

Country:	Ecuador
Request Identification Number:	2015000061

Title:	Options for implementing systems to harness energy from the waste of small and medium livestock farms
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Summary of the CTCN Technical Assistance

The waste generated from the production process in the agriculture sector represents an opportunity to produce various products, including energy and biofertilizers, instead of representing a source of pollution for soils, water and air, with a negative impact on public health and biodiversity conservation. Ecuador has requested technical assistance from CTCN to develop an implementation plan to identify sustainable management models that harness energy from the manure of livestock production units.

The response plan comprises four activities:

The first involves establishing a baseline that takes into account the local context and available information on the use of biodigesters in Ecuador and analysing successful experiences of national biogas programmes in countries on other continents.

The second activity involves the technological analysis of biodigesters in the subsectors and regions prioritized in the first activity, describing the inputs and outputs of the biodigester.

The third activity involves the installation and selection of pilot biodigesters at livestock production units.¹ The pilot biodigesters will involve various models in the subsectors and regions, helping establish dimensions, installation and maintenance methods, the monitoring of production and the use of by-products (primarily biogas and biofertilizers), net emissions of methane and nitrous oxide from livestock activity, cost-benefit analysis of the technology and its contribution to income in livestock farming.

The fourth activity covers the systematization and communication of the results and lessons learned from the technical assistance among the various stakeholders, including farming families, technicians, researchers, academics and politicians.

This response plan aims to develop tools to support the future development of a sustainable biodigester sector, allowing the promotion and large-scale implementation of the technology in order to harness the waste biomass from livestock production.

1. Overview of the CTCN technical assistance

1.1 Technology aspects

There are a number of technologies that can be used to harness waste biomass from livestock farming, including pyrolysis, gasification, composting and anaerobic digestion. Anaerobic digestion through the use of biodigesters has shown considerable potential in their implementation on small and medium livestock operations, primarily in Southeast Asia and Africa but also more recently as part of national biogas programmes under way in Latin America.

The technologies implemented in these programmes, which now cover over half a million family systems, are appropriate or intermediate technology biodigesters. Such biodigesters do not normally

¹ In some cases biodigesters that have been previously installed in the field by other initiatives will be selected.

have active heating or internal mixing systems, helping to keep investment and maintenance costs to a minimum. The most common appropriate or intermediate biodigesters are fixed dome models built from materials such as bricks and cement. Fixed dome models have been used to great success in Asia and Africa, although to a lesser extent in Latin America, due to the increased cost of labour and transporting materials, as well as their adaptation to cold climates. The most common appropriate or intermediate technology biodigesters in Latin America are tubular models, on account of their low cost and the fact that they have been proven to work well in the cold climates of the Andes using designs that harness solar radiation for heating.

In Ecuador, as in the rest of Latin America, tubular biodigesters have also been the most successful model, and this type of system (with its wide range of variations) has been chosen as the technological baseline to be promoted and implemented, notwithstanding any other attractive technologies that may be identified during the analysis.

The tubular model has already been validated and there are various scientific publications in international journals that report positive and competitive results under various conditions and substrates. It is also necessary to define the differences between tubular biodigester models and compare them by implementing various systems that can be monitored and whose characteristics can be determined under real operating conditions to ensure the certification of the technology.

Biodigesters can be used for the production of renewable energy (biogas), helping reduce the dependence of farms on fossil fuels and recycle nutrients (biofertilizers) to maintain or improve the fertility of the soil and reduce the use of agrochemicals and the pollution of water sources. Biodigesters can also contribute to the adaptation to and mitigation of climate change in the agriculture sector. The former approach (adaptation) involves the production of biogas as a source of renewable energy and the use of biofertilizers to protect soil from erosion, improve its fertility and support the restoration and conservation of forests (by reducing the pressure for logging for firewood), helping ensure the availability and quality of water and other ecosystem services. In terms of the latter approach (mitigation), biodigestion directly reduces emissions of greenhouse gases (GHGs) such as methane² and nitrous oxide by manure, indirectly reduces the use of fossil fuels and chemical fertilizers, and the application of treated manure to fields increases the carbon stock of soils.

The implementation and large-scale promotion of biodigesters is limited by the local conditions of countries and regions, and they are not normally well known among producers in countries without national programmes. In countries that do have biodigester implementation programmes, the biggest problem has been that the installed technologies have not been subject to a quality control process, partly because these have not been defined. Both the different technology suppliers and users may make contrasting decisions, once again as a result of the lack of certification and validation of the technologies, together with a lack of agreed user manuals for the installation, use, maintenance and harnessing of biodigesters.

The technical assistance must generate the inputs or evidence to be used in the design of policies and policy instruments for the promotion of the biodigester component as part of Ecuador's National Biomass Programme (*Programa Nacional de Biomasa de Ecuador*, PNABE) going forward.

1.2 Objectives (outcomes)

The main objective of this technical assistance is to develop tools to support the future development of a sustainable biodigester sector in Ecuador, allowing the promotion and large-scale implementation of the technology in order to make use of waste biomass from livestock production. A fully developed biodigester sector must involve farmers as both producers and users of waste biomass, the presence of

² Biodigesters capture the methane produced during anaerobic digestion, which, when burned, produces carbon dioxide with a warming power 21 times less than methane.

appropriate technologies and certified technology suppliers able to meet the demand, and the provision of quality control, technical support, research and development, the promotion of the technology and financial mechanisms to support its implementation. In this respect, it is necessary to consolidate the results of the experience and share them with the main stakeholders and public and private sectors to allow them to be used as inputs in the PNABE biodigester component.

This primary objective involves a number of specific goals:

- Survey of the agricultural and livestock sector and the potential for manure production in Ecuador.
- Estimating the technical potential for biodigesters in Ecuador by livestock subsector³ and region to define strategies for the implementation and promotion of this technology.
- Analysing the most suitable biodigester technologies for implementation in Ecuador, in line with the survey of the agriculture sector.
- Installation of pilot biodigesters for validating/certifying the most adequate technologies and generating inputs for technical users and decision makers.
- Transferring results to stakeholders in the biodigester sector in order to provide an input for the development of policies and policy instruments to promote the implementation of biodigesters at the national level in the context of PNABE.

1.3 Results (outputs expected from CTCN assistance)

A baseline is available to serve as a diagnostic of the country's agriculture sector and the potential demand for biodigesters among small and medium producers. There is also information on successful experiences of national biogas programmes in other continents (activity 1).

Taking into account the reality of Ecuador, a technological and financial analysis of the biodigester models is available by livestock subsector and region. Information has also been produced for a quality control protocol for service providers (activity 2).

The inputs and capacities required to develop a biodigester sector are available in terms of the following: defined demonstrative biodigesters; monitoring of the operation, maintenance and usage of biodigesters; and the contribution of biodigesters to the adaptation to and mitigation against climate change (activity 3).

The results of the project have also been systematized and communicated to various actors in the livestock production chain, including inputs for developing the biodigester component in the context of PNABE (activity 4).

1.4 Expected use of outputs

To develop a sustainable biodigester sector in Ecuador it is necessary to develop a road map that takes into account the reality of the country and considers the lessons learned in other countries. Such a road map must begin with a survey of the agriculture sector in order to determine the technical potential of biodigesters and identify the most appropriate technologies for their promotion for Ecuador's livestock subsectors and regions. In this respect, it is necessary to establish appropriate biodigester models for monitoring the establishment, maintenance, products, inputs and costs in order to generate evidence that helps to raise awareness among producer organizations and, suppliers of technical services and that serves as an input for the design of policies and policy instruments.

³ Specifically the poultry, pork and bovine subsectors; the term production subsector or livestock subsector will be used throughout this document.

Based on the results obtained, the Ministry of the Environment of Ecuador (*Ministerio del Ambiente de Ecuador*, MAE) and the network of public and private institutions (implementation partners) will continue actions to share knowledge and experience, together with the implementation of projects on the use of biodigesters. However, if the conditions are favourable, the country may develop the proposal for the development of the biodigester component as part of PNABE.

2. Description of the Assistance

2.1 Activities

Activity 1: Baseline and potential demand for biodigesters

A baseline will be established based on the context of the agriculture sector, the processing and externalities (positive and negative) of manure, the use of biodigesters and the potential demand for this technology by production subsector and region. The participation of men and women in the management and benefits of the processing of manure will also be considered.

Activity 1.1 Analysis of the context and identifying types of farms

Survey of the country, focusing on the agriculture and energy sectors, as well as factors that influence environmental policy. This will be followed by a historic overview of the introduction of biodigesters in Ecuador, focusing on the most significant experiences, designs that have been implemented and the use of biogas and biofertilizers in order to extract the lessons learned from the processes for the implementation of biodigesters in Ecuador.

The most common types of farms will also be defined by subsector and region, based on the following criteria: **i)** the area occupied by the farm; **ii)** uses of the land; **iii)** number of animals; **iv)** climate conditions; **v)** system for the farming of livestock and estimated annual volume of manure produced; **vi)** system for the treatment of manure and destinations of by-products; **vii)** annual consumption and billing of electricity and LPG gas for production and domestic use; **viii)** for the consumption of wood, the time spent gathering wood and who carries out this task (men, women, young people, others) and the cost when it is purchased; **ix)** the role of men and women in managing manure and the daily use of biogas energy (where biodigesters are used); and **x)** applicable environmental legislation.

This information will be gathered from secondary sources, such as the agriculture census for 2012 and technical reports of programmes and projects in Ecuador. Information will also be gathered on the subsectors (poultry, pork and bovine dairy) for the regions considered in the implementation. This will be done using focus groups, choosing at least five producers per regional organization from each production subsector. The key producers or informers will be chosen based on a range of criteria, such as willingness to participate, size (small or large producer per the last national agriculture census), whether they have over 10 years of production activity, whether livestock farming is their main source of income and other criteria deemed relevant by the team.

This diagnostic will be used to identify priority subsectors and regions for technical assistance and the potential demand for biodigesters.

Deliverables 1.1	Delivery date
<i>A document on the state of the agriculture and energy sectors and the potential demand for biodigesters among small and medium producers, including a summary of discussions during meetings with</i>	<i>Week 8</i>

the local groups

Activity 1.2 Analysis of international biogas programmes

A survey of secondary information on the experience of biogas programmes that have been implemented in Asia, Africa and Latin America will be carried out. Some of these may provide inputs for the technologies and help identify factors (from a technical, political, institutional, social, cultural or economic perspective) that have contributed to the successful adoption of biodigesters to ensure the sustainability of large-scale adoption and scaling up. There will also be a national analysis of Ecuador’s existing policies and policy instruments with the potential to support the implementation of a biodigester component as part of PNABE in the future. The analysis will be between 15 and 25 pages long, with a professional design, photographs and English and Spanish versions. It will have a brief introduction written by the head of CTCN and MAE and will display the logos of CTCN, MAE and the implementing partner.

Upon completion of the activity, a brief summary of the lessons learned for the achievements and challenges that have been identified will be produced.

Deliverables 1.2	Delivery date
<i>A publication bringing together the successful experiences of national biogas programmes in Asia, Africa and Latin America, with the characteristics indicated in the description of the activity.</i>	<i>Week 12 for the Spanish version; week 15 for the English version</i>
<i>A summary (maximum one page) of lessons learned for the achievements and challenges identified in activity 1</i>	<i>Week 16</i>

Activity 2: Technological analysis of biodigesters

A technical analysis of the biodigester system will be carried out for the livestock subsectors and regions prioritized in activity 1, characterizing the inputs and outputs and the biodigester as a system. The information for each component will help determine the strengths and weaknesses for the improvement of the technology by universities or public or private research centres.

The information in activity 1.1 will be used to select a sample of farms based on the different types of farms based on criteria defined by the technical team for considering the variability of biodigester models. For each of the chosen production units, the inputs for the biodigester (in this case the manure by-product) will be described in terms of the following: **i)** livestock species from which the manure originates; **ii)** availability and quality; **iii)** processing prior to and during the loading of the biodigester (e.g. maturation, additives, manure–water ratio); and **iv)** implications of existing regulations for the handling and use of manure at the farm.

The following information will be gathered for the outputs of the system: **i)** potential production and characteristics of the by-products of the anaerobic digestion process; **ii)** the potential use of by-products for domestic use and production; **iii)** the extent to which by-products replace energy sources and chemical fertilizers for biogas and biofertilizers, respectively; **iv)** the sale of by-products in line with the conditions of the production unit (e.g. location, topography, use of the soil, predominant crops, agricultural practices); **v)** implications for the regulation of the handling of by-products.

Biodigester technologies will be analysed to identify the design preferences of potential users and local and climate factors related to the design. Information will also be gathered on the suppliers of materials and equipment, technical services for the installation and maintenance of biodigesters in

Ecuador and the bodies responsible for certifying and monitoring the quality of the service provided by these companies. Furthermore, it will be important to define the models, size and costs of standard biodigesters in line with the type of producer at the subsector and regional levels.

The biodigester models identified will be subject to a financial analysis to calculate the installation and annual maintenance costs, savings from the reduction in the consumption of other sources of energy (electricity, LPG, other) and chemical fertilizers. Activity 3 will then analyse other indicators, such as GHG emissions and the replacement of fossil fuels and synthetic fertilizers.

Upon completion of the activity, a brief summary of the lessons learned for the achievements and challenges that have been identified will be produced.

Deliverables 2	Delivery date
<i>A technical report with the characterization of the inputs and outputs for the system and the technological and financial analysis of biodigester models by subsector for the selected regions</i>	<i>Week 24</i>
<i>A report on the quality control protocol for service providers (materials, equipment and technical assistance)</i>	<i>Week 30</i>
<i>A summary (maximum one page) of the lessons learned for the achievements and challenges identified in activity 2</i>	<i>Week 31</i>

Activity 3: Pilot biodigester implementation, monitoring and characterization

A series of pilot biodigesters (at least five) will be implemented, covering various models, for the subsectors and regions (defined in activity 2) in order to establish dimensions, installation and maintenance methods, the monitoring of production and the use of by-products (primarily biogas and biofertilizers), net emissions of GHGs (methane and nitrous oxide) from livestock farming, the participation of men and women, cost-benefit analysis of the technology and its contribution to income for livestock farming. The documents required for local capacity-building will also be produced.

The pilot biodigesters will be implemented in public research institutes and livestock farms. The selection of the biodigesters for monitoring will also consider those installed as part of the GENCAPER project in the priority subsectors and regions. A monitoring system will be established for the pilot biodigesters to gather the following information: **i)** characterization and systematization of the design method (models); **ii)** records of the costs and time spent on the installation of biodigesters through to their full operation; **iii)** determining maintenance costs, identifying the main faults and corrections; **iv)** processing of manure before loading; **v)** annual volume and quality of manure used for loading; **vi)** annual production and quality of by-products in terms of the concentration of hydrosulfuric acid and carbon dioxide for biogas and macronutrients (NPK) for biofertilizer; **vii)** sale of products and volumes; **viii)** consumption of electricity, LPG or other energy source, and chemical fertilizer. The monitoring information will be used to produce a report and PowerPoint presentation for training technicians and producers on the use, maintenance and harnessing of biodigesters.

The information will also be used to estimate net GHG emissions (methane and nitrous oxide) from livestock farming and a cost-benefit analysis of the technology and its contribution to income for livestock farming will be carried out. A quantitative analysis will be conducted on how biodigesters contribute to climate change adaptation, considering factors such as the contribution of organic

material and nutrients to soils, the quantity of manure that is not discharged (or reduction in the volume discharged) to water sources related to the increase in the quantity and quality of water for human consumption or other production purposes, and a similar analysis will be carried out for firewood for cooking, since the replacement of wood by biogas helps restoring the coverage of forests with positive consequences for generating ecosystem services and the conservation of biodiversity, changes that increase the resiliency of agricultural and livestock landscapes. This information will be used to produce a document on the contribution of biodigesters to the adaptation to and mitigation against climate change for farms.

The monitoring will take into account gender in terms of requirements differentiated by gender and the participation of men and women in the management of manure from livestock farming.

A method for monitoring the operation of the biodigester and measuring the quantity and quality of output materials will also be developed. Public research institutes and interested universities will also participate in this process in order to build local capacity. The expert who is assigned will run a workshop in the field to train technicians (belonging to stakeholder institutions) for all the pilot programmes on the monitoring method. Monitoring will also take place via field trips and e-mail and telephone communication.

Upon completion of the activity, a brief summary of the lessons learned for the achievements and challenges that have been identified will be produced.

<i>Deliverables 3</i>	Delivery date
<i>A document and PowerPoint presentation for training technicians and producers on the characterization of the operation of pilot biodigesters</i>	Week 50
<i>A report and PowerPoint presentation for training technicians and producers on the use, maintenance and harnessing of biodigesters based on a gendered approach</i>	Week 40
<i>A report and PowerPoint presentation for training technicians and producers on the contribution of biodigesters to the adaptation to and mitigation against climate change for farms</i>	Week 50
<i>A report on the training workshop for R&D technicians on the monitoring and characterization of biodigesters</i>	Week 40
<i>A summary (maximum one page) of the lessons learned for the achievements and challenges identified in activity 3</i>	Week 41

Activity 4 Systematization and communication of the information to produce inputs for the development of a PNABE biodigester component

The results obtained will be systematized for use as an input to the PNABE biodigester component in line with the baseline, technical potential for demand and the biodigester technologies that are most suitable for Ecuador. The result of this activity will be communicated to parties in developing the PNABE biodigester component for a sustainable biodigester sector in Ecuador.

Activity 4.1 Systematization of results

The results obtained during the technical assistance will be analysed to produce an input document for the subsequent development of a PNABE biodigester component. The analysis will consider the political, social, economic, cultural and technological factors that can

contribute to the adoption of biodigesters to ensure the sustainability of the process of large-scale adoption and scaling up.

Guidelines will be produced for the implementation of primary (demand and supply, value chain and financial mechanisms) and secondary (monitoring, technical assistance, quality control and R&D) processes of the PNABE biodigester component. The report will include a section on recommendations for the steps to be taken in the design and implementation of the PNABE biodigester component.

<i>Deliverables 4.1</i>	Delivery date
<i>Document for the systematization of results: “Towards a sustainable biodigester sector in Ecuador: Inputs for a biodigester component of PNABE”</i>	Week 49

Activity 4.2 Dissemination of technical assistance

The information produced will be shared with the main stakeholders via the websites of the MAE or other local partners that are involved. The platforms of international institutions involved in the process (consortium responsible for technical assistance) will also be used to share the results and lessons outside the country. Efforts will be made to participate in national and international events, such as seminars and conferences, sharing experience via conference presentations and posters.

A one-day workshop will be run and figures involved in the development of a sustainable biodigester sector will be encouraged to participate. The participants (maximum of 30 people) will include unions of producers, technology suppliers, implementing institutions, research centres, universities and policy decision makers.

Upon completion of the activity, a brief summary of the lessons learned for the achievements and challenges that have been identified will be produced.

Annex 6 contains a summary of the activities and deliverables for the technical assistance plan.

<i>Deliverable 4.2</i>	Delivery date
<i>A report on the workshop for the communication of results involving the main figures in the sustainable development of biodigesters in Ecuador</i>	Week 52
<i>A summary (maximum one page) of the lessons learned for the achievements and challenges detected in activity 4</i>	Week 53

2.2 Synergies and Baseline Setting

The GENCAPER project was implemented during the 2014–2015 period to promote activities to mitigate against and adapt to climate change in Ecuador by harnessing biomass energy from the agriculture sector, specifically pork production units. The approach forms part of the modification of the energy and production matrix set out in the country’s national well-being plan. The project will serve as a starting point, since it has already implemented pilot biodigesters for training pork producer

guilds in the province of Santo Domingo de Los Tsáchilas and El Oro. Information has also been produced on the costs and timescales for implementation and maintenance and cost reductions for heat energy and chemical fertilizers, which has formed the basis of user manuals for technicians and producers. The experience in the Intag Valley will also be taken into account. Ecuador's first household biodigester programmes were implemented in the valley and the local peasant association has successfully undertaken a process to replicate the technology in the both valley and the provinces of Loja and Cuenca.

It is also important to note that as part of its policy to diversify its energy matrix and its strategy to adapt to and mitigate against climate change, Ecuador is requesting further technical assistance from CTCN on technology transfer and promotion for waste biomass gasifiers and biodigesters to reduce GHGs from municipal solid waste. Both proposals involve biodigesters as a tool but focus on different sectors and scales. In this respect, it will be important to develop synergies between both initiatives with respect to the impact on the energy matrix, the reduction of GHG emissions and other shared social and environmental benefits.

2.3 Timeline

Activity	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
1 <u>Baseline and potential demand for biodigesters</u>												
1.1 Analysis of the context and identifying types of farms	x	x										
1.2 Analysis of international biogas programmes	x	x	x	x								
2 <u>Technological analysis of biodigesters</u>				x	x	x	x	x				
3 <u>Pilot biodigester implementation, monitoring and characterization</u>							x	x	x	x	x	x
4 <u>Systematization and dissemination of information</u>												
4.1 Systematization of results									x	x	x	x
4.2 Dissemination of technical assistance										x	x	x

2.4 Expertise required

Resources required (approximate no. of days)	Description of resources required
Activity 1	Baseline and potential demand for biodigesters.
40	Technological research and development for biodigesters, national biogas and agribusiness programmes.
28	Sustainable livestock production systems, alternative energy models, management and implementation of projects with biodigesters, monitoring and evaluation.
10	Social communication and production of teaching materials.
<i>Event 1</i>	Gathering secondary information, field visits to previously implemented biodigester projects, meetings with stakeholders in the sector.
<i>Materials</i>	Transport, access to statistics databases, office.
Activity 2	Technological analysis of biodigesters.

19	Technological research and development for biodigesters, national biogas and agribusiness programmes.
54	Sustainable livestock production systems, alternative energy models, management and implementation of projects with biodigesters, monitoring and evaluation.
10	Social communication and production of teaching materials.
<i>Event 1</i>	Gathering secondary information, review of standards, field visits to previously implemented biodigester projects, meetings with stakeholders in the sector.
<i>Materials</i>	Transport, access to scientific and technical databases, office.
Activity 3	Pilot biodigester implementation, monitoring and characterization.
25	Technological research and development for biodigesters, national biogas and agribusiness programmes.
160	Sustainable livestock production systems, alternative energy models, management and implementation of projects with biodigesters, monitoring and evaluation.
5	Social communication and production of teaching materials.
<i>Event 1</i>	Implementation and monitoring of demonstrative biodigesters, production of reports with visual material and PowerPoint presentations for training.
<i>Materials</i>	Transport, access to physicochemical laboratory and monitoring equipment for biodigesters, biodigesters, office.
Activity 4	Systematization and communication of the information to produce inputs for the development of a PNABE biodigester component.
21	Technological research and development for biodigesters, national biogas and agribusiness programmes.
38	Sustainable livestock production systems, alternative energy models, management and implementation of projects with biodigesters, monitoring and evaluation.
10	Social communication and production of teaching materials.
<i>Event 1</i>	Meetings and workshops with stakeholders.
<i>Materials</i>	Transport, office, others.

2.5 Main partners

Stakeholder	Support function for the implementation of CTCN assistance
MAGAP: Ministry of Agriculture, Livestock, Aquaculture and Fishing (Ecuador)	<i>Farm use</i>
IICA: Inter-American Institute for Cooperation on Agriculture	<i>Systematization of information and outreach materials</i>
ASPE: Association of Ecuadorian Pork Farmers	<i>Pilot biodigesters</i>
AGSO: Association of Livestock Farmers of Sierra and Oriente	<i>Pilot biodigesters</i>
ESPE-IASA: University of the Armed Forces – Engineers / Agricultural and Livestock Engineering Specialism	<i>Pilot biodigesters</i>
INER: National Institute of Energy Efficiency and Renewable Energies	<i>Energy use – research</i>

<i>(Ecuador)</i>	
MEER: <i>Ministry of Electricity and Renewable Energy (Ecuador)</i>	<i>Energy use – policy</i>
MAE: <i>Ministry of the Environment of Ecuador</i>	<i>Estimates of emissions reductions (mitigation), coordination and identification of participants in workshops for sharing results and lessons learned</i>

2.6 Indicative budget

Activities	Estimated Budget (in USD)
Activity 1: Baseline and potential demand for biodigesters	USD \$ 55,000
Activity 2: Technological analysis of biodigesters	USD \$ 45,000
Activity 3: Pilot biodigester implementation, monitoring and characterization	USD \$ 113,000
Activity 4: Systematization and communication of information	USD \$ 37,000
Total	USD \$ 250,000

Implementation of this Response Plan will be led by the Climate Technology Centre (including selection, contracting, supervision and monitoring of implementation partners) in close coordination with the corresponding National Designated Entity and relevant national actors. Implementation will be led by an international consortium or network partner of CTCN. The estimated cost of this Response Plan is USD \$ 250,000.

2.7 Gender considerations

The participation of men and women (adults and young people) will be considered in the composition of the team implementing the response plan and the target group of the intervention. It should be noted that half the pilot production units for the GENCAPER project are managed by women. Consultation and monitoring events for biodigesters will take into account the contributions of women and men, since each family member has roles that interact, directly or indirectly, with the operation and use of by-products of the biodigester. The capacity-building processes will also aim to strike a balance between the participation of men and women (young people and adults). For young people, the focus will be on contributing to national incentive programmes or strategies to ensure the replenishment of the agriculture sector by younger generations.

2.8 Risk identification and risk mitigation

Risk	Consequence	Probability	Mitigation measure
Environmental	El Niño weather phenomenon, earthquakes and volcanic activity may affect the implementation and	Medium–low	Tubular biodigesters are flexible and semi-prefabricated, allowing them to withstand earthquakes.

	operation of biodigesters.		
Financial	Extreme events may affect agricultural production and the economy.	Medium–low	The Government has mechanisms to deal with and ameliorate the impact of extreme events (agricultural insurance). In addition to the financial credit mechanisms to facilitate access to biodigesters, it will also be necessary to consider extreme situations insofar as possible.
	Market distortions affecting livestock products or better business opportunities may result in the closure of production units at which pilot biodigesters have been established.	Low	A sufficient number of pilot biodigesters must be chosen and letters of commitment must be signed to guarantee the necessary monitoring time.
External	Low LPG prices.	Low	Biodigesters do not only focus on taking advantage of the potential to produce biogas but also entail the integrated management of waste and recycling of nutrients through the use of biofertilizers, meaning that the energy component represents just one aspect.
	Lack of security prevents visits to certain regions for gathering information of interest to the project.	Medium–low	Secondary information and a panel of experts will be used. It may also be possible to identify another region with similar characteristics.

3. Long-term impacts of the assistance

3.1 Expected climate change-related benefits

	CTCN climate technology impact	Anticipated contribution from CTCN assistance
1	Climate technologies adapted to the national context are identified and prioritized to enable their deployment and/or transfer in the requesting countries	The design of biodigesters for different scales of livestock farms as an alternative source of energy using manure, which contributes to adapting to and mitigating against climate change.
2	A new national Technology Needs Assessment (TNA) and Technology Action Plan (TAP) as a result of the response	An inventory of climate technologies for the various production subsectors and prioritization in terms of cost effectiveness (for mitigation).
3	Progress made against mitigation objectives (i.e. energy and carbon intensity reduction) as a result of the response	Reduction in the intensity of carbon emissions from processing manure at livestock farms (pork and bovine dairy).
4	Progress made against adaptation or resilience objectives (e.g. climate vulnerability index improvement) as a result of the response	More diversified energy production matrix at farms and prevention or reduction of the degradation of natural resources, particularly water, soils, forests and biodiversity.
5	New mitigation or adaptation technology projects/initiatives implemented as a result of the response	Projects for the scaling up and sustainability of the biodigester component for the production of heat energy and electricity at livestock farms.
6	New or strengthened policies/laws developed, approved and enacted as a result of the response	Policies for harnessing waste for biomass and not just treatment.
7	New policies/laws where climate change was mainstreamed as a result of the response	Policies for the capture of biogas in treatment processes for waste biomass.
8	Country integrating climate change mitigation and/or adaptation issues into its planning and policies as a result of the response	Contributions involving actions to strengthen the synergy between adaptation and mitigation, whose approach is already present in the policies for the national well-being programme (2013–2017), the national environmental programme and the national climate change strategy.
9	New or strengthened Public-Private Partnerships (PPP) created directly as a result of the response	Public institutions in the agriculture, energy and environmental sectors will strengthen joint activities and those involving the private sector such as associations of

		producers and other partners in the production chain (e.g. suppliers of technical and financial services).
10	New or strengthened twinning arrangement created as a result of the response	New public and private institutions will be added to the CTCN consortium, together with bilateral agreements between institutions for the exchange of experiences in their areas.
11	Capacities to access and attract public and private finance increase to enable financing of technology deployment	Capacity building covering both the target group and national implementers.
12	Post-response intervention funding attributable to the response	The response plan includes inputs for developing a component to promote a national biodigester initiative as part of PNABE. In terms of implementation and sustainability, it will guide the identification of national and international sources of funding.
13	Framework and analysis of local production developed to enable deployment of national production of climate technologies	The response plan will identify the most appropriate digester technologies for Ecuador by production subsector, scale and region, incentivizing local R&D and strengthening local technology suppliers.

3.2 Co-benefits

	Sustainable Development Goal	Contribution from CTCN assistance
1	End poverty in all its forms everywhere	Increase the income of owner families and employees working at livestock farms. There will also be an economic benefit for families involved in the sale of biofertilizers and other links in the production chain.
2	End hunger, achieve food security and improved nutrition, and promote sustainable agriculture	The use of biofertilizers has the potential to increase and diversify the sustainable production of food, improving food security and nutrition.
3	Ensure healthy lives and promote well-being for all at all ages	Reducing sources of pollution for water sources, soils, food and air that have a negative impact on public health.

4	Ensure inclusive and equitable quality education and promote life-long learning opportunities for all	Family relationship with closed-cycle production (permaculture) through the use and harnessing of biodigesters.
5	Achieve gender equality and empower all women and girls	The project will promote equitable participation of women and men in the processes for implementing the response plan, decision-making and the implementation of good practices for livestock farms in terms of generating energy from manure.
6	Ensure availability and sustainable management of water and sanitation for all	The use of biodigesters will reduce the pollution of water sources, helping guarantee the availability and quality of water for various uses in communities, as well as the conservation of aquatic biodiversity.
7	Ensure access to affordable, reliable, sustainable, and modern energy for all	Biodigesters can contribute as a source of renewable energy and increase the energy autonomy of livestock farms.
8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Biodigesters help harness the resources of farms that may otherwise be classed as waste, improving financial sustainability and reducing the farm's external dependency.
9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	Biodigesters increase the resilience of producers by making farms less dependent on external inputs, both in terms of energy and agrochemicals.
10	Reduce inequality within and among countries	Innovation will be generated and transferred in line with the different scales of livestock production units.
11	Make cities and human settlements inclusive, safe, resilient and sustainable	The decentralized introduction of biodigesters will guarantee suitable processing of waste and its use at the local level.
12	Ensure sustainable consumption and production patterns	The biodigesters that have been considered are classed as appropriate or intermediate technologies, ensuring the sustainability and capacity of local production.

13	Take urgent action to combat climate change and its impacts	The integrated treatment of manure using anaerobic biodigesters contributes to the adaptation to mitigation against climate change. Mitigation may be both direct and indirect.
14	Conserve and sustainably use the oceans, seas and marine resources for sustainable development	Reducing the pollution of rivers and the use of nitrogen chemical fertilizers, which are replaced by biofertilizers, can help prevent negative impacts on marine ecosystems.
15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	Biofertilizers produced from biodigesters support prevention, restoration and conservation for soils. The use of energy from manure also reduces the consumption of wood and plant biomass, helping maintain forests and conserve biodiversity.
16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	The application of laws for livestock farms to address negative externalities for the environment that are committed to the well-being of people and providing a favourable environment for the adoption of technologies to overcome problems with manure at livestock farms.
17	Strengthen the means of implementation and revitalize the global partnership for sustainable development	The promotion and implementation of biodigesters in Ecuador has a direct impact on the region of Latin America, which faces similar problems, contributing lessons learned at the regional level.

3.3. Post-assistance plans and actions

The following activities will take place upon completion of the technical assistance:

- Dissemination of the results obtained among actors in the agriculture sector, financial institutions, technology suppliers, the national government (MAE, MEER and MAGAP) and local governments in the regions of greatest interest, in addition to universities and research centres. The results of the project will serve as inputs for designing or changing policies and policy instruments for the integrated management of manure using biodigesters.
- Search for funding from national, regional and local governments, in addition to international cooperation in the design and development of the PNABE biodigester component.
- Strengthening of a biomass network or association in Ecuador (if one exists) or helping create one to bring together actors in the sector.

- Begin developing standards with the competent authority in areas such as the certification of biogas installers, quality control for installations and the use of biogas and biofertilizers.

3.4 Monitoring and reporting of technical assistance results and impacts

The activities and expected outcomes of this technical assistance are explicitly described in sections 1.3–3 and the table of performance indicators below (see also the framework in Annex 1 of this response plan). The progress and results of activities will be closely supervised by the principal implementer of this response plan, with support from Ecuador’s NDE and CTCN. The principal implementer is responsible for verifying the progress of technical assistance against the timeline and the associated outcomes and for communicating the results to the NDE and CTCN. Upon completion of each activity, the principal implementer will provide a brief summary of the lessons learned, reflecting on the progress made and achievements and challenges encountered during the activity. The principal implementer will organize a monthly teleconference with the parties involved in the implementation to determine the progress of the technical assistance, as well as any challenges and requirements for adjustment, etc. All changes arising from the activities, processes and/or approaches as they are set out in the response plan must be approved by CTCN and the NDE prior to application.

Performance indicators of CTCN Assistance

Response output <i>(linking to sec 1.2)</i>	How output will be used to ensure creation of result	Expected result	Expected outcome of result <i>(linking to sec 1.1)</i>	Anticipated impact that outcome will produce <i>(linking to section 3)</i>
Document “Status of the agriculture and energy sectors, potential demand for biodigesters among small and medium producers and a summary of meetings with local groups”	This document will analyse the subsectors, regions and types of producers and determine the viability of developing a biodigester sector in the country.	Awareness of the agriculture sector in Ecuador by region, subsector and scale, with a feasibility study evaluating the technical potential for the installation of biodigesters by region, subsector and scale.	This result can be used to prioritize production scales, regions and sectors and identify strategies based on the most attractive scales, regions and subsectors in terms of the viability of a sustainable biodigester sector in the future.	Development of a framework and analysis for local production to allow the national production of climate technologies.
Publication “Successful experiences of national biogas programmes in Asia, Africa and Latin America”	This document will set out the most relevant factors influencing the success or failure of programmes so they can be taken into account in the development of a sustainable biodigester sector in Ecuador.	Identification of the key factors for successes and failures in the development of a biodigester sector in other countries.	Evaluation of which of the factors fit the circumstances of Ecuador.	Development of a framework and analysis for local production to allow the national production of climate technologies.
Report “Characterization of inputs and outputs for the system and technological and financial analysis of biodigester models by subsector for the chosen	This document will identify the environmental conditions and models of biodigesters that are most suitable for each agriculture sector and climate.	Information on the most suitable models and designs of biodigesters for implementation in Ecuador, in line with the type of producer, sector and region.	Based on this technological analysis, it will be possible to begin to promote specific technologies in line with supply and demand.	The new national plan for the evaluation of technology requirements and technological action as a result of the response.

regions”				
Report “Quality control protocol for service providers (materials, equipment and technical assistance)”	The biodigester component in Ecuador requires the use of a quality control protocol for service providers.	Guidelines for quality control and technical assistance for biodigester suppliers in Ecuador.	Improving the technical, economic and environmental efficiency of the biodigester sector in Ecuador.	Scaling up of biodigester projects.
Document and PowerPoint “Characterization of the operation of pilot biodigesters”	Having characterized the pilot biodigesters, it will be possible to determine the real operating parameters, costs, construction solutions and technical requirements.	Biodigesters characterized under real operating conditions, certification technological designs.	The monitoring and characterization of these biodigesters will input into policy formulation	Progress made based on the mitigation objectives (reduction of energy consumption and the intensity of carbon emissions) as a result of the response. Progress made based on the adaptation or resilience objectives (improvement in the index measuring climate vulnerability) as a result of the response.
Document and PowerPoint “Use, maintenance and harnessing of biodigesters with a gender approach”	This document standardizes, validates and consolidates the technology designs and provides the country with promotional material based on real experiences and with a gender approach from the outset.	The inputs required to begin the promotion, implementation and operation of biodigesters for the development of a sustainable biodigester sector in Ecuador.	This input will make it possible to begin development of the PNABE biodigester component.	Execution of new projects or initiatives for mitigation and adaptation technologies as a result of the response. New or strengthened public–private partnerships as a result of the response.
Document and PowerPoint	This document will provide a valuation based on experimental	Experimental data on CO ₂ equivalent avoided per	This document will support arguments for considering	The new national plan for the evaluation of technology

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“Contribution of biodigesters to the adaptation to and mitigation against climate change by farms”	results of the potential of biodigesters as a climate technology.	operating biodigester and contributions to the adaptation to and mitigation against climate change.	this technology as part of Ecuador’s adaptation and climate change policies.	requirements and technological action as a result of the response.
Report “Training workshop for R&D, monitoring and characterization of biodigesters”	Trained staff will be able to support the monitoring and characterization of biodigesters, in addition to undertaking their own research.	25 teachers/researchers/students from the most recent courses will be aware of R&D, monitoring and characterization methods for biodigesters.	This workshop will build local R&D capacities.	Execution of new projects or initiatives for mitigation and adaptation technologies as a result of the response.
Document “Towards a sustainable biodigester sector in Ecuador: Inputs for a biodigester component of PNABE”	This document will provide the inputs required to develop the PNABE biodigester component.	The information required to develop the PNABE biodigester component for the sustainable development of a biodigester sector in Ecuador will be available.	The document will be used to develop a plan that sets out the road map for beginning activities for the PNABE biomass component.	Ecuador’s inclusion of the issues related to mitigation against or adaptation to climate change in its plans and policies as a result of the response. New or strengthened public-private partnerships as a result of the response.
Report “Workshop for the communication of results involving the main figures in the sustainable development of biodigesters in Ecuador”	This dissemination will ensure figures involved have the capacity to build synergies for the development of the PNABE biodigester component.	Awareness of the results of the technical assistance (technologies, impacts, potential etc.) among the figures involved in developing a sustainable biodigester sector.	This dissemination will build the capacity to create synergies for the development of the PNABE biodigester component.	Ecuador’s inclusion of the issues related to mitigation against or adaptation to climate change in its plans and policies as a result of the response. New or strengthened public-private partnerships as a result of the response.

4. Signatures

Signatures of the requesting country

NDE

Request Proponent

Name:

Name:

Title:

Title:

Date:

Date:

Signature:

Signature:

Signatures of the CTCN

CTCN Director

Climate Technology Manager

Name:

Name:

Title:

Title:

Date:

Date:

Signature:

Signature:

Annex 1: Response Logframe

Activity <i>(link to sec 2)</i>	Description of sub-activities conducted by the CTCN	Output/ Deliverable <i>(link to sec 2.9)</i>	Expected Outcome <i>(link to sec 3)</i>	Main national partners involved	Objectively Verifiable Indicator <i>(see Annex 5 guidance)</i>	Means of Verification (data source, method of collection, responsibility and periodicity)
Activity 1: <i>Baseline potential demand for biogas</i>	<p>A1.1 Analysis of the context and identifying types of farms</p> <p>A1.2 Analysis of international biogas programmes</p>	<p>R1.1 Document “Status of the agriculture and energy sectors, potential demand for biogas among small and medium producers and a summary of meetings with local groups”</p> <p>R1.2 Publication “Successful experiences of national biogas programmes in Asia, Africa and Latin America”</p>	<p>Information on the circumstances facing the agriculture sector in Ecuador by region, subsector and scale.</p> <p>Availability of a feasibility study evaluating the technical potential for the installation of biogas and information on the success factors for other initiatives in other countries.</p>	<p>MAE, MAGAP, MEER, INIAP, INER</p>	<p>I1.1: Number of men and women providing information.</p> <p>I1.2: Number of figures involved in the biogas sector considered.</p> <p>I1.3: Number of field visits to existing projects.</p> <p>I1.4: Number of secondary sources considered.</p>	<p>V1.1: Records of participants in meetings.</p> <p>V1.2: Photographic evidence from field visits.</p> <p>V1.3: Bibliography considered in studies.</p> <p>V1.4: Databases and maps.</p>
Activity 2: <i>Technological analysis of biogas</i>		<p>R2.1: Report “Characterization of inputs and outputs for the system and</p>	<p>Information available on the most suitable models and designs of</p>	<p>MAE, MEER, INER</p>	<p>I2.1: Number of biogas models, sectors and regions considered.</p>	<p>V2.1: Databases and reports.</p>

		<p>technological and financial analysis of biodigester models by subsector for the chosen regions”</p> <p>R2.2: Report “Quality control protocol for service providers (materials, equipment and technical assistance)”</p>	<p>biodigester for implementation in Ecuador, in line with the type of producer, subsector and region. Guidelines for quality control and technical assistance by biodigesters suppliers.</p>		<p>I2.2: Number of quality control protocols for biodigesters.</p>	
<p><i>Activity 3: Pilot biodigester implementation, monitoring and characterization</i></p>		<p>R3.1 Document and PowerPoint “Characterization of the operation of pilot biodigesters”.</p> <p>R3.2 Document and PowerPoint “Use, maintenance and harnessing of biodigesters with a gender approach”</p> <p>R3.3 Document and PowerPoint “Contribution of biodigesters to the adaptation to and</p>	<p>Availability of characterized biodigesters under real operating conditions, certification of technological designs. Availability of the inputs required to begin the promotion, implementation and operation of biodigesters.</p>	<p>MAE, MAGAP, MEER, INIAP, INER</p>	<p>I3.1: Number of pilot biodigesters installed. I3.2: Number of men and women related to the management of manure. I3.3: Number of participants in the workshop, grade and evaluation after training. I3.4: Number of men and women trained by production subsectors.</p>	<p>V3.1: Photographic evidence of installed biodigesters, monitoring databases and characterization report. V3.2: Electronic document. V3.3: Electronic document and map of biodigesters. V3.4: Workshop records, attendance record and evaluation.</p>

		mitigation against climate change by farms” R3.4 Report “Training workshop for R&D, monitoring and characterization of biodigesters”				
<i>Activity 4: Systematization and communication of information</i>	A4.1 Systematization of results A4.2 Dissemination of technical assistance	R4.1: Document “Towards a sustainable biodigester sector in Ecuador: Inputs for a biodigester component of PNABE” R4.2: Report “Workshop for the communication of results involving the main figures in the sustainable development of biodigesters in Ecuador”	The information required to develop the PNABE biodigester component for the sustainable development of a biodigester sector in Ecuador. The method and results of the technical assistance are known by the figures involved in the process.	MAE, MAGAP, MEER, INIAP, INER	I4.1: Recommendations, scope of the dissemination, level of detail used, incorporation of recommendations. I4.2: Number of participants in the workshop, grade and evaluation after training.	V4.1: Final document. V4.2: Workshop records, attendance record and evaluation.

Annex 2: Response budget

The detailed budget is attached to the response as an Excel file.

Annex 3: Terms of reference for the assistance provider

The following table provides a summary of the requirements for experts suggested in the implementation of the response plan.

Expert	Requirements
Specialist with experience in sustainable livestock farming systems.	Masters degree or PhD in agricultural sciences. At least five years of experience in livestock and climate change projects, the quantification of GHGs in livestock systems using different methods, strategies for reducing the emission of GHGs and proven ability producing technical publications for various target audiences. It is desirable for the candidate to be bilingual in Spanish and English.
Specialist in energy systems with experience in the management and implementation of biodigester projects.	Masters degree or PhD in agricultural or environmental sciences, with at least five years of experience managing projects and implementing, monitoring and evaluating biodigesters. Producing communications materials for various target audiences. It is desirable for the candidate to be bilingual in Spanish and English.
Specialist in biodigesters with experience of technology R&D and national biogas programmes.	Masters degree or PhD in agricultural or environmental sciences or similar. At least five years of international experience in the design and implementation of R&D projects for biodigesters in countries in Latin America and other continents. Producing technical and scientific publications. It is desirable for the candidate to be bilingual in Spanish and English.
Specialist in the management of agricultural waste and agribusiness.	Masters degree or PhD in agricultural or environmental sciences, agribusiness, projects for financing climate technologies or similar. At least five years of international experience in the development of small and medium commercial biodigester projects, added value and the sale of derivative products. Producing communications materials for various target audiences. It is desirable for the candidate to be bilingual in Spanish and English.

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<p>Specialist in social communication and producing educational materials.</p>	<p>Degree (preferably a masters) in communication sciences. At least five years of experience working on communication strategies and producing technical notes and materials for various target audiences. It is desirable for the candidate to be bilingual in Spanish and English.</p>
<p>Technician for the monitoring and analysis of data.</p>	<p>Undergraduate degree in agricultural sciences or similar. At least five years of experience in the monitoring and evaluation of local or national biogas programmes (or similar) and handling databases.</p>

Annex 4: Indicative list of performance indicators

Overall Activity	Specific Activity	Indicator
Capacity Building	<ul style="list-style-type: none"> ▪ development and delivery of workshops ▪ development and delivery of training (e.g. webinars, e-learning, ad-hoc) ▪ development and delivery of toolkits 	Number of participants trained or training days received; Post training evaluation and feedback (and minutes); CTCN Knowledge Management System (KMS) users; Webinar content/minutes/feedback; e-learning content/feedback
Advisory	<ul style="list-style-type: none"> ▪ development of needs assessment/ studies/ reports/ etc. ▪ establishment/development of recommendations 	Diversity of sources used; Response Implementer efforts days; Recommendations; Scope of dissemination; Level of detail used; Feedback; Uptake of recommendations
Policy development	<ul style="list-style-type: none"> ▪ development of strategy ▪ drafting of implementation plan ▪ formulation inputs to policy/ law 	Strategy available and adapted to local context and national priorities; Number of interview/events conducted to developed the strategy/ plan; Strategy/Plan dissemination; Number of technologies recommended in the strategy/plan; Scope of changes recommended by the strategy/plan.
Project implementation	<p>Mitigation</p> <ul style="list-style-type: none"> ▪ Energy supply ▪ Energy use ▪ Industry ▪ Transport ▪ Agriculture ▪ Waste management ▪ Forestry <p>Adaptation</p> <ul style="list-style-type: none"> ▪ Water ▪ Infrastructure, transport and urban design ▪ Early warning and environmental assessment ▪ Coastal zones ▪ Agriculture and forestry 	Outputs available and adapted to local context and national priorities; Level of private sector participation; Planning/Outputs distributed to decision makers with feedbacks; Integration of outputs/outcomes into planning of host country; implementation of outputs/outcomes by host country or other multi/bi-lateral organization; Level of cooperation between Response Implementer, NDE and Response Proponent(s).

Overall Activity	Specific Activity	Indicator
	<ul style="list-style-type: none"> ▪ Human health ▪ Marine and fisheries 	
Development of a new partnership or strengthening of an existing one	<ul style="list-style-type: none"> ▪ Development/ Establishment of basis for Twinning ▪ Development/ Establishment of basis for PPP ▪ Development/ Establishment of basis for knowledge partnership 	Number of meetings between potential partners in the initiative, agreements between national institutions and between national and international institutions (public and private), agreements to strengthen the management of knowledge.

Annex 5: Summary of activities and deliverables for the technical assistance plan.



Baseline and potential demand for biodigesters

- Survey of agriculture and energy sectors and demand for biodigesters
- Successful experiences at the international level

Technological analysis of biodigesters

- Technological and financial analysis of biodigesters
- Quality control protocol for service providers

Pilot biodigesters, monitoring and characterization

- Characterization of the operation of pilot biodigesters
- Manual for the use, maintenance and harnessing of biodigesters
- Contribution of biodigesters to the adaptation to and mitigation against climate change for farms
- Training workshop for monitoring biodigesters

Systematization and dissemination of information

- Systematization of the results of the technical assistance
- Dissemination workshop with key figures