of transport service played roles in non-functionality. The main reasons were the lack of dung in four dry months (11%), turret valve damaged with gas leakage (5%) and total dismantled bio-digesters (5%).

In the SNNP region the survey was conducted in the dry season where there was no sufficient dung and water as responded by 50% of the households. Other reasons attributed to the poor functionality of bio-digesters were lack of labour to mix dung (12.5%) and inappropriate site selection (8.3%).

In the Somali region, in addition to the shortage of water (20%), there were other reasons for non-functionality of bio-digesters including feedstock shortage (14%) and stove valve damage (3%).

I.5.2.3 – Is there an adequate response to users' complaints about malfunctioning?

[68] NBPE+ Programme Baseline Study. Report by Sak Business and Personal Development PLC. May 2018.

The fact that the rates of non-functionality stay incredible high is because there is no proper follow-up to the complaints of the users or the users do not complain at all. Many bio-digesters are poorly constructed, some domes crack, turrets and pipes are exposed and break, but a high percentage of malfunctioning is caused by default appliances and valves and by improper feeding of the bio-digester.

Most users don't dare to touch the installations because they do not understand them and even minor repairs that could be considered maintenance are not done, but they are not to blame. Users don't have a phone number either of the local Woreda expert or of the CSC, because it has never been given to them or because they have lost it.

In a number of cases has been observed that highly motivated Woreda experts regularly visit the bio-digester installations and/or rapidly answer to complaints of the users. The contrary is also true that users complain but get no follow-up.

The fact that the non-functionally problem has been a constant of the programme for 10 years was signalled in the NBPE+ Programme Baseline Study mentioned above and recently this is being systematically signalled by the CSC, and that the problem persists is an indication that users' complains about malfunctioning are not followed and that this is probably one of the reasons for the abandonment of the installations.

I.5.2.4 – Long delay between complaint and repair due to the lack of accessories and appliances.

The above is mostly true because of both lack of accessories and appliances at Woreda and even at Zone level and because of transportation problems and sometimes because of uninterested Woreda staff as they are not financially compensated for it. The households with some problems in their bio-digesters faced difficulties to communicate with the biogas experts also because in some cases there was no Woreda and Zone level energy administration, and the few region level staff cannot reply to the many demands by households. The region level experts are also aiming at quantity rather than quality as the funding was based on the number of bio-digesters constructed regardless of functionality.

There after-sales services are often not provided because of lack of transport, the masons were not able to visit the households' bio-digesters regularly. The bio-digesters were highly scattered and the distance between the residential places of masons and the bio-digester constructed areas were far and inaccessible.

I.5.2.5 – Malfunction due to quality of construction.

There were few cases in the sample where one could observe that the bio-digesters were constructed by skilled masons and with pride for what they did. Most default cases are poor finishing of the exposed surfaces, which in itself is not a problem but lets you wonder about the quality of the finishing of the interior of the dome, this one a crucial factor for functionality and for obtaining the amount of gas that one could expect (many users complained about insufficient gas production, but this could also be caused by poor feeding of the bio-digester).

In a considerable number of cases turrets were not protected and pipes were exposed above ground, and this invariably has led to pipe damage, gas leakage or the plant stopping functioning altogether. Cracking of the dome has also been reported to the evaluators (in one case the family had to stop using the water from their well as even animals refused to drink it, the evaluators could confirm the foul smell of the water) and this problem is known to the programme implementers, which again shows poor quality of construction. Another observed problem is that the hole in the outlet through which the bio-slurry outflows is too high, and this is a capital fault as it can lead to the slurry in the dome to be pushed up the turret and the pipes, effectively blocking the flow of gas. In a large number

of cases the dome is also not properly covered often even being exposed and compromising the stability of the construction, see picture below.

*Figure 95 – Not properly covered dome affecting the stability of the inlet.*

I.5.2.6 - Malfunction due to mismatch between resources (dung, water, time) and cooking needs.

A bio-digester is designed to be fed every day and the gas used every day, it is not meant to accumulate gas to save it for the Injera baking. When selecting specific size for a family one looks from the point of view of demand for energy taking into consideration the cooking habits of the family and the number of people. One has to look also from the point of view of resources, is there enough dung available to feed the bio-digester and enough water available for mixing the dung. This leads to a compromise in the size chosen.

As the sampled households have shown there is often a mismatch between the available resources and the energy needs. If the bio-digester is properly sized according to the available dung this often has the consequence that there is not enough gas to cook all meals and moreover to bake Injera. This can lead to the situation that the bio-digester is working properly but user lacks interest in feeding it, especially if there is no scarcity of wood and water collection is a problem.

I.5.2.7 - Malfunctioning due to improper training of users.

This is a recurring problem, in all regions one finds a large quantity of users that are not properly trained, or were properly trained but the person in charge left the household. Most problems arise from improper feeding of the bio-digester, too little feeding, not adding the right quantity of water, etc. Another recurring problem is that users are not aware that the water drain should be regularly opened to let the condensed water escape.

**Box 6 – Some points of concern**

Low quality of construction leading to malfunctioning besides being a reputational damage to the programme can lead to pernicious effects. Many situations in all regions indicate that in fact biogas must be escaping to the atmosphere (also if too high quantities of dung are fed into the bio-digester related to the energy need of the family). This means that the NBPE+ in these situations is putting into the atmosphere more GHG than would be the case if the dung was traditionally used directly in the field.

This would also be the case if one would promote the use of the bio-digester to produce bio-slurry independently of the energy needs of the family. This is another reason why users should be properly trained in feeding the bio-digester.

Saving biogas to use it for Injera cooking should also be discouraged, the bio-digesters are designed to be fed and the biogas used every day, otherwise there is a tipping point where the biogas begins escaping to the atmosphere through the outlet chamber.

It was also observed that bio-digesters have been and are being promoted in parts of the country where there is no lack of firewood and this firewood is grown sustainably. This obviously reduces the climate benefits of the use of biogas (certainly all the other benefits still apply). The problem in this case is that at the least problem (and especially if there is no adequate and quick response) the user tends to abandon the installation.

Also in all regions one finds that often a reason for abandonment of the installations are the high expectations created about the performance of the installation, because users are not properly informed about the limitations especially related to the possibility of baking Injera.

**Conclusion: the JC is not validated.** The bio-digesters are not functioning adequately, the rates of non-functionality are very high, the minimum acceptable rate of functionality to create confidence in the technology and not damage the reputation of the programme should be above 95%. The quality of construction and the improper training of the users is a main cause of non-functionality. The quality of after-sales services is well below of what should be acceptable.

### 3.5.3. JC 5.3 - Assessment of the quality of construction.

**Indicators:**
I.5.3.1 – Check dimensions and lay-out.
I.5.3.2 – All components properly installed.
I.5.3.3 - Are there two slurry pits?
I.5.3.4 – Check quality and safety of gas pipes and connections, and possible gas losses.
I.5.3.5 – Water drain available.
I.5.3.6 – Look for possible gas losses.

I.5.3.1 – Check dimensions and lay-out.

Most of a bio-digester is buried under the ground and filled with slurry and impossible to control. External observation and a limited number of measurements indicated a number of small problems with dimensions. The lay-out mostly followed the one given in the drawings. One critical problem observed in a number of installations was that the level of the slurry opening in the outlet dome was too high and this could lead to slurry getting into the pipes, a critical failure.

The quality of the plastering of the inlet and outlet was generally poor. This is in itself not a problem, the worry is if this is an indication of the quality of the interior plastering of the dome, in this case a major, critical problem as it leads to gas losses, with evident damage to the global environment and a reason for decreased users' satisfaction.

A recurring problem is that the dome of the bio-digester was not covered with the required quantity of earth. In some cases it was observed that the cover had been washed away. This can indicate that the dome was not buried to the required depth.

I.5.3.2 – All components properly installed.

A large quantity of turrets was not properly protected. Pipes were laid on the ground and sometimes floating above the ground. Inside the houses pipes were sometimes not fixed properly.

I.5.3.3 – Are there two slurry pits?

In the large majority of cases, there were two slurry pits. Almost all slurry pits were not covered to protect them from sunlight, greatly decreasing the quality of the slurry due to the loss of Nitrogen. In a small number of cases rainwater could freely run into the slurry pits.

I.5.3.4 – Check quality and safety of gas pipes and connections, and possible gas losses.

As indicated above gas pipes were laying on the ground, this is not safe and was also one of the observed reasons for the non-functionality of the bio-digesters. Pipes are usually HDPE or PPA/PPR both of which have or should have ultraviolet protection and when properly installed under the ground should pose no problems. Connections for both types of pipe are different, HDPE connections requiring no tools and a low level of skills, PPA/PPR pipes require tools and a skilled mason, most gas leaks were observed in this type of pipes.

Gas losses in pipes were not very frequently observed, because when pipes were broken there was no feeding of the installation. Another issue that limited the observation of gas losses was that at the time of the visits there was no sufficient gas pressure to detect gas losses, either because of insufficient feeding or because gas was used just before the visit.

I.5.3.5 – Water drain available.

Water drain was installed in practically all installations. There were cases that the gas drain was inaccessible either due to placing it at a wrong location, or because the use covered it, in one case was buried under the ground. In very few cases the gas drain was not placed at the lowest point of the pipe.

**Conclusion: the JC is partly validated.** Most installation were constructed according to dimensions with minor problems but in general poor plastering, not all components were properly installed, especially the turrets and pipes which could lead to unsafe situations and is an important reason for non-functionality. Water drains were mostly available. Two slurry pits were the norm as was the norm that they were not covered to protect them from sunlight.

### 3.5.4. JC 5.4 - Use of bio-slurry.

**Indicators:**
I.5.4.1 – Evaluate the use of bio-slurry.
I.5.4.2 – Have users been trained (man/female)?
I.5.4.3 – Assess the users' opinion on the value of bio-slurry.

I.5.4.1 – Evaluate the use of bio-slurry.

Ethiopia is implementing a series of interrelated programmes to achieve agricultural transformation through improved fertiliser consumption which remained at 23.8 kg/ha in contrast to the 62 kg/ha for the world and 141.3 kg/ha for South Africa[69]. Improving the low consumption of fertilisers will be achieved through introduction of inorganic fertilisers, domestically producing inorganic fertilisers and by producing and using organic fertilisers. This has created opportunity to promote organic fertilisers at individual farmer's level to complement and, if possible, replace the imported inorganic fertilisers.

Important for the use of bio-slurry is to mainstream its use by involving the MoA in its agricultural extension system to incorporate bio-slurry in its soil fertility related demonstrations. These efforts include:

- Development of quality standards on slurry management and utilisation.
- Identifying linkages to extension services and integrate in agricultural sector development.

[69] SNV supports promotion of bio-slurry as high value fertiliser. March 2017.

- Identify linkages with particular agricultural value chains.
- Development of guidelines.
- Supporting an evidence-base of organic fertilisers in different agro-ecological settings and production systems.
- Identifying ways of promoting bio-slurry use in women's agricultural and food security related activities.

The Soil Fertility and Management Directorate under the MoA included bio-slurry as one of soil fertility management technologies. Thus, in principle bio-slurry activities are planned, implemented and evaluated by the ministry at all levels. In line with it, experts' trainings were organised by the Soil Fertility and Management Directorate to regional soil fertility management staff in soil fertility management technologies and practices[70].

It was found that bio-digester households in both Afar and Amhara regions apply bio-slurry in their farms. In Afar about 60% and 65% in Amhara reported using bio-slurry.

In Afar region, 18 out of 30 households (60%) reported using bio-slurry. Bio-slurry was applied on different crops including corn, barely, sorghum, vegetables, fruits, coffee, animal feed and hinna.
In Amhara 78 out of 120 households (65%) reported applying bio-slurry to a variety of crops including Teff, corn, wheat, barely, sorghum, Faba bean, vegetables, fruits, coffee, chat, sugarcane and hinna.

In Afar and Amhara regions, most farmers practice is spreading liquid or composted bio-slurry in vegetable gardens. Transporting to fields was less practiced because of small volume of bio-slurry production (associated with insufficient feeding and non-functionality of digester plants) as well as distances of the farms.

In Gambella there was no recognised use of bio-slurry because of the poor experience of applying bio-slurry to agricultural land. The demand for bio-slurry was very low because the subsistence farmers had fertile soil. There was also poor extension service and lack of awareness to promote bio-slurry for agriculture. Even households in urban areas who constructed bio-digester faced the problem of disposing the bio-slurry, because the households situated in urban areas had no agricultural land. The soil fertility improvement department of the Gambella BoA has no financial support to run any bio-slurry activities.

In Oromia bio-slurry was well-utilised in most parts of the region for different agricultural crops. Bio-slurry was mostly used in composted form, mostly for maize, wheat, teff, cabbage, grass and barley.

In SNNP bio-slurry was used at the households' farm and sold in local markets. Bio-slurry was used for the growth of pasture grass so as to increase the yield of livestock. However, bio-slurry pits were not shaded in all samples.

In the Somali region, the bio-slurry was not well utilised because crop cultivation was not widely practiced. Most of the bio-slurry produced was freely flowing even without pits. About 50% of the bio-digesters had no bio-slurry pit at all.

Almost all user households do not keep records of bio-slurry production and its application. The actual quantity of bio-slurry production by a bio-digester was not measured. The volume of bio-slurry production is also expected to be much lower than the potential due to the under-feeding of the bio-digesters.

In general, users do not maintain records on the quantity of bio-slurry applied on different types of crops as well as the timing of application.

[70] Interim Narrative Report Year 2 - Period: April 12, 2018 to April 11, 2019. SNV

I.5.4.2 – Have users been trained (man/female)?

The agricultural professionals working in crop and soil fertility department were trained about biogas and bio-slurry at national level in Adama in 2005 and since then occasional training has been given in different institutes. However, the application of bio-slurry on soil and improvement of soil fertility was not well taken by different stakeholders, because of the lack of budget and lack of institutional ownership of the bio-slurry activity.

Overall, users' training was found inadequate. About 84% in Afar and 88% in Amhara reported they received training during the initial feeding of the bio-digesters and 63% in Afar and 67% in Amhara received training during plant completion.

Only 44%and 55% of users in Afar and Amhara reported they received training on management of their plants operation. The vast majority of the users' reported that they were not provided with operation manual. Merely 13% in Afar and 25% in Amhara reported they were given leaflets on the operation of their plants.

The training of agricultural development agents and energy experts at the local level on bio-slurry management was generally inadequate. Because of the above, users' training on bio-slurry management was inadequate. Similarly, users were not provided with guidance materials on bio-slurry management (production, storage, and application).

I.5.4.3 – Assess the users' opinion on the value of bio-slurry.

In Oromia, the field observations showed the use of bio-slurry for fattening livestock, by using bio-slurry to the growth of pasture grass. Households stated that bio-slurry was better than chemical fertiliser to improve soil fertility, and improved crop quality and quantity. In SNNP bio-slurry was used at the households' farm and sold in local markets. The effect of bio-slurry on the growth of maize and grass was easily detected by the deeper green colour, while light green colour was observed in unapplied areas. Therefore, in SNNP, the role of bio-slurry in improving plant growth and soil fertility was highly appreciated by farmers.

Although the impact of bio-slurry application on crop yield has not been measured, user households reported that application of liquid and composted form of bio-slurry resulted in incremental yield of major crops.

Users' farmers reported decrease in pests/diseases incidence with bio-slurry use. Since these are the mere perceptions of user farmers, no definite conclusion can be drawn without a focused R&D in this regard.

**Conclusion: the JC is partly validated.** Users are using bio-slurry, but there regional differences some regions have little or no use for bio-slurry. The training of users on the use of bio-slurry is in almost all regions inadequate and they are not provided with instruction materials. When used bio-slurry is highly appreciated.

### 3.5.5. JC 5.5 - Adequacy of Quality Control.

**Indicators:**
I.5.5.1 – Is the quality control set-up adequate?
I.5.5.2 – Is it cost effective, or should other methods been used?
I.5.5.3 – Are there penalties for masons / BCEs for reiterated failures in the quality of construction?
I.5.5.4 – Are there -and why- regional difference in the approach to and implementation of quality control?

I.5.5.1 – Is the quality control set-up adequate?

Quality control is guided by a quality control protocol (QC1 during construction and QC2 after completion) are carried out for all installed bio-digesters. Out of which, 100 % are done by Woreda energy offices in all regions and 10 % checking are carried out by RBPCUs. There is also a third quality control (EQ3) done by NBPCUs and SNV, however the 5% checking has not always been done.

The quality control activities are carried out both at regional and Woreda level with periodic support by the regional Water, Mines and Energy Bureaus or Agencies. Quality control formats (at different construction levels), standard construction agreement, detailed digester designs (different capacity/sizes), Standardised Warranty Certificate and Quality Control Enforcement Chart with Responsibility Matrix developed, have been shared with all RBPCUs for its application.

This is a very complex system, it is however a very common system which has been applied in other countries with success. The low rates of functionality are however an indication that this system is not functioning properly in Ethiopia.

I.5.5.2 – Is it cost effective, or should other methods been used?

It is surely a costly system but there are no alternatives in a market that is still at infancy stage of development and with the "brick-and-mortar" model used.

Other models of bio-digesters that work in a truly private market fashion do not need this complex system, because the bio-digester quality is controlled in the factory and the installation is performed by their own high trained staff. These companies which have bio-digesters and their appliances as their only line of business, do not want to risk their future by delivering low-quality not functional bio-digesters.

I.5.5.3 – Are there penalties for masons / BCEs for reiterated failures in the quality of construction?

There are no penalties for failures in the quality of construction. Also masons are difficult to penalise because they sometimes disappear and go to work somewhere else. Recently, in some regions, masons and BCEs that systematically deliver low-quality installations are refused to build new installations. BCEs have in principle a much stronger interest in constructing high quality installations. In many regions the tender system for construction helps in selecting out inferior masons and/or BCEs.

I.5.5.4 – Are there -and why- regional difference in the approach to and implementation of quality control?

There are no significant differences in the approach to quality control. The differences and the quality of "quality control" are mostly caused by factors as lack of transportation and motivation of the government officials.

Related to the after-sales service, masons were assumed to continue supplying after-sales- service for two years, and then a proportion of the payment of the construction is given at the end of the second year of completing construction. However, the lack of transport, the occurrence of water and feed shortage in dry season urges to abandon bio-digesters and made the quality of the after-sales service very low. The high turnover rate of government staff also reduced the control of masons.

**Conclusion: the JC is partly validated.** The quality control system is adequate for the technology being used, but overly complex and expensive, as compared with "off-the-shelf" technologies. Quality control has not been functioning well, as can be deduced from the high rate of non-functionality.

### 3.5.6. JC 5.6 - Are the bio-digesters meeting the needs of the users.

**Indicators:**
I.5.6.1 – Are the users satisfied with the bio-digester?
I.5.6.2 – Are their cooking needs being satisfied by the biogas?
I.5.6.3 – Are they able to bake Injera?
I.5.6.4 – What other energy sources were they previously using for cooking and how they compare the situation now with the former?
I.5.6.5 – Have the users been properly trained in the use and maintenance of the bio-digester?
I.5.6.6 – Are they aware that there is a national Customer Service Centre they can approach when experiencing problems?
I.5.6.7 – Have users approached the national Customer Service Centre?

I.5.6.1 – Are the users satisfied with the bio-digester?

In Afar water and dung shortage was reported as the main disadvantage by 19% and 13% of the respondents, respectively. The main problem with availability of dung is associated with the movement of cattle for pasture away from residential places.

In Amhara region water shortage was reported by 10% while 8% reported dung shortage.

Other issues stated in Afar and Amhara as a disadvantage of the bio-digester include high labour requirement; lighting replacement not available in market; gas output not adequate to meet household's daily cooking energy needs; lack of Injera Mitad (Injera baking stove); gas output not consistent, hand mixing of dung, firewood collection easier than dung collection, flooding and gas smell especially during dry season.

In the Gambella region, there was little experience on utilising bio-digester technologies in the study period of May 2021. The communication between the biogas coordination offices, households and masons was very low. The biogas was considered as if it belongs to some external property and not properly owned. The presence of sufficient firewood also reduced the effort to know about bio-digester technology. Poor extension services and low rate of promotion also reduced the expansion of bio-digester technology. Some households perceived some disadvantages of biogas such as odour and lack of bio-slurry disposal place.

In the Oromia region, people had good experience of utilising biogas and bio-slurry. However, there was the difficulty of getting water in the dry season. The effort to dig deep water well was very low as responded from local administrators. The toilet constructed was left without usage because of lack of proper follow up and lack of proper promotion to use toilet connection. Some households had a toilet constructed without that they were interested in that.

In the SNNP region, the users were much appreciating the energy and fertiliser value of bio-digester technology.

In the Somali region, households with bio-digesters were experienced in the utilisation of biogas. The households also wanted to stick to the bio-digester technology especially for cooking purpose. Since the rural areas of Somali region was devoid of any vegetation for firewood, but endowed with many livestock, bio-digester technology is appropriate to be used. The local people were also highly interested and some of the households want to install additional bio-digesters on their own source of finance. The regional government committed and supplied dung mixer and solar home lighting system as a promotion of bio-digester technology. The biogas light lamps were installed in all

households but not functioning. As a result all the households with bio-digesters owned solar home lighting system, which was subsidised from the regional energy office.

In Chapter 2 the data collected through field visits indicates (high) satisfaction rates or willingness to recommend the technology to others: Afar 87.5%; Amhara 87%; Gambella: 69,2%: Oromia: 95.5%; SNNP: 78.8%; and Somali: 100%.

I.5.6.2 – Are their cooking needs being satisfied by the biogas?

In the Gambella region, the presence of firewood, the lack of pasture grass and water in dry season and the livestock disease reduced the utilisation of bio-digester technology. Moreover, all the households surveyed were electrified, so the use of biogas for lighting was reduced. The average number of persons in a household was seven that utilise 253.5 kg of firewood per month. The use of biogas saves 11.0% in hot season to 46.0% in cold season on the amount of firewood utilised, this varied significantly among households.

In the Oromia region, in some households, the energy from biogas totally replaced woodfuel by 42 to 66%.

In the SNNP region, although bio-digester technology is not easily affordable, those households using the technology saved in their wood consumption by 50-60% and fertiliser expenditure by 50-100% at individual household level. Biogas reduced the time required for wood collection and saved money by over 30%.

In the Somali region, the bio-digester technology was highly important in areas where there are no other cooking energy sources like firewood. The lack of firewood triggered households to store rainwater for their bio-digester. The rural people of Somali region highly appreciated the biogas cooking system which they did not know before. Characteristics of household with completed bio-digesters showed that the bio-digester technology saved 44 to 55% of firewood collection time, the highest being in cold season (67%) and the lowest being in hot season (41%).

I.5.6.3 – Are they able to bake Injera?

The ability to bake Injera is directly correlated with the size of the installed bio-digester, 8 $m^3$ being the minimum size required to satisfy the Injera baking needs of an average family. This minimum size was sometimes not sufficient for Injera baking which may depend on the amounts to be baked and of frequency of feeding the digesters as observed in the field assessment.

For example in Year 3 of the programme, 5,395 bio-digesters were installed, the majority 85% (4,614) are 6 $m^3$ size, while the remaining 15% installed household domestic bio-digesters are 4 $m^3$ (4%), 8 $m^3$ (10%) and 10 $m^3$ (1%)[71]. Thus, in principle only11% of the users are able to bake Injera with biogas, depending on the biogas consumption of the Injera stove.

I.5.6.4 – What other energy sources were they previously using for cooking and how they compare the situation now with the former?

Most households in rural areas of Ethiopia use predominantly firewood with a small percentage using charcoal. In peri-urban areas the use of charcoal increases, but these are in principle not the target areas of the biogas programme.

The users who installed the bio-digesters which are functioning very much appreciate the time saved in collecting firewood and money saved when they had to buy charcoal and/or firewood. They are

[71] Interim Narrative Report Year 3 - Period: April 12, 2019 to April 11, 2020. SNV.

also aware of the additional benefit of health condition improvement in comparison to the use of firewood with its associated smoke.

They are mostly not satisfied that they cannot cook Injera on biogas but this is nothing the programme can do about, as it is said above it depends on the size of the bio-digester and this size depends on the amount of dung available and also on the availability of sufficient water.

I.5.6.5 – Have the users been properly trained in the use and maintenance of the bio-digester?

The users were somehow trained on how to use the bio-digester and its accessories. However, there were some households that were not trained how to feed properly and lacked follow-up. During field survey, some households stated that they were afraid of feeding their digester during crop harvesting season, by assuming some crop seeds may enter to the digester and close the pipe. Then in the presence of dung and water, some bio-digesters were not functioning because of lack of proper training. On the other hand, most of the households were not trained how to maintain the bio-digester and its accessories.

I.5.6.6 – Are they aware that there is a national Customer Service Centre they can approach when experiencing problems?

Most users were not aware of the existence of the national CSC, neither had they had a number to contact it.

I.5.6.7 – Have users approached the national Customer Service Centre?

The CSC is only doing out-bound calls and there are no in-bound calls still today because the CSC did not get the contact number for this to be possible.

A quotation from the Mid-Term Review report[72]: *"Yet, the repair of non-functional bio-digesters still needs a significant impetus as was witnessed in Dabat Woreda (Amhara) where all three visited bio-digesters built in 2017 were dysfunctional, apparently due to poor masonry work. According to the beneficiaries, the problems were reported to the Woreda energy office repeatedly, including through interaction with the CSC, but their complaints had not been enacted upon. In Bona Woreda (SNNP) a similar but different story unfolded, as three bio-digesters visited were not functional. In one case this seemed to be related to poor masonry work, and in two cases to lack of labour for the voluminous first feeding. Whereas the Dabat case clearly points to dysfunctional lines of quality management, the Bona case stresses the need for close follow-up with beneficiaries - and possibly also stricter user selection to ensure robustness."*

**Conclusion: the JC is validated.** Users of well-functioning bio-digesters are generally satisfied and are aware of the benefits in terms of savings and health. Not being able to bake Injera ranks high in the dissatisfaction of the users, but this aspect is probably more related to wrong promotion as it should be clear that certain bio-digester sizes do not produce sufficient energy to bake Injera. Users are generally not aware of the existence of the CSC, some have contacted the CSC with complaints with not apparent follow-up. Users are in general not well trained in the feeding and maintenance of the bio-digesters.

## 3.6. EQ6 - Sustainability

**EQ6: To what extent has the EU support contributed to sustainable energy and social inclusion goals, and are the outcomes sustainable both nationally and regionally?**

[72] NBPE+ Mid-Term Review - Final Report. Peter Ton, Abiyot Tilahun Eshete, Kassa Mekonnen. May 18, 2020.

Rationale: Besides removal of barriers, grants can introduce issues that would otherwise not or not likely be considered from a pure financial perspective. These issues are a pro-poor and inclusive approach, including all environmental safeguards in the project's design, preparation and implementation, a conducive approach for productive activities and including gender aspects in all or most phases of the project. But grants can also introduce distortions in the market that compromise sustainability. The sustainability of the NBPE+ is crucial especially once the external support and subsidy is removed. The extent to which sustainability issues were incorporated into the design (analysed in EQ4) and implementation and the extent to which there is evidence that the NBPE+ will continue to provide benefits will be examined. This has led to the following judgement criteria:
JC 6.1 Degree to which the NBPE+ contributed to EU social development goals.
JC 6.2 Degree to which the NBPE+ contributed to EU environmental and climate goals.
JC 6.3 Degree to which the NBPE+ contributed to addressing market weaknesses and stimulating private sector involvement
JC 6.4 Degree to which carbon credits can foster the sustainability of the biogas sector.
JC 6.5 Degree to which the long-term institutional capacity has been strengthened.
JC 6.6 Is a bio-digester programme financially sustainable (beyond donor/GoE grants + subsidies).

Coverage: The question considers aspects across all parts of the implementation. (policy support, capacity development, and outcomes). Sustainability has different dimensions: financial, institutional, policy, and environmental.

Link with OECD/DAC evaluation criteria: The EQ addresses the sustainability of the intervention (extent to which outcomes that have been delivered will continue in the future).

Link with IL: EQ6 focuses on whether the resources (time, capacity, knowledge and funds available) that delivered the outcomes, will likely continue in the future (impact), Sustainability has already been analysed *by design* in EQ4.

**Box 7 - Summary answer to EQ6.**

1. The NBPE+ contributed to EU social development goals, by the increased number of households with access to modern energy services, and by the permanent and/or temporary jobs that have been created. Gender has been partially mainstreamed, but the programme is not –and cannot by its nature- address the needs of the marginalised and poor population. The quality of the evidence is strong.

2. The NBPE+ contributes to the environmental and climate goals of the EU, although its impacts may be a bit less than initially assumed. The quality of the evidence is strong.

3. The NBPE+ contributed to addressing market weaknesses and stimulating private sector involvement. Nevertheless, the programme is not sustainable without GoE and/or donor funds. The quality of the evidence is strong.

4. The carbon credits to be obtained increase the sustainability of the bio-digester market. The amounts are however not what was expected due mainly to a higher rate of malfunctioning of the bio-digesters and probably inaccurate monitoring of the installations. The quality of the evidence is strong.

5. The long-term institutional capacity has been strengthened, however the sustainability is not fully guaranteed. Nevertheless, the NBPE+ and its former phases have capacitated and increased the knowledge of government staff about the biogas market and even though they have been put in different places in the institutions they still are aware of the large impacts and benefits of the technology. The quality of evidence is more than satisfactory.

6. The bio-digester programme is not financially sustainable (beyond donor/GoE grants + subsidies). The quality of evidence is more than satisfactory.

**Conclusion**: The NBPE+ contributed to EU environmental and climate goals and partly to the social development goals by the increased number of households with access to modern energy services. The NBPE+ contributed to addressing market weaknesses and stimulating private sector involvement. The long-term institutional capacity has been strengthened. Nevertheless, the programme is not sustainable without GoE and/or donor funds and/or carbon credits.

### 3.6.1. JC 6.1 - Degree to which the NBPE+ contributed to EU social development goals.

**Indicators:**
I.6.1.1 – Increase in (or targeting of) the number of households with access to modern cooking energy services.
I.6.1.2 – The extent to which the NBPE+ led to greater access to modern cooking energy services by marginalised and/or poor population groups.
I.6.1.3 – Extent to which the programme led to permanent or temporary jobs being created.
I.6.1.4 – Extent to which the programme succeeded in the mainstreaming of gender aspects into the design (analysed in EQ3 and EQ4) and implementation of the programme.

I.6.1.1 - Increase in (or targeting of) the number of households with access to modern cooking energy services.

The numbers of households targeted to be provided with bio-digesters is 36,000. Until the end of 2020, the NBPE+ has provided access to modern energy services to 10,906 households (quantitative indicator, the indicator is less brilliant if one takes into account the quality of what has been constructed).

I.6.1.2 – The extent to which the NBPE+ led to greater access to modern cooking energy services by marginalised and/or poor population groups.

As discussed in EQ4 a bio-digester programme is not the most adequate instrument to address marginalised groups or service the poor population, plainly because to have the smallest size of bio-digester (4 $m^3$) one needs to have at least 4 cows. One could also debate whether some people in Ethiopia who have just sufficient animals to feed a small bio-digester cannot be -by accepted definitions of poverty- classified as poor people.

I.6.1.3 – Extent to which the programme led to permanent or temporary jobs being created.

The programme has led to permanent and/or temporary jobs being created. The amounts are variable, because many masons are temporarily active in bio-digester construction, do other types of construction in the meanwhile and many move permanently to other kind of construction, as the never-ending training of masons by the programme shows.

I.6.1.4 – Extent to which the programme succeeded in the mainstreaming of gender aspects into the design (also analysed in EQ3 and EQ4) and implementation of the programme.

Despite the activities implemented, the programme has not succeeded in the mainstreaming of gender aspects into the implementation of the programme. There are some female masons but the number of women in the implementing structures of the GoE is negligible[73].

[73] Biogas dissemination scale-up programme (NBPE+) gender mainstreaming and social inclusion baseline and strategy formulation study report. April 2018.

Of course, that by the nature of the programme, the largest beneficiaries are women, so in this respect by default gender is mainstreamed. Cooking is a task with a strong gendered role pattern, large time implications, and also a relatively high (potential) household budget component so that it can play a crucial influence in shifting gender roles, gendered responsibilities, and decision-making. Field observation indicated that a number of men started using biogas stoves more frequently than traditional stoves due to the ease of use, this suggests that biogas cooking may be a step towards changing gender roles and norms. Women's control over the small day-to-day budget for cooking fuels (if they buy) is higher than over the (very large) investment for a bio-digester. So one cannot have a conclusive answer to this indicator, furthermore, one could doubt about the pretension of such a programme to influence and change deep rooted cultural and social habits in Ethiopia.

**Conclusion: the JC is partly validated**: The NBPE+ contributed to EU social development goals, by the increased number of households with access to modern energy services, and by the permanent and/or temporary jobs that have been created. Gender has been partially mainstreamed, but the programme is not –and cannot by its nature- address the needs of the marginalised and poor population.

### 3.6.2. JC 6.2 - Degree to which the NBPE+ contributed to EU environmental and climate goals.

**Indicators:**
I.6.2.1 – Environmental and climate change impact assessments are undertaken (or systems in place to do so).
I.6.2.2 – Environmental and climate change performance is monitored and reported on (or systems in place to do so).
I.6.2.3 – The extent to which the NBPE+ led to improved environmental performance.
I.6.2.4 – The extent to which the NBPE+ led to improved climate performance.

I.6.2.1 – Environmental and climate change impact assessments are undertaken (or systems in place to do so).

SNV has several studies and calculations on the environmental impacts of the use of bio-digesters. The most reliable assessment is the one related to the sale of carbon credits under Carbon Initiative for Development (Ci-Dev), see JC 6.4 below.

I.6.2.2 – Environmental and climate change performance is monitored and reported on (or systems in place to do so).

The environmental and climate change performance is monitored and reported on the annual reports provided by the SNV and measured by the reduction of GHG emissions. The system however functions taking average impact numbers and the calculation method is not evident. These reductions might in some cases be less than calculated, because it is assumed for all regions that there is shortage of firewood and that its growth is not sustainable. This is not true for all parts of the country. For bio-slurry that has a large environmental impact this is also a difficult calculation because every farmer is a specific situation. SNV has published some studies[74] that show the large impact of using bio-slurry.

I.6.2.3 – The extent to which the NBPE+ led to improved environmental performance.

[74] Scaling-up the adoption of bio-digesters: Lessons learned from Were Ilu Woreda. SNV 2020. Using Bio-slurry for a Sustained, Maximum Farm Production and Productivity, SNV, no date.

As mentioned above deforestation is reduced by the use of biogas instead of firewood and also a small contribution by the reduction of the use of kerosene for lighting. Bio-slurry instead on chemical fertiliser also contributes to the reduction of environmental impacts.

I.6.2.4 – The extent to which the NBPE+ led to improved climate performance.

By the impacts mentioned above the emission of GHGs is reduced and this has a positive impact on climate change.

**Conclusion: the JC is validated.** The NBPE+ contributes to the environmental and climate goals of the EU, although its impacts may be a bit less than initially assumed.

### 3.6.3. JC 6.3 - Degree to which the NBPE+ contributed to addressing market weaknesses and stimulating private sector involvement.

**Indicators:**
I.6.3.1 – The extent to which the NBPE+ contributed to advancing or implementing energy sector reforms related to improving private sector involvement.
I.6.3.2 – The number of SMEs and/or individual masons engaged in construction and assuring continuous operation of the bio-digesters.
I.6.3.3 – The demand for and awareness raising actions were adequate.
I.6.3.4 – The procedures and processes were streamlined and did not impose undue delays or costs.
I.6.3.5 – Is there a market without donor or government inputs?

I.6.3.1 – The extent to which the NBPE+ contributed to advancing or implementing energy sector reforms related to improving private sector involvement.

The NBPE+ has been heavily involved via SNV in improving private sector development and lately trying to shift away from training individual masons to capacity development of BCEs for them to have basic business systems and structures in place. A private sector development strategy has been approved by the NBP-SC[75], SNV is cooperating with the United Nations Development Programme to provide mason training and skills certification; also Business Skills development to BCEs and masons are being provided. MFIs have been also trained in the provision of loans to the biogas sector, but all this has not led to energy sector reforms related to private sector involvement. The GoE policies have been until recently not conducive to private sector involvement, but that has changed. The government structures involved at all levels in the biogas programme have a large degree of control and this is not stimulating for private sector ownership and involvement. The question of whether this would be possible using the "brick-and-mortar" technology has been analysed in EQ3. So the answer to this indicator is negative.

I.6.3.2 – The number of SMEs and/or individual masons engaged in construction and assuring continuous operation of the bio-digesters.

As mentioned under JC 3.2, in the year 2020 there were around 137 registered BCEs in business, with 274 masons, including 17 females. Additional 482 individual masons are in business[76].

Amhara is the regions where this process is more developed[77]. Following the implementation of the Bio-digester Construction Work and BCE Establishment Manual and other systems, the majority of the Woredas formalised at least one BCE. As of June 2019, a total number of 90 BCEs, consisting

[75] National Framework for Private Sector Development under Public-Private Partnership (PPP) in Ethiopian Biogas Sector, January 2016
[76] SNV Presentation on Bio-digester Technology & the Programme. April 2021.
[77] Ethiopia, institutionalising bio-digester private sector development. SNV publication, no date.

of 339 members have been formalised in the region using the trade category of 'biogas businesses recently included in Ethiopian Standard Industrial Classification (Ministry of Trade). This is facilitated by the Technical and Vocational Education Training (TVET) and Enterprise Development Office. A private sector association has also been recently established in Amhara Region.

SNV supports BCEs in business plan preparation and business coaching. SNV has so far supported 11 BCEs in Amhara region and 19 BCEs in other regions in business plan preparation and provided business coaching to owners-managers of BCEs. This, combined with other interventions, tries to contribute to the sustainable development of bio-digester business at the local level.

I.6.3.3 – The demand for and awareness raising actions were adequate.

NBPE+ awareness raising on bio-digester and bio-slurry finds place in many ways: public gatherings, field days, school clubs, etc., for example in the third year of the programme[78], 26 of these sessions were organised. SNV also organised one national festival on biogas and bio-slurry. The awareness development sessions were frequently organised in new programme regions targeting different partners, pastoral and agro-pastoral communities, students, Kebele leaders, model farmers and potential households. The basic information on bio-digester (benefits, and requirements) is communicated during the awareness development sessions. As a result of such continuous awareness development efforts, the demand for bio-digesters among the rural communities of Ethiopia is improving from time to time.

There are also sensitisation workshops at region level to improve the responsiveness, cooperation and commitment of regional government to the bio-digester technology. Accordingly, 9 sensitisation workshops (64 % of the plan) were held to concerned stakeholders on the programme challenges in the regional context. The workshops were held in all new programme regions (Afar, Gambella, Benishangul-Gumuz and Somali). This has happened because the regional stakeholders in these programme regions were less aware about bio-digester technology and also the challenges to scale-up the technology in these emerging regions were tough. It also helped the participants to enhance their awareness on various biogas programme issues, roles and responsibilities of implementation partners in programme implementation, finance and credit management, and procurement administration.

Orientation/Awareness creation workshops were conducted for more than 60 potential users at five different potential areas (Amhara=2, Tigray=1, SNNPR=1, Oromia= 1) for promotion of larger size bio-digester.

These awareness raising activities and some others are essential for the promotion of the programme and they are adequate in the sense that it is the most direct way to reach out to potential beneficiaries and users of the technology. However, there are many gaps in this awareness, for example, in the Gambella energy office, the evaluator has been informed that there are higher government officials and politicians that do not know "what biogas is". Similarly, there are many farmers that do not know about the biogas. That means additional promotion and awareness creation to farmers and officials in the new regions is still needed.

I.6.3.4 – The procedures and processes were streamlined and did not impose undue delays or costs.

The processes are streamlined and clear to all implementation partners, however, it does not mean that they are followed, such as is apparently the case with quality control. The large amount of procedures and rules are on one hand caused by the large and complex institutional structure of the country and on the other hand due to the type of technology being promoted ("brick-and-mortar") that requires many checks and balances to be implemented properly.

[78] Interim Narrative Report Year 3 - Period: April 12, 2019 to April 11, 2020. SNV.

I.6.3.5 – Is there a market without donor or government inputs?

Under the different phases of the NBPE the programme has been operating for 12 years and at the moment there is no market without donor or government inputs and the market that exists needs to be constantly massaged and stimulated, otherwise it would collapse. So, the answer is negative.

**Conclusion: the JC is validated**: The NBPE+ contributed to addressing market weaknesses and stimulating private sector involvement. Nevertheless the programme is not sustainable without GoE and/or donor funds.

### 3.6.4. JC 6.4 - Degree to which carbon credits can foster the sustainability of the biogas sector.

**Indicators:**
I.6.4.1 – Assess plans to get carbon credits.
I.6.4.2 – Is the intended use of carbon credits likely to support the sustainability of and the continuation of a biogas sector?

I.6.4.1 – Assess plans to get carbon credits.

Carbon finance is a general term applied to resources provided to projects that are generating or are expected to generate greenhouse gas (GHG) emission reductions in the form of the purchase of such emission reductions which are tradable on the carbon market (over USD 100 billion annually[79]).

The Development Bank of Ethiopia is the Coordinating and Managing Entity of the Ethiopia Clean Cooking Energy Program of Activity ("Program Entity") executes an emission reduction purchase agreement ("ERPA") with the International Bank of Reconstruction and Development (IBRD) in its capacity as trustee ("Trustee" of the carbon fund of the Carbon Initiative for Development (Ci-Dev). Under Ethiopia Clean Cooking Energy Program of Activity (PoA), household bio-digesters implemented under National Biogas Program are included as eligible sub project activities, with the Ministry of Water Irrigation and Energy as implementation entity.

The PoA "Ethiopia Clean Cooking Energy" was registered on March 18, 2016 under the UNFCCC. The Coordinating and Managing Entity owns all certified emission reduction (CER) generated under the PoA. The Agreement Period is seven (7) years Crediting Period, which may be renewed twice, adding up to a total maximum Credit Period of twenty-one (21) years.[80]

Bio-digesters installed from January 2015 are included in the PoA, crediting period starting April 2016. Monitoring, Reporting and Verification of the first 2 years (April 2016 - March 2018) has been completed for 4,475 digesters installed from 2015 to the first quarter of 2017. First issuance already done with CER of 34,880 tons, which translate to about USD 390,000. This is first ever CER issuance for Ethiopia[81].

The 2nd round of Reporting for the period of Apr 2018 to Dec 2019 is for 16,142 digesters installed from 2015 to 2019. The actual CER amount to be claimed is calculated as 72,000 tons, compared to the estimate of 175,000 in the registered PoA and 141,000 in the delivery schedule of the signed ERPA between the World Bank and the Government of Ethiopia[82].

[79] Carbon Finance Guide for Local Governments, 2009; World Bank

[80] Carbon Fund of the Carbon Initiatives for Development CDM Sub-Project Agreement Ethiopia Clean Cooking Energy Program of Activity by and between DBE and MoWIE, 2016

[81] Interim Narrative Report Year 3 - Period: April 12, 2019 to April 11, 2020. SNV.

[82] Interim Narrative Report Year 3 - Period: April 12, 2019 to April 11, 2020. SNV.

**Table 30 – Number of bio-digesters certified in the two verification rounds[83]**

| Period | Oromia | Tigray | SNNP | Amhara | Somali | Afar | Gambella | Benishagul-Gumuz | Total |
|---|---|---|---|---|---|---|---|---|---|
| 2015 | 285 | 671 | 427 | 557 | | | | | 1,940 |
| 2016 | 606 | 402 | 555 | 593 | | | | | 2,156 |
| 2017 Q1 | 146 | 47 | 56 | 128 | | | | | 377 |
| Total under CPA 1 | 1,037 | 1,120 | 1,038 | 1,278 | | | | | 4,475 |
| 2017 Q2-Q4 | 609 | 243 | 250 | 783 | | | | | 1,885 |
| 2018 | 764 | 502 | 113 | 1,183 | 42 | 5 | | 18 | 2,627 |
| 2019 | 693 | 635 | 386 | 2,152 | | 28 | 9 | | 3,903 |
| Total under CPA 2 | 2,066 | 1,380 | 749 | 4,118 | 42 | 33 | 9 | 18 | 8,415 |

*CPA – CDM Programme Activities*

Other than malfunction, another possible reason that a bio-digester is excluded from emission reductions calculation/generation is lacking sufficient monitoring data. In other words, a working bio-digester may not be able to be included in the monitoring report if it does not have proper monitoring data that meets CDM verification requirement. In any case it seems that the amount of carbon credits to be registered is lower than planned.

I.6.4.2 – Is the intended use of carbon credits likely to support the sustainability of and the continuation of a biogas sector?

Domestic bio-digesters potentially reduce GHG emissions with 1.7 to 5.9 tonnes $CO_2$eq per plant per year, depending on the local conditions where the bio-digesters are located, especially the (non)-availability of sustainable firewood[84]. An estimate shows that 16,142 bio-digester installations, made during 2015-2019 period can bring USD 861,176/year of carbon finance through the Ci-Dev ERPA, assuming a functionality rate of 77%[85]. As it can be seen above, the revenue amount is going to be lower.

A carbon fund has been established and designated under NBPCU/MoWIE. This fund is named as the "NBPE/MoWIE Clean Cooking Carbon Fund". The funds will allow for a subsidy, reducing the sale price for consumers, and support a performance-based maintenance incentive. All the CER revenues will be collected by DBE and the revenue generated will be transferred from DBE to NBPE/MoWIE Clean Cooking Carbon Fund account. NBPCU transfers:

a) 27% of the fund to the RBPCU, RBPCUs transfer it to the Households for repair and "maintenance[86]" either directly or through other mechanisms like using BCEs, Woreda Energy offices etc.
b) 73% of the revenue is used for the contribution to investment cost (subsidy) for the new bio-digester technology users, according to the ERPA. The transfer of this fund will follow the above system as well.

**Users Benefit Plan**: the sustainable operation of the bio-digester technology depends on its regular repair and maintenance. In this context the support for AfSS can be better options to provide benefits to users. AfSS is conducted by the mason or BCEs for the first two years of the bio-digesters lifetime.

83 Source: Personal communication with Mrs. Peng Liu from the World Bank, July 1, 2021.

84 Domestic biogas projects and carbon revenue; A strategy towards sustainability? Felix ter Heegde, May 2008.

85 Interim Narrative Report Year 3 - Period: April 12, 2019 to April 11, 2020. SNV

86 This is a euphemism, as a well-constructed bio-digester has no need for any major repair and the maintenance cost is virtually zero. What it is meant is the rehabilitation of non-functioning bio-digesters that have been poorly constructed. The word that should be used is "rehabilitation", which is also the word commonly and correctly used by SNV.

To provide the repair and "maintenance" of non-functioning bio-digesters there shall be a regular monitoring and checking the status of each bio-digester at RBPCU/Woreda level so that the non-functioning digesters will get repair and "maintenance" within a short period of time.

**Program Management**: Program Management consists of a regular management of the program and management of carbon related activities. Carbon related activities will be executed according to the annual work plan of NBPE/MoWIE.

**Direct Subsidy**: the remaining 73% of the total earned ER revenue is allocated for direct contribution to investment cost (subsidy). The direct contribution to investment cost will be delivered to new bio-digester users as per the National Steering Committee decisions on the investment incentive for bio-digesters.

If the original amounts of carbon credits would be obtained this would very much increase the sustainability of the programme. In any case any amount of revenue from carbon credits can increase the sustainability of the bio-digester market.

**Conclusion: The JC is validated**. The carbon credits to be obtained increase the sustainability of the bio-digester market. The amounts are however not what was expected due mainly to a higher rate of malfunctioning of the bio-digesters and probably inaccurate monitoring of the installations.

### 3.6.5. JC 6.5 - Degree to which the long-term institutional capacity has been strengthened.

**Indicators:**
I.6.5.1 – Has the activity, its design and its implementation been embedded in participating government structures and their capacity strengthened?
I.6.5.2 – Have follow-on activities (by the GoE, regional governments, other donors) resulted from the NBPE+ intervention?

I.6.5.1 – Has the activity, its design and its implementation been embedded in participating government structures and their capacity strengthened?

The activity has been embedded by design and by implementation in existing government structures. The NBPCU is part of the MoWIE and the RBPCUs are embedded in the regional energy bureaus. The capacity of these NBPE+ organisations has been strengthened, however, due to the high turn-over of staff the sustainability of these capacity efforts is not guaranteed.

I.6.5.2 – Have follow-on activities (by the GoE, regional governments, other donors) resulted from the NBPE+ intervention?

The MoA has been getting more and more involved in the NBPE+ by recognising the importance and stimulating their regional offices to get more involved in the promotion of the use of bio-slurry. Regional governments recognising the large social and environmental benefits of the use of bio-digesters have been putting extra financial resources into the programme. Donors are preparing some follow-up actions like the use of large-size bio-digesters linked to the agricultural value chain[87]. Also the approach followed by NBPE+ for large-scale bio-digesters has been reproduced in other countries in the region (see EQ7).

**Conclusion: the JC is partly validated.** The long-term institutional capacity has been strengthened, however the sustainability is not fully guaranteed. Nevertheless, the NBPE+ and its former phases have capacitated and increased the knowledge of government staff about the biogas market and

[87] Personal communication of Mr. David Otieno, Proramme Manager of ENDEV-GIZ, on June 2, 2021.

even though they have been put in different places in the institutions they still are aware of the large impacts and benefits of the technology.

### 3.6.6. JC 6.6 - Is a bio-digester programme financially sustainable (beyond donor/GoE grants + subsidies)

**Indicators:**
I.6.6.1 – Will there be a bio-digester market without a programme fostering it?
I.6.6.2 – Will there be a market without investment subsidies?
I.6.6.3 – Will there still be a financing mechanism for bio-digesters?
I.6.6.4 – Is the bio-digester construction sufficiently attractive for masons and BCEs?

I.6.6.1 – Will there be a bio-digester market without a programme fostering it?

The very high programmatic and technical assistance costs are related to the kind of technology used. The only bio-digesters that until recently when well-constructed have proven to be reliable are the fixed dome models. However, because the technology is built on-site this will always be an obstacle for the complete commercialisation and market orientation and consequently of the sustainability of any biogas programme. This has changed and now there are in the market reliable and proven technologies that are being disseminated without a programme, purely on a commercial basis. However, in Ethiopia is doubtful if this could happen without subsidy, due to the very low income of most farmers.

I.6.6.2 – Will there be a market without investment subsidies?

Programmatic costs are only one way of looking at the issue of sustainability. The general question is, whether the support structures that have been developed for the programme can be down-scaled the moment that there is a critical mass achieved of satisfied users, awareness of the benefits of the bio-digester technology and enough choice of qualified masons and BCEs to supply the technology. This critical mass has not been achieved.

This means that many of the stakeholders involved in the programme will cease to have an active role, and/or will have internalised the costs of their assistance in their own operation, and/or the government is financing some costs from its own budget, this being amply justified by the large economic, social and environmental benefits of the biogas programme and or the programme finds an external source of financing like the Clean Development Mechanism emission reduction credits to finance the subsides and some manageable form of overall quality control, so that users are protected and the expansion of the technology is not undermined. So, the answer is that there will not be a market without investment subsidies, however this market could be closer with a different kind of bio-digester technology.

I.6.6.3 – Will there still be a financing mechanism for bio-digesters?

Apart from external donor financing and government contributions, a possible financing mechanism is the utilisation of carbon credits generated by the bio-digester installation at least to support investment subsidies.

Access to finance has been an important factor in the adoption of bio-digester technology. At the user s' level MFIs were disbursing loans for potential bio-digesters users to ease financing the up-front costs of the installations. This financing activity is suffering from challenges that caused by the lack of collateral from users, low repayments rates due to low functionality, awareness gap and low commitment of MFI staff. This has made the loan administration cost higher to MFIs and as a result the sector is becoming less attractive to them.

I.6.6.4 – Is the bio-digester construction sufficiently attractive for masons and BCEs?

The very low retention rate of masons shows that the business is not attractive to them. BCEs have slowly becoming more a reality in many regions, but they can only work because many costs are not internalised in their operations, such as promotion.

**Conclusion: the JC is not validated**. The bio-digester programme is not financially sustainable (beyond donor/GoE grants + subsidies).

## 3.7. EQ7 – Impact perspectives

**EQ7: Which outcomes have already been achieved (i.e. are the NBPE+ outputs being used by the partner and other stakeholders and in what way) and their likely impact? Which outcomes may still be achieved?**

Rationale: The possible long-term impacts of the NBPE+ are to be determined by the degree of achievement and sustainability of the outcomes of the programme. The link between outcomes and impact is one of the most difficult to provide factual evidence for, because it is a forward looking exercise. If in any case one can prove the achievement of the outcomes and its likely sustainability (EQ6) one can go a long way in assuming that the impact is and will be there.

Just as a recap the overall objectives of the NBPE+ which coincide with the outcomes of the programme are:

- To improve the living standards of targeted farmers and their families, in the Ethiopian regions of Afar, Amhara, Benishangul-Gumuz, Gambella, Oromia, Southern Nations, Nationalities & People's Region (SNPPR), Somali and Tigray.
- To reduce the overexploitation of biomass cover in the 8 regions and to reduce Greenhouse Gas (GHG) emissions.
- To develop 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 above has led to the following JCs:
JC 7.1 Degree of appropriateness of the outcomes.
JC 7.2 What external factors have (or can still) foster or jeopardise the trajectory of the programme outcomes.
JC 7.3 Have there been unintended outcomes.
JC 7.4 Has the policy/strategy process been improved by the activity.

Link with OECD/DAC evaluation criteria: The EQ addresses impact (the degree to which the programme is enabling market based instruments that can be replicated without grant funding).

Link with IL: The EQ focuses on the logical links related to how the grants provided to support the programme lead to physical investments (outputs) and to establishing a self-replicating market-based mechanism (outcomes).

**Box 8 – Summary answer for EQ7**

1. The outcomes were –not all- appropriate and well-defined by design at the beginning of the programme but they cannot be all considered realistic. The implementation is failing in many aspects and it will be unlikely that all outcomes will be realised. The quality of the evidence is strong.

2. There was no evidence about the effect of external factors on the outcomes of the programme. The samples were done in six regions, the remaining two regions were not visited for security reasons, so one cannot say anything with certainty, but it is likely that the security situations is influencing the outcomes of the programme in those regions. The quality of the evidence is indicative.

3. There have been some positive unintended outputs/outcomes that were not planned at the beginning of the programme. The quality of the evidence is strong.

4. The national and regional policy for the biogas sector has not been improved. The inclusion of some bio-digester construction targets in some policy documents is a positive sign, likewise the interest of the MoA. Amhara and some other regions are increasingly owning and co-financing the programme, but this is not the result of some change in policy, but in the future this might happen. The quality of the evidence is strong.

**Conclusion**: The living conditions of a considerable number of families have been improved although less than planned. The reduction of GHG is probably also less than assumed, not only because of the high rate of non-functionality, but also because many bio-digesters have been disseminated in areas where the shortage of firewood is not acute and the firewood is grown sustainably. There have been a number of outputs/outcomes not previously planned. Although the programme has been working in developing a viable bio-digester sector embedded in an enabling policy environment, this has not yet been achieved. It is unlikely that the outcomes will be achieved in the remaining time of the NBPE+, so the likely impact of the programme will be less than usually assumed.

### 3.7.1. JC 7.1 - Degree of appropriateness of the outcomes.

**Indicators:**
I.7.1.1 – Were the outcomes that were suggested at the beginning of the programme realistic?
I.7.1.2 – Are they still realistic and will be achieved?

The EU sustainable energy cooperation through the NBPE+ aims at creating outputs that will lead to the following outcomes (two additional outcomes are not analysed in this evaluation):

- **Outcome 1: A total of 180,000 rural people** are supported for and own 36,000 bio-digesters. By the end of 2020 this number should be 17,190.
- **Outcome 2: Improved affordability of bio-digesters** with access to credit and improved gender balance and pro-poor orientation.
- **Outcome 3: Sector capacity development** expedited for a sustainable domestic bio-digester sector with private sector development and engagement of other partners (in order to implement and maintain the policies and reforms and ensure transparent and inclusive governance, which in turn are dependent on: i) well informed biogas sector studies; ii) raised stakeholder awareness and iii) trained and capacitated staff and of public and private institutions).

I.7.1.1 – Were the outcomes that were suggested at the beginning of the programme realistic?

The objective of 36,000 bio-digesters seemed realistic. Increased affordability was to be obtained by increased access to credit and lower the costs of the bio-digester, both seemed realistic.

As discussed under EQ3, 4 and 6 the improved gender balance was well intended but not that realistic, in the face of what the NBPE+ was able to influence. Gender balance has been an objective throughout the programme implementation, but a programme cannot change by itself deep rooted cultural gender balances. The programme developed initiatives in capacity development where women were always targeted. As illustrated in the Systems Change Model below**,** capacity development interventions may facilitate structural and transformative systemic change by supporting the development of policies, practices and resource flows; acting as catalysts for relationships, connections, and power dynamics between the actors in the system; and helping them to gradually transform their beliefs and behaviour, in order to adapt to the evolving context, but they are no guaranty for change.

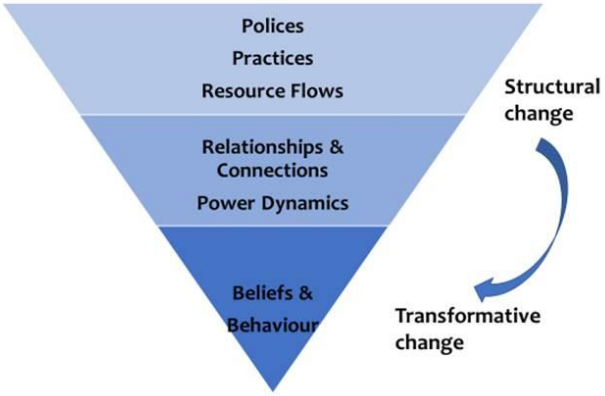



*Figure 96 – Capacity development as an instrument to promote transformative systemic changes[88].*

A point where it could have had more success was in the gender structure of the several government implementation agencies, but here again this is a male-dominated environment. As also analysed in EQ4 and 6, the NBPE+ by the nature of the target group cannot be considered a pro-poor programme.

The outcome of a sector capacity development expedited for a sustainable domestic bio-digester sector with private sector development and engagement of other partners (in order to implement and maintain the policies and reforms and ensure transparent and inclusive governance), was realistic because the EU is putting a very large amount of resources to attain this objective. However, looking at what had been achieved in private sector development in all the previous phases, it might not have been that realistic.

I.7.1.2 – Are they still realistic and will be achieved?

Considering that at the end of 2020 the number of bio-digesters build was 10,906 and that this number should have been 17,190 the original objective of 36,000 bio-digesters does not seem realistic now. This was partly caused by the COVID-19 pandemic during 3 quarters of 2020, but the main cause is the lack of performance of the new regions.

Increased affordability can be primarily obtained by massive increases in the construction of bio-digesters, this is not happening the numbers are not increasing by those amounts that could lower overheads and increase efficiency of construction and moreover the costs of cement is increasing disproportionally. Cluster approach can partly help lower overheads, but it is not sure that this would translate in lower bio-digester costs as the profit margins at which most BCEs operate are not large. Access to credit would facilitate people's access to bio-digesters, but is generally weak in rural areas. MFIs aim to lower the bar, by using social cohesion and social control as back-up mechanisms for reimbursement (replacing collateral). An evaluation[89] at the end of ABPP II showed that despite a range of efforts made, ABPP was not able to generate significantly more access to credit and this is also not likely in Ethiopia, where due to low repayments rates some MFIs are withdrawing from bio-digester credit provision. Some regions of Ethiopia do not even promote access to credit within the programme.

Considering the gender and pro-poor aspects they were not very realistic at the beginning of the programme, they are not realistic now and they will not be achieved. The gender aspects have been already thoroughly discussed in EQ3, 4 and 6.

88 From: The Water of Systems Change by Kania, Kramer & Senge, FSG 2018

89 Africa Biogas Partnership Programme (ABPP) - Phase II Effect Evaluation. Final Report, May 13, 2019

As also discussed in other EQs, biogas programmes, especially in a market-oriented set-up, do not automatically contribute to "leave no one behind". People need to have at least a couple of cattle for operating the bio-digester, and need to have financial resources to make the up-front investment. Observations during field visits confirmed the impression that many bio-digester owners are not poor, by Ethiopia rural standards. Yet, many of the "wealthier" bio-digester owners may still be considered "poor" from a global perspective.

The achievement of a sector capacity development to expedite a sustainable domestic bio-digester programme is yet not realistic and it is doubtful whether it will be realised.

**Conclusion: the JC is not validated**. The outcomes were –not all- appropriate and well-defined by design at the beginning of the programme but they cannot be all considered realistic. The implementation is failing in many aspects and it will be unlikely that all outcomes will be realised.

### 3.7.2. JC 7.2 - What external factors have (or can still) foster or jeopardise the trajectory of the programme outcomes?

**Indicators:**
I.7.2.1 – Political factors.
I.7.2.2 – Regional instability.
I.7.2.3 – Other.

There was no evidence about the effect of these external factors on the outcomes of the programme. The field mission could not go to a substantial amount of the sample areas in the country, but one cannot generalise this to the country conditions. The samples were done in six regions, the remaining two regions were not visited for security reasons, so one cannot say anything with certainty, but it is likely that the security situations is influencing the outcomes of the programme in those regions.

### 3.7.3. JC 7.3 - Have there been unintended outcomes?

**Indicators:**
I.7.3.1 – In the programme itself
I.7.3.2 – By other development partners.
I.7.3.3 – Other private sector initiatives in the biogas for households sector.

I.7.3.1 – In the programme itself

After some years of working together to integrate the bio-digester programme with dairy, SNV dairy project (BRIDGE) leadership realised that BRIDGE project should be seeking the bio-digester technology and hence, contacting the NBPE+ staff and not the other way round. This is because of the recognition that bio-digesters are an appropriate technology for all dairy farmers, to manage the huge pile of dung, and also address other issues like energy (including for milk processing) and fertiliser (bio-slurry for fodder production). Earlier, NBPE+ staff was pursuing BRIDGE staff, at times, without much result. The situation is changing fast. With the above change, attempts are being made in SNV, to develop a dairy project with bio-digester component.

Virtual but effective learning/sharing platforms (with use of Telegram, a social media like WhatsApp) with hundreds of people, have been established with two themes – namely: (i) bio-slurry promotion, and (II) private sector development. There other Telegram Groups too, for federal and regional level communication and learning. Here, a short description of the Private Sector Telegram Groups[90]:

[90] NBPE+ Year 3 Narrative report.

- Telegram Group on Bio-digester Private Sector Team created. The major members (as of April 2021, 172) are owner-managers of BCEs and experts (Woreda, zone and regional level). The main benefits of creating this channel are: (i) sharing information (including pictures, videos documents, and case studies) on private actors' progress mainly BCEs and lessons learned, (ii) increasing members' interaction (i.e. bio-digester private sector/actor and support team).
- The Bio-slurry Telegram Group has 208 members (Spring 2021). Due to the COVID pandemic, SNV promoted better use of technology to improve communication, during this difficult time. The result is fascinating as people, including government experts across the country learn and share on the programme, biogas and bio-slurry posting their work and achievements.

Use of bio-slurry for seed dressing to facilitate seed germination, which came up as an idea and got piloted successfully, now being promoted all over the country, has been another very important unintended outcome. Seed dressing by bio-slurry improves the seedlings resilience against diseases and promotes healthier and faster growth, leading to better yield. This way of bio-slurry use was not envisaged before.

Another unintended outcome was the use of bio-slurry to grow pasture grass and then in turn to fattening livestock in the dry season, the use of bio-slurry to protect agricultural crops from pests, and the creation of income sources by selling bio-slurry.

I.7.3.2 – By other development partners.

Some development partners have discussed about expansion of the 'larger size bio-digester piloting' with use of the modality, design and capacity to address urban sanitation problems. Also the follow up phase of DGIS ABPP, now called Africa Biogas Component, as part of the EnDev, has a strong component on medium (larger) size bio-digesters in Kenya. It is a EUR 6.7 M budget for this medium (larger) size bio-digesters component in Kenya and it is funded by Danida, while the rest of the African Biogas Component in 5 African countries is being funded by DGIS (EUR 25 M).
This is definitely a not-so-intended outcome of the larger size bio-digester component in NBPE+. The piloting in Ethiopia is the first in its kind in Africa or even other countries, with a unique market based approach.

I.7.3.3 – Other private sector initiatives in the biogas for households sector.

Concerning other private sector initiatives in the biogas for households sector, nothing concrete to be mentioned yet.

**Conclusion: the JC is validated.** There have been some positive unintended outputs/outcomes that were not planned at the beginning of the programme.

### 3.7.4. JC 7.4 - Has the policy/strategy process been improved by the activity?

**Indicators:**
I.7.4.1 – Evidence of changes in national policy / strategy.
I.7.4.2 – Evidence of changes in regional policy / strategy

The policy process has not been improved, the biogas sector is considered to be part of the renewable energy sector and no specific policy for the biogas sector has been developed. Concerning the strategy, bio-digester targets have been included in the main plans of the GoE. (See also EQ1, 2 and 6). The MoA issued letters to all eight regions promoting the use of bio-slurry during agricultural seed sowing. One household bio-digester owner was informed to share bio-slurry to ten farmers who have no household bio-digester. This however is not a strategic change as no budget has been attached to these activities.
The same applies for the regional policy/strategy related to biogas.

**Conclusion: the JC is not validated**. The national and regional policy for the biogas sector has not been improved. The inclusion of some bio-digester construction targets in some key documents is a positive sign, likewise the interest of the MoA.

## 3.8. EQ8 – Coordination, complementarity and added-value.

**EQ8: To what extent the EU intervention in the biogas sector is coordinated, complementary and of added value, and brings additional benefits to what would have resulted from Member States' interventions only?**

Rationale: Aid and investments in sustainable energy have significantly increased in Ethiopia in the last decade and donors and multilateral financing institutions have multiplied their interventions and instruments of support. However, achieving the SE4All and SDGs goals will still require large contributions. In this complex context with multiple actors, ***coordination*** with EU Member States (MS) and other development partners (DP) at country levels, as well as ***complementarity*** with actions of EU MS, are essential to ensure the effectiveness of sustainable energy cooperation. This has led to the following JCs:
JC 8.1 Degree to which EUD support to the biogas sector contributed to policy and operational coordination mechanisms.
JC 8.2 Degree to which EUD biogas programme within the sustainable energy agenda was complementary with MS' actions.
JC 8.3 Degree to which EUD support to the biogas sector has added valued compared to MS interventions.
JC 8.4 Degree to which the EUD intervention is visible.

Coverage: The EQ addresses policy and operational coordination, complementarity, and added-value of the intervention.

Link with OECD/DAC evaluation criteria: The EQ addresses the relevance, efficiency, effectiveness, and sustainability criteria.

Link with IL: The question focuses on the links between EU interventions areas and other donor strategies and actions, with a focus on MS.

**Box 9 – Summary answer for EQ8**

1. EUD took an active role in developing strong mechanisms for sustainable energy cooperation and coordination at policy and operational level. EUD was also actively involved in existing coordination groups. The NBPE+ is a concrete intervention, which the EUD can utilise in the coordination in these dialogue platforms. The quality of the evidence is more than satisfactory.

2. The evidence showed good complementarity between EU and MS actions as informed by the different energy sector interventions and other forms of division of labour. Furthermore, EU complementarity also involved the principle of inclusiveness of other DP. The quality of the evidence is strong.

3. There is evidence that EU support demonstrated significant value added. EU facilitated a joint greater effort of the EU and Members States towards sustainable energy. At operational level the EU initiatives added value in bridging financial gaps and scaling-up impacts. The quality of the evidence is more than satisfactory.

4. Despite minor improvements to be realised, the NBPE+ initiatives were visible and the project complies with visibility contracts. The quality of the evidence is more than satisfactory.

**Conclusion:** The EU intervention in the biogas sector is coordinated, complementary and of added value, and brings additional benefits to what would have resulted from MS interventions only.

### 3.8.1. JC 8.1 - Degree to which EUD support to the biogas sector contributed to policy and operational coordination mechanisms.

**Indicators:**
I.8.1.1 – Evidence of NBPE+ involvement and contribution to coordination at policy level.
I.8.1.2 – Evidence of NBPE+ involvement and contribution to country coordination groups/mechanisms.
I.8.1.3 - Can or could similar changes have been achieved without NBPE+ action, or did EU programme make a difference?

I.8.1.1 – Evidence of NBPE+ involvement and contribution to coordination at policy level.

The NBPE+ has been involved in working with the MoWIE in trying to influence their policy and putting the biogas sector more prominent in their renewable energy policy. The GoE however, finds that the renewable energy policies already included in the general energy policy are sufficient and that the biogas sector is enough covered by those policies. Nevertheless the NBPE was able to influence and be mentioned in the GTP I and II, with concrete targets to be achieved. The CRGE strategy mentions the reduction of firewood via the dissemination of clean cooking alternatives. The NBPE+ has been pushing and achieving some success in getting the MoA to acknowledge the importance of bio-slurry as a high quality fertiliser, but this has yet not been translated into policy or in budget allocations.

At regional level the NBPE+ has been deeply and firmly involved and is coordinating with the Regional Bureaus of Energy. The regions acknowledge the importance of biogas in their development efforts and are contributing with significant amounts from their own resources to the programme. So, while there is progress that there has been no firm success at influencing policy at the national level. At regional level the coordination (not on policy but more on the implementation level) is very good.

I.8.1.2 – Evidence of NBPE+ involvement and contribution to country coordination groups/mechanisms.

The EUD is involved in the Energy Sector Development Partners Forum where at the highest level donors coordinate their interventions with the government.

It is estimated that since 2010 the Government has received USD 2.3 billion of external financing earmarked for climate change[91]. The GoE engages DP operating in the country in the preparation, implementation and monitoring of the broader development plans and strategies through various dialogue architectures. The Government and the Development Assistance Group have established joint dialogue fora to facilitate and create synergy on Government and DP development efforts. The most important related to the NBPE+ are the Sector Working Groups which bring together the Government and DP at the sector level to discuss and address sectorial policy and programme issues. These sector groups play a critical role to ensure the effectiveness of development cooperation by safeguarding that aid is fully aligned to sectorial plans and strategies, thus ensuring the ability of the national plan to deliver results. Forums serve as a discussion platform to promote the exchange of information and guide informed policy dialogue and programmatic efforts. So, via the EUD the NBPE+ is involved in the discussions of these coordination mechanisms and platforms

91 Action Document for Climate Change Sector Reform Performance Contract in Ethiopia. EUD.

which contribute to an increased coordination at policy level, measured by trust, political and financial commitments as well as harmonisation between EU and MS.

Recently the Development Assistance Group committee approved the proposal submitted by the EU and Norway for a new working group named "Climate Resilient Green Economy (CRGE) Forum" which aims to serve as a discussion platform to promote the exchange of information and facilitate dialogue and programmatic efforts in relation to the CRGE. The forum is also relevant for informing and guiding future efforts such as the GTP III. The position and design of the CRGE Forum allows it to play a critical role in ensuring the effectiveness of development cooperation within the CRGE sector.

The NBPE+ assisted with coordination at country level, through studies, such as biogas users' surveys, bio-slurry use plans, private sector reinforcement, etc., which provided a framework for donor coordination. The coordination mechanisms and platforms contributed to an increased coordination at policy level, measured by trust, political and financial commitments as well as harmonisation between EU and MS.

I.8.1.3 – Can or could similar changes have been achieved without NBPE+ action, or did EU programme make a difference?

It is evident that these coordination efforts take place independently of the NBPE+, but this programme provides the EUD with data and concrete policy lessons-learned that is exchanged in these fora.

**Conclusion: the JC is validated.** EUD took an active role in developing strong mechanisms for sustainable energy cooperation coordination at policy and operational level. EUD was also actively involved in existing coordination groups. The NBPE+ is a concrete intervention, which the EUD can utilise in the coordination in these dialogue platforms.

### 3.8.2. JC 8.2 - Degree to which EUD biogas programme within the sustainable energy agenda was complementary with MS' actions.

**Indicators:**
I.8.2.1 – Absence (or instance) of overlap and duplication of the EU programme with EU Member States activities.
I.8.2.2 – Instance (or absence) of synergies between the EU support and support from EU MS.
I.8.2.3 – Can or could similar changes have been achieved without EU action, or did EU action make a difference?

I.8.2.1 – Absence (or instance) of overlap and duplication of the EU programme with EU Member States activities.

The EU is already supporting the Ethiopian Climate Change agenda through relevant complementary actions, notably in climate change mitigation and adaptation, the most relevant for the NBPE+ being:

- *RESilience Building Programme for EThiopia (RESET)* is implemented in 41 Woredas and includes the promotion of natural resource management, climate change adaptation, and disaster risk management.
- *Energising Development* programme which aims at disseminating improved cookstoves, increase number of public institutions with solar PV for electric services and increase the number mini-grids providing electricity services in off grid's villages.

The complementarity between EU and MS has been sufficiently well analysed at programming stage and there is no overlap or duplication of efforts.

I.8.2.2 – Instance (or absence) of synergies between the EU support and support from EU MS.

Besides that the NBPE+ does not duplicate any EUD intervention, the participation in the above mentioned dialogue platforms ensures that there is no duplication of efforts between the EU and the MS. The participation of the EUD in the Energy Sector Development Partners Forum is very important for the coordination and synergies with other donor programmes. A matrix of donors' interventions in Ethiopia in the energy sector[92] shows many programmes targeting the clean cooking sector, but there is not a single bio-digester programme. So, there is not overlap of activities of the NBPE+ with other MS programmes and in general with other DP, and the evidence showed a good division of labour between the EU and other DP.

I.8.2.3 – Can or could similar changes have been achieved without EU action, or did EU action make a difference?

The EU action made a difference concerning the continuation of the NBPE and of giving the resources that were intended to make the biogas sector more sustainable. Complementarity with other MS actions could not have been achieved without the NBPE+ intervention.

**Conclusion: the JC is validated.** The evidence showed good complementarity between EU and MS actions as informed by the different energy sector interventions and other forms of division of labour. Furthermore, EU complementarity also involved the principle of inclusiveness of other DP. Quality of evidence: strong/more than satisfactory.

### 3.8.3. JC 8.3 - Degree to which EUD support to the biogas sector has added valued compared to MS interventions.

**Indicators:**
I.8.3.1 – Presence (or absence) of examples where the required support was of a scale or nature that could not be supported as well by MS.
I.8.3.2 – Evidence that EU programme has filled a gap not met by MS interventions. Potential gaps to be investigated: geographical i.e. regional in Ethiopia, technological, financial, and within the energy for cooking area of intervention.

I.8.3.1 – Presence (or absence) of examples where the required support was of a scale or nature that could not be supported as well by MS.

The required support was of a nature that could not / would not be supported by other MS. The total budget of the ABPP II for 6 countries from 2014 to 2017 was EUR 27 million, of which EUR 22.6 million by DGIS (EUR 20.1 million for Phase II plus EUR 2.5 million balance of Phase I, the remaining balance coming from several other sources[93]. The NBPE+ support from the EU was of a comparable scale and was intended to push the NBPE towards a sustainable private sector market. No other donor was at that time willing to come up with such an amount of resources.

I.8.3.2 – Evidence that EU programme has filled a gap not met by MS interventions. Potential gaps to be investigated: geographical i.e. regional in Ethiopia, technological, financial, and within the energy for cooking area of intervention.

[92] Energy Sector Development Partners Forum - Matrix of Support Programs. Support to the Off-Grid Sector – *Version 22 April 2021.*

[93] Africa Biogas Partnership Programme (ABPP) - Phase 2. Effect Evaluation. Final Report, May 13, 2019

Other MS were not willing to fill the gap in the modern energy for cooking services in Ethiopia, not with this technology and not with this amount of resources. Many other donors had activities in the modern energy cooking sector, but limited to improved cookstoves[94].

The EU initiative added value that leveraged political commitment that already existed from previous phases of the NBPE, strengthened policy dialogue, leveraged financial commitments, and skills as well as increasing results and impacts.

**Conclusion: the JC is validated.** There is evidence that EU support demonstrated significant value added. EU facilitated a joint greater effort of the EU and Members States towards sustainable energy. At operational level the EU initiatives added value in bridging financial gaps and scaling-up impacts.

### 3.8.4. JC 8.4 - Degree to which the EUD intervention is visible.

**Indicators:**
I.8.4.1 – Compliance with visibility contracts if any.
I.8.4.2 – Presence or absence of a communication and visibility plan.
I.8.4.3 – Evidence that communication and visibility plans have been implemented successfully.

I.8.4.1 – Compliance with visibility contracts if any.

Effective communication concerning these operations helps raise awareness of the external policies and actions of the EU in its role as a global player, and provides accountability and transparency on the use of EU funds to taxpayers and the citizens of partner countries. The Communication and Visibility Requirements document[95] is meant to ensure that any communication on EU-funded external actions is consistent with the Union's values and political priorities and with other EU-related communication activities and events.

SNV has put in place measures to ensure the compliance with these requirements.

I.8.4.2 – Presence or absence of a communication and visibility plan.

SNV developed a Communication and Visibility Plan[96] following the EU Guidelines and submitted to EUD. It got revised in 2019 with some changes in the way SNV logo is placed vis-à-vis EU and GoE logos.

The communication and visibility plan covers all activities with profile raising opportunity from start-up activities to project completion. It is meant to highlight accomplishments and benefits received by project beneficiaries as a result of the action and those activities leading to the handover of project management to the communities and other local stakeholders. The Plan takes into account considers the EU communications and visibility manual and follows the guidelines for briefings, release of written or electronic materials, interfacing with the press/media, presentations, invitations, setting up of project signs and all other materials that aim to highlight the action and the participation of EU in the project.

I.8.4.3 – Evidence that communication and visibility plans have been implemented successfully.

94 Energy Sector Development Partners Forum - Matrix of Support Programmes: Support to the Off-Grid Sector – Version 22 April 2021.
95 Communication and Visibility in EU-financed external actions - Requirements for implementing partners (Projects). EU, January 1, 2018.
96 Communication and Visibility Plan NBPE+, SNV, 2019.

For any communication SNV includes in documents, reports, signboards, manuals, etc. the EU logo. SNV complies for example with the requirement that it requests persons to sign their consent before pictures and videos are taken. SNV communicates inside SNV, to stakeholders and to outsiders the achievements of the programme in the SNV website, in Telegram, etc.

On the ground the bio-digesters have no sign of the EU funding, but this would not be of any use and have little impact as no one in these isolated places knows what the EU logo signifies. The cluster approach (where there is a high concentration of bio-digesters installed) will allow placing signs along the road with much higher visibility, and that has been done in the past for example in the Wondo Genet village in SNNP.


*Figure 97 - Sign post in bio-digester village of Wondo Genet, SNNP*

But at offices that are supported by the NBPE+ there could have been more prominent a sign on the outside indicating the EU support.

**Conclusion: the JC is validated.** Despite minor improvements to be realised, the NBPE+ initiatives were visible and the project complies with visibility contracts.

# 4. Conclusions and recommendations

The conclusions and recommendation provided here are only those that impact the NBPE+ at macro-level and when implemented would change substantially the *modus operandi* of the programme. Because of this they can be controversial and are worth a profound analysis. SNV in its annual reports often analyses the progress of the programme and provided recommendations at micro-level. The BUS surveys and other programme documents provide many relevant recommendations at micro-level. The 2020 Mid-term Review report also provided plenty of recommendations at this level.

As per the ToR, the evaluation was only asked to look at the first three objectives of the programme. Nevertheless, the analysis could not be done without taking in account some aspects related to the other two objectives.

## 4.1. Conclusions

**C1 – Inclusion of new regions, cost per bio-digester**

C1 - The strongest conclusion of this evaluation is that the extension of the NBPE to the four new regions has been a failure in terms of efficacy, efficiency, limited outreach in terms of numbers of bio-digesters constructed and reputation damage to the programme due to the high rate of non-functionality of bio-digesters in these regions. It is a misallocation of resources that, when used in other regions of the country, could have had a much higher impact in terms of poverty mitigation, gender, health, agricultural productivity, sanitation and local and global environment. The "leave no one behind" might be a good political argument but a not a very programmatic decision. The strongest argument against the inclusion of these new regions is the very limited bio-digester potential, only 3.28% of the total national potential. It is completely understandable that the GoE, for reasons of geographic inclusion, wants to have these regions included, but this is a political decision and something about which the EUD should have been more aware of its consequences. Furthermore, the former ABPP programme management (HIVOS) has alerted to this low potential and numbers were provided by SNV showing that this was not the way to go.

C1 – One benchmark set by the ABPP in 2009 was to reach at the end of the programme period in 2012 a total of programme costs and subsidies of € 450 per bio-digester. Taking into account the different exchange rates of 2011 and 2020, those costs in 2011 were € 537 per bio-digester. The total programme cost in Year 3 of the NBPE+ was € 686 per bio-digester, while the programme cost in the first two quarters of 2020 was € 943 (and unlikely that COVID-19 is the reason for this increase). Devaluation of a currency is often linked to inflation, where the inflation effects are already most likely already discounted in number above. Therefore, against the expected increase in efficiency of the programme, this efficiency has decreased. This conclusion has serious consequences for the sustainability of the programme, because if the institutional set-up continues to be the present one, when external funds stop the GoE and regional governments would have to support these costs. The proceeds from carbon credits are not a solution as they will hardly be sufficient to cover the costs that have been agreed under that support.

C1 – When one considers the programme costs for the new regions, these costs per bio-digester are in Year 3 of the programme, € 1,923 for Afar, € 1,011 for Beninshangul/Gumuz, € 3,023 for Gambella and € 1,381 for Somali. There is not a single plausible justification for these costs, and the argument of equity fails totally as with the unit cost of one bio-digester in Gambella one could have financed 11 bio-digesters in Amhara. Not even the fact that these are new regions is a justification because one is comparing costs at the third year of the programme and a programme that had already many years of lessons-learned and could easily transfer those and also skills to the new regions. In the third year of the ABPP those costs –adapted for exchange rate differences- were € 537, as indicated above.

**C2 – Top heavy government structure, reduced GoE contribution, discarded other possibilities for implementation in new regions.**

C2 – Due to the huge size of the country and the administrative divisions, the NBPE+ has a very complex institutional structure. At federal and regional level, the NBPE+ is paying high staff salaries, office costs, supporting costs. The question in terms of sustainability is whether this is something to keep doing both in terms of functions and in terms of who is paying for it. This institutional structure is not unusual as compared to other biogas programmes, what is unusual is the number of people involved, it is too heavy. For example, the NBPCU is supposed to have 11 paid positions, the National Programme Manager, a Partnership Development Officer, two Biogas Engineers (positions that have been almost permanently vacant, and no one noted the difference) a Planning and Evaluation Officer, a financial head and cashier, 2 secretary, 1 general support officer, 2 drivers and 1 messenger and cleaner. Most of the technical functions have been performed by SNV, but even when this will change it still is not justifiable to have this level of staffing at national level. Also, having 2 cars (1 car equals 20 motorbikes that are highly necessary at Zone and Woreda level to perform real duties) and two drivers is hardly justifiable for the type of functions of the NBPCU. If one argues that the cars are used for quality control (that is not being sufficiently done or not being done properly), the officers mostly fly to the regions and it would be much cheaper to rent a car locally.

C2 – The GoE provided around 50% of total programme costs in the former phases of the NBPE and in NBPE+ it provides around 8.75%. It is difficult to understand that this regression has been accepted for a programme that provides so many benefits for the country and its population and can provide an interesting stream of foreign exchange in the form of the payment for the CERs. It is also difficult to understand this fact in terms of the sustainability of the programme.

C2 - Amhara is piloting an effort to change the institutional approach and empowered Zones to take overall responsibility for bio-digester dissemination. The RBPCU introduced a system for weekly update and holds all responsible bodies accountable. These structures are responsible for installation, capacity development, planning, monitoring, and evaluation, among others. The division of roles and responsibilities and the increased accountability energised RBPCU and regional energy bureau staff to boost bio-digester installation, provided needs-based technical backstopping for Zones and Woredas, and engaged in a periodical monitoring and evaluation. Each Zone is authorised to procure locally manufactured accessories/appliances like stoves and dome pipes.

C2 – When the expansion to the new regions took place it was decided to reproduce exactly the same RBPCU structure. The programme documents mention the possibility of alternative implementation structures the so-called Alternative Implementation Partners, but this was rapidly discarded with the argument that there were no such feasible partners. In these regions there are established NGOs and Community organisations that would not be more difficult to upgrade and train than trying to create a private sector bio-digester construction sector.

**C3 – Rate of functionality lower than desired and acceptable.**

C3 – The rate of functionality is much lower than what has been assumed up to now. This evaluation found (and the sample was very big) in some regions substantial differences with the numbers that are being reported by SNV and that mostly are taken from Biogas Users' Surveys. This conclusion is supported independently by other studies, compare for example the Baseline Survey of 2018 (Table 30) with the BUS of the same year (Table 31). The functionality rates found by the CSC agree in general with the findings of this evaluation or are slightly higher. Any average functionality rate below 95% (a target of the ABPP) is a reputational damage to the NBPE+ and the programme is very far from achieving it. A caveat here is that this evaluation was done in the dry season, where in some regions there was a reduction in the amount of water and dung available to feed the bio-digesters.

**C4 – Quality control not functioning as expected, users not adequately trained (failure of after-sales service), users not properly identified (needs assessment) and/or informed.**

C4 – Technical non-functionality is linked to inadequate capacity of masons who are not able to deliver a high-quality bio-digester. But the NBPE+ has a complex system of quality control (necessary with the type of technology used) that apparently is not working well enough. The first two levels of quality control are crucial (QC1 and QC2) and if one looks at the high rates of non-functionality, this system is not working. Especially QC1 during construction is where at an early stage one still can detect if the dome is finished properly in order to avoid gas leakage, after that only indirectly one could come to this conclusion (less gas produced than what reasonably could be expected). The local Woreda staff gets compensated for these tasks (RBF), but one can doubt about their quality (staff turn-over is high), they have to travel long distances and get paid amounts that according to them are not incentive enough to do the work and some simply lack the motivation. Also one cannot exclude fraud, because only after approval they get compensated, but if they reject the installation besides that they will have to wait for the money, they will have to go again to the same place. The evaluation as even come across cases where the bio-digester was registered in the system as completed and there was no bio-digester at all.

C4 - It has been found that users are not properly trained in the feeding of the bio-digester (it is systematically reported as one cause of non-functionality, but one should be aware that feeding problems can mean many different things), this is both a failure of the initial training that has to be provided by the masons and by Woreda staff who are supposed to provide after-sales service. In fact, there were cases that both the masons and Woreda staff lacked means of transport to follow-up the necessary activities.

C4 – If a user at the least problem with the installation does not inform the Woreda officer as the evaluation has found in a number of cases or does not call the CSC (supposing they have the number) this can indicate that they do not perceive the benefits of the bio-digester or that they don't have real benefits. Often this attitude is linked to: (i) sufficient and easily available firewood, (ii) water is difficult to obtain, (iii) do not value the use of bio-slurry, (iv) have a solar lamp or electricity, (v) don't have enough dung, (vi) can't bake Injera, (vii) lack of labour to feed the bio-digester, etc. This indicates that (i) the needs assessment has not been properly done, there is too little dung and/or water, or plenty of firewood, bio-slurry is of no use, (ii) the user thinks wrongly that he/she can bake Injera with an installation smaller than 8 $m^3$, etc. This indicates that the promotion officers should be better trained to assess and explain to the user the consequences of investing in a bio-digester.

**C5 – Bio-digester private sector participation not as expected.**

C5 – After 11 years of the NBPE where the development of a bio-digester private sector has been an objective from the very beginning, the development of the private sector is still at infant stage as it is mentioned in recent programme documents. Also, one can have doubts about the claim that the NBPE+ is a PPP venture because the government at all levels has complete control of the programme, tells the private sector where to build (targets), tells what to build (the brick-and mortar model) and almost all construction is done after promotion by the local Woreda staff. A rudimentary development of the private sector is found in some regions, but they have to be coached at all levels to perform. This situation is not sustainable, but it is difficult to envision that at the present state of development of the private sector in rural areas of Ethiopia, this could have been done differently.

**C6 – Insufficient technology innovation / introduction.**

C6 – The NBPE+ is promoting only the "brick-and-mortar" model, while at the moment there are "off-the-shelf" models that perform the same or better and have a proven track record of tenths of thousands of installations in Africa, India and Latin America. These models when adopted would mean a paradigm shift for the NBPE+. This has been extensively discussed in Chapter 3 under EQ3, some of the major advantages are. (i) this would create a true private sector led bio-digester market,

where almost all the government structures now supporting the NBPE+ would be not necessary, (ii) the quality control system would be completely unnecessary only a small sample of the installations would be controlled to protect users, (iii) training of masons would also not be required as these companies rely on their highly trained and skilled personnel, (iv) two employees can install one to two bio-digesters a day, (v) MFIs would be more inclined to accept the bio-digester as collateral as the installation can almost in its totality be reprocessed, and (vi) these companies are highly professional and don't need any Business Development Services or support. In summary the programme costs would be much lower which would substantially increase sustainability. Some disadvantages are: (i) the technology needs to be imported (unless the volume of sales justify national production) and is generally more expensive than the "brick-and-mortar" model (but this depends on the size of the market, in India one of these international companies producing flexible bio-digesters is fabricating at half of the price of the "brick-and-mortar" model), so it would require the same subsidies as the present ones. The subsidy could even be higher because many of the RBF provided to the "brick-and-mortar" model are not necessary and could be channelled to lower the costs for the user, (ii) the technology would need to have the same benefits as other renewable energy technologies, such as the waiver of import tax duties, and (iii) the FOREX problem would need to be addressed at national level to create the conditions that this would not be a bottleneck.

**C7 – Cluster approach.**

C7 - The construction of bio-digesters is thinly spread around the country and the distance between bio-digester households with accessible roads is large. If the construction would be clustered, this would decrease the cost of construction, because transport issues could be more easily dealt with and at lower costs (it has for example been mentioned that the transport of sand to an isolated household is a problem as only large trucks are available), masons could be more productive if they could work on several bio-digesters simultaneously, quality control can be done more efficiently. MFIs, do not consider the fixed-dome bio-digesters promoted by the NBPE+ as collateral. The wealth of the customers consists mainly of cattle, which is also generally not considered collateral due to its mobile nature. The cluster approach makes loan access easier because an MFI would be more able to ask for group collateral, it reduces transaction costs and makes the collection of repayments easier and cheaper.

**C8 – CSC is providing value for money.**

C8 - The CSC is providing a valuable service and a lot of information is being generated which when properly used by the RBPCU, Zone and Woreda experts could drastically reduce the number of unsatisfied clients and the amount of mal-functioning bio-digesters. The information provided by the CSC is sufficiently detailed to locate the customer and the cause for non-functionality is identified, however, there are not any indications that the findings of the CSC have been followed-up locally.

**C9 – Carbon credit benefits lower than expected.**

C9 – The GoE has appointed the DBE as the custodian of the carbon project in NBPE and DBE has signed an agreement with the World Bank to get carbon credits to the programme that could generate a substantial amount of money, making many aspects of the programme sustainable. However, the second round of verification and reporting for the period of April 2018 to December 2019 has certified only 8,415 bio-digesters instead of the 16,142 originally planned. This indicates that the verification company only certified 51.2% of the bio-digesters for both reasons of non-functionality and for an incomplete bio-digester database; this reduces drastically the amount of CERs to be received. One should be careful with this conclusion as besides mal-functioning another reason can be that insufficient monitoring data was available (the evaluation mission was not provided with a report from the verification company, only aggregate data).

**C10 – High drop-out rate of masons.**

C10 - The high rate of drop-out of masons has severe consequences in terms of programme efficiency because new masons need continuously to be trained. This is also reflected in the quality of construction as masons do not get time to mature their skills and improve their productivity. This high drop-out rate is linked to the perceived low benefits of bio-digester construction, the isolation of most construction sites and the many alternatives for employment elsewhere. The cluster approach is one way to decrease the high drop-out rate of masons. But the most effective way is to make the mason payment rate market based, as it has been discussed for years, and is currently being implemented.

**C11 – Gender mainstreaming not really successful and poverty issues cannot be adequately addressed by a biogas programme.**

C11 – Cross-cutting issues: Gender mainstreaming has not been quite successful and it is questionable if the NBPE+ is the most pertinent instrument to change deeply engraved cultural patterns. Women strongly benefit from the biogas programme as users, but play a minor role in implementation structures. Beyond developing a smaller size bio-digester, encouraging subsidisation and creating access to credit a biogas programme is not the best way to address poverty issues as a farmer needs a minimum amount of cows to be able to feed a bio-digester. Poverty issues in cooking energy can much better be addressed by improved cookstoves eventually coupled with a solar lantern for light, for which some programmes are already being implemented in the country.

**C12 – NBPE+ is highly relevant for the GoE, for the EU and for the users.**

C12 – The evaluation found that the NBPE+ is highly relevant to the development and global objectives of the GoE, regional governments and of the EU, and when bio-digesters are functioning they provide valuable services to the user. However, besides the inclusion of a number of bio-digester construction targets in a number of strategic documents, this relevance has not found its way into policy and/or key renewable energy documents. The NBPE+ has influenced the GoE in a recent strategy to mention the more encompassing concept of "clean energy" instead of "off-grid electrification".

C12 - In government and donor circles, support to biogas sector development has especially been associated with the aim for sustainable access to renewable energy. However, this does not sufficiently cover and describe the integrated livelihood development potential and the actual impacts of bio-digesters, which are multiple and diverse. In fact, the bio-digester technology sits on the nexus of energy, agriculture, soil fertility, forestry, water, climate, gender and sanitation. New funding opportunities may be found once the full impacts of bio-digesters are understood at different levels.

C12 – This also implies that the NBPE+ should seek synergies with other programmes in water, sanitation, health, agricultural productivity, forestry, etc. what actually is already being done by the programme.

**C13 – MoA despite recognising the value of bio-slurry has not allocated budget for its dissemination.**

C13 – In areas where bio-slurry is used –this is not everywhere- it is a benefit that the users, being farmers, highly appreciate and it strongly benefits the country as chemical fertiliser or the components for its fabrication do not need to be imported. The MoA has recognised its importance and recommends its use and has advised its regional staff to promote it. However, local staff has no budget allocated to this activity, so this recognition has little impact.

**A number of important conclusions at micro-level:**

C14 – The gas lamp provided by the programme is a constant source of problems to and frustration of the users. This is a common feature in all biogas programmes. It also burdens the after-sales service where it exists, because the gas mantle needs often to be substituted. The costs of piping, installation and the gas lamp itself are comparable or higher than a good quality solar lantern with phone charging.

C15 – The field missions have found that the users either by limitations on the amount of dung or water or because they have not been properly trained, do not feed the bio-digesters at the prescribed regular intervals. This can influence proper functioning of the bio-digester.

## 4.2. Recommendations

**R1 – Inclusion of new regions.**

R1 – It is recommended that the NBPE+ stops supporting with programmatic resources (staff, offices, promotion incentives, etc.) the new regions. If the GoE finds it important to support these regions to keep geographic cohesion, the GoE and/or the regional governments could pay all staff costs and all staff costs related expenses. The support of SNV in terms of training of staff could eventually continue, supporting the development of BCEs, etc. What certainly should continue is the subsidy to the investment otherwise the users in these areas would be penalised.

**R2 – Top heavy government structure, reduced GoE contribution, involvement of existing institutions.**

R2 – The structure, functions and composition of the NBPCU and to a lesser extent of the RBPCU should be completely reviewed. The functions at national level should be drastically reduced and could be done by a very limited number of persons with the main tasks to oversee and monitor the progress of the programme in the regions and report to the government. All other technical functions should be with the RBPCU, done by SNV (as is presently the case) or outsourced. Sustainability would be an issue unless the functions are fully integrated in the regional government structures. The financial officer should be one integrated in the financial department of the MoWIE. The GoE programme funds should be transferred directly –if this is possible in the government set-up- by the MoF to the regions, and the financial department of MoWIE would aggregate the regional use of funds and report to the MoF. Transfer of external programme funds should continue to go directly from SNV to the regions.

R2 – Alternatively, the re-established Ethiopian Rural Energy Development and Promotion Centre, under the MoWIE, could assume the coordination role at the national level. This role is within the mandate of the Ethiopian Rural Energy Development and Promotion Centre.

R2 – In order to improve programme sustainability the contribution of the GoE to the programme should be substantially increased. This aligns with a number of other recommendations provided here.

R2 – In order to make the programme more sustainable the NBPE+ should be integrated in the regional government programmes and financial budgets. Many regions are already providing substantial amounts of funds to support the programme, but the institutionalisation of the programme at regional level would make the flow of funds more predictable and sustainable. Supporting Regional Energy Bureaus to develop Regional Bio-digester Strategic Plans or road maps may be important – that will cover all aspects: vision, stakeholder analyses, goals/objectives, action planning, financing needs and funding strategy, institutional arrangement for implementation, M&E framework, etc.

R2 – Transfer all training and quality control functions to the regional level, but it might be cheaper and more efficient to outsource these functions and make the RBPCU as lean as possible and fully integrated in and paid by the regional governments.

R2 – In order to make the programme more sustainable the training of and skills certification of masons should be outsourced to specialised regional institutions like the TVETs. This applies also for business skills development for the BCEs. Both are already in the process of implementation. The programme continuing the training and paying 100% of the cost is acceptable, from an equity angle, but not sustainable. The QC3 functions of the RBPCU and SNV should be outsourced regionally.

**R3 – Rate of functionality lower than desired and acceptable.**

R3 – A clear target of 95% average functionality rate should be set for the NBPE+. Functionality as known and also explained in this report depends on a number of factors that can be in some degree influenced by the programme, so the definition of functionality should be clear and clearly understood by all participants in the programme and by evaluators. Technical functionality that depends on the quality of construction is the first and most important one and one where the programme has primary responsibility and should guarantee (and this shows whether the quality control is functioning or not). Feeding and maintenance problems are another big reason for non-functionality and this depends on promotion (creating false expectations), training of the user (programme responsibility) and after-sales service (programme responsibility).

**R4 – Quality control not functioning as expected, users not adequately trained (failure of after-sales service), users not properly identified (needs assessment) and/or informed.**

R4 – Revise the RBF fees for quality control. Devise a system to also link functionality (introducing a quality parameter) to the payment of the RBF, even though this is probably difficult as the mistakes sometimes appear much later and the officer might have been moved. Provide decent transportation for the Woreda officer to do their tasks related to quality control and after-sales service. This could be done by having a pool of motorbikes at Zone level that according to a rotation schedule would be available to Woreda officers for justified and pre-defined tasks.

R4 – Another solution for quality control that would work efficiently with the cluster approach is to outsource the quality control tasks and bring them outside government control. This could be done by a person or group of well-trained biogas professionals, compensated on a RBF basis, and with penalties in case of cheating.

R4 – Start a comprehensive programme of rehabilitation of non-functional bio-digesters, and call it like it should be called i.e., "rehabilitation", because this is not "maintenance", well-constructed bio-digesters hardly need any maintenance other than that done by the user. Start by identifying the source of non-functionality: (i) technical structural, this involves high-skilled masons (ii) technical appliances, this involves after-sales-service, (iii) feeding problems by inadequate training of the user, this involves fresh training provided as after-sales-service (iv) feeding problems due to insufficient quantities of dung or water, this requires a reassessment of the physical conditions (which apparently have been wrongly assessed during promotion and acquisition) and the motivation of the user, and decide on the course of action, and (v) physical feeding problems and completely demotivated user, it might be wise to consider the installation lost. This is most likely to happen in areas where there is plenty of firewood, bio-slurry is not used and/or electricity is available. The after-sales-service in many regions needs a complete overhaul, as one source of non-functionality is the poor service delivered to the user.

**R5 – Bio-digester private sector participation not as expected.**

R5 – Even though it is difficult to create a true bio-digester private sector in rural Ethiopia, the efforts of the programme in this direction should be continued. A possible solution for reducing the dependency of the private sector on the government might be to allow the private sector to follow a market-based approach and determine the level of the price of the installation depending on location (but the investment incentives to the user should be maintained and the RBF would go to the BCE). This might be difficult due to the purchasing power of the rural population of Ethiopia.

**R6 – Insufficient technology innovation / introduction.**

R6 – Consider seriously the quick introduction of "off-the-shelf" models into the programme. Because it is unlikely that an international private company –even after being incorporated in Ethiopia as the law requires- would accept to be commanded by government structures, partnership agreements would have to be developed where the cooperation with the NBPE+ is defined. These bio-digesters would also need subsidies to make them attractive to the user (not to increase profits). The import of bio-digesters should be treated as any other renewable energy technology and have the right to import tax waivers, other tax breaks and access to foreign currency.

**R7 – Cluster approach.**

R7 - It is recommended to start implementing the construction of bio-digesters in clusters with a sufficiently large number of households engaged to construct bio-digesters simultaneously. This requires that the promotion efforts are intensified until a threshold of households is reached allowing for efficient construction of the bio-digesters.

R7 - Cooperation/collaboration with projects and institutions for a cluster approach. If one can guarantee a well-constructed bio-digester, institutional promotion should also be mainstreamed. SNV supports programmes in dairy or livestock that could be the first partners. There are many rural development projects or organisations that the programme could cooperate with for a win-win situation. For example, there are different projects on different decentralised energy solutions, like Improved Cookstoves, solar PV rural electrification, biofuel and micro-hydropower mini grids. Some of them are supported by external development partners like GIZ under the Energising Development (EnDev) programme. SNV is implementing the enabling environment component of the clean cooking sector, under the EnDev programme, for which GIZ is the programme manager.

R7 – Another way of clustering is to limit the number of Woredas in each region so as to use the resources optimally for maximisation of results (quantity and quality/functionality). Woredas are selected and listed per region for the purpose of focussing efforts. Installations may happen even outside the listed Woredas. However, focus will be limited to the listed ones.

**R8 – CSC is providing value for money.**

R8 - There should be a clear line of responsibility at regional, Zone and Woreda level to act and contact users when a complaint is received or a contact made by the CSC that indicates that there is a functionality problem. Users should be provided with a colourful and plasticised card where the number (preferably a four-digit number) of the CSC is displayed.

**R9 – Carbon credit benefits lower than expected.**

R9 – It is recommended to improve the quality of the monitoring data necessary for getting the CERs credits. Also, when the cause of failed verification is malfunctioning of the bio-digester, immediate action should be taken to identify and solve the problem as indicated in R4 above.

**R10 – High drop-out rate of masons.**

R10 – The retention of highly skilled masons should be improved by clustering the construction of bio-digesters and paying a market conform rate to the masons.

**R11 – Gender mainstreaming not really successful and poverty issues cannot be adequately addressed by a biogas programme.**

R11 – As to gender mainstreaming and inclusion strategies, besides having gender and social inclusive programme designing, planning and budgeting, there is a need for monitoring elements and indicators, and sensitising staff to implement the agreed actions. For this one needs organisational support and motivation to work on gender and social inclusion and sensitive leadership and organisational culture. Targeting subsidies and credit lines to address social issues like gender inequality or poverty issues has proven not to be the best strategy and should not be promoted.

R11 - In promotion activities to attract new users and to keep women (that mostly cook and are the most affected by the harmful firewood smoke) interested in having a functioning bio-digester, raising the awareness on the harmful health effects of traditional cooking should be strongly emphasised. This role should not be left up to individual biogas or cookstove programmes, but rather be addressed by the GoE as a separate intervention with national and regional radio and television campaigns.

**R12 – NBPE+ is highly relevant for the GoE, for the EU and for the users.**

R12 – It is recommended that the GoE recognises the importance of the NBPE+ for the country by developing adequate policy frameworks for its functioning, including import tax waivers for components and systems.

R12 – The GoE should emphasise towards donors that the bio-digester programme operates in the nexus of energy, agriculture, soil fertility, forestry, water, climate, gender and sanitation. New funding opportunities may be found once the full impacts of bio-digesters are understood at different levels.

**R13 – MoA despite recognising the value of bio-slurry has not allocated budget for its dissemination.**

R13 – After the initial training of the users provided by the NBPE+, the extension activities of the use of bio-slurry should be taken over by the MoA. This implies that a budget should be made available by the GoE and MoA people trained. This also implies that a national bio-slurry strategy should be developed. If possible the users should be trained in the use of bio-slurry for high-value crops.

**R14 – Promote solar lanterns and efficient injera stoves.**

R14 – The NBPE+ should start promoting the use of solar lanterns and/or in cooperation with existing programmes in the country. Do not give the solar lamps for free. There are on the market improved Injera biomass stoves that are more efficient because they incorporate a sauce making possibility, and this could be adapted to the existing biogas Injera stoves.

**R15 – Proper feeding, use and maintenance of bio-digesters.**

R15 - Review the manuals and systems to emphasise the requirement that bio-digesters should be fed every day, in all promotion and extension materials. Also emphasise in the training that the biogas produced by bio-digesters is meant to be used every day (otherwise biogas might escape to the atmosphere with the consequent negative climate effects). Provide the user with a colourful and plasticised poster with as little as possible words (if necessary in local languages) where the feeding and maintenance procedures are shown.

When adopted many of the recommendations above would take time to be implemented and they would have as a consequence that a substantial amount of the programme funding will not be spent.

It is therefore recommended that the NBPE+ should have a neutral budget extension, the amount of years dependent on which recommendations are implemented and the resources saved with their implementation.

## 4.3. Lessons-learned

In many respects the programme is doing what should be done, at least in a "business-as-usual" perspective: the government structures are in place, although the central ones are over-staffed, the necessary activities are being implemented, manuals and training materials are being developed, training is being provided, and yet the programme is not achieving its objectives. Where staff is mostly needed at Zone and Woreda level to do promotion and more important to provide after-sales service, it is often not there, their payment is low and most important transportation means are lacking. So, it is not surprising the high turnover rate of staff (also at central level) and the lack of motivation.

A Results-Based Financing approach may require up-front/prior investments for promotion and demand creation activities. Also, the Results-Based Financing amount needs to be periodically adjusted to reflect market prices. Promotion and demand creation needs to have a more professional approach as sometimes false expectations are created, that later lead to disappointment of the user and abandonment of the bio-digester. Targeted households must be fully informed of what it takes for a successful operation of a bio-digester: must have sufficient dung for daily feeding, water and availability and commitments of daily labour requirements. During promotion and acquisition these aspects should be clearly explained to the households.

The success of a bio-digester development programme depends on capturing the full financial, economic and health benefits: energy services for cooking, baking, lighting; bio-slurry utilisation as well as improved toilet and sanitation. This requires strong coordination among key stakeholders including energy, agriculture and health.

A government-enabled private bio-digester sector development may take some time and requires a strategic and long-term planning. Alternatively approaches to reduce government dependency should be implemented, such as, promoting a different kind of technology that requires less programme functions to be performed.

A high rate of non-functionality of bio-digesters is a key obstacle for success. Repair/rehabilitation of non-functional bio-digesters needs to be prioritised. The causes for non-functionality such as lack of dung and water, accessories, pipes, fittings and labour are good lessons for future development of bio-digester technology. The functionality of bio-digesters also depends on the availability of dung and water in dry and wet seasons. The presence of cattle diseases and associated death also affect the functionality of bio-digester. Therefore, a collaborative effort of different sectors is needed including livestock, crop, and forestry for the proper functioning and utilisation of bio-digester technology.

The toilets constructed were not utilised in many households. Therefore prior agreement is needed before constructing toilet as this can reduce the cost. If the user refuses, then the toilet pipe should be installed, protected and closed in case the user changes his/her mind. The biogas lamps are a constant source of problems, most of them are not working, a solar lantern should be installed instead of biogas lamps to save energy for cooking and to avoid recurring maintenance.

The lessons taken from biogas on reducing the amount of firewood used for household cooking and bio-slurry organic fertiliser for improving soil and crop quality and the awareness of this were limited to a reduced number of households. Moreover, only few households have been utilising bio-slurry for livestock pasture (fodder) and in turn to fattening livestock even in dry season. Those few lessons should be scaled up to increase the impact of the bio-digester technology on the society. Then it is

important to work with agricultural development agents and local community association to improve the uses of bio-digester technology.

Low quality of construction leading to malfunctioning besides being a reputational damage to the programme can lead to pernicious effects. Many situations in all regions indicate that in fact biogas must be escaping to the atmosphere (also if too high quantities of dung are fed into the bio-digester related to the energy need of the family). This means that the NBPE+ in these situations is putting into the atmosphere more GHG than would be the case if the dung was traditionally used directly in the field. This would also be the case if one would promote the use of the bio-digester to produce bio-slurry independently of the energy needs of the family. This is another reason why users should be properly trained in feeding the bio-digester.

Saving biogas to use it for Injera cooking should also be discouraged, the bio-digesters are designed to be fed and the biogas used every day, otherwise there is a tipping point where the biogas begins escaping to the atmosphere through the outlet chamber.

It was also observed that bio-digesters have been and are being promoted in parts of the country where there is no lack of firewood and this firewood is grown sustainably. This obviously reduces the climate benefits of the use of biogas (certainly all the other benefits still apply). The problem in this case is that at the least difficulty (and especially if there is no adequate and quick response from an after-sales service) the user tends to abandon the installation.

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35. Strategies for Improvement of Functionality (Supplementary Plan). SNV

36. Strategies for Improvement of Mason Retention (Supplementary Plan). SNV

37. Strategy for Improvement of Affordability through Access to Credit (Supplementary Plan). SNV

38. Strategies for Improvement of Piloting Larger Size Bio-digesters (Supplementary Plan). SNV

39. The power of dung - Lessons learned from on-farm bio-digester programmes in Africa. ESMAP, WB, 2019.

40. Using Bio-slurry for a Sustained, Maximum Farm Production and Productivity, SNV, no date.

# Annex I – Schedule of the Mission and Field Work

**Work Programme in Addis Ababa and selected regions**

| Nº | Date | When | Activity |
|---|---|---|---|
| | | | All Team |
| 1. | Mon 17 May | Morning | Arrival Team Leader in Addis Ababa |
| | | Afternoon | Technical Evaluation Team Meeting |
| | | | SNV Country Director and SNV Team |
| 2. | Tue 18 May | Morning | EU Delegation Ethiopia |
| | | | State Minister MoWIE, Chair of NBPE+ SC |
| | | Afternoon | SNV NBPE+ staff - Implementation Support, Products and Quality Dvlp. |
| | | | SNV NBPE+ staff - PSD, Credit |
| | | | SNV NBPE+ staff - Programme finance |
| | | | SNV NBPE+ staff – MEAL |
| 3. | Wed 19 May | Morning | NBPCU / Coordinator |
| | | | Customer Service Centre |
| | | Afternoon | Ministry of Finance /NOA, cancelled |
| | | | Development Bank of Ethiopia, cancelled |
| 4. | Thu 20 May | All day | Pilot Testing of Survey Tools in SNNPR, Meeting with SNNP RBPCU |
| 5. | Fri 21 May | All day | Pilot Testing of Survey Tools in SNNPR, Meeting with OMO MFI |
| 6. | Sat 22 May | | Finalise Survey Tools, Preparation for field |
| | | | Júlio Castro and Mekonnen Kassa |
| | Sun 23 May | | |
| 7. | Mon 24 May | All day | Travel to Region Amhara Region/Bahir Dar |
| 8. | Tue 25 May | All day | Meeting with Deputy Head of Energy Bureau of MoWIE |
| | | | Meeting with Amhara RBPCU, Meeting with Injera stove manufacturer |
| 9. | Wed 26 May | All day | Travel to Awi Zone, Meeting with Zone coordinator, field survey |
| 10. | Thu 27 May | All day | Field survey households |
| 11. | Fri 28 May | All day | Team leader travels back to Bahir Dar |
| | | | Meeting with the manager of the RBPCU, Travel back to Addis Ababa |
| | | | Júlio Castro |
| 12 | Sat 29 May | All day | Working at the hotel |
| 13. | Sun 30 May | | |
| 14. | Mon 31 May | All day | Trip to Oromia, Júlio Castro and Miftah Akedir |
| | | | Meeting Manager RBPCU and other staff, Field Survey |
| 15. | Tue 1 June | All day | Meeting with Energy Coordinator of the DBE, phone and mails to other stakeholders, working at hotel |
| 16. | Wed 2 June | Morning | Meeting with director and several staff of SNV |
| | | Afternoon | Meeting with the manager of the GIZ/EnDev programme, working at hotel |
| 17. | Thu 4 June | All day | Working at the hotel, preparing debriefing, debriefing EUD |
| | Fri 5 June | | Departure of Team Leader |

## Field visits of Technical Evaluation of bio-digesters in Gambella, Oromia, SNNP (and Sidama) and Somali

| Date | Region | Town or city | Activity |
|---|---|---|---|
| May 20-21 | Sidama | Hawassa | Questionnaire pre-test and visit bio-digester village |
| May 23-28 | Gambela | Gambela | Data collection on bio-digesters |
| May 31-June 7 | Oromia | Asela, Wondo Genet | Data collection on bio-digesters |
| June 7-June 12 | Sidama and SNNP | Arba Minch, Wolaita Sodo | Data collection on bio-digesters |
| June 13-June 14 | Oromia | Jimma | Data collection on bio-digesters |
| June 15-June 20 | SNNP | Welkite | Data collection on bio-digesters |
| June 27-June 31 | SNNP | Welkite | Data analysis and report writing on bio-digesters |
| July3-July 7 | Somali-Jigjiga | Jigjiga | Data collection on bio-digesters |
| July8-July 10 | Oromia | Abichu | Data collection on bio-digesters |
| July12-July 31 | SNNP | Welkite | household bio-digester data analysis and report writing |
| August 1 -10 | SNNP | Welkite | Report writing on on bio-digesters |

Contact person during bio-digesters visit in Gambella, Oromia, SNNP (and Sidama as part of SNNP) and Somali

| Region | Name of Contact Person | Responsibility | Telephone nr. |
|---|---|---|---|
| Gambella | Mesfin | Gambella Region Biogas Coordination Unit | 0963142252 |
| Oromia | Bayisa | Oromia Region Biogas Coordination Unit | 0927172130 |
| Sidama | Fasil | Sidama Region Biogas Coordination Unit | 0964103410 |
| SNNP | Zerihun | SNNP Region Biogas Coordination Unit | 0916831959 |
| Somali | Abdurabi | Somali Region Biogas Coordination Unit | 0924917148 |

## Field Programme of Technical evaluation of bio-digesters in Afar and Amhara

| N° | Date | Activity / Place |
|---|---|---|
| | Pilot Testing of Households Questionnaire | |
| 1 | Thu May 20, 2021 | Travel and Work in Hawassa City |
| 2 | Fri May 21, 2021 | Work in Hawassa, Travel to Addis Ababa |
| | Amhara Region, Bahir Dar, Awi and East Gojjam Zones | |
| 3 | Mon May 24, 2021 | Travel From Addis Ababa to Bahir Dar |
| 4 | Tue May 25, 2021 | Meeting with BoWIE and GM Enterprise (Injera Stove Producer) and Travel to AWI Zone |
| 5 | Tue May 25, 2021 | Work in Bahir Dar travel to travel to Awi Zone |
| 6 | Wed May 26, 2021 | Awi Zone, Guagua Woreda |
| 7 | Thu May 27, 2021 | Awi Zone, Dangila Zuria Woreda |
| 8 | Fri May 28, 2021 | Awi Zone, Banja Woreda |
| 9 | Sat May 29, 2021 | Machakal Woreda and Travel to Debre Markos |
| 10 | Sun May 30, 2021 | Non-working day |
| 11 | Mon May 31, 2021 | East Gojjam Zone, Gozamin Woreda |
| 12 | Tue June 1, 2021 | East Gojjam Zone, Basoliben Woreda |
| 13 | Wed June 2, 2021 | East Gojjam Zone, Aneded Woreda |
| 14 | Thu June 3, 2021 | East Gojjam Zone, Gozamin Woreda |
| 15 | Fri, June 4, 2021 | East Gojjam Zone, Bibugn Woreda |
| 16 | Sat, June 5, 2021 | East Gojjam Zone, Enarj Enawga Woreda |
| 17 | Sun, June 6, 2021 | East Gojjam Zone, Dejen Woreda |
| 18 | Mon, June 7, 2021 | Travel from Dejen to Addis Ababa |
| | Afar Region | |
| 19 | Tue June 7, 2021 | Travel from Addia Ababa to Afa |
| 20 | Tue June 8, 2021 | Travel from Metehara to Semera |
| 21 | Wed June 9, 2021 | Afar, Zone 1, Dubti Woreda |
| 22 | Thu June 10, 2021 | Afar, Zone 1, Assayita Woreda |
| 23 | Fri June 11, 2021 | Afar, Zone 1, Afambo Woreda |
| 24 | Sat June 12, 2021 | Afar, Zone 1, Assayita Woreda |
| 25 | Sun June 13, 2021 | Afar, Zone 1, Amibara Woreda |
| 26 | Tue June 14, 2021 | Travel to Awash to Addis Ababa |
| | Amhara, Region North Shoa Zone | |
| 27 | Thu June 29, 2021 | Travel to North Shoa Zone, Debrebirhan |
| 28 | Thu June 30, 202 | North Shoa Zone, Angolelena Tera Woreda |
| 29 | Fri July 1, 2021 | North Shoa Zone, Basona Werana Woreda |
| 30 | Sat July 2, 2021 | North Shoa Zone, Menz Mama, Woreda |
| 31 | Sun July 3, 2021 | North Shoa Zone, Tarma Ber, Woreda |
| 32 | Mon July 4, 2021 | North Wello Zone, Kalu Woreda to Debrebirhan |
| 33 | Tue July 5, 2021 | Stakeholder meeting |
| 34 | Wed July 6, 2021 | North Shoa Zone, 1Minjar Shenkora |
| 35 | Thu July 7, 2021 | North Shoa Zone, Asagirt, Woreda |
| 36 | Fri July 8, 2021 | Stakeholder interview, Bureau of Agriculture |
| 37 | Sat July 9, 2021 | Travel to Addis Ababa |

# Annex II – List of persons met.

| Name | Position |
|---|---|
| EUD | |
| [redacted] | Team Leader Economy & Infrastructure<br>Programme Manager Energy |
| SNV | |
| [redacted] | Ethiopia Country Director<br>Deputy Country Director<br>Team Leader, NBPE+ / Energy Sector Leader (until May 2021)<br>Senior Expert – Institutional Development (Deputy Team Leader), NBPE+<br>Monitoring and Evaluation Expert, Biogas Programme<br>Multi-country Project Manager<br>Senior Expert, NBPE+<br>Technical Expert, Product and Quality, NBPE+<br>Technical Expert, Product and Quality, NBPE+<br>Technical Support, Implementation Support, NBPE+<br>Technical Expert, Implementation Support, NBPE+<br>Bio-slurry Technical Expert, Impiementation Support, NBPE+<br>PSD Expert, NBPE+<br>Bio-slurry Value Chain Expert, NBPE+<br>Credit Finance Expert, NBPE+<br>NBPE+ Project Finance Officer, NBPE+<br>Project Grant Partners Finance Officer, NBPE+ |
| | |
| [redacted] | State Minister MoWIE and Chair of SC<br>NBPE+ National Programme Coordinator<br>SNNP Biogas Programme Coordinator<br><br>Amhara Biogas Programme Coordinator<br>Oromia Biogas Programme Coordinator<br>Oromia Finance Manager RBPCU<br>DBE Energy Team Coordinator<br>SNNP OMO MFI Credit Service Directorate Director<br>Team Leader, NBPE Customer Support Centre<br>Programme Director – GIZ Energy Programme Director Ethiopia |
| By phone and mail | |
| [redacted] | World Bank<br>Fund Management Unit, Climate Change |

| Region/Zone/Woreda | Name | Position | Telephone |
|---|---|---|---|
| **Amhara Region** | | | |
| BoWIE | [redacted] | Deputy Bureau Head | |
| GM Clean Energy | | General Manager | +251 923419752 |
| **Awi Zone** | | | |
| Awi Zone | | Team Leader Zone Energy | +251 918127263 |
| Awi Zone | | Team Leader Zone Energy | +251 923419752 |
| Awi Zone | | Zone Energy Expert | +251 912664462 |
| Dangila Woreda | | Woreda Energy Team Leader Zone Energy | +251 918711088 |
| Guanga Woreda | | Energy Team Leade | |
| **East Gojjam Zone** | | | |
| East Gojjam Zone | | Team Leader Zone Energy | +251 913073360 |
| Gozamin Woreda | | Biogas Expert | +251 934376382 |
| Aneded Woreda | | Woreda Energy Team Leader | +251 918473285 |
| Baso Liben Woreda | | Biogas Expert | +251936321639 |
| Bibugn Woreda | | Biogas Expert | +251973063100 |
| **North Shoa Zone** | | | |
| North Shoa Zone | | Energy Team Leader | +251 925402486 |
| Angelalana Tera Woreda | | Energy Team Leader | +251 906642977 |
| Gissona Werana Woreda | | Biogas Expert | +251 910676625 |
| Menz Mama Woreda | | Water, Mines and Energy Office Head | +251 913944243 |
| Menz Mama Woreda | | Biogas Expert | +251 921131276 |
| Tarma Ber | | Biogas expert | +251 920521803 |
| Minjar Woreda | | Biogas Mason | |
| Asagirt Woreda | | Biogas Expert | +251 922373437 |
| **Afar Region** | | | |
| BWoIE | [redacted] | Director Energy Development | +251 921233818 |
| Regional RBPCU | | RBPCU Coordinator | +251 912273954 |
| Afar Region RBPCU | | RBPCU Biogas Expert | +251 913071048 |
| Afar Region | | Biogas Mason | +251 942815091 |
| | | | |

# Annex III - Sample Size and Sampling Strategy

## Sample size

Adequate sample size is crucial to any credible evaluation. Generally, the sample size depends on the acceptable level of significance, Power of the study and expected effect size. A statistical power analysis will be used for sample size determination. With a Significance level (alpha) = .05; and Statistical Power = 0.90, and a minimum detectable effect size of 20 percentage points, and non-response and cluster effect. The figure below illustrates the application of Statistical Power Analysis. Based on these variables, we estimate a total sample size of 207 households.

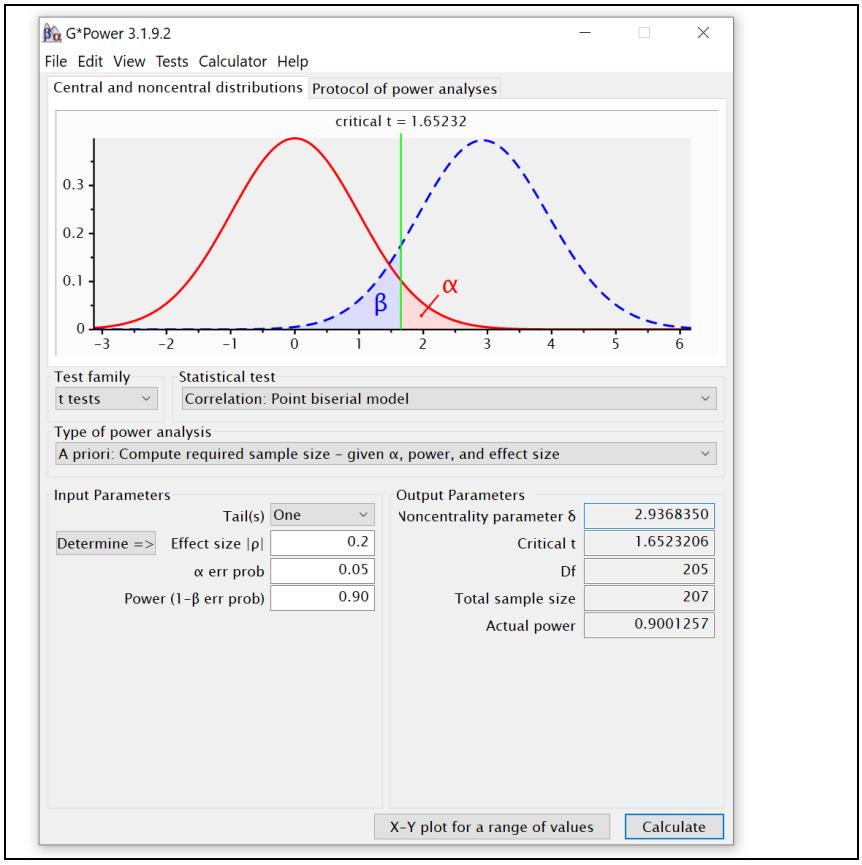


*Figure 98 - Statistical Power Analysis and Optimal Sample Size*

For security reasons Benishangul-Gumuz and Tigray regions are excluded from the field visits. The sample therefore includes six programme regions: Afar, Amhara, Gambella, Oromia, SNNP and Somali. As a new region was created during the implementation phase, SNNPR should be understood here as including both the new SNNP region and the new Sidama region (i.e. sites can be located in these two regions).

## Sampling Strategy

Accordingly to the bio-digester user database, a total of 8,429 bio-digesters have been constructed over the last three years (see Annex VI). The distribution of the total number beneficiaries varies considerably across regions. About 53% of the total were constructed in Amhara region, followed by 18% in Oromia, 16% in Tigray and 10% in SNNPR as shown in Table 8 below.

**Table 31 - Number of Bio-digesters Constructed by Region**

| Region | Year 1 | Year 2 | Year 3 | Grand Total | % |
|---|---|---|---|---|---|
| Afar | | 10 | 51 | 61 | 0.7 |
| Amhara | 546 | 982 | 2,899 | 4,27 | 52.5 |
| Benishangul Gumuz | | 27 | 82 | 109 | 1.3 |
| Gambella | | 3 | 22 | 25 | 0.3 |
| Oromia | 164 | 352 | 1,001 | 1,517 | 18.0 |
| SNNPR | 101 | 206 | 514 | 821 | 9.7 |
| Somali | | 38 | 65 | 103 | 1.2 |
| Tigray | 220 | 385 | 761 | 1,366 | 16.2 |
| Grand Total | 1,031 | 2,003 | 5,395 | 8,429 | 100.0 |
| % | 12.2 | 23.8 | 64.0 | 100.0 | |

A stratified sampling method is used to ensure adequate representation of regions with small number of bio-digesters that might otherwise not have a large enough presence in the sample about which to make statistical generalisations. That is, to ensure that the sample size within each region is sufficient for making credible generalisations about each region.

In a disproportionate stratified sample, the size of each sample region is not proportionate to its size in the overall number of bio-digesters. Some regions are over-sampled or under-sampled relative to their actual proportion of the population. Further, for some types of statistical analyses, a minimum sample size is needed for each region. Given the time constraints, a minimum 30 households in those regions with be sampled.

The table below illustrates a disproportionate stratified sample. For example, 11.6% of the total sample will be drawn from the Afar region to achieve a minimum number of 30 respondents, although the region accounts for only 0.7% of the digesters in the overall number of bio-digesters constructed. On the other hand, 42% of the sample respondents will be drawn from the Amhara region, compared to 53% in the overall bio-digesters.

However, when reporting the survey results at country level, the estimates will be mathematically "weighted" back to the entire number of digesters. The weighting process will account for the under- and over-representation of regions that occurred during sampling.

**Table 32 - Sample Distribution by Region**

| Region | Bio-digesters constructed | | | | | Sample proportion to size | Adjusted Sample Size | |
|---|---|---|---|---|---|---|---|---|
| | Year 1 | Year 2 | Year 3 | Total | % | | Number | % |
| Afar | | 10 | 51 | 61 | 0.7 | 2 | 33 | 11.6 |
| Amhara | 546 | 982 | 2,899 | 4,427 | 52.5 | 109 | 120 | 42.0 |
| B/G | | 27 | 82 | 109 | 1.3 | 3 | | |
| Gambella | | 3 | 22 | 25 | 0.3 | 1 | 25 | 8.8 |
| Oromia | 164 | 352 | 1,001 | 1,517 | 18.0 | 38 | 42 | 14.6 |
| SNNPR | 101 | 206 | 514 | 821 | 9.7 | 21 | 33 | 11.6 |
| Somali | | 38 | 65 | 103 | 1.2 | 3 | 33 | 11.6 |
| Tigray | 220 | 385 | 761 | 1366 | 16.2 | 34 | | |
| Grand Total | 1,031 | 2,003 | 5,395 | 8,429 | 100.0 | 211 | 286 | 100.0 |
| % | 12.2 | 23.8 | 64.0 | 100.0 | | | | |

The result when one looks at the sample distribution by Region and Zones is given below.

**Table 33 - Sample distribution by Region and Zone**

| Region/Zone | Sample size (n=) | Year 1 | Year 2 | Year 3 | Total |
|---|---|---|---|---|---|
| Afar | 33 | | 5 | 28 | 33 |
| Zone 1 | | | 5 | 22 | 27 |
| Zone 2 | | | - | 6 | 6 |
| Amhara | 120 | 16 | 29 | 75 | 120 |
| Awi | | 1 | 2 | 6 | 8 |
| East Gojjam | | 2 | 6 | 26 | 35 |
| North Shewa | | 5 | 7 | 12 | 24 |
| South Wello | | 7 | 11 | 27 | 45 |
| Wag Himra | | 1 | 3 | 5 | 8 |
| Gambella | 25 | | 3 | 22 | 25 |
| Anywaa | | | 1 | 20 | 21 |
| Gambella town | | | 2 | 2 | 4 |
| Oromia | 42 | 5 | 12 | 25 | 42 |
| Arsi | | 1 | 3 | 11 | 16 |
| Jimma | | 2 | 2 | 5 | 9 |
| North Shewa | | 0 | 1 | 3 | 4 |
| West Arsi | | 1 | 6 | 5 | 13 |
| SNNPR | 33 | 4 | 9 | 20 | 33 |
| Gamo | | | 1 | 5 | 6 |
| Gurage | | 1 | 1 | 3 | 5 |
| Kembata Tembaro | | 0 | 2 | 4 | 5 |
| Sidama | | 0 | 2 | 3 | 5 |
| Wolayita | | 3 | 3 | 6 | 12 |
| Somali | 33 | | 12 | 21 | 33 |
| Fafan | | | 12 | 21 | 33 |
| Sample size by year | 286 | 24 | 71 | 191 | 286 |
| % | | 9 | 25 | 67 | 100 |

# Annex IV – List of sampled bio-digesters

| Gambella Region | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **No.** | **Region** | **Zone** | **Woreda** | **Kebele** | **Plant Code** | **Year** | **Installation Month/Year** | **Name of User** | **Sex** | **Size (m3)** | **Model** |
| 1 | Gambella | Anywaa | Abobo | Meder 11&12 | GM AB 19 | Year 3 | 2020 | [redacted] | | 6 | SINIDU 2008 |
| 2 | Gambella | Anywaa | Abobo | Meder 11&12 | GM AB 14 | Year 3 | 2020 | | | 6 | SINIDU 2008 |
| 3 | Gambella | Anywaa | Abobo | Meder 11&12 | GM AB 23 | Year 3 | 2020 | | | 6 | SINIDU 2008 |
| 4 | Gambella | Anywaa | Abobo | Meder 7 | GM AB 3 | Year 3 | 2019 | | | 6 | SINIDU 2008 |
| 5 | Gambella | Anywaa | Abobo | Mender 13 | GM AB 1 | Year 3 | 2019 | | | 6 | SINIDU 2008 |
| 6 | Gambella | Anywaa | Abobo | Mender 17 | GM AB 10 | Year 2 | 2018 | | | 6 | SINIDU 2008 |
| 7 | Gambella | Anywaa | Abobo | Mender 7 | GM AB 9 | Year 3 | 2019 | | | 6 | SINIDU 2008 |
| 8 | Gambella | Anywaa | Abobo | Mender 7 | GM AB 2 | Year 3 | 2019 | | | 6 | SINIDU 2008 |
| 9 | Gambella | Anywaa | Abobo | Mender 8 | GM AB 8 | Year 3 | 2019 | | | 6 | SINIDU 2008 |
| 10 | Gambella | Anywaa | Abobo | Mender 8 | GM AB 4 | Year 3 | 2019 | | | 6 | SINIDU 2008 |
| 11 | Gambella | Anywaa | Abobo | Mender 8 | GM AB 6 | Year 3 | 2019 | | | 6 | SINIDU 2008 |
| 12 | Gambella | Anywaa | Abobo | Mender 8 | GM AB 7 | Year 3 | 2019 | | | 6 | SINIDU 2008 |
| 13 | Gambella | Anywaa | Abobo | Mender 8 | GM AB 13 | Year 3 | 2020 | | | 6 | SINIDU 2008 |
| 14 | Gambella | Anywaa | Abol | Bonga | GM AB 21 | Year 3 | 2020 | | | 6 | SINIDU 2008 |
| 15 | Gambella | Anywaa | Gambella | Pinkew | GM AB 18 | Year 3 | 2019 | | | 6 | SINIDU 2008 |
| 16 | Gambella | Anywaa | Gambella Zuria | Abol Kir | GM AB 15 | Year 3 | 2020 | | | 6 | SINIDU 2008 |
| 17 | Gambella | Anywaa | Gambella Zuria | Abol Town | GM AB 16 | Year 3 | 2020 | | | 6 | SINIDU 2008 |
| 18 | Gambella | Anywaa | Gambella Zuria | Abol Town | GM AB 17 | Year 3 | 2020 | | | 6 | SINIDU 2008 |
| 19 | Gambella | Anywaa | Gambella Zuria | Bonga | GM AB 26 | Year 3 | 2020 | | | 6 | SINIDU 2008 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | Gambella | Anywaa | Gambella Zuria | Bonga | GM AB 25 | Year 3 | 2020 | [redacted] | | 6 | SINIDU 2008 |
| 21 | Gambella | Anywaa | Gambella Zuria | Gambella Town | GM AB 24 | Year 3 | 2020 | | | 6 | SINIDU 2008 |
| 22 | Gambella | Gambella Town | Gambella Town | Gambella Town | GM AB 5 | Year 3 | 2020 | | | 6 | SINIDU 2008 |
| 23 | Gambella | Gambella Town | Gambella Town | Gambella Town | GM AB 20 | Year 3 | 2020 | | | 6 | SINIDU 2008 |
| 24 | Gambella | Gambella town | Gambella town | Kebele 01 | GM AB 13 | Year 2 | 2018 | | | 6 | SINIDU 2010 |
| 25 | Gambella | Gambella town | Gambella town | Kebele 01 | GM AB 2 | Year 2 | 2018 | | | 6 | SINIDU 2010 |
| | | | | | | | | | | | |
| **Oromia Region** | | | | | | | | | | | |
| **Ser. No.** | **Region** | **Zone** | **Woreda** | **Kebele** | **Plant Code** | **Year** | **Installation Month/Year** | **Name of User** | **Sex** | **Size (m3)** | **Model** |
| 1 | Oromia | Arsi | Bele Gesger | Koshimo | | Year 3 | Mar_2020 | [redacted] | | 6 | SINIDU 2008 |
| 2 | Oromia | Arsi | Bele Gesger | Koshimo | | Year 3 | Mar_2020 | | | 4 | SINIDU 2008 |
| 3 | Oromia | Arsi | Bele Gesger | Koshimo | | Year 3 | Mar_2020 | | | 6 | SINIDU 2008 |
| 4 | Oromia | Arsi | Lode Hetosa | Ligaba 01 | | Year 3 | Mar_2020 | | | 6 | SINIDU 2008 |
| 5 | Oromia | Arsi | Lode Hetosa | Ligaba 01 | | Year 3 | Mar_2020 | | | 4 | SINIDU 2008 |
| 6 | Oromia | Arsi | Munesa | D/Ashe | | Year 3 | Mar_2020 | | | 8 | SINIDU 2008 |
| 7 | Oromia | Arsi | Munesa | D/Ashe | | Year 3 | Mar_2020 | | | 6 | SINIDU 2008 |
| 8 | Oromia | Arsi | Seru | Jida Jiru | | Year 2 | Mar_2019 | | | 6 | SINIDU 2008 |
| 9 | Oromia | Arsi | Seru | Jida Jiru | | Year 2 | Mar_2019 | | | 6 | SINIDU 2008 |
| 10 | Oromia | Arsi | Shirka | Hela Mekana | | Year 1 | 2017 | | | 6 | SINIDU |
| 11 | Oromia | Arsi | Shirka | Hela Mekana | | Year 1 | 2017 | | | 6 | SINIDU |
| 12 | Oromia | Arsi | Shirka | Zenbaba Hela | | Year 1 | 2017 | | | 6 | SINIDU |
| 13 | Oromia | Arsi | Shirka | Zenbaba Hela | | Year 1 | 2017 | | | 6 | SINIDU |
| 14 | Oromia | Arsi | Shirka | Zenbaba Hela | | Year 1 | 2017 | | | 6 | SINIDU |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 15 | Oromia | Arsi | Tiyo | Sh/Chebet | | Year 3 | May_2019 | [redacted] | 6 | SINIDU 2008 |
| 16 | Oromia | Arsi | Tiyo | Sh/Chebet | | Year 3 | May_2019 | | 6 | SINIDU 2008 |
| 17 | Oromia | Jimma | Gera | Boge Dedo | | Year 1 | 2017 | | 6 | SINIDU |
| 18 | Oromia | Jimma | Gera | Bore Gogo | | Year 1 | 2017 | | 6 | SINIDU |
| 19 | Oromia | Jimma | Gera | Bore Gogo | | Year 1 | 2017 | | 6 | SINIDU |
| 20 | Oromia | Jimma | Gumay | G/Dege | | Year 3 | Nov_2019 | | 6 | SINIDU 2008 |
| 21 | Oromia | Jimma | Gumay | G/Dege | | Year 3 | Nov_2019 | | 6 | SINIDU 2008 |
| 22 | Oromia | Jimma | Gera | Boge Dedo | | Year 1 | 2017 | | 6 | SINIDU |
| 23 | Oromia | Jimma | Gera | Bore Dako | | Year 1 | 2017 | | 6 | SINIDU |
| 24 | Oromia | Jimma | Gera | Bore Gogo | | Year 1 | 2017 | | 6 | SINIDU |
| 25 | Oromia | Jimma | Gera | Bore Dako | | Year 1 | 2017 | | 6 | SINIDU |
| 26 | Oromia | North Shewa | Abichu | A/Goro | | Year 2 | Jan_2019 | | 8 | SINIDU 2008 |
| 27 | Oromia | North Shewa | Abichu | Akabdo | | Year 2 | Feb_2019 | | 8 | SINIDU 2008 |
| 28 | Oromia | North Shewa | Abichu | G/Moye | | Year 2 | Jan_2019 | | 8 | SINIDU 2008 |
| 29 | Oromia | North Shewa | Grar Jarso | Banshe | | Year 3 | Jul_2019 | | 6 | SINIDU 2008 |
| 30 | Oromia | North Shewa | Grar Jarso | Kotche | | Year 3 | Jul_2019 | | 6 | SINIDU 2008 |
| 31 | Oromia | West Arsi | Dodola | B/Adele | | Year 3 | Mar_2020 | | 6 | SINIDU 2008 |
| 32 | Oromia | West Arsi | Dodola | B/Adele | | Year 3 | Mar_2020 | | 6 | SINIDU 2008 |
| 33 | Oromia | West Arsi | Dodola | B/Adele | | Year 3 | Mar_2020 | | 6 | SINIDU 2008 |
| 34 | Oromia | West Arsi | Dodola | Hetchema | | Year 3 | May_2019 | | 6 | SINIDU 2008 |
| 35 | Oromia | West Arsi | Dodola | Hetchema | | Year 3 | May_2019 | | 6 | SINIDU 2008 |
| 36 | Oromia | West Arsi | Dodola | K/Bereda | | Year 3 | Feb_2020 | | 8 | SINIDU 2008 |
| 37 | Oromia | West Arsi | Dodola | K/Bereda | | Year 3 | Feb_2020 | | 6 | SINIDU 2008 |
| 38 | Oromia | West Arsi | Dodola | K/Bereda | | Year 3 | Feb_2020 | | 4 | SINIDU 2008 |
| 39 | Oromia | West Arsi | Kofale | W/Alkeso | | Year 1 | 2018 | | 6 | SINIDU 2008 |
| 40 | Oromia | West Arsi | Kofale | W/Alkeso | | Year 1 | 2018 | | 6 | SINIDU 2008 |
| 41 | Oromia | West Arsi | Kofale | W/Alkeso | | Year 1 | 2018 | | 8 | SINIDU 2008 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 42 | Oromia | West Arsi | Wondo | B/Gugisa | | Year 2 | Aug_2018 | [redacted] | 6 | SINIDU 2008 |
| 43 | Oromia | West Arsi | Wondo | B/Gugisa | | Year 2 | Aug_2018 | | 6 | SINIDU 2008 |
| 44 | Oromia | West Arsi | Wondo | B/Gugisa | | Year 2 | Aug_2018 | | 6 | SINIDU 2008 |
| | | | | | | | | | | |
| **SNNP Region** | | | | | | | | | | |
| **Ser. No.** | **Region** | **Zone** | **Woreda** | **Kebele** | **Plant Code** | **Year** | **Installation Month/Year** | **Name of User** | **Size (m3)** | **Model** |
| 1 | SNNPR | Gamo | Kucha | Shochora | 4378 | Year 2 | 43252 | [redacted] | 6 | Sinidu-2008 |
| 2 | SNNPR | Gamo | Kucha | Shochora | 4629 | Year 2 | Feb,2019 | | 6 | Sinidu-2008 |
| 3 | SNNPR | Gamo | A/zuriya | k.shara | 4632 | Year 3 | September,2019 | | 6 | sinidu |
| 4 | SNNPR | Gamo | M/Abaya | Ankober | SN+ HOPE 63 | Year 3 | June,2019 | | 6 | Sinidu 2010 |
| 5 | SNNPR | Gamo | M/Abaya | K/mulato | SN-388 | Year 3 | January,2020 | | 8 | Sinidu 2010 |
| 6 | SNNPR | Gurage | Enamor | Garad | 4440 | Year 3 | May,2019 | | 6 | Sinidu 2010 |
| 7 | SNNPR | Gurage | Enamor | Mekena | SH-328 | Year 3 | Oct,2019 | | 6 | Sinidu 2010 |
| 8 | SNNPR | Gurage | Ezha | Yeseraye | SH-369 | Year 3 | Jan,2020 | | 6 | Sinidu 2010 |
| 9 | SNNPR | Gurage | Ezha | Weradeba | SH-390 | Year 3 | Feb,2020 | | 6 | Sinidu 2010 |
| 10 | SNNPR | Gurage | Ezha | Agena 01 | SH-4886 | Year 3 | Mar,2020 | | 6 | Sinidu 2010 |
| 11 | SNNPR | Kembata Tembaro | Kedidagamela | Jore | 4449 | Year 1 | 01/02/2018 | | 6 | CR |
| 12 | SNNPR | Kembata Tembaro | Kedidagamela | Jore | 4451 | Year 1 | 01/02/2018 | | 6 | CR |
| 13 | SNNPR | Kembata Tembaro | Kedida Gamela | Abonsa | 4725 | Year 2 | Feburary,2019 | | 6 | Sinidu-2010 |
| 14 | SNNPR | Kembata Tembaro | Kedida Gamela | Abonsa | 4730 | Year 2 | Feburary,2019 | | 6 | Sinidu-2010 |
| 15 | SNNPR | Kembata Tembaro | Hadaro Tunto | 2gna tunto | SN- 4154 | Year 3 | October,2019 | | 6 | Sinidu 2010 |
| 16 | SNNPR | Kembata Tembaro | Hadaro Tunto | 2nd tunto | 251 | Year 3 | January,2020 | | 8 | Sinidu 2010 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | SNNPR | Sidama | Wondo Genet | Wetera Kechma | 4345 | Year 1 | 01/01/2018 | [redacted] | | 6 | CR |
| 18 | SNNPR | Sidama | Wondo Genet | Wesha | 4346 | Year 1 | 01/04/2018 | | | 6 | CR |
| 19 | SNNPR | Sidama | Wondo Genet | Wohsa | 4674 | Year 2 | March,2019 | | | 8 | Sinidu-2008 |
| 20 | SNNPR | Sidama | Shebedino | Morecho Negesha | SN+ HOPE 4361 | Year 3 | Jun,2019 | | | 6 | Sinidu 2010 |
| 21 | SNNPR | Sidama | Shebedino | M/Negash | SN+HOPE - 306 | Year 3 | July,2019 | | | 6 | Sinidu 2010 |
| 22 | SNNPR | Wolayita | Offa | Geleko | 4308 | Year 1 | 01/10/2017 | | | 6 | Sinidu |
| 23 | SNNPR | Wolayita | Offa | Galuka | 4117 | Year 1 | 01/12/2017 | | | 6 | Sinidu |
| 24 | SNNPR | Wolayita | Offa | Okoto sere | 4720 | Year 2 | January,2019 | | | 6 | Sinidu-2008 |
| 25 | SNNPR | Wolayita | Offa | Okoto sere | 7 | Year 2 | January,2019 | | | 6 | Sinidu-2008 |
| 26 | SNNPR | Wolayita | Offa | Mancha | 15 | Year 2 | February,2019 | | | 6 | Sinidu-2008 |
| 27 | SNNPR | Wolayita | Offa | Mancha | 11 | Year 2 | March,2019 | | | 6 | Sinidu-2008 |
| 28 | SNNPR | Wolayita | Boloso sore | wurmuma | Sn-hope-284 | Year 3 | Nov.,2019 | | | 6 | Sinidu 2010 |
| 29 | SNNPR | Wolayita | Boloso sore | Wururuma | SN-Hope-484 | Year 3 | Dec.,2019 | | | 6 | Sinidu 2010 |
| 30 | SNNPR | Wolayita | Boloso sore | Arka 02 | 4940 | Year 3 | March,2020 | | | 6 | Sinidu 2010 |
| 31 | SNNPR | Wolayita | Boloso sore | Arka 01 | 5084 | Year 3 | April,11,2020 | | | 6 | Sinidu 2010 |
| 32 | SNNPR | Wolayita | Damot pulasa | G/kabecho | 4966 | Year 3 | March,2020 | | | 6 | Sinidu 2010 |
| 33 | SNNPR | Wolayita | Damot pulasa | G/kabecho | 1951 | Year 3 | March,2020 | | | 6 | Sinidu 2010 |
| | | | | | | | | | | | |
| **Somali Region** | | | | | | | | | | | |
| **Ser. No.** | **Region** | **Zone** | **Woreda** | **Kebele** | **Plant Code** | **Year** | **Installation Month/Year** | **Name of User** | **Sex** | **Size (m3)** | **Model** |
| 1 | Somali | Fanfan | Gursum | Degahle | SOAB42 | Year 2 | 01/08/2018 | [redacted] | | 6 | Sinidu 2008 |
| 2 | Somali | Fanfan | Gursum | Degahle | SOAB16 | Year 2 | 01/08/2018 | | | 6 | Sinidu 2008 |
| 3 | Somali | Fanfan | Gursum | Degahle | SOAB43 | Year 2 | 01/07/2018 | | | 6 | Sinidu 2008 |
| 4 | Somali | Fanfan | Gursum | Degahle | SOAB53 | Year 2 | 01/07/2018 | | | 6 | Sinidu 2008 |
| 5 | Somali | Fanfan | Gursum | Degahle | SOAB45 | Year 2 | 01/07/2018 | | | 6 | Sinidu 2008 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 6 | Somali | Fanfan | Gursum | Degahle | SOAB48 | Year 2 | 01/10/2018 | [redacted] | 6 | Sinidu 2008 |
| 7 | Somali | Fanfan | Gursum | Degahle | | Year 2 | 01/09/2018 | | 6 | Sinidu 2008 |
| 8 | Somali | Fanfan | Gursum | Degahle | SOAB58 | Year 2 | 01/11/2018 | | 6 | Sinidu 2018 |
| 9 | Somali | Fanfan | Gursum | Degahle | SOAB41 | Year 2 | 01/11/2018 | | 6 | Sinidu 2008 |
| 10 | Somali | Fanfan | Gursum | Degahle | SOAB35 | Year 2 | 01/11/2018 | | 6 | Sinidu 2008 |
| 11 | Somali | Fanfan | Gursum | Degahle | SOAB47 | Year 3 | 2019 | | 6 | Sinidu 2008 |
| 12 | Somali | Fanfan | owbarre | ged-gedlac | 156 | Year 3 | 2019 | | 6 | Sinidu 2008 |
| 13 | Somali | Fanfan | owbarre | ged-gedlac | 158 | Year 3 | 2019 | | 8 | Sinidu 2008 |
| 14 | Somali | Fanfan | owbarre | lafa-ise | 152 | Year 3 | 2019 | | 8 | Sinidu 2008 |
| 15 | Somali | Fanfan | owbarre | lafa-ise | 154 | Year 3 | 2019 | | 8 | Sinidu 2008 |
| 16 | Somali | Fanfan | owbarre | Lafa-ise/harqurux | 101 | Year 3 | 2019 | | 8 | Sinidu 2008 |
| 17 | Somali | Fanfan | owbarre | Lafa-ise/harqurux | 103 | Year 3 | 2019 | | 8 | Sinidu 2008 |
| 18 | Somali | Fanfan | owbarre | Lafa-ise/harqurux | 105 | Year 3 | 2019 | | 8 | Sinidu 2008 |
| 19 | Somali | Fanfan | owbarre | Lafa-ise/harqurux | 107 | Year 3 | 2019 | | 8 | Sinidu 2008 |
| 20 | Somali | Fanfan | owbarre | Lafa-ise/harqurux | 109 | Year 3 | 2019 | | 8 | Sinidu 2008 |
| 21 | Somali | Fanfan | owbarre | Lafa-ise/harqurux | 111 | Year 3 | 2019 | | 8 | Sinidu 2008 |
| 22 | Somali | Fanfan | owbarre | Lafa-ise/harqurux | 113 | Year 3 | 2019 | | 8 | Sinidu 2008 |
| 23 | Somali | Fanfan | owbarre | Lafa-ise/harqurux | 115 | Year 3 | 2019 | | 8 | Sinidu 2008 |
| 24 | Somali | Fanfan | owbarre | Lafa-ise/subusha | 117 | Year 3 | 2019 | | 8 | Sinidu 2008 |
| 25 | Somali | Fanfan | owbarre | Lafa-ise/subusha | 119 | Year 3 | 2019 | | 8 | Sinidu 2008 |
| 26 | Somali | Fanfan | owbarre | Lafa-ise/subusha | 121 | Year 3 | 2019 | | 8 | Sinidu 2008 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 27 | Somali | Fanfan | owbarre | Lafa-ise/subusha | 123 | Year 3 | 2019 | [redacted] | 8 | Sinidu 2008 |
| 28 | Somali | Fanfan | owbarre | Lafa-ise/subusha | 125 | Year 3 | 2019 | | 6 | Sinidu 2008 |
| 29 | Somali | Fanfan | owbarre | Lafa-ise/subusha | 127 | Year 3 | 2019 | | 6 | Sinidu 2008 |
| 30 | Somali | Fanfan | owbarre | Lafa-ise/subusha | 129 | Year 3 | 2019 | | 6 | Sinidu 2008 |
| 31 | Somali | Fanfan | Shabeley | karamardha_R | 142 | Year 3 | 2019 | | 8 | Sinidu 2010 |
| 32 | Somali | Fanfan | Shabeley | karamardha_R | 140 | Year 3 | 2019 | | 8 | Sinidu 2010 |
| 33 | Somali | Fanfan | Shabeley | karamardha_R | 141 | Year 3 | 2019 | | 8 | Sinidu 2010 |
| 34 | Somali | Fanfan | Tulli-guled | Warabaley | 134 | Year 3 | 2019 | | 8 | Sinidu 2010 |
| 35 | Somali | Fanfan | Tulli-guled | Warabaley | 136 | Year 3 | 2019 | | 8 | Sinidu 20130 |

**List of Sample Bio-digesters in Amhara and Afar Regions**

| Ser. Nº | Region | Zone | Woreda | Kebele | Name Head HH | Plant code |
|---|---|---|---|---|---|---|
| 1 | Amhara | Awi | Guangua | Dangula | [redacted] | AM NBPE+ 7495 |
| 2 | Amhara | Awi | Guangua | Dangula | | |
| 3 | Amhara | Awi | Guangua | Dangula | | AM NBPE+ 9058 |
| 4 | Amhara | Awi | Guangua | Dangula | | + AF WE 84 |
| 5 | Amhara | Awi | Guangua | Dangula | | |
| 6 | Amhara | Awi | Guangua | Dangula | | |
| 7 | Amhara | Awi | Guangua | Dangula | | + AF AB - 6 |
| 8 | Amhara | Awi | Guangua | Dangula | | + AF WE 107 |
| 9 | Amhara | Awi | Guangua | Dangula | | + AF WE 85 |
| 10 | Amhara | Awi | Guangua | Dimama Manguda | | |
| 11 | Amhara | Awi | Guangua | Dimama Manguda | | AM 6985 |
| 12 | Amhara | Awi | Guangua | Dimama Manguda | | AM NBPE+ 7110 |
| 13 | Amhara | Awi | Banja | Wusla | | |
| 14 | Amhara | Awi | Banja | Wusla | | |
| 15 | Amhara | Awi | Banja | Wusla | | |
| 16 | Amhara | Awi | Banja | Wusla | | |
| 17 | Amhara | Awi | Banja | Wusla | | AM NBPE+ 9075 |
| 18 | Amhara | Awi | Banja | Wusla | | AM NBPE+ 7331 |
| 19 | Amhara | Awi | Banja | Wusla | [redacted] | AM NBPE+ 7114 |
| 20 | Amhara | East Gojjam | Mechakel | Kuashiba | | AM NBPE+ 7254 |
| 21 | Amhara | East Gojjam | Mechakel | Kuashiba | | AM NBPE+ 7465 |
| 22 | Amhara | East Gojjam | Mechakel | Kuashiba | | AM NBPE+ 6275 |
| 23 | Amhara | East Gojjam | Mechakel | Amanuel Zuria | | |
| 24 | Amhara | East Gojjam | Mechakel | Amanuel Zuria | | AM NBPE+ 7000 |
| 25 | Amhara | East Gojjam | Mechakel | Amanuel Zuria | | AM NBPE+ 6981 |
| 26 | Amhara | East Gojjam | Mechakel | Amanuel Zuria | | AM NBPE+ 6973 |
| 27 | Amhara | East Gojjam | Mechakel | Amanuel Zuria | | |
| 28 | Amhara | East Gojjam | Mechakel | Amanuel Zuria | | |
| 29 | Amhara | East Gojjam | Gozamin | Addisa ena Gulit | | AM NBPE+ 7245 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 30 | Amhara | East Gojjam | Gozamin | Addisa ena Gulit | [redacted] | AM 9087 NBPE+ |
| 31 | Amhara | East Gojjam | Gozamin | Addisa ena Gulit | | |
| 32 | Amhara | East Gojjam | Gozamin | Addisa ena Gulit | | AM 9074 NBPE+ |
| 33 | Amhara | East Gojjam | Gozamin | Addisa ena Gulit | | AM 9076 NBPE+ |
| 34 | Amhara | East Gojjam | Gozamin | Addisa ena Gulit | | AM 9055 NBPE+ |
| 35 | Amhara | East Gojjam | Gozamin | Dedegeb | | AM 6319 NBPE+ |
| 36 | Amhara | East Gojjam | Gozamin | Dedegeb | | |
| 37 | Amhara | East Gojjam | Gozamin | Dedegeb | | |
| 38 | Amhara | East Gojjam | Gozamin | Degem | | |
| 39 | Amhara | East Gojjam | Gozamin | Degem | | AM 7219 NBPE+ |
| 40 | Amhara | East Gojjam | Gozamin | Degem | | |
| 41 | Amhara | East Gojjam | Gozamin | Degem | | |
| 42 | Amhara | East Gojjam | Gozamin | Degem | | |
| 43 | Amhara | East Gojjam | Gozamin | Limchmo | | |
| 44 | Amhara | East Gojjam | Gozamin | Limchmo | | |
| 45 | Amhara | East Gojjam | Gozamin | Degem | | AM 9143 NBPE+ |
| 46 | Amhara | East Gojjam | Gozamin | Degem | | AM 7028 NBPE+ |
| 47 | Amhara | East Gojjam | Gozamin | Degem | | AM 4944 |
| 48 | Amhara | East Gojjam | Gozamin | Amber Zuria | | AM 7152 NBPE+ |
| 49 | Amhara | East Gojjam | Gozamin | Amber Zuria | | |
| 50 | Amhara | East Gojjam | Gozamin | Yewisha | | AM 9267 NBPE+ |
| 51 | Amhara | East Gojjam | Gozamin | Aneded | | AM 9273 NBPE+ |
| 52 | Amhara | East Gojjam | Gozamin | Amber Zuria | | AM 6433 NBPE+ |
| 53 | Amhara | East Gojjam | Gozamin | Amber Zuria | | |
| 54 | Amhara | East Gojjam | Gozamin | Amber Zuria | | AM 6422 NBPE+ |
| 55 | Amhara | East Gojjam | Gozamin | Amber Zuria | | AM 7161 NBPE+ |
| 56 | Amhara | East Gojjam | Gozamin | Amber Zuria | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 57 | Amhara | East Gojjam | Gozamin | Amber Zuria | [redacted] | AM 7498 NBPE+ |
| 58 | Amhara | East Gojjam | Gozamin | Amber Zuria | | AM 5667 NBPE+ |
| 59 | Amhara | East Gojjam | Gozamin | Yebo Arjena | | AM 7266 NBPE+ |
| 60 | Amhara | East Gojjam | Gozamin | Yebo Arjena | | AM 7305 NBPE+ |
| 61 | Amhara | East Gojjam | Gozamin | Yebo Arjena | | AM 7318 NBPE+ |
| 62 | Amhara | East Gojjam | Gozamin | Yebo Arjena | | AM 10559 NBPE+ |
| 63 | Amhara | East Gojjam | Gozamin | Yebo Arjena | | |
| 64 | Amhara | East Gojjam | Gozamin | Yebo Arjena | | AM 7461 NBPE+ |
| 65 | Amhara | East Gojjam | Gozamin | Yebo Arjena | | |
| 66 | Amhara | East Gojjam | Gozamin | Yebo Arjena | | AF WE 57 |
| 67 | Amhara | East Gojjam | Gozamin | Yebo Arjena | | AM 7308 NBPE+ |
| 68 | Amhara | East Gojjam | Gozamin | Yebo Arjena | | AM 7301 NBPE+ |
| 69 | Amhara | East Gojjam | Gozamin | Yebo Arjena | | + AF WE 150 |
| 70 | Amhara | East Gojjam | Gozamin | Yebo Arjena | | + AF WE 105 |
| 71 | Amhara | East Gojjam | Gozamin | Diko Kanta | | AM 6410 NBPE+ |
| 72 | Amhara | East Gojjam | Gozamin | Diko Kanta | | AM 5666 NBPE+ |
| 73 | Amhara | East Gojjam | Gozamin | Diko Kanta | | |
| 74 | Amhara | East Gojjam | Gozamin | Diko Kanta | | AM 7202 NBPE+ |
| 75 | Amhara | East Gojjam | Gozamin | Diko Kanta | | AM 7106 NBPE+ |
| 76 | Amhara | East Gojjam | Gozamin | Diko Kanta | | |
| 77 | Amhara | East Gojjam | Gozamin | Diko Kanta | | |
| 78 | Amhara | East Gojjam | Gozamin | Diko Kanta | | |
| 79 | Amhara | East Gojjam | Gozamin | Gena Memcha | | AM 5618 NBPE+ |
| 80 | Amhara | East Gojjam | Gozamin | Gena Memcha | | AM 6342 NBPE+ |
| 81 | Amhara | East Gojjam | Gozamin | Gena Memcha | | |
| 82 | Amhara | East Gojjam | Enarj Enawga | Bichena | | |
| 83 | Amhara | East Gojjam | Enarj Enawga | Zachana | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 84 | Amhara | East Gojjam | Enarj Enawga | Zachana | [redacted] | AMTG 7472 |
| 85 | Amhara | East Gojjam | Enarj Enawga | Zachana | | AMTG 7475 |
| 86 | Amhara | East Gojjam | Enarj Enawga | Zachana | | AM NBPE+7793 |
| 87 | Amhara | East Gojjam | Enarj Enawga | Zachana | | AM NBPE+6517 |
| 88 | Amhara | East Gojjam | Enarj Enawga | Zachana | | |
| 89 | Amhara | East Gojjam | Enarj Enawga | Zachana | | |
| 90 | Amhara | East Gojjam | Dejen | Sebshinto | | |
| 91 | Amhara | North Shoa | Angelele | Tsigereda | | |
| 92 | Amhara | North Shoa | Angelele | Tsigereda | | |
| 93 | Amhara | North Shoa | Angelele | Tsigereda | | |
| 94 | Amhara | North Shoa | Baso Werena | Abamotie | | AM NBPE+5710 |
| 95 | Amhara | North Shoa | Baso Werena | Abamotie | | + AF WE 76 |
| 96 | Amhara | North Shoa | Baso Werena | Abamotie | | AM NBPE+5702 |
| 97 | Amhara | North Shoa | Baso Werena | Abamotie | | AM NBPE+ 7310 |
| 98 | Amhara | North Shoa | Baso Werena | Abamotie | | AF WE 40 |
| 99 | Amhara | North Shoa | Baso Werena | Abamotie | | |
| 100 | Amhara | North Shoa | Menz Mama | Aritina nicha | | AM NBPE+5702 |
| 101 | Amhara | North Shoa | Menz Mama | Aritina nicha | | AF WE 20 |
| 102 | Amhara | North Shoa | Menz Mama | Aritina nicha | | AM NBPE+ 9264 |
| 103 | Amhara | North Shoa | Menz Mama | Aritina nicha | | |
| 104 | Amhara | North Shoa | Menz Mama | Aritina nicha | | |
| 105 | Amhara | North Shoa | | Ataye | | AM NBPE+ 6300 |
| 106 | Amhara | North Shoa | Tarma Ber | Asfachew | | |
| 107 | Amhara | North Shoa | Tarma Ber | Asfachew | | |
| 108 | Amhara | North Shoa | Tarma Ber | Asfachew | | AM NBPE+ 7028 |
| 109 | Amhara | South Wello | Kalu | Wedajo 022 | | |
| 110 | Amhara | South Wello | Kalu | Arabo 021 | | AF WE 22 |
| 111 | Amhara | South Wello | Kalu | Arabo | | AF WE 47 |
| 112 | Amhara | North Shoa | Minijar Shenkora | Kiticha | | AF WE 62 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 113 | Amhara | North Shoa | Minijar Shenkora | Kiticha | [redacted] | AM NBPE+ 6306 |
| 114 | Amhara | North Shoa | Minijar Shenkora | Kiticha | | AM NBPE+ 7197 |
| 115 | Amhara | North Shoa | Minijar Shenkora | Kiticha | | AF WE 53 |
| 116 | Amhara | North Shoa | Minijar Shenkora | Kiticha | | AM NBPE+ 10439 |
| 117 | Amhara | North Shoa | Minijar Shenkora | Kiticha | | |
| 118 | Amhara | North Shoa | Minijar Shenkora | Kiticha | | AF WE 17 |
| 119 | Amhara | North Shoa | Asagrity | Wena | | AF WE 55 |
| 120 | Amhara | North Shoa | Asagrity | Wena | | AF WE 43 |
| 121 | Amhara | North Shoa | Asagrity | Wena | | |
| 122 | Amhara | North Shoa | Asagrity | Wena | | |
| 123 | Amhara | North Shoa | Asagrity | Wena | | |
| 124 | Afar | zone 1 | Dubti | Aliese | | AF WE 58 |
| 125 | Afar | zone 1 | Dubti | Aliese | | AM NBPE+ 10262 |
| 126 | Afar | zone 1 | Dubti | Aliese | | |
| 127 | Afar | zone 1 | Dubti | Aliese | | AM NBPE+ 6331 |
| 128 | Afar | zone 1 | Assayita | Berga | | |
| 129 | Afar | zone 1 | Assayita | Berga | | AM NBPE+ 7315 |
| 130 | Afar | zone 1 | Assayita | Berga | [redacted] | AF WE 18 |
| 131 | Afar | zone 1 | Assayita | Berga | | AF WE 16 |
| 132 | Afar | zone 1 | Assayita | Berga | | |
| 133 | Afar | zone 1 | Assayita | Berga | | |
| 134 | Afar | zone 1 | Assayita | Berga | | |
| 135 | Afar | zone 1 | Assayita | Berga | | |
| 136 | Afar | zone 1 | Assayita | Berga | | AF WE 45 |
| 137 | Afar | zone 1 | Assayita | Berga | | |
| 138 | Afar | zone 1 | Assayita | Berga | | AM NBPE+ 10509 |
| 139 | Afar | zone 1 | Assayita | Berga | | AF WE 21 |
| 140 | Afar | zone 1 | Assayita | Berga | | + AF WE 105 |
| 141 | Afar | zone 1 | Assayita | Berga | | + AF WE 105 |
| 142 | Afar | zone 1 | Afambo | Alasa Bolo | | AM NBPE+ 6143 |
| 143 | Afar | zone 1 | Afambo | Alasa Bolo | | AM NBPE+ 7473 |
| 144 | Afar | zone 1 | Afambo | Alasa Bolo | | |
| 145 | Afar | zone 1 | Afambo | Alasa Bolo | | AM NBPE+ 7513 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 146 | Afar | zone 1 | Afambo | Alasa Bolo | [redacted] | + AF WE 87 |
| 147 | Afar | zone 1 | Afambo | Alasa Bolo | | + AF WE 123 |
| 148 | Afar | zone 1 | Assayita | Hinale 1st meda | | + AF WE 110 |
| 149 | Afar | zone 1 | Assayita | Hinale 1st meda | | + AF WE 105 |
| 150 | Afar | zone 1 | Assayita | Hinale 1st meda | | + AF WE 106 |
| 151 | Afar | zone 1 | Assayita | Hinale 1st meda | | AM NBPE+ 6306 |
| 152 | Afar | zone 1 | Amibara | | | |
| 153 | Afar | zone 1 | Amibara | | | AF WE 39 |
| 154 | Afar | zone 1 | Amibara | | | + AF WE 105 |
| 155 | Afar | zone 1 | Amibara | | | |
| 156 | Afar | zone 1 | Amibara | | | AF WE 38 |
| 157 | Afar | zone 1 | Amibara | | | AF WE 41 |
| 158 | Afar | zone 1 | Amibara | | | + AF AB -9 |

# Annex V - Photo Exhibits from Afar and Amhara.

*Exhibit 1. Sinking Bio-digester, Gozamin Woreda, East Gojjam Zone Amhara region*

*Exhibit 2. Bio-digester prone to erosion, Gozamin Woreda, East Gojjam Zone Amhara region*

*Exhibit 3. Broken pipeline, Gozamin Woreda, East Gojjam Zone Amhara region*

*Exhibit 4. Broken pipe, Dangla Zurya, Awi Zone, Amhara region*

*Exhibit 5. Broken pipe, Dangla Zurya, Awi Zone, Amhara region*

*Exhibit 6. Broken pipeline, Assayita Woreda, Zone 1, Afar Reggion*

*Exhibit 7. Unprotected Gas pipeline exposed to damage by animals and children, Dangla Woreda, Awi Zone Amhara Region.*

*Exhibit 8. Gas leakage uncovered during the technical evaluation mission Banja Woreda, Awi Zone, Amhara Region*

*Exhibit 9. Gas leakage uncovered during the technical evaluation mission and repaired by Woreda Energy Expert, Banja Woreda, Awi Zone, Amhara Region*

*Exhibit 10. Broken lighting, Guangua and Banja Woredas, Awi Zone and Mechakel Woreda, East Gojjam Zone, Amhara Region Amhara Region*

*Exhibit 11. Non-functional Bio-digester due to lack of dung Cattle movement to dstant areas for Pasture, Afambo Woreda, Zone 1, Afar Region*

*Exhibit 12. Abandoned Bio-digester due to flooding (Overflow of the Awash reviver). Assayita Woreda, Zone 1, Afar Reggion*

*Exhibit 13. Dung water mixer (Bio-digester insttallations in Afar region are equipped with mixer.*

*Exhibit 14. Solar Lanterns are provided as replacement to biogas lighting to protect grass hut homes against fire. Afar Region*

*Exhibit 15. Well-protected turret, Bibugn Woreda, East Gojjam Zone Amhara region*

*Exhibit 16. Protected Inlet, clean toilet, protected cmpost pit and increase in mango yield associated with bio-slurry application. Kalu Woreda, South Wello Zone, Amhara Region*

*Exhibit 17. Application of Bio-slurry, Bibugn Woreda, East Gojjam Zone Amhara region*

# Annex VI - Statistical Tables

## Table 1. Sample Distribution

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| **Sample size (n=)** | | | 35 | 123 | 25 | 44 | 33 | 35 |
| Sample household % | | | 12% | 42% | 8% | 15% | 11.2% | 12% |

## Table 2. Household characteristics

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| **Average Household size** | 276 | 0.3 | 7.1 | 5.7 | 7 | 7.3 | 7.3 | 9.6 |
| **Distribution of households by Family Size** | | | | | | | | |
| Family Size | | | | | | | | |
| 2 | 2 | | 0.0% | 1.6% | - | - | | |
| 3 | 12 | | 2.9% | 7.3% | 7.7% | 2.3% | | |
| 4 | 26 | | 0.0% | 14.6% | 15.4% | 9.1% | 6.1% | |
| 5 | 41 | | 22.9% | 19.5% | - | 11.4% | 12.1% | |
| 6 | 48 | | 8.6% | 20.3% | 15.4% | 13.6 | 24.2% | 11.8% |
| 7 | 50 | | 17.1% | 21.1% | 7.7% | 20.5 | 18.2% | 5.9% |
| 8 | 34 | | 25.7% | 8.9% | 23.1% | 13.6% | 3.0% | 11.8% |
| 9 | 29 | | 8.6% | 2.4% | 23.1% | 11.4% | 33.3% | 11.8% |
| 10 | 18 | | 5.7% | 0.8% | 7.7% | 13.6% | | 23.5% |
| 11 | 8 | | 2.9% | 0.0% | 0.0% | | | 20.6% |
| 12 | 5 | | - | - | - | 4.5% | | 8.8% |
| 13 | 1 | | | | | | | 2.9% |
| 14 | 1 | | | | | | | 2.9% |
| 15 | 1 | | | | | | 3.0% | |

## Table 3. Characteristics of heads of household

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| **Sex of Head of household** | | | | | | | | |
| Male (%) | 205 | | 54% | 91% | 76.9% | 81.8% | 78.8% | 88.2% |
| Female (%) | 73 | | 40% | 7% | 23.1% | 18.2% | 21.2% | 11.8% |
| **Mean Age of head of HH** | 271 | | 42 | 45 | 39.1 | 45.2 | 41.4 | 40.3 |
| **Education of Head of HH** | | | | | | | | |
| Illiterate | 94 | | 51% | 33% | 7.7% | 15.9% | 6.1% | 76.5% |
| Read and Write | 139 | | 14% | 33% | 92.3% | 94.1% | 93.9% | 23.5% |
| Years of formal education of head of Household | | | | | | | | |
| 1 | 10 | | 0.0% | 0.0% | 7.7% | 15.9% | 3.0% | 2.9% |
| 2 | 5 | | 0.0% | 0.8% | 0.0% | 6.8% | 3.0% | |
| 3 | 8 | | 0.0% | 2.4% | 7.7% | 6.8% | | 2.9% |
| 4 | 12 | | 5.7% | 5.7% | 7.7% | - | 6.1% | |
| 5 | 12 | | 5.7% | 1.6% | 7.7% | 4.5% | 12.1% | 2.9% |
| 6 | 15 | | 0.0% | 5.7% | 7.7% | 11.4% | 6.1% | |
| 7 | 13 | | 2.9% | 3.3% | 0.0% | 9.1% | 12.1% | |
| 8 | 9 | | 0.0% | 3.3% | 15.4% | 4.5% | | 2.9% |
| 9 | 7 | | 2.9% | 1.6% | 0.0% | 2.3% | 9.1% | |
| 10 | 24 | | 0.0% | 5.7% | 15.4% | 13.6% | 24.2% | 2.9% |
| 11 | 1 | | 0.0% | 0.8% | 0.0% | - | | |
| 12 | 2 | | 2.9% | 0.0% | 0.0% | - | | 2.9% |
| College Diploma | 12 | | 2.9% | 0.0% | 7.7% | 4.5 | 12.1% | |
| Bachelor's Degree | 2 | | 2.9% | 0.0% | 15.4% | 4.6 | 6.0% | 2.9% |

## Table 4. Awareness and promotion media

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| Radio | 9 | | 0.0% | 1.6% | 4.8% | 6.8% | 6.1% | 2.9% |
| Television | 11 | | 0.0% | 0.8% | 4.8% | 6.8% | 12.1% | 5.7% |
| House-to-house promotion by Energy Experts and masons | 152 | | 91.4% | 19.5% | 85.7% | 61.4% | 69.7% | 80.0% |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Information during community meeting | 109 | | 17.1% | 72.4% | 4.8% | 11.4% | 12.1% | 11.4% |
| Recommendation by bio digester users | 20 | | 0.0% | 13.8% | 0.0% | 6.8% | | |
| Other: Recommendation by Agri. Development Agents | 4 | | 0.0% | 0.8% | 0.0% | 6.8% | | |

**Table 5. Purpose for installation of Bio-digester**

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| Cooking | 273 | | 91.4% | 95.9% | 92.3% | 100.0% | 100.0% | 100.0% |
| Lighting | 212 | | 14.3% | 90.2% | 7.7% | 90.9% | 71.4% | 91.2% |
| Fertilizer use | 155 | | 42.9% | 75.6% | 15.4% | 52.3% | 65.7% | 0.0% |
| Other: Toilet | 30 | | 0.0% | 1.6% | 0.0 | 20.5% | 57.1% | 0.0% |

**Table 6. Households Ownership of Cattle**

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| Oxen | 266 | | 3.2 | 2.6 | 1.5 | 1.7 | 1.1 | 1.5 |
| Cows | 266 | | 7.3 | 2.5 | 7.1 | 5.6 | 4.4 | 10.5 |
| Other livestock | 265 | | 5.1 | 3.1 | 9.1 | 5.4 | 4.4 | 16.3 |
| Distribution of HHs by ownership of Cattle (Oxen and Cows) | | | | | | | | |
| 0 | 3 | | 8.6% | 0.0% | | 0.0% | | |
| 1 | 1 | | 0.0% | 0.8% | | 0.0% | | |
| 2 | 14 | | 5.7% | 8.1% | | 4.5% | | |
| 3 | 24 | | 0.0% | 15.4% | 15.4% | 6.82% | | |
| 4 | 44 | | 5.7% | 17.1% | 7.7% | 15.91% | 36.4% | 2.9% |
| 5 | 46 | | 8.6% | 22.8% | 7.7% | 11.36% | 24.2% | 2.9% |
| 6 | 29 | | 11.4% | 4.1% | 23.1% | 15.91% | 27.3% | 2.9% |
| 7 | 22 | | 11.4% | 7.3% | 7.7% | 9.09% | 6.1% | 5.9% |
| 8 | 20 | | 2.9% | 9.8% | | 6.82% | | 11.8% |
| 9 | 7 | | 0.0% | 0.8% | 7.7% | 4.55% | 3.0% | 5.9% |
| 10 | 9 | | 2.9% | 0.8% | 7.7% | 4.55% | | 11.8% |
| 11 | 6 | | 0.0% | 1.6% | | 2.27% | | 8.8% |
| 12 | 7 | | 2.9% | 0.0% | | 6.82% | | 8.8% |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 13 | 2 | | | | | | 5.9% |
| 14 | 10 | 8.6% | 0.0% | 15.4% | 4.5% | 3.0% | 5.9% |
| 15 | 7 | 2.9% | 0.0% | | 4.5% | | 11.8% |
| 16 | 2 | 2.9% | 0.8% | | 0.0% | | |
| 17 | 1 | 0.0% | 0.8% | | 0.0% | | |
| 20 | 5 | 5.7% | 0.0% | | 0.0% | | 8.8% |
| 21 | 1 | | | | 2.3% | | |
| 22 | 2 | 2.9% | 0.0% | | 0.0% | | 2.9% |
| 25 | 3 | 0.0% | 0.0% | 7.7% | | | 2.9% |
| 30 | 1 | 0.0% | 0.0% | | | | |
| 40 | 2 | 5.7% | 0.0% | | | | |

## Table 7. User Contribution to bio digester installation

| | Digester size, $m^3$ | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|---|
| | 4 | 3 | | | | | 4500 | | |
| Cash and in-kind, ETB/HH | 6 | 246 | | 4,349 | 2,950 | 7438.5 | 7487 | 6690 | 6400 |
| | 8 | 28 | | | | | 7800 | 9150 | 8950 |
| | 10 | | | | | | | | |

## Table 8. Functionality of Bio-digester plants

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| Fully functional | 200 | | 62.5% | 72.4% | 77% | 75% | 69.7% | 73.5% |
| Not functioning | 79 | | 37.5% | 27.6% | 23% | 25% | 30.3% | 26.5% |

## Table 9. Distribution of Non-functional bio-digesters by Number of Months

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| Average number of months bio-digester plants not functioning | 59 | | 5.4 | 4.8 | 18.6 | 6.9 | | |
| Distribution of non-functioning bio digesters by number of months | | | | | | | | |
| Less than 1 month | 1 | | 8.3% | 0.0% | 0.0% | 0.0% | | |
| 1 | 5 | | 16.7% | 8.8% | 0.0% | 0.0% | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2 | 9 | | 8.3% | 17.6% | 0.0% | 0.0% | 3.0% | 2.9% |
| 3 | 8 | | 8.3% | 14.7% | 0.0% | 0.0% | | 5.9% |
| 4 | 14 | | 25.0% | 8.8% | 0.0% | 11.4% | 3.0% | 5.9% |
| 5 | 3 | | 0.0% | 5.9% | 0.0% | 0.0% | 3.0% | |
| 6 | 9 | | 8.3% | 8.8% | 0.0% | 6.8% | 6.1% | |
| 7 | 4 | | 0.0% | 8.8% | 0.0% | 0.0% | 3.0% | |
| 8 | 5 | | 0.0% | 11.8% | 0.0% | 2.3% | | |
| 10 | 5 | | 8.3% | 8.8% | 0.0% | 0.0% | | 2.9% |
| 12 | 7 | | 16.7% | 0.0% | 0.0% | 2.3% | 6.1% | 5.9% |
| Above 12 months | 8 | | 8.3% | 0.0% | 23.0% | 2.3% | 6.1% | 2.9% |

**Table 10. Main reason for non-functioning of bio-digester**

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| Failure of appliance | 50 | | 2.9% | 12.2% | 66.7% | 36.4% | 50% | 11.1 |
| Bio-digester is physically damaged | 29 | | 2.9% | 5.7% | | 18.2 | 10% | 22.2% |
| Insufficient dung for feeding | 59 | | 54.3% | 13.0% | 33.3% | 9.1% | | |
| Insufficient water input | 33 | | 25.7% | 10.6% | | 18.2% | | 66.7% |
| Lack of time for feeding | 27 | | 8.6% | 11.4% | | | 10% | |
| Improper site for construction | 10 | | | | | | 20% | |
| Switch to other energy sources | 10 | | | | | | 10% | |
| Other | 14 | | 2.9% | 1.6% | | 18.2 | | |

**Table 11. Benefits of biogas use**

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| Fuel saving | 240 | | 94.3% | 94.3% | 75% | 50% | 88.9% | 16.7% |
| Expenditure saving | 105 | | 0.0% | 11.4% | 75% | 50% | 88.9% | 16.7% |
| Fuel collection time saving | 234 | | 77.1% | 94.3% | 75% | 100% | 100% | 50% |
| Cooking time saving | 235 | | 77.1% | 95.1% | 75% | 96.4% | 100% | 50% |

## Table 12. Fuel displaced by biogas use

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| Fuelwood | 143 | | 80.0% | 93.5% | 75% | 50% | 88.9% | 16.7% |
| Charcoal | 9 | | 0.0% | 7.3% | 75% | 100% | 100% | 100% |
| Kerosene | 5 | | 0.0% | 4.1% | 0% | 2.3% | 12.1% | 0% |
| Drywell batteries | 4 | | 8.6% | 0.8% | 0% | 4.5% | 6.1% | 0% |

## Table 13. Expenditure saving, ETB/Month/Household

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| **Firewood** | | | | | | | | |
| n= | 187 | | 28 | 115 | 13 | 44 | 33 | 34 |
| Expenditure saving, ETB/month/HH | 200 | | - | - | 275.4 | 303.4 | | |
| **Charcoal** | | | | | | | | |
| n= | 66 | | - | 9 | 13 | 44 | | |
| Expenditure saving, ETB/month/HH | 158 | | - | 6.1 | 301.1 | 269.0 | | |
| **Kerosene** | | | | | | | | |
| n= | 5 | | - | 5 | - | - | | |
| Expenditure saving, ETB/month/HH | 158 | | - | 2.5 | - | - | | |
| **Candle** | | | | | | | | |
| n= | - | | - | - | | | | |
| Expenditure saving, ETB/month/HH | - | - - | - | - | | | | |
| **Drywell Batteries** | | | | | | | | |
| n= | 5 | | 3 | 2 | 13 | - | | |
| Expenditure saving, ETB/month/HH | 158 | | 8.6 | 1.2 | 12.0 | - | | |

## Table 14. Use of bio-slurry by households

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| n= | 210 | | 33 | 120 | 13 | 44 | 33 | 34 |
| Yes | 128 | | 18 | 78 | 4 | 40 | 24 | 31 |
| No | 82 | | 15 | 42 | 9 | 4 | 9 | 3 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| % | | | | | | | | |
| Yes | 128 | | 54.5% | 65.0% | 30.8% | 90.9% | 72.7% | 90.2% |
| No | 82 | | 45.5% | 35.0% | 69.2% | 9.1% | 27.3% | 8.8% |

## Table 15. How bio-slurry used

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| As it is | 77 | | 66.7% | 62.8% | 23.1% | 18.2% | 15.2% | |
| Composting | 111 | | 16.7% | 6.4% | 7.7% | 59.1% | 30.3% | |
| After drying | 61 | | 16.7% | 30.8% | | | 9.1% | 91.2% |
| Both composting and after drying | 6 | | 0.0% | 0.0% | 0.0% | 9.1% | 6.0% | |
| Both as it is semiliquid and composting | 5 | | 0.0% | 0.0% | 0.0% | 4.6% | 9.1% | |
| As it is semiliquid and after drying | 1 | | 0.0% | 0.0% | 0.0% | 0.0 | 3.0% | |
| Not utilized | 12 | | - | - | 69.2% | 9.1% | 27.3% | 8.8% |
| Other | - | - | 0.0% | 0.0% | - | | | |

## Table 16. Impact of Application of bio-slurry on crop yield

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| **Teff** | | | | | | | | |
| n= | 3 | | - | 3 | - | | | |
| Increased | 8 | | | 66.7% | - | 18.2% | | |
| Decreased | - | | | 0.0% | - | | | |
| Not yet known | - | | | 33.3% | - | | | |
| Do not know | - | | | 0.0% | - | | | |
| **Corn** | | | | | | | | |
| n= | 108 | | 5 | 22 | 2 | 33 | 15 | 31 |
| Increased | - | | 40.0% | 72.7% | 15.4% | | | 91.2% |
| Decreased | - | | 0.0% | 0.0% | - | | | |
| Not yet known | - | | 60.0% | 27.3% | - | | | |
| Do not know | - | | 0.0% | 0.0% | - | | | |
| **Wheat** | | | | | - | | | |

| | | | | | |
|---|---|---|---|---|---|
| n= | 49 | - | 20 | - | |
| Increased | - | #DIV/0! | 80.0% | - | 66.0% |
| Decreased | - | #DIV/0! | 0.0% | - | |
| Not yet known | - | #DIV/0! | 20.0% | - | |
| Do not know | - | #DIV/0! | 0.0% | - | |
| **Barely** | | | | | |
| n= | 10 | 2 | 8 | - | |
| Increased | - | 50.0% | 50.0% | - | |
| Decreased | - | 0.0% | 0.0% | - | |
| Not yet known | - | 50.0% | 50.0% | - | |
| Do not know | - | 0.0% | 0.0% | - | |
| **Sorghum** | | | | | |
| n= | 15 | 6 | 9 | - | |
| Increased | - | 66.7% | 55.6% | - | |
| Decreased | - | 0.0% | 0.0% | - | |
| Not yet known | - | 33.3% | 44.4% | - | |
| Do not know | - | 0.0% | 0.0% | - | |
| **Faba bean** | | | | | |
| n= | 25 | 1 | 24 | - | |
| Increased | - | 0.0% | 66.7% | - | |
| Decreased | - | 0.0% | 0.0% | - | |
| Not yet known | - | 100.0% | 33.3% | - | |
| Do not know | - | 0.0% | 0.0% | - | |
| **Vegetables** | | | | | |
| n= | 37 | 4 | 32 | 1 | |
| Increased | - | 50.0% | 81.3% | 7.7% | |
| Decreased | - | 0.0% | 0.0% | - | |
| Not yet known | - | 50.0% | 18.8% | - | |
| Do not know | - | 0.0% | 0.0% | - | |
| **Fruits** | | | | | |
| n= | 9 | 2 | 6 | 1 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Increased | - | 100.0% | 83.3% | 7.7% | | |
| Decreased | - | 0.0% | 0.0% | - | | |
| Not yet known | - | 0.0% | 16.7% | - | | |
| Do not know | - | 0.0% | 0.0% | - | | |
| **Coffee** | | | | | | |
| n= | 6 | 1 | 5 | - | | |
| Increased | - | 100.0% | 60.0% | - | | |
| Decreased | - | 0.0% | 0.0% | - | | |
| Not yet known | - | 0.0% | 40.0% | - | | |
| Do not know | - | 0.0% | 0.0% | - | | |
| **Chat** | | | | | | |
| n= | 3 | - | 1 | - | | |
| Increased | - | #DIV/0! | 0.0% | | | |
| Decreased | - | #DIV/0! | 0.0% | | | |
| Not yet known | - | #DIV/0! | 100.0% | | | |
| Do not know | - | #DIV/0! | 0.0% | | | |
| **Animal Feed** | | | | | | |
| n= | 1 | 1 | - | | | |
| Increased | - | 100.0% | #DIV/0! | | | |
| Decreased | - | 0.0% | #DIV/0! | | | |
| Not yet known | - | 0.0% | #DIV/0! | | | |
| Do not know | - | 0.0% | #DIV/0! | | | |
| **Sugarcane** | | | | | | |
| n= | 1 | - | 1 | | | |
| Increased | 11 | #DIV/0! | 100.0% | | 12.1% | 16.0% |
| Decreased | - | #DIV/0! | 0.0% | | | |
| Not yet known | - | #DIV/0! | 0.0% | | | |
| Do not know | - | #DIV/0! | 0.0% | | | |
| **Hinna** | | | | | | |
| n= | 5 | 1 | 4 | | | |
| Increased | - | 100.0% | 75.0% | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Decreased | - | | 0.0% | 0.0% | | | | |
| Not yet known | - | | 0.0% | 25.0% | | | | |
| Do not know | - | | 0.0% | 0.0% | | | | |
| Not utilized | 9 | | | | 9 | | | |

## Table 17. Chemical Fertilizer Substituted and Expenditure Savings

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| **Chemical Fertilizer Substitution** | | | | | | | | |
| **Urea** | | | | | | | | |
| n= | 29 | | 5 | 24 | 0 | 0 | 4 | 1 |
| Urea Before, kg | 134 | | 65 | 144 | | | 100 | 100 |
| Urea After, kg | 60 | | 20 | 68 | | | 44 | 50 |
| Urea Saving, Kg | 70 | | 45 | 75 | | | 56 | 50 |
| **DAP** | | | | | | | | |
| n= | 38 | | 6 | 32 | 0 | 0 | 4 | 0 |
| DAP Before, kg | 131 | | 90 | 138 | | | 100 | |
| DAP After, kg | 60 | | 25 | 65 | | | 44 | |
| DAP Saving, Kg | 72 | | 65 | 73 | | | 56 | |
| | | | | | | | | |
| **Expenditure saving on Urea and DAP** | | | | | | | | |
| **Urea** | | | | | 0 | 0 | | 0 |
| n= | 29 | | 5 | 24 | | | 4 | 1 |
| Expenditure on Urea before, ETB | 29 | | 862 | 2,278 | | | 1197.5 | 600 |
| Expenditure on Urea After, ETB | 29 | | 140 | 1,059 | | | 474 | 300 |
| Expenditure Saving on Urea, ETB/HH/Year | 29 | | 722 | 1,219 | | | 724 | 300 |
| **DAP** | | | | | | | | |
| n= | 35 | | 4 | 31 | 0 | 0 | 4 | 0 |
| Expenditure on DAP before, ETB | 35 | | 1,450 | 2,115 | | 0 | 1367.5 | 0 |
| Expenditure on DAP After, ETB | 35 | | 731 | 853 | | | 581.2 | |
| Expenditure Saving on DAP, ETB/HH/Year | 35 | | 719 | 1,262 | | | 786.2 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Average Expenditure savings on Urea and DAP** | 36 | | 1,297 | 2,206 | | | | |

## Table 18. Disadvantages of Bio-digester plant

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| None | 189 | | 57.1% | 63.4% | 30.8% | 90.9% | 97% | 11.8% |
| Dung shortage | 14 | | 11.4% | 8.1% | | | | |
| Firewood collection easier than dung collection | 1 | | 0.0% | 0.8% | | | | |
| Flooding | 1 | | 0.0% | 0.8% | | | | |
| Gas not adequate to meet daily energy needs | 4 | | 0.0% | 3.3% | | | | 11.8% |
| Gas supply is inconsistent/intermittent | 1 | | 0.0% | 0.8% | | | | |
| Gas smell | 4 | | 0.0% | 0.8% | 23.1% | | | |
| Hand mixing of dung | 2 | | 0.0% | 1.6% | | | | |
| Labour requirement | 8 | | 2.9% | 4.1% | | | | 5.9% |
| Lighting replacement not available in market | 4 | | 0.0% | 3.3% | | | | |
| No Injera Mitad | 4 | | 5.7% | 1.6% | | | | |
| Water shortage, distant | 50 | | 17.1% | 9.8% | | 25.0% | | 61.8% |
| Lack of bioslurry disposal | 2 | | - | - | 15.4% | | | |
| More money spent for biodigester or credit | 31 | | - | - | 7.7% | 6.8% | 54.5% | 8.8% |
| Inappropriate place | 1 | | | | | 2.3% | | |
| Unknown | 3 | | - | - | 23.1% | | | |

## Table 19. Bio-digester User Satisfaction

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| *Overall, to what extent is your household satisfied with your bio-digester plant?* | | | | | | | | |
| Highly Satisfied | 171 | | 87.5% | 75.6% | 30.8% | 43.2% | 27.3% | 44.1% |
| Satisfied | 26 | | 0.0% | 11.4% | 23.1% | 6.8% | 6.1% | 11.8% |
| Neutral | 26 | | 3.1% | 8.1% | 15.4% | 6.8% | 24.2% | 5.9% |
| Unsatisfied | 23 | | 3.1% | 1.6% | 15.4% | 18.2% | 9.1% | 20.6% |
| Highly unsatisfied | 31 | | 0.0% | 0.8% | 15.4% | 25.0% | 33.3% | 17.6% |

## Table 20. Health Impacts of Bio-digester Use

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| Eye irritation | | | | | | | | |
| Reduced | 244 | | 88.6% | 91.9% | 61.5% | 95.5% | 75.8% | 73.5% |
| Not reduced | - | | 0.0% | 0.0% | | | | |
| Do not know | 5 | | 0.0% | 1.6% | 15.4% | | | |
| Respiratory infection | | | | | | | | |
| Reduced | 116 | | 11.4% | 9.8% | 61.5% | 95.5% | 75.8% | 73.5% |
| Not reduced | - | | 0.0% | 0.0% | | | | |
| Do not know | 119 | | 65.7% | 75.6% | 15.4% | | | |
| Coughing | | | | | | | | |
| Reduced | 134 | | 28.6% | 19.5% | 61.5% | 95.5% | 75.8% | 73.5% |
| Not reduced | - | | 0.0% | 0.0% | | | | |
| Do not know | 105 | | 54.3% | 68.3% | 15.4% | | | |
| Fire injury | | | | | | | | |
| Reduced | 221 | | 68.6% | 78.9% | 61.5% | 95.5% | 75.8% | 73.5% |
| Not reduced | - | | 0.0% | 0.0% | | | | |
| Do not know | 17 | | 17.1% | 7.3% | 15.4% | | | |
| No use | 14 | | - | - | 23.1% | 4.5% | | 26.5% |
| Improved sanitation by removing waste | 77 | | | | | 100% | 100% | |

**Table 21. Do you recommend to others to install bio-digester plant?**

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| Yes | 241 | | 91.4% | 95.1% | 69.2% | 72.8% | 78.8% | 73.5% |
| Yes only if ours is repaired | 18 | | 0.0% | 0.8% | | 22.7% | 11.2% | 8.8% |
| Yes for households with enough labour | 1 | | 0.0% | 0.8% | | | | |
| Declined to respond/unclear about | 3 | | 2.9% | 0.0% | 15.4% | | | |
| Support water provision before installation | 5 | | | | | | | 14.7% |
| No | 8 | | 0.0% | 0.0% | 15.4% | 4.5% | 10% | 2.9% |

**Table 22. Bio-digester Characteristics**

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| Connected to toilet (= Yes) | 166 | | 40.0% | 74.0% | 15.4% | 79.5% | 72.7% | 0.0% |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Site is clean (= Yes) | 267 | 94.3% | 96.7% | 76.9% | 93.2% | 90.9% | 100.0% |
| Site is exposed to sun (= Yes) | 274 | 94.3% | 95.9% | 92.3% | 100.0% | 100.0% | 100.0% |
| Site has no shade trees (= Yes) | 271 | 94.3% | 95.9% | 76.9% | 100.0% | 97.0% | 100.0% |
| Top filling erosion prone (= Yes) | 46 | 28.6% | 29.3% | 0.0% | 0.00% | 0.0% | 0.0% |
| Turret with main valve cover (= Yes) | 181 | 65.7% | 54.5% | 84.6% | 72.7% | 45.5% | 97.1% |
| Cover finish smooth (= Yes) | 272 | 94.3% | 95.1% | 100.0% | 100.0% | 93.9% | 100.0% |
| Two compost pits (= Yes) | 188 | 74.3% | 73.2% | 38.5% | 70.5% | 63.6% | 44.1% |
| Compost pits protected against rain (= Yes) | 36 | 11.4% | 22.8% | 0.0% | 6.8% | 3.1% | 0.0% |
| Indoor pipes are properly secured (= Yes) | 262 | 85.7% | 87.8% | 100.0% | 100.0% | 100.0% | 100.0% |
| Gas pressure meter is at correct spot (= Yes) | 270 | 88.6% | 93.5% | 100.0% | 100.0% | 100.0% | 100.0% |

## Table 23. Distribution of Sample of Size of Bio-digester

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| Digester size,$m^3$ | | | | | | | | |
| 4 | 3 | | 0.0% | 0.0% | - | 6.8% | | |
| 6 | 243 | | 94.3% | 95.1% | 100.0% | 81.8% | 90.9% | 41.2% |
| 8 | 29 | | 0.0% | 0.8% | - | 11.4% | 9.1% | 58.8% |
| 10 | 2 | | 0.0% | 1.6% | - | | | |

## Table 24. Distribution of sample by Year of Construction of Bio-digester

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| 2017 | 14 | | 2.9% | 2.4% | - | 27.3% | 6.1% | |
| 2018 | 47 | | 5.7% | 14.6% | 38.5% | 18.2% | 15.2% | 26.5% |
| 2019 | 119 | | 34.3% | 36.6% | 61.5% | 29.5% | 48.5% | 73.5% |
| 2020 | 84 | | 48.6% | 37.4% | - | 25.0% | 30.3% | |
| 2021 | 6 | | 2.9% | 4.1% | - | | | |

## Table 25. User training

| | n= | MOE (95% CL) | Afar | Amhara | Gambella | Oromia | SNNP | Somali |
|---|---|---|---|---|---|---|---|---|
| User training is provided (= Yes) | 236 | | 40.0% | 55.3% | 100.0% | 97.7% | 97.0% | 100.0% |
| Training was given during Initial feeding and operation (= Yes) | 271 | | 85.7% | 87.8% | 100.0% | 95.5% | 100.0% | 100.0% |
| Training was given during plant completion (= Yes) | 194 | | 57.1% | 67.5% | 100.0% | 100.0% | 100.0% | 100.0% |
| Operational Manual are provided to household (= Yes) | 35 | | 11.4% | 25.2% | 0.0% | 0.0% | 0.0% | 0.0% |

# Annex VII – Number of bio-digesters constructed by year and region.

| | | NBPE+ Bio-digester Installation Trend in Year 1 (April 12, 2017 to April 11, 2018) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Region** | **Year 1 Target** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr 1-11** | **Total** | **% Progress** |
| **Amhara** | 170 | 14 | 7 | 26 | 117 | - | 44 | 16 | 50 | 74 | 239 | 587 | 345% |
| **Oromia** | 210 | 57 | 6 | 10 | 4 | 5 | 2 | 5 | 23 | 44 | 8 | 164 | 78% |
| **SNNPR** | 140 | | | | 18 | 8 | 26 | 5 | 11 | 15 | 18 | 101 | 72% |
| **Tigray** | - | | | | 14 | 15 | 25 | 21 | 38 | 17 | 90 | 220 | |
| | | | | | | | | | | | | | |
| **Afar** | 160 | | | | | | - | | | | | 0 | 0% |
| **Ben/Gumuz** | 140 | | | | | | - | 3 | | | 13 | 16 | 11% |
| **Gambella** | 60 | | | | | | - | | | | | 0 | 0% |
| **Somali** | 160 | | | | | | - | | 3 | | 9 | 12 | 8% |
| **Total** | **1,040** | **71** | **13** | **36** | **153** | **28** | **97** | **50** | **125** | **150** | **377** | **1,100** | 106% |

| | | NBPE+ Bio-digester Installation Trend in Year 2 (April 12, 2018 to April 11, 2019) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Region** | **Year 2 Target** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr 1-11** | **Total** | **%** |
| **Amhara** | 800 | 99 | 301 | 12 | 8 | 23 | 34 | 24 | 20 | 76 | 71 | 210 | 104 | 982 | 123% |
| **Oromia** | 350 | 22 | 29 | 22 | 27 | 15 | 2 | 13 | 34 | 55 | 44 | 89 | 0 | 352 | 101% |
| **SNNPR** | 250 | 9 | 14 | 10 | 3 | 8 | 11 | 10 | 10 | 26 | 30 | 60 | 15 | 206 | 82% |
| **Tigray** | 350 | 48 | 86 | 33 | 13 | 8 | 13 | 17 | 33 | 16 | 20 | 98 | 0 | 385 | 110% |
| | - | | | | | | | | | | | | | | |
| **Afar** | 50 | | | | | | - | 2 | 0 | 0 | 3 | 0 | 5 | 10 | 20% |
| **Ben/Gumuz** | 75 | | 6 | - | - | 8 | 3 | 10 | 0 | 0 | 0 | 0 | 0 | 27 | 36% |
| **Gambella** | 50 | | | 2 | | | - | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 6% |
| **Somali** | 75 | | 0 | 13 | | 8 | 8 | 0 | 3 | 0 | 1 | 5 | 0 | 38 | 51% |
| **Total** | **2,000** | **178** | **436** | **92** | **51** | **70** | **71** | **76** | **100** | **173** | **170** | **462** | **124** | **2,003** | **100%** |

| Region | Year 3 Target | NBPE+ Bio-digester Installation Trend in Year 3 (April 12, 2019 to April 11, 2020) | | | | | | | | | | | | | Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 12-Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr 1-11 | | |
| **Amhara** | 1,202 | 158 | 591 | 100 | 78 | 51 | 200 | 200 | 230 | 115 | 144 | 201 | 401 | 430 | 2,899 | 241% |
| **Oromia** | 1,485 | 60 | 66 | 85 | 67 | 46 | 15 | 24 | 55 | 60 | 140 | 185 | 135 | 63 | 1001 | 67% |
| **SNNPR** | 990 | 14 | 55 | 55 | 24 | 22 | 17 | 21 | 31 | 35 | 57 | 52 | 92 | 39 | 514 | 52% |
| **Tigray** | 990 | 70 | 85 | 111 | 39 | 19 | 28 | 30 | 28 | 46 | 53 | 71 | 147 | 34 | 761 | 77% |
| | | | | | | | | | | | | | | | | |
| **Afar** | 360 | 2 | - | - | 3 | - | - | 0 | 2 | 4 | 8 | 15 | 8 | 9 | 51 | 14% |
| **Ben/Gumuz** | 315 | - | 4 | 4 | 4 | 3 | 2 | 4 | 4 | 7 | 4 | 13 | 32 | 1 | 82 | 26% |
| **Gambella** | 135 | - | 1 | - | - | 1 | - | 0 | 1 | 0 | 5 | 10 | 4 | 0 | 22 | 16% |
| **Somali** | 360 | 1 | 1 | - | - | 11 | 6 | 2 | 2 | 18 | 0 | 16 | 8 | 0 | 65 | 18% |
| **Total** | **5,836** | **305** | **803** | **355** | **215** | **153** | **268** | **281** | **353** | **285** | **411** | **563** | **827** | **576** | **5,395** | **92%** |

| Region | Year 4 Target | NBPE+ Bio-digester Installation Trend in Year 4 (April 12, 2020 to December 31, 2020) | | | | | | | | | | | | | Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 12-Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | | |
| **Amhara** | 3,000 | 120 | 136 | 186 | 162 | 157 | 130 | 125 | 185 | 191 | | | | | 1,392 | 46% |
| **Oromia** | 2,227 | - | 90 | 73 | 78 | 58 | 42 | 41 | 60 | 79 | | | | | 521 | 23% |
| **SNNPR** | 1,294 | - | 22 | 1 | 7 | 12 | 16 | 14 | 38 | 38 | | | | | 148 | 11% |
| **Tigray** | 1,485 | 31 | 56 | 76 | 38 | 20 | 8 | 17 | 0 | 0 | | | | | 246 | 17% |
| **Sidama** | | | | | | | | | 2 | 0 | | | | | 2 | |
| | | | | | | | | | | | | | | | | |
| **Afar** | 150 | - | - | 3 | - | - | - | 0 | 10 | 8 | | | | | 21 | 14% |
| **Ben/Gumuz** | 250 | - | - | - | - | - | - | 2 | 1 | 2 | | | | | 5 | 2% |
| **Gambella** | 100 | - | - | - | NR | NR | NR | 2 | 5 | 0 | | | | | 7 | 7% |
| **Somali** | 250 | - | - | - | 5 | 6 | - | 10 | 35 | 10 | | | | | 66 | 26% |
| **Total** | **8,756** | **151** | **304** | **339** | **290** | **253** | **196** | **211** | **336** | **328** | **-** | **-** | **-** | **-** | **2,408** | **28%** |

**Percentage of installations in the new regions**

Year 1 =2.6%
Year 2 = 4.1%
Year 3 = 4.3%
Year 4 = 4.3%