HOUSEHOLD BIODIGESTER MARKET DEVELOPMENT IN ZAMBIA

LESSONS LEARNT FROM THE ENERGY FOR AGRICULTURE PROJECT

SNV Netherlands Development Organisation
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SNV Sweden Sverige

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List of Abbreviations

BCC	-	Behavioural Change Campaign
BCE	-	Biodigester Construction Enterprises
BMH	-	Biogas Marketing Hub
CBO	-	Community-based Organisation
DoE	-	Department of Energy
E4A	-	Energy for Agriculture
FAO	-	Food and Agriculture Organization
LPG	-	Liquified Petroleum Gas
MoE	-	Ministry of Energy
NGO	-	Non-Governmental Organisation
SDG	-	Sustainable Development Goals
SIDA	-	Swedish International Development Aid
SIDA	-	Swedish International Development Cooperation Agency
ZMW	-	Zambian Kwacha (currency)
ZNBAEA	-	Zambia National Biogas and Alternative Energy Association

Acknowledgement by SNV

With this report, SNV is pleased to share the results and lessons learnt from the Energy4Agriculture project, funded by the Swedish International Development Cooperation Agency (SIDA) through the Swedish Embassy in Lusaka and implemented by SNV Zambia between 2015 and 2019.

SNV expresses its gratitude to SIDA as the donor for this project, in particular appreciating the partnership, flexibility and guidance during programme implementation. Furthermore, SNV thanks the Government of Zambia for their support in bringing the project to success. We thank the Department of Energy for chairing the Project Advisory Committee and offering strategic guidance, alongside the representatives from Ministry of Agriculture, Ministry of Livestock, Energy Regulation Broad, Zambia Bureau of Standards, and Dairy Association of Zambia.

The E4A project started the market for biodigesters in Zambia, delivering nearly 5,000 biodigesters across the country and support over 50 biodigester construction companies, while engaging government and private sector stakeholders in dialogue and awareness-raising on the benefits of biogas. The project is an important example of SNV's ambition to achieve systems change, by kick-starting a new market, leveraging finance from households and businesses, encouraging government and other stakeholders to consider and adopt new approaches to the rural clean cooking challenge, and shifting norms and paradigms around the use of biogas as a sustainable alternative to solid biomass.

Nevertheless, the household biodigester market and ecosystem in the country remains in early-stage development, still pioneering the essentials. Continued support to the sector will be required to eventually achieve a self-sustaining and flourishing sector. Scaling the market for biodigesters requires access to affordable finance, and a more structured and directly supportive enabling environment. We look forward to continuing the work and collaboration on further advancing this sector going forward together with our partners.

Marjon Tuinsma
Country Director
SNV Zambia

Acknowledgement by the Department of Energy

On behalf of the Ministry of Energy, I would like to thank the Swedish Government for supporting the successful implementation of the Energy for Agriculture project through the Netherlands Development Organisation SNV in Zambia. The E4A project has contributed towards Government's goal of increasing access to clean energy through the development of the biodigester market in Zambia. The project has further raised awareness about the diverse benefits of biodigesters during engagements with Government, Cooperating partners, private sector, Non-Governmental Organisations and other key stakeholders. As a project key result area, the project has contributed to the successful introduction of biodigester technology in the Country.

Special thanks go to the Ministry of Agriculture, Ministry of Livestock, Energy Regulation Broad, the Zambia Bureau of Standards, and the Dairy Association of Zambia for their input and support. We further thank SNV Zambia for their continued cooperation in implementing biogas projects in Zambia.

We look forward to continued cooperation with SNV, the Swedish Embassy and other stakeholders in the development and promotion of the biogas sector in Zambia.

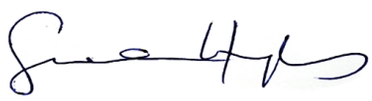
Arnold M. Simwaba
Acting Director
DEPARTMENT OF ENERGY

Acknowledgement by the Swedish Embassy

With the E4A project, the biodigester sector in Zambia has started changing in promising ways through widespread adoption of household biodigesters contributing to the enhancement of rural livelihoods.

The Swedish Embassy expresses its thanks to SNV for their leadership in implementing this programme since 2015, and to the Department of Energy and the other government partners from the Ministry of Agriculture, Ministry of Livestock, Energy Regulation Broad, and Zambia Bureau of Standards for their support in this process. Sweden, in its development cooperation with Zambia, with its overarching goal of helping people to improve their living conditions, targets energy and agriculture with focus on private sector and sustainable market development, and appreciates the in-depth engagement of the private sector in this project.

Through progress made on a wide range of building blocks within the E4A project's long-term vision, the project has demonstrated its capacity to introduce household biodigesters as a commercial and sustainable market product. We are delighted to see the continuation of this work under the current INCREASE (Increasing Climate Resilience in Energy & Agriculture Systems and Entrepreneurship) project funded by Sweden, and look forward to seeing continued progress in the market development for biogas in Zambia.



Susanna Hughes
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Introduction

SNV Netherlands Development Organisation in Zambia implemented the 6.5 million Euro Energy for Agriculture (E4A) project, a biodigester project funded by the Swedish International Development Cooperation Agency (SIDA) through the Swedish Embassy in Lusaka. The E4A project sought to increase access of households, public services, and businesses to productive biodigester technology, to ultimately improve livelihoods through providing mostly farming households access to clean energy, increased employment and income, and improved living conditions through productive use of biogas and bioslurry.

Among other interventions, the E4A project was designed to initially facilitate construction of 3,375 biodigesters by April 2018 but was extended up to December 2019 to install 1,200 additional biodigesters, bringing the new target to 4,575 units. For the implementation of the project, SNV set up coordination units across Zambia in Namwala, Choma, Monze, Mazabuka, Lundazi, Katete, Kabwe, Ndola and Kasama.

Though the market is still at a very early, pre-commercial stage, the E4A project achieved unprecedented results in the context of Zambia over the duration of the project between May 2015 and December 2019. The E4A project managed to support the installation of 4,878 digesters through a market-based approach over a period of five years (2015-2019), i.e. 3% of the technical potential[1]. The project provided not only access to clean energy and potent organic fertiliser for thousands of rural families; it also built capacities of businesses in the sector which generated employment and income in the rural areas.

The E4A project gathered knowledge and evidence during design and implementation. This knowledge supported the project by informing performance improvements, competitive advantage, innovation, the sharing of lessons learned, integration and continuous improvement of the process and outcomes. Information and knowledge management within E4A helped to make knowledge and reliable data available to inform decision-making throughout the project life cycle, reduce the cost-of-service delivery, and align understanding of the benefits of biodigester technology.

The purpose of this report is to share the knowledge gathered, to capture the lessons learnt under the E4A project and to document these for use by others in similar projects. This document shares knowledge about the experience of developing and implementing a biodigester programme that is comprehensive in scope and requires broad stakeholder participation. Specifically, the document highlights the project approach and lessons learnt with the aim of promoting the replication of desirable outcomes while learning how to mitigate undesirable outcomes in similar projects.

[1] *A market study conducted by SNV in 2018 arrived at a technical potential of about 148,000 household digesters based on cattle population in Zambia alone. SNV. (2019). Biodigester Market Study in Zambia. Final Report.*

Background to Biodigesters

Biodigester technology is a decentralized, environment-friendly technology based on the decomposition of organic materials in the absence of oxygen (anaerobic digestion). Organic matter is put into a closed container or structure called a biodigester (or bioreactor) where it is consumed by anaerobic bacteria to produce biogas, a combustible mixture of mainly methane (CH_4) and carbon dioxide (CO_2). Biogas may be used for cooking, lighting, or, at a larger scale, for generating electricity. Bioslurry, the digested matter produced during the anaerobic digestion process, may be applied in different ways, including as an organic fertiliser in crops and vegetables, in fish farming, and as a feed supplement for livestock.

Biodigesters provide multiple benefits for smallholder farming households (see Figure 1), creating additional income, increased well-being, reduced vulnerability, and improved food security. As such, biodigesters integrate well in mixed farming systems. They reinforce internal cycles on the farm where output (manure) becomes input for energy generation (biogas) and fertiliser production (bioslurry), the latter in turn being input for agricultural production.

Furthermore, the dissemination of household biodigesters contributes, directly and indirectly, to various Sustainable Development Goals (SDGs) as shown in Figure 2. Biodigesters provide biogas, a clean energy source, and process organic waste into bioslurry, an organic fertiliser, contributing to reducing air and water pollution, thereby supporting SDG3: Health and wellbeing, as well as SDG6: Clean water and sanitation. Furthermore, biogas contributes to meeting household energy needs e.g. for cooking and lighting, contributing to SDG7: Affordable and clean energy. Reduced household air pollution supports better health for women and children and reduces the labour burden for women (e.g. on collection of firewood), which ultimately contributes to SDG5: Gender equality.

Biodigester technology contributes directly to reducing greenhouse gas emissions by capturing methane, a greenhouse gas, and using it for productive purposes, responding to SDG13: Take urgent action to combat climate change and its impacts. Reduced dependence on firewood collection also protects forestry resources, thereby reducing risk of desertification and destruction of natural habitats, ultimately contributing to SDG15: Life on land (Biodiversity, forests and desertification).

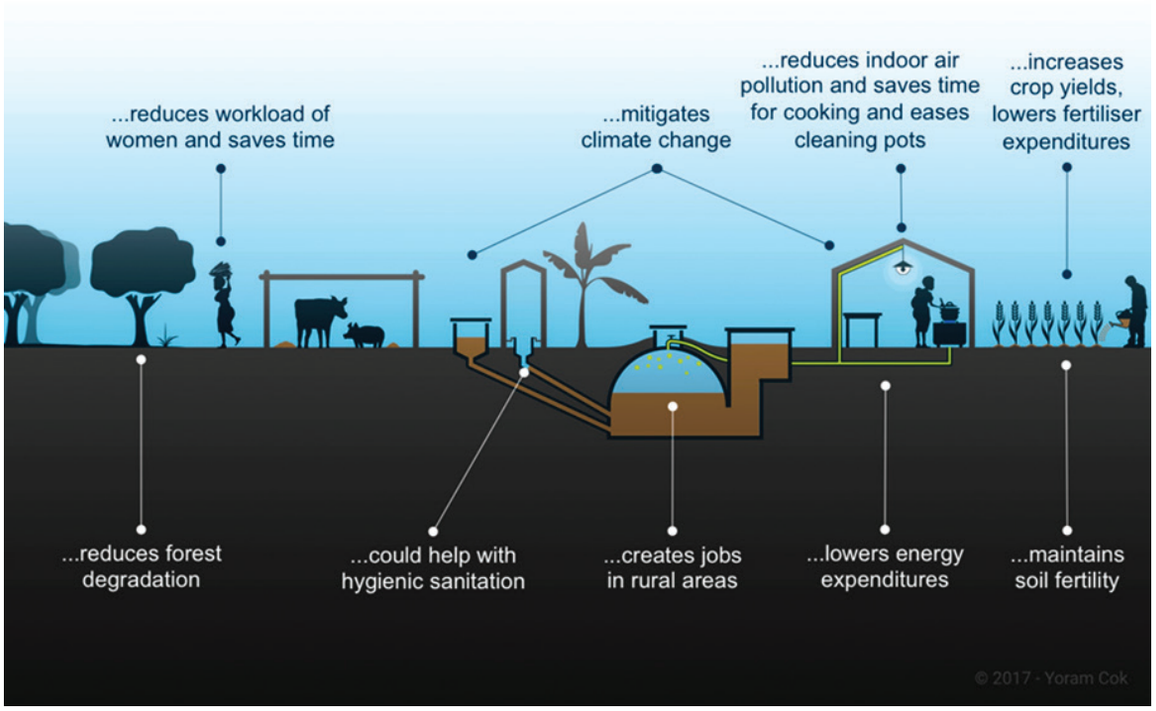


FIGURE 1: THE VALUE PROPOSITION OF BIODIGESTERS FOR SMALLHOLDER FARMERS

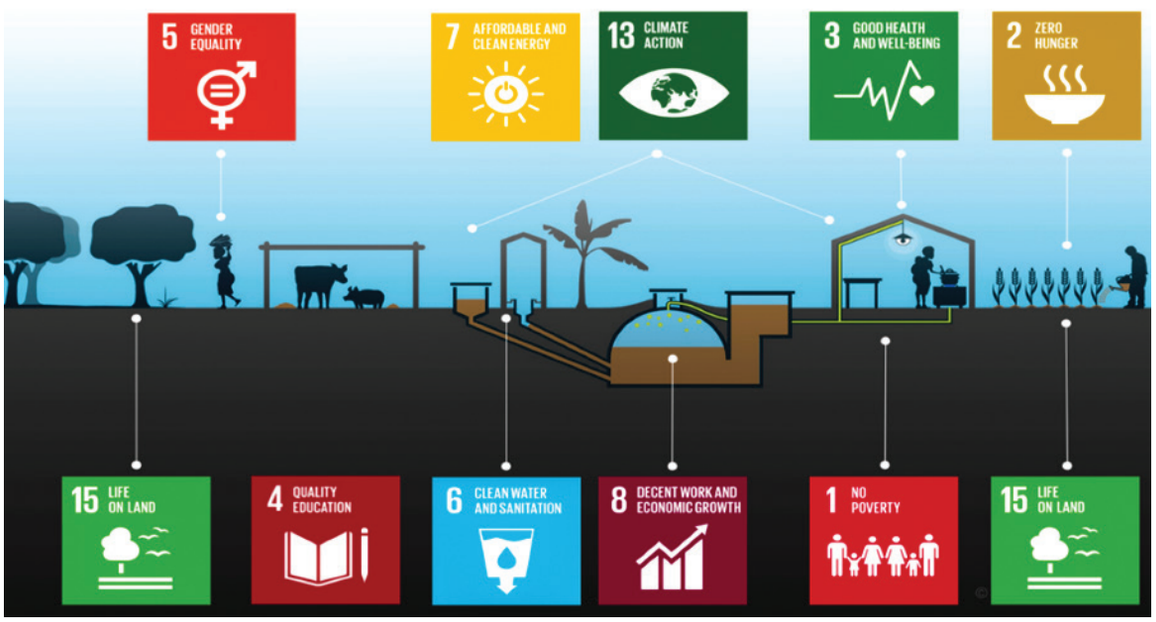


FIGURE 2: CONTRIBUTION OF BIODIGESTERS TO SUSTAINABLE DEVELOPMENT GOALS

E4A Project Results

This section summarises the results of the E4A project across the areas of demand, supply, technology, access to finance and enabling environment. An overview of the project functions and concepts of quality is provided in Annex 2.

The E4A project was measured against several performance indicators and overachieved all targets including increased access to secure and sustainable energy, number of trained masons, number of biodigesters sold, and the cumulative number of operational biodigesters.

By the end of 2019[2], the E4A project delivered the following results:

- Installation 4,877 biodigesters (increasing from 50 biodigesters in 2015 to over 1,000 every year from 2016 to 2019)
- Mobilising and working with over 70 farmers' (largely dairy) cooperatives and several other local partners in promotion and marketing of biodigesters
- Engagement and strengthening of over 50 biodigester construction enterprises (BCEs) which provide marketing, construction, and after-sales service
- Establishment and strengthening of the Zambia National Biogas and Alternative Energy Association in 2017. The project helped selected masons and BCEs register the Association which serves inter alia as a mechanism for bringing together member BCEs and masons as well as serving as an institution for self-regulation of BCEs and masons
- Training of over 400 biodigester installers

The final project targets and results against the original targets are summarised in Table 1 .

INDICATOR	TARGET	RESULTS (2019)	PERFORMANCE OVER TARGET
Increased access to secure and sustainable energy (#people)	27,450	29,922	109%
Number of trained masons	150	423	253%
Number of biodigesters sold	4,575	4,877	106%
Cumulative number of operational biodigesters	4,277	4,518	106%

TABLE 1: E4A PERFORMANCE INDICATORS AND RESULTS

[2] *The project received a cost extension up to December 2019, resulting in higher targets.*

Demand

The E4A project aimed to trigger consumer demand through promotion and access to finance. Despite encountering difficulties in developing formal access to credit, the project managed to create demand among others by introducing an investment incentive. The project's end-line evaluation, conducted by independent consultants towards the end of 2019, confirms the project generated good demand for biodigesters and attests to the project intervention eliciting a relatively high level of satisfaction by most biodigester adopters. The report states that out of "the 186 phone respondents who expressed their satisfaction levels regarding the performance of their biodigesters, more than sixty percent (60%) were satisfied with the performance of their biodigesters" and that "dissatisfaction is caused by the delayed responses for completing the installations and/or the households' own delay in filling up the biodigesters with the substrate."[3]

The project installed 4,877 biodigesters across Zambia, with 60% of installations in Southern Province (Figure 3). The higher uptake in Southern Province can be explained by the dominance of dairy farming in the area (Figure 5) and the decision to start E4A project interventions in this region. The project was later expanded to all other provinces until the E4A project covered the entire country, except Luapula and North-Western provinces, by the end of 2017. This reflected in the scale up of installations which increased steadily from 2015 and peaked in 2018 (Figure 4).[4]

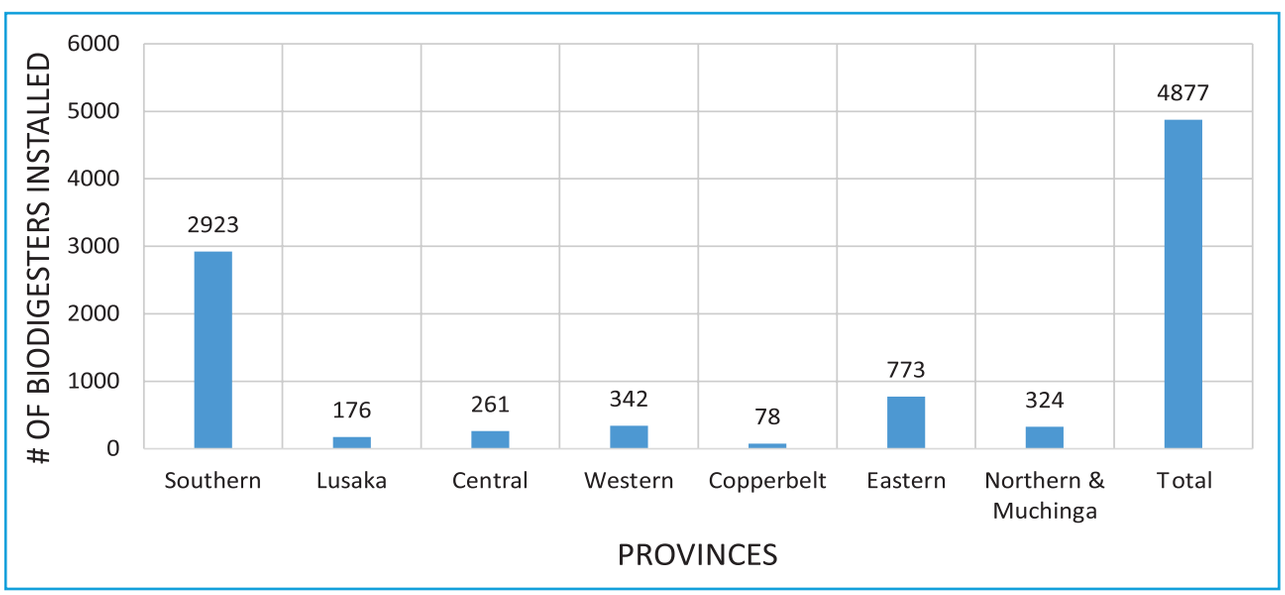


FIGURE 3: GEOGRAPHIC SPREAD OF BIODIGESTER INSTALLATIONS UNDER E4A PROJECT

[3] *AnChiCon Ltd. (2020). End-line Evaluation for Energy for Agriculture (E4A) Project. Volume 1: The Report.*

[4] *Following inception in Southern province, the project expanded to Lusaka. Project activities were extended to Northern and Muchinga province following Government's request to start biodigester promotional activities in those provinces. The expansion to Eastern, Central and Copperbelt Provinces was motivated by the relatively high number of dairy cattle populations. SNV further secured a good working partnership with Heifer International who are actively involved in livestock development initiatives. Initial project activities were started in Western Province in September 2017 and prompted by the project's engagement with a new farmer-support enterprise based in Mongu, Entrepreneurship and Technology Park.*

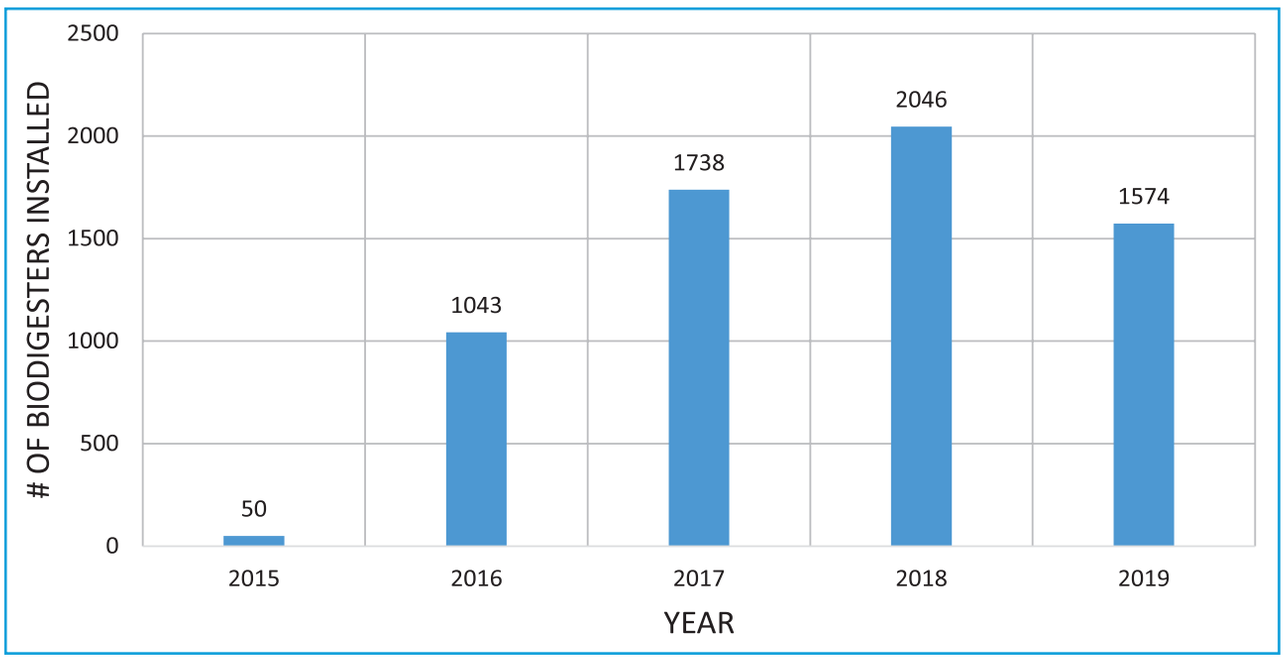


FIGURE 4: ANNUAL BIODIGESTER INSTALLATIONS UNDER E4A PROJECT

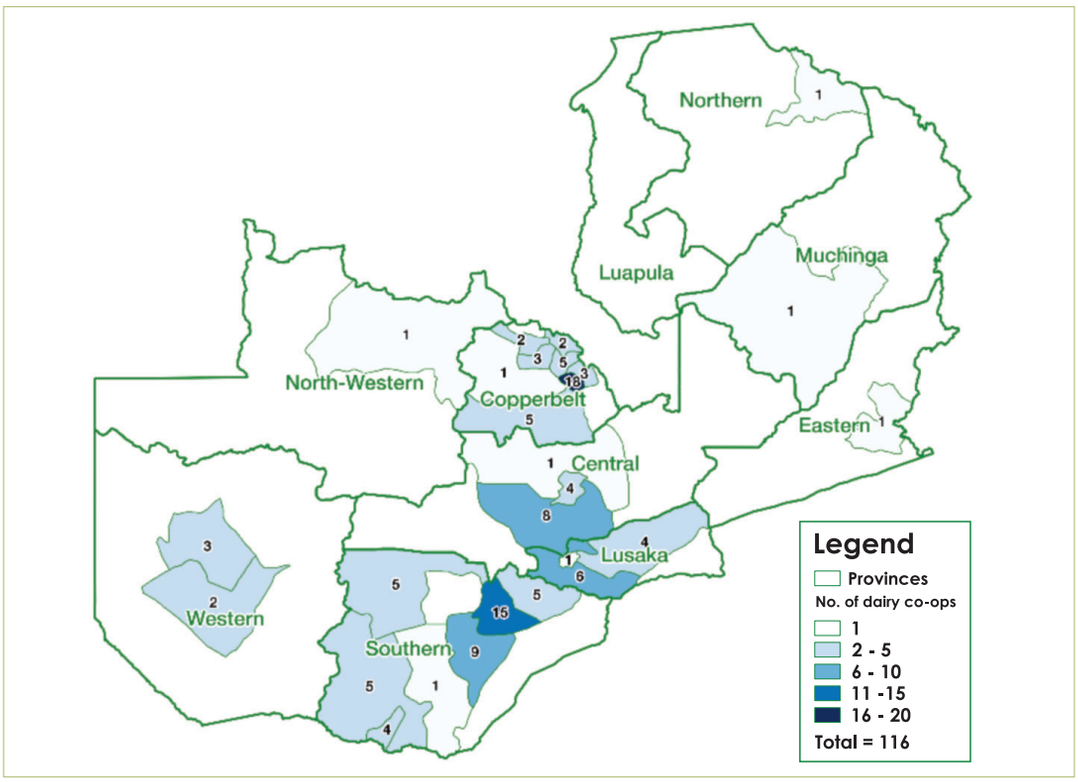


FIGURE 5: GEOGRAPHICAL DISTRIBUTION OF DAIRY COOPERATIVES

Biodigester Marketing Hubs (BMHs) greatly contributed to awareness raising and scale up of installations by serving as information and promotion centres for biodigester technology. Most BMHs were dairy cooperatives where associated milk collection centres marketed the technology to their member farmers (see Annex 4). The hubs were also mobilised by the project to serve as channels for the receipt of the incentive payments by their members – the introduction bonus would be paid for sets of ten farmers through MoUs signed with the BMHs.

By December 2019 the project had developed relationships with over 70 farmer cooperatives and over 50 biodigester construction companies in the project areas. In addition, several financial

institutions were engaged in the project as well. Cooperatives integrated both BCEs and financial institutions within the BMHs to provide construction services, awareness raising and financing support to farming households. Financial institutions active in the project were limited to three savings and credit cooperatives (SACCOs) in Choma, Monza and Namwala.[5] The E4A project's national and regional Biogas Support Units coordinated the process as part of the overall project implementation (see Figure 6 on how BMHs were integrated in the E4A project implementation).

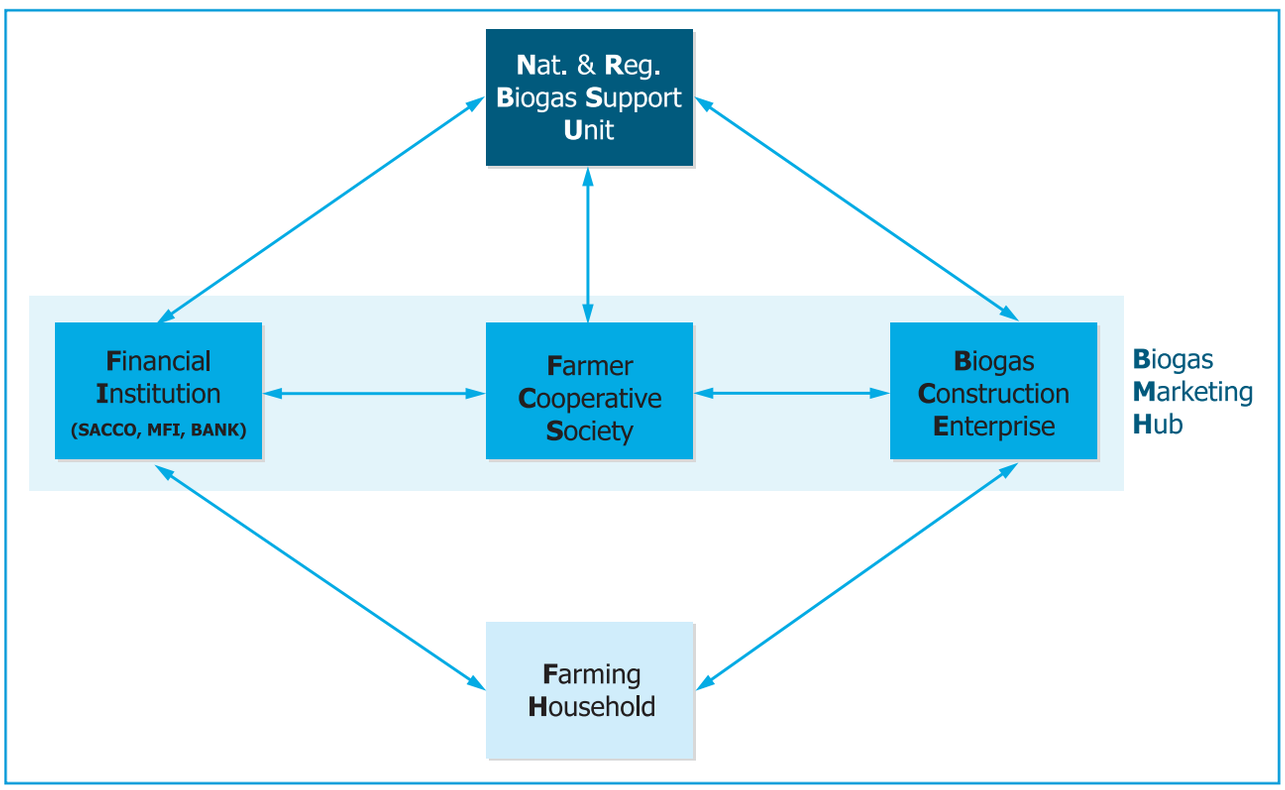


FIGURE 6: BIODIGESTER MARKETING HUBS

[5] *The E4A project engaged the SACCOs to provide affordable credit to members wishing to install biodigesters through 'biogas loans'. However, the majority of biodigesters remained self-financed.*

Supply

To strengthen the supply side of the biogas sector in Zambia, the project focused on developing the supply of biodigesters and productive appliances through skills development, results-based finance incentives and customer satisfaction assurance.

The E4A project has been able to build a market from nought, engaging and strengthening a variety of local stakeholders such as individual masons, BCEs and biogas marketing hubs (BMHs) to deliver critical functions for market development. E4A focused on strengthening technical, administrative and entrepreneurial skills of masons and BCEs, improving functionality (product quality and after sales service provision), establishing and mobilising BMHs and value chain linkages, amongst others. In terms of market transformation, the hub-focused marketing and value chain development approaches started to show promising results, particularly in Southern and Eastern Province. The initial success of the project has attracted interests from different stakeholders, including the suppliers of prefabricated biodigesters, indicating first signs of a shift in market dynamics.

Overall, the project trained 423 masons, and worked with 53 BCEs, relatively evenly spread across provinces (Figure 7). For a full list of trained BCEs, see Annex 3. Out of these BCEs engaged in the marketing, installation and after sales of brick dome digesters, 45 were still active by the end of the E4A project in 2019.

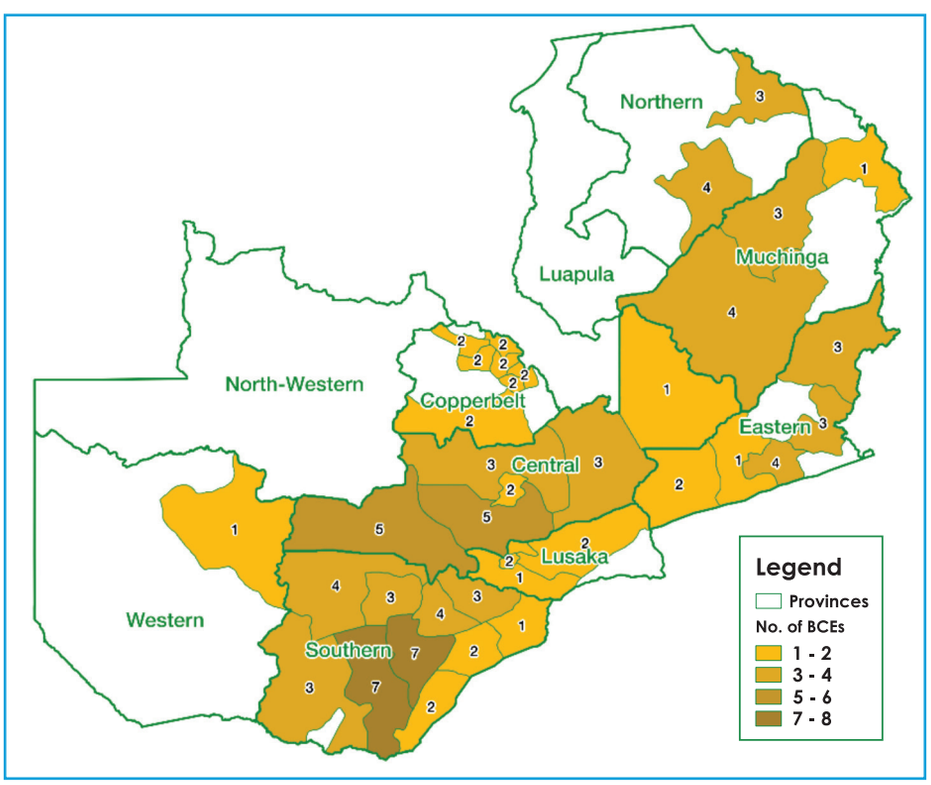


FIGURE 7: NUMBER OF BCES ENGAGED BY PROVINCE

Technology

Between 2015 and 2019, the E4A project promoted the following biodigester models:

- Carmatec - fixed dome biodigester (2015)
- ZamDigester - fixed dome biodigester (2016 - 2019)
- HDPE biodigester (SimGas) (piloted in 2017)
- Flexiplastic biodigester (by Biogas International) (piloted in 2017 – 2018)
- SolidState Digester - fixed dome biodigester (2018 - 2019)

The E4A project focused primarily on fixed dome biodigesters due to the benefits for local enterprise development, job creation and longevity of the installation. Fixed dome technology is a robust and proven technology that has a technical lifetime of minimum 15 years, if constructed and operated well. The Carmatec fixed dome biodigester was adopted under the E4A project during its inception phase towards the end of 2015 (accounting for 1% of installations), but later replaced by the more efficient ZamDigester model. The brick dome ZamDigester model accounted for 94% and a more water-efficient adaptation, the SolidState Digester, made up 4% of reported sales.[6]

Prefabricated biodigesters only accounted for less than 1% of reported sales as the project primarily focused on piloting these technologies to test market interest. E4A piloted the SimGas HDPE model biodigester which was largely unsuccessful due to maintenance issues. The project further piloted 12 flexi plastic biodigesters by Biogas International, which were successful but not scaled-up. As of 2019, companies such as HomeBiogas and Sistema.bio had introduced prefabricated biodigester technologies in Zambia but these were not supported under the E4A project.

EXHIBIT 1: CONSTRUCTION OF FIXED DOME BIODIGESTERS

[6] *Construction and Operations & Maintenance manuals for the ZamDigester and SolidState Digester are available on https://snv.org/project/energy-agriculture-e4a*

Access to Finance

The investment cost of a fixed dome biodigester is related to its size and materials used. Prices range from ZMW11,000 (EUR761) for a 4m3 installation to ZMW26,786 (EUR1,853) for a 21m3 installation[7]. The typical size of installation is a 6m3 biodigester costing approximately ZMW12,870 (EUR890).BCEs will typically charge approximately one-third of the cost of materials to cover for their labour cost and a small profit margin. The margin is estimated at around 10%. (Table 2)

Fixed dome biodigesters in Zambia tend to be rather expensive due to the high cost of cement, a major material in construction, as well as a higher cost of gas stoves and ancillary plumbing material. Additionally, rather high tax on these imported appliances adds to the landed cost in hardware shops. Most biodigester adopters live in remote areas of rural districts, adding to transport cost of materials and appliances.[8]

Investment cost (ZMW 2019)	**4m3**	**6m3**	**9m3**	**14m3**	**21m3**
Materials	7,200	8,000	9,200	11,100	14,300
Labour	2,800	3,700	6,000	8,000	10,050
Total cost	**10,000**	**11,700**	**15,200**	**19,100**	**24,350**
Margin@10%	1,000	1,170	1,520	1,910	2,435
Total incl. retail margin	**11,000**	**12,870**	**16,720**	**21,010**	**26,785**
Investment cost (EUR 2019)	**4m3**	**6m3**	**9m3**	**14m3**	**21m3**
Materials	498	553	636	768	989
Labour	194	256	415	553	695
Total cost	**692**	**809**	**1,051**	**1,321**	**1,684**
Margin@10%	69	81	105	132	168
Total incl. retail margin	**761**	**890**	**1,156**	**1,453**	**1,853**

TABLE 2: INVESTMENT COSTS FOR FIXED DOME BIODIGESTERS IN 2019 IN ZMW AND EUR

Despite the benefits and the long life of the biodigester technology for end users, the upfront investment is a main barrier to adoption considering the low average income of a rural farming household of ZMW2,000-3,000/annum (EUR140 - 210)[8]. Consumer loans for biodigesters are rare and typically have high interest rates even for customers able to provide collateral. Savings groups and family savings appeared to be the main sources for households to invest in biodigesters.

To partially address the financial barrier, the E4A project provided a fixed investment incentive (introduction bonus) reducing the final price of the digester by ZWA2,000 (EUR140) (for the first 750 digesters and reduced to ZMW1,5000 (EUR100). In addition, the project provided a functionality incentive of ZMW2,000 (EUR140) per biodigester installed. This incentive was however only paid after verification of quality and functioning of the installed biodigester. The functionality incentive was introduced to motivate BCEs to provide quality services in terms of installation and after-sales services, assuring functionality of the biodigesters installed. While the introduction bonus helped to reduce the initial upfront cost for the biodigester owner, both payments went directly to the BCE.

[7] *Based on data collected by E4A project's National Biogas Support Unit. An exchange rate of 14.46 ZMW per EUR has been adopted throughout the report based on the 2019 average exchange rate reported by Bank of Zambia: https://www.boz.zm/average-exchange-rates.htm*

[8] *SNV. (2019, April 29). Biodigester Market Study in Zambia. Final Report & SNV/EcoTech. (2017). Final Report, Biogas Users Survey 2016/17.*

Investment cost (EUR 2019)	4m3	6m3	9m3	14m3	21m3
Materials less introduction bonus@EUR100	398	453	536	668	889
Labour	194	256	415	553	695
Total cost	**592**	**709**	**951**	**1,221**	**1,584**
Margin@10%	59	71	95	122	158
Total incl. retail margin	**651**	**780**	**1,046**	**1,343**	**1,743**
Total less functionality incentive@ EUR140	511	640	906	1,203	1,603

TABLE 3: INVESTMENT COSTS AND FINAL PRICING FOR FIXED DOME BIODIGESTERS IN 2019 WITH E4A BONUS AND INCENTIVE PAYMENTS

Combined, the bonus and incentive brought the investment cost down by 13% for a 21m3 digester to 33% for a 4m3 digester, the smallest size. The 6m3 digester was the most popular installation size, with the bonus and incentive covering 28% of costs (Table 3). At an estimated cooking fuel cost of ZMW9 (EUR0.62)[9] per day for a 6-person household using biomass, this results in a payback time for a 6m3 biodigester of just under 3 years with the full incentive payment compared to 4 years at full cost (Figure 8).

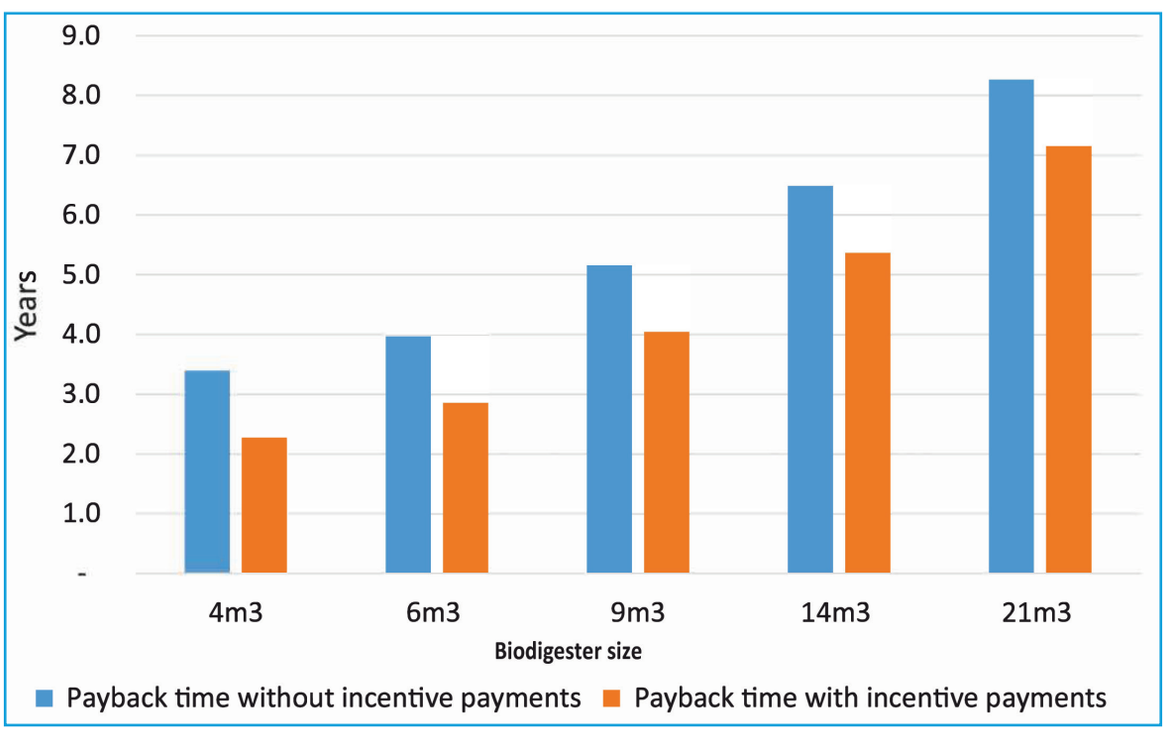


FIGURE 8: PAYBACK PERIOD FOR BIODIGESTERS BY SIZE WITH AND WITHOUT INCENTIVE PAYMENTS

Initially designed to benefit 750 households only, the bonus and incentive scheme, being highly effective and efficient, was eventually extended to 4,100 biodigester owners. The remainder of installations was built at full cost.

[9] *M Price, T Jones, N Scott. (2021) MECS Zambia Cooking Transitions. Working Paper 08/Mar/2021*

Enabling Environment

In order to build an adequate enabling environment to support market development, the E4A project supported policy development and R&D. To this end, the project carried out and provided support to

- a study to determine the potential of private sector participation in the biogas sector [10],
- a study to assess the potential of biomass resources that could be harnessed to meet energy needs[11],
- stakeholder coordination and engagement, and
- national policy making processes.

Through these activities, the project generated a constructive environment for stakeholder engagement. The project engagements resulted in the formation of a Project Advisory Committee (PAC), chaired by a representative from Department of Energy, to provide strategic direction to the project and guide the implementation of activities and priorities. The Committee met five times throughout the project and comprised representatives from the Ministry of Agriculture, Ministry of Fisheries and Livestock, Energy Regulation Broad, Zambia Bureau of Standards, Forestry Department, Rural Electrification Authority and Dairy Association of Zambia. Furthermore, the E4A project joined working groups set up by government and donor partners to discuss matters pertaining to renewable energy, energy efficiency and clean cooking solutions. Specifically, the project

- contributed to Department of Energy-led formulation of the SE4 ALL Agenda and Investment Prospectus,
- provided input to the process to exempt appliances from import taxes through the Off-grid Energy Taskforce, and
- participated in energy consultative platforms such as the Off-grid Energy Taskforce's initial discussion in 2019 on clean cooking advocacy.

In 2017, the E4A project engaged local consultants Mamaju Training Centre to support BCEs and selected masons to formally establish the Zambia National Biogas and Alternative Energy Association (ZNBAEA). ZNBAEA was instituted primarily to promote exchange among its members and create prospective business opportunities. In 2018, Mamaju Training Centre provided mentorship support to ZNBAEA, enabling them to draft an operational plan, open an office, and open a bank account. In 2019, the E4A project supported ZNBAEA to hold their first Annual General Meeting, and provided office furniture and equipment, helping the Association to operationalise its office.

[10] *The study is available for download on* ***Energy for Agriculture (E4A) | SNV World***
[11] *Ibid.*

Lessons Learnt

As evidenced by the project results, many elements under the E4A project were implemented successfully throughout the project, yielding important lessons for best practice and success factors. However, some aspects developed less smoothly than anticipated. This chapter highlights the main lessons learnt throughout the implementation of the E4A project. These lessons may help to increase effectiveness, efficiency, replicability and sustainability of projects of similar nature in future. The lessons learnt cover successes and failures related to three aspects of the E4A project: demand side management, supply side strengthening and enabling environment.

Demand-side Management

- Households are willing to invest considerably in quality biodigester technology when they are sensitised to the long-term benefits arising from the investment: Uptake of new products or services requires continuous, thorough and systematic user education and behaviour change communication. The more time prospective customers are prepared beforehand to learn and appreciate a service or solution, the more likely they are to pay for the service by mobilising their own financial and material resources.

  The biodigester promotional cycle as shown in Annex 1 comprises various steps from familiarisation to after-sales services that need to be disseminated in an organised manner. Experience shows that time needed to complete this cycle in the beginning of the project was 3-4 months on average. The time requirement gradually decreased to a maximum of two months as a result of effective promotion and behavioural change communication (BCC).

  Marketing activities were not only done by the project but also by value chain organisations such as dairy cooperatives, BCEs, local NGOs and community-based organisations (CBOs). For instance, the adoption of biodigesters during E4A significantly increased with excursions and learning visits of prospective customers to functional biodigesters.

  In areas where the demand is scattered and remote, a clustering strategy proved to be a replicable model to tackle the problems associated with scattered demand (incl. e.g. higher cost of service). Resources were focused on developing the market in several discrete villages that demonstrated opportunity, which then led to a snow-balling effect within the clusters.

  Another issue was that the market for larger installations and diversification of biodigester designs proved extremely difficult due to low levels of awareness and absence of finance. Larger farmers who had enough feedstock available for medium to large biodigesters showed interest but were not willing to invest.

  Access to affordable finance for households is key to scale the market. In the absence of such financing, investment subsidies may continue to be required: The biodigester user survey reported that 41% of respondents earn less than ZMW2,000 (EUR140) per month (while the 2019 market study found an average monthly income of ZMW3,000 (EUR210)), indicating the interest of even low-income groups to adopt the technology. However, despite considerable efforts taken under E4A, it proved to be challenging to attract commercial financial institutions to the biodigester market. Out of the total of all digesters installed under the project, only 2% were financed through a formal credit[12].

  Against this background, investment subsidies are essential to drive the adoption of a new technology, particularly in low-income environments. The uptake of biodigesters slowed down significantly after an initial investment bonus allocated for the first 750 biodigesters was exhausted

[12] *SNV/EcoTech. (2017). Final Report, Biogas Users Survey 2016/17*

in 2016. Adoption increased substantially when the bonus was re-introduced, even at a lower rate of ZMW1,500 (EUR100) (against the initial rate of ZMW2,000 (EUR140)). With SIDA approving the revised and reduced introduction bonus, the sales of biodigesters started showing an upward trend. The project was able to install more than 1,000 biodigesters in a period of just 8 months.

Supply-side Strengthening

- Private sector development is key to provide qualified services to customers. It has been very challenging to establish, strengthen and mobilise the private sector in a pre-commercial market that is seen as less lucrative. At the start of the E4A project in 2015, there was an absence of supply side actors in the market as the technology was unknown in Zambia. The project had to start with training and capacity building of individual masons. Over time, efforts were made to move these masons towards (formal) BCEs.

  Capacities of supply side actors were gradually built overtime with good results, but challenges remained. With some exceptions, many BCEs still lack professionalism despite efforts to motivate and convince these nascent private sectors to provide quality product and services. The E4A project provided incentives, such as a result-based functionality incentive[13] and support services, incl. technical backstopping and capacity building to motivate start-up companies to fully own the process of sales and marketing, construction and after-sales services. Perhaps, the project in its attempt to keep the technology affordable for households, has been too strict on the margins to be earned by the BCEs when installing biodigesters.

  The E4A project could have provided additional support to enterprises such as partial pre-financing of upfront capital costs to establish biogas-based appliances manufacturing suited for connection to biodigesters, further skills development, or support to import the relevant tools and appliances from abroad. However, attempts by the project to engage manufacturers were unsuccessful.

  In this context, it is also important to mention the importance of the project donor's flexibility to accept contingency planning whenever needed, especially with regard to successfully building the capacity of private sector actors. SIDA's flexibility in accepting changes in the provisions of introduction bonus, functionality incentive and research and development helped a lot in successfully implementing capacity building initiatives and motivating private sector actors to be involved more efficiently and effectively.

- Bioslurry and the productive use of biogas remained underutilised, and their benefits need to be promoted more structurally to increase financial returns from biodigesters: Out of the two important biodigester outputs – biogas and bioslurry - the primary focus of the E4A project, by design, was on the production and utilisation of biogas. The outcome of the biodigester user survey indicated that only 53% of respondents are applying bioslurry for productivity improvement on their farms, although 68% of respondents think that bioslurry has very high nutrient value.

  The E4A project could have made stronger efforts in intensifying the use of bioslurry as an important input to green farming. This could have been achieved through mobilising local agriculture extension offices and establishing a working relationship with a specialised institute like the Organic Farming Promotion Unit of the Ministry of Agriculture.

  The project could also have placed a stronger focus on promoting and developing supply chains for appliances and equipment that optimise the use of biodigesters (e.g. use of biogas for brooding, chilling, drying, etc.).

[13] *The functionality incentive was paid upon completion and full operationality of the biodigester, to an amount of EUR150 per unit in the beginning of the project, reduced to EUR100 after two years*

Enabling Environment

- Networking with other like-minded value-chain organisations and working with local leadership makes the implementation of biodigester projects more efficient and effective: Working with local dairy cooperatives and other value chain organisations such as local NGOs/CBOs brought together prospective customers at local level and at reduced mobilisation cost. For example, the E4A project worked with Czech NGO People in Need (PIN) and Heifer International making promotion of biodigesters more efficient. Similar synergies emerged during learning and networking meetings with Agri-Pro-Focus, a Dutch agribusiness networking organisation, and participation in AgriTech Exhibitions, an agricultural technology and equipment platform operating in Zambia at the time.

  Working closely with local leadership in Chikankata district yielded remarkable results in a short timeframe. About 200 biodigesters were installed in less than six months as a result of locally embedded campaigns to popularise the technology. The success in Chikankata district is to be attributed to the joint efforts of local traditional leaders, local cooperatives and local government officers.

  These types of multi-stakeholder platforms help in driving synergies, building trust and expediting the implementation process. However, the promotional messages to be disseminated by different stakeholders need to be consistent and coordinated. Too high expectations from users due to inflated promises (for example on the availability of affordable biogas chillers and brooder heaters) from project staff or partners backfire sooner or later.

  Strong efforts and regular consultations with the concerned government authorities are needed to create a supportive enabling environment for biodigesters: At the start of the E4A project, biodigesters proved not to be a priority sector for the government, evidenced by the absence of proper policies, targets, programmes, budget and staffing. Regular communication with relevant authorities helped in getting support, but proactive government-led initiatives to popularise biodigesters continued to be lacking. The E4A project's endeavour resulted in the formation of a Project Advisory Committee chaired by a representative from the Ministry of Energy and comprising of representatives from the Ministry of Agriculture, Ministry of Livestock, Energy Regulation Broad, Zambia Bureau of Standards, and Dairy Association of Zambia. The purpose of this Committee was to provide strategic direction to the project and guide the implementation of activities and priorities through bi-annual meetings and exposure visits.

  Despite the lack of significant results on the policy or regulatory side, the project has been successful in raising awareness and changing the mind-set of authorities towards the biogas sector. For example, several biodigester projects were included in the Energy Action Agenda and Investment Prospectus under the framework of Sustainable Energy for All by the Department of Energy. The E4A project could have expanded capacity development of government officials through further (international) exposure visits, local field visits, and regular meetings at central and provincial levels.

Recommendations

Lessons learnt from the E4A project suggest that the following recommendations need to be implemented to ensure continued successful development of the Zambian biodigester market:

- **Strengthen the biomass policy framework and broader enabling environment for biodigesters:**

  Despite an increasing demand for biodigester technology, market expansion is still low in part due to limited involvement of the government to create a supportive enabling environment. An updated National Biomass Policy with a focus on biodigesters may serve as an overarching guide for accelerated deployment and demonstrate political commitment. The policy offers opportunities to adopt more ambitious targets for biodigesters including for biogas and bioslurry and expand market scope from smaller, residential installations to medium and large-scale biodigesters.

  Close co-ordination between policy makers focused on renewable energy deployment, agriculture, health, gender, climate change, education, trade, regional development, industry, and labour is key. Through such coordination, government could guide the development of institutional capacity and 'soft infrastructure' such as business support services and technical capacity development for the biodigester sector. Appropriate public sector investment in physical infrastructure, training and skills development, and governance crowds in private sector investment and supports effective market growth.

- **Promote biodigesters for productive purposes and diversify end use applications of biogas and bioslurry to improve rate of return:**

  Return on investment for biodigesters needs to be improved by tailoring different productive end uses in different segments of the value chain in relevant sectors (e.g., agriculture, food processing, animal husbandry, cottage industries, service and retail). Examples of such end uses include biogas for milk chilling and brooder heating; bioslurry for mushroom cultivation, vegetables farming; pulverisation and packaging of dried bioslurry to sell in markets.

  Productive uses will attract further suppliers from the agribusiness sector, allowing faster scaling up and market penetration. At the same time, the selection of biodigester design must be based on the demands of local communities and should be complemented by adequate training to ensure that the biodigester products are optimally used.

  Financial incentives and tools are an important requirement to support the deployment of biodigesters, including for productive uses. Donor funded results based financing mechanisms are one option but need to be complemented by a range of other tools such as low interest loans, tax incentives and import duty exemptions for biodigester related appliances. Engagement with financiers to develop biodigester loans for productive assets with lower interest rates will help to increase uptake.

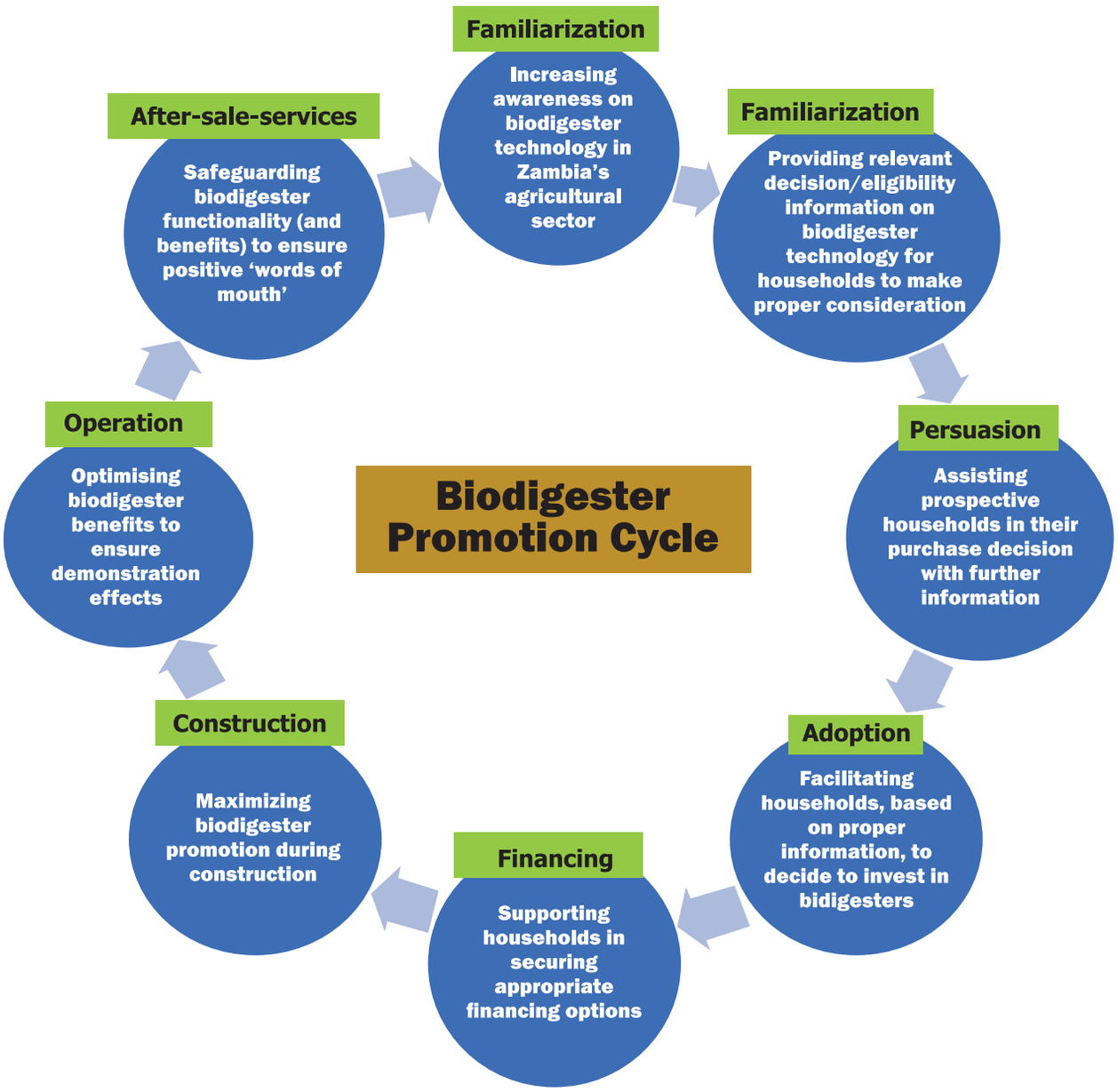
- **Expand access to finance options for suppliers and end users through adequate financing facilities:**

  To develop a sustainable market, donor funded incentives for biodigesters will need to be phased out eventually. To enable such a transition, access to alternative sources of finance like carbon financing will be necessary to continue market expansion and help to scale operations of successful

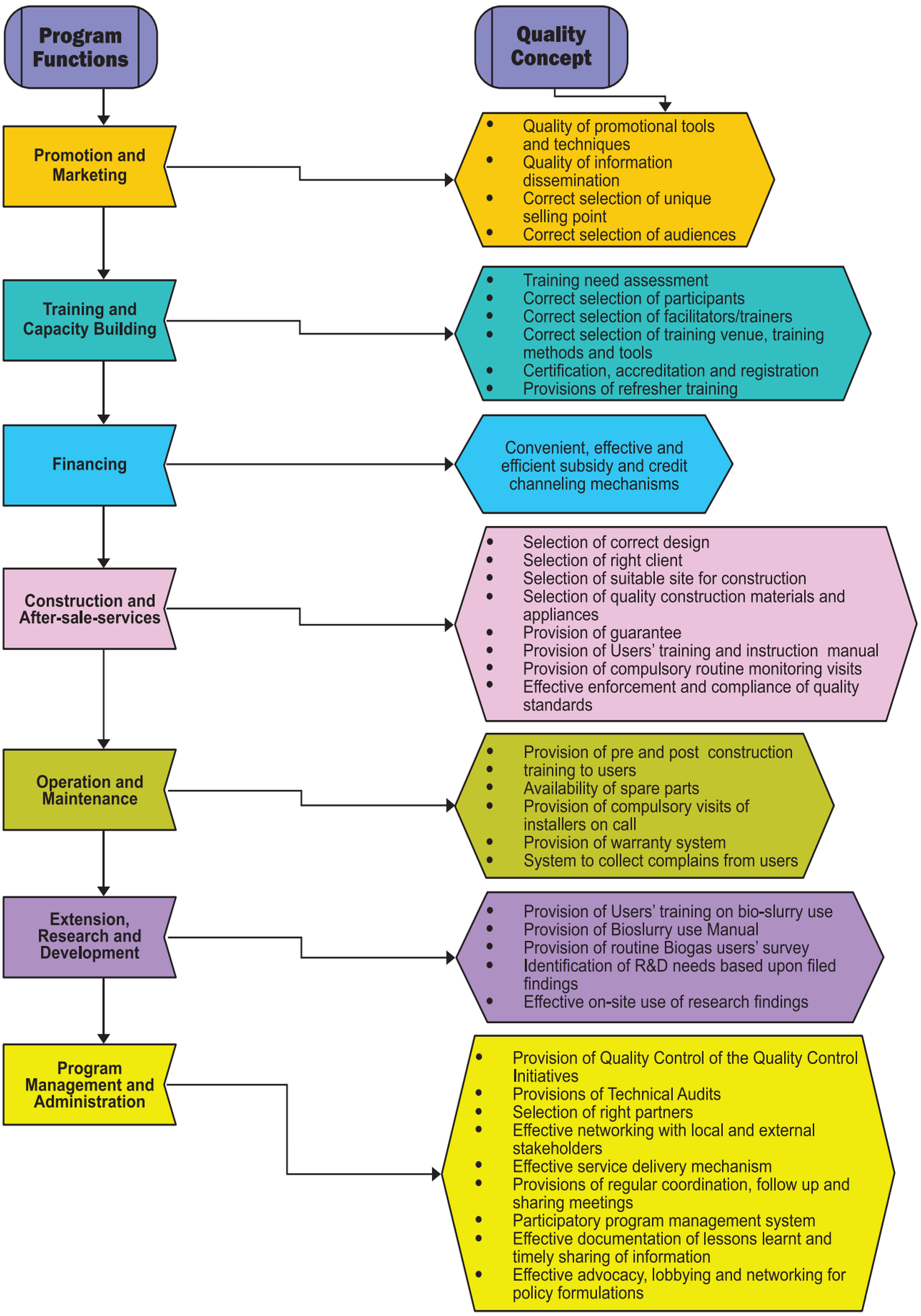
and professional BCEs. Similarly, end user finance options also need to be promoted. Such finance support can include a government led initiative to establish a dedicated credit guarantee fund servicing local financing institutions and lease to own arrangements, initially derisked through grant funding.

Meanwhile, the results based financing approach can be used to further guide the market. To kick start the market for bioslurry, a component to promote the aggregation and sales of bioslurry can be integrated into existing incentive structures. Furthermore, a differentiated incentive structure can also be applied to cater to the need of customers in remote areas where the cost of quality service delivery tends to be very high due to scattered demand and poor infrastructures. Such a differentiated incentive structure will also further promote the cluster approach to biodigester deployment, by lowering the cost of operations and making after-sale services more effective and efficient in such isolated areas.

Annex 1: Biodigester Promotion Cycle



Annex 2: E4A Project Functions and Concepts of Quality



Annex 3: List of BCEs

S/NO	NAME OF BCE	LEAD PERSON	LOCATION
1.	Abiasheck General Dealers	Abias Chuungwe	Itezhi Tezhi - Central
2.	ALPHAMARK Readings	Nicholas Musonda	Mbala - Northern
3.	Aluda Construction	Given Mweemba	Kabwe - Central
4.	Anmut Sur Moi	Kasaila Musonda	Lusaka & Katete - Eastern
5.	Bartmulu Enterprise	Barton Mulonga	Namwala - Southern
6.	Bbuyugoh Enterprise	Overt Hachilala	Namwala - Southern
7.	Biojoe Construction	Joseph Banda	Petauke - Eastern
8.	BMK Evening General Dealers	Brave M Kamukuwe	Monze - Southern
9.	Bobman Ventures	Alex Mwape	Mazabuka - Southern
10.	BRAWS Construction Company	Robin Simbaya	Isoka - Muchinga
11.	Brichi Construction & Suppliers Ltd	Juspy Siambaza	Kabwe- Central
12.	Chigangawa Construction	Clement Phiri	Lundazi- Eastern
13.	Chile Agrow Enterprise	Fred Chilelesho	Mumbwa – Central
14.	Chris Lwanja General Dealers	Banji Hichaambwa	Monze - Southern
15.	Cindy Construction	Cindy Moonze	Choma - Southern
16.	Clean Construction Company	Mwanza Assale	Livingstone - Southern
17.	Cleanken General Dealers	Kennedy Nyirenda	Kabwe – Central
18.	Covious General Dealers	Cosmas Hamungala	Batoka, Choma - Southern
19.	DAKT General Dealers	David Nganzimbi	Mazabuka - Southern
20.	Efungo Construction Company	Funuwayo Ngoma	Chipata - Eastern
21.	Greenergy Construction	Joseph Phiri	Kabwe - Central
22.	Hamus Tech Construction & Engine'ng	Craine Habasimbi	Copperbelt
23.	Innom Contractors & General Dealers	Innocent Mundia Mubi	Kaoma - Western
24.	J Majuru General Dealers	Jubeck Majuru	Kabwe – Central
25.	Janta Biogas Construction	Lackwell Mudenda	Choma - Southern
26.	JC Gift from God	James Chansa	Mpika - Muchinga
27.	Kaamwa General Dealers	Jacob Mwamba	Mumbwa – Central
28.	Kalims General Dealers	Abraham Kalimwengo	Luanshya-Copperbelt
29.	Kanda Mbunge Contractors	Kawengo Ndala	Kalabo - Western
30.	Kapman Enterprises	Chris Kaputula	Namwala - Southern
31.	Kapomba Agro Dealers Limited	Tiyezye Daka	Chipata - Eastern
32.	Kinalujova construction	Josamu Chizawu	Serenje
33.	Kosima General Dealers	Konnie Simapuka	Kalomo - Southern
34.	Kupama General Dealers	Stanford Mwape	Kalomo - Southern
35.	L K Investment	Oscar Mulenga	Kasama - Northern
36.	Malaole Construction	Oscar Mwale	Katete - Eastern
37.	MAZAJO Construction	Francis Matamba	Chinsali - Muchinga
38.	MICMARY Company	Michael Chisanga	Kasama - Northern

39.	Mondili General Dealers	Enos Muswala	Kalomo - Southern
40.	Muwemu General Dealers	Webster Mumba	Kalomo - Southern
41.	Muzbeck Engineering & Construct	Clever Muzyamba	Kabwe – Central
42.	Omadi Enterprises	Omelo Mumba	Sinda - Eastern
43.	Pecunious Enterprises	Robinson Chisenga	Itezhi-Tezhi – Central
44.	PIJARO General Dealers	Marshal Tembo	Kasama - Northern
45.	Pros Construction	Kelvin Soko	Lusaka
46.	Rebukali General Dealers	Lloyd Dimuna	Monze, Mazabuka - Southern
47.	Simunzele General Dealers	Visitor Hankwembo	Choma - Southern
48.	Southhills Enterprise	Kennedy M Mulinda	Lusaka
49.	Sunzu Investments Limited	Lwenga Musonda	Mbala - Northern
50.	Sustainable Water Solutions	John Miller Sakala	Monze - Southern
51.	Tilayi Agricultural Energy Solutions	Chilala Simweena	Choma - Southern
52.	Xerobix enterprises	Buddy Hankalu	Mazabuka - Southern
53.	Zeluzako Construction Company	Kennedy Botha	Lundazi- Eastern

Annex 4: List of Farmer Cooperatives

S/NO	NAME OF COOPERATIVE	LEAD PERSON	LOCATION
1.	Balaka Multi-Purpose Cooperative	Charles Choma	**Kabwe, Kapiri Mposhi**
2.	Batoka Dairy Cooperative	Madrit Mayela	**Batoka**
3.	Chafulu Farm Block Cooperative	Aaron Banda	**Sinda- Katete Region**
4.	Chachalaca Cooperative	Jackson Malambo	**Monze**
5.	Chikumba Cooperative	Mitty Choonya	**Chikankata**
6.	Chimuka Cooperative	Cephas Namainga	**Monze**
7.	Chimwala Women's Development Group	Chairperson	**Chipata**
8.	Chiasmi Cooperative	Hopday Majata	**Chikankata**
9.	Chitongo Dairy Cooperative	Justine Ncube	**Chitongo, Namwala**
10.	Choma Dairy Cooperative	Robert Muudala	**Choma**
11.	Dam Side Multi Purpose	Mweetwa Kamilo	**Monze**
12.	Dumba Cooperative		**Mazabuka**
13.	Eastgate Cooperative	Dan Chibanza	**Monze**
14.	Fisenge Dairy Coop Union	Peggy N Mwape	**Luanshya -Copperbelt**
15.	Haanamaila Agriculture	Victor Chikomba	**Gwembe**
16.	Hachaanga Women's Club	Pule Michael	**Monze**
17.	Hachaanga Multi Purpose Cooperative	Alfred Moonga	**Monze**
18.	Hamafa Cooperative	Conirade Hachwombwe	**Chikankata**
19.	Hamisanga Multi Purpose Cooperative	Freddy Mweemba	**Monze**
20.	Hazobe Farmers Group	Phillip Hazeze	**Gwembe**
21.	Kakoma Cooperative	Timba George	**Monze**
22.	Kalomo Dairy Cooperative	Jonathan Mweebo	**Kalomo**

23.	Kapinga Cooperative	Humphrey Chimuka	**Mazabuka**
24.	Kapulanga Nalucha Agriculture	Petronella Moonga	**Gwembe**
25.	Kasaka Seed Growers	Chairperson	**Monze**
26.	Kasiwe Cooperative	Phizwell Mainza	**Chikankata**
27.	Katumbi Cooperative	Voster Lweendo	**Chikankata**
28.	Kayona Cooperative	Mercy Mwiinga	**Chikankata**
29.	Kayuni Cooperative	Chairperson	**Monze**
30.	Kudam Agricultural cooperative	Chairperson	**Monze**
31.	Mafulelwa Cooperative	Luka Banda	**Sinda- Katete Region**
32.	Magoye Cooperative	FulFulga Ndungu	**Mazabuka**
33.	Matepeta Agricultural Cooperative	Mebelo Mangolwa	**Monze**
34.	Matepeta Agricultural Coop	Margret Maamba	**Monze**
35.	Mbabala Cooperative	Chairperson	**Choma**
36.	Miyoba Agricultural Cooperative	Milimo John	**Monze**
37.	Miyoba Women's Club	Catherine Buncombe	**Monze**
38.	Monze Dairy Cooperative	Munachoonga Muleya	**Monze**
39.	Mpatamato Dairy Coop Union	Agnes Beas	**Luanshya Copperbelt**
40.	Mufulira Dairy Cooperative Union	Ruth G Zulu	**Mufulira-Copperbelt**
41.	Mukuku Cooperative	Highness Malambo	**Mazabuka**
42.	Mungaila Dairy Cooperative	Dawson Siwala	**Mungaila Namwala**
43.	Munjile Cooperative	Budy Mweemba	**Mazabuka**
44.	Mutumbi Women's Club	Gertrude Sililo	**Gwembe**
45.	Mutumbi Women's Multi Purpose	Catherine Magabba	**Gwembe**
46.	Nabuuka Cooperative	Kelvin Mwiinga	**Chikankata**
47.	Nachibuli Cooperative	Chairperson	**Monze**
48.	Nalucha Woman Agricultural	Brenda Moonga	**Gwembe**
49.	Namwala Central Dairy Cooperative	Humphrey Mayodan	**Namwala**
50.	Ngoma Yangu	Maanya Talisilia	**Gwembe**
51.	Niko Dairy Cooperative	Lucas Munakwenka	**Niko, Namwala**
52.	Nteme Dairy Cooperative	Dimuna Malambo	**Monze**
53.	Pemba Dairy Cooperative	Ben Chatembwa	**Monze**
54.	SACCO Monze	Jeff Munengo	**Monze**
55.	Shalwiindi Cooperative	Hainess Mwenda	**Chikankata**
56.	Silwili Dairy Cooperative	Mutelo Michelo	**Monze**
57.	Simutwe Cooperative		**Chikankata**
58.	Tweende Tubone	Judith Dibulu	**Gwembe**
59.	Twesheko Cooperative	Collen Mazwi	**Mazabuka**
60.	Zimba Dairy Cooperative	Moses Sing'ambwa	**Zimba**
61.	Kasamfu Cooperative	Chairperson	**Serenje**
62.	Chiyumu Bee Keeping Club	Chairperson	**Monze**
63.	Twikatane Women's Club	Chairperson	**Choma**
64.	Kasusu Agricultural Cooperative	Chairperson	**Choma**

65.	Kabwe Agricultural Cooperative	Chairperson	**Choma**
66.	Mayobo Agricultural Cooperative	Chairperson	**Choma**
67.	Chenjela Women's Development Group	Chairperson	**Chipata**
68.	Simumbwe Agricultural Cooperative	Chairperson	**Choma**
69.	Chishi Cooperative	Chairperson	**Kabwe**
70.	Chikola B Cooperative	Chairperson	**Chisamba**
71.	Tagona Cooperative	Chairperson	**Katete**
72.	Buyantashi Women's Club	Chairperson	**Kapiri Mposhi**
73.	Mpima Women's Club	Chairperson	**Kabwe**
74.	Serenje Women's Club	Chairperson	**Serenje**

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