Food and Agriculture Organization of the United Nations

GREEN AGRICULTURE DEVELOPMENT IN HAINAN BASED ON THE LIVESTOCK-BIOGAS-CROP CIRCULAR MODEL

May 2022

SDGs:

Country:	The People's Republic of China
Project Code:	TCP/CPR/3703
FAO Contribution:	USD 211 000
Duration:	1 July 2020 – 31 December 2021
Contact Info:	FAO Representation in China FAO-CN@fao.org

Implementing Partner

Ministry of Agricultural and Rural Affairs (MARA).

Beneficiaries

Livestock farmers in Hainan Province.

Country Programming Framework (CPF) Outputs

CPF (2016-2020) Priority Area 1: Fostering sustainable and climate resilient agricultural development.

BACKGROUND

The rapid development of a large-scale and intensive farming industry in Hainan has led to a sharp increase in livestock and poultry manure, which poses a significant challenge to both the ecological environment and human health. The treatment and disposal of livestock manure have become a bottleneck that limits the development of the breeding industry in a green and sustainable way. In recent years, China has attached great importance to the development of ecological circular agriculture. Biogas treatment has arisen as an important way to manage livestock manure. By utilizing manure to produce biogas and then promoting the use of biogas, rural areas can greatly reduce the use of fuel and coal. Rural sanitation and living environment can be improved, and soil health and plant growth can also benefit from the provision of biogas slurry nutrient. If well managed, the biogas can provide an effective and efficient alternative in support of green and ecological agriculture development.

Hainan Province is a tropical island in China. Tropical cash crops, and livestock and poultry farming are the major income sources for Hainan farmers. Located in the north of Yazhou District, Sanya City, Hainan Province, Beiling Village is home to 3 857 famers, including 3 852 from the Li ethnic minority, accounting for 99.9 percent of the total. Local villagers rely on mango and banana as the main cash crops.

In Beiling Village, which was designated as a key village for poverty reduction, the local government has provided targeted interventions in support of goat industry development for the improvement of local livelihoods. How to best manage and use the goat manure for green and sustainable agriculture development raises a challenge for local communities.

Adhering to the goal of building an ecological island and promoting ecological agriculture development, Hainan Province has carried out a long-term exploration of the recycling of biogas slurry. However, the output and quality of biogas slurry and biogas residue remain unstable in different seasons. In addition, rural villages and towns do not have the capacity to build the supporting facility for waste disposal. Furthermore, owing to the lack of knowledge, waste gas, water and other residuals are freely emitted into the environment without any treatment, which has led to soil acidification, soil nutrient imbalance and serious soil degradation. Excessive biogas slurry has also led to the secondary pollution of groundwater. In this context, the Government of China requested technical assistance from FAO to help Hainan Province to identify, adapt and extend a set of innovative and integrated technical specifications and standards for the management of biogas slurry and biogas slurry nutrient in the context of local tropical agriculture development. The specific aim of the project was to build a "livestock-biogas-crop" ecological circular agriculture model in which livestock manure would be used for the development of biogas and biogas slurry would be treated to feed crops, including areca and other fodder crops. An integrated and innovative set of technologies would be identified, optimized and demonstrated. Finally, through participatory training, the developed technical package would be extended to local farmers, with possible replication in other parts of the country that are similarly challenged by manure management and biogas promotion.

IMPACT

The project has contributed to enhanced agriculture production, an improved environment and increased household incomes for farmers in the tropical island of Hainan. The technologies introduced by the project will not only increase the quality and productivity of products and reduce the application of chemical fertilizers, but will also benefit the environment and land fertility if applied over the long term. The model developed by the project may also be relevant for scaling up elsewhere in the country.

Achievement of results

The project introduced a "livestock-biogas-crop" ecological circular agriculture model, which enables the use of livestock and poultry manure resources for energy and fertilizer purposes by means of biogas generation, storage and residue management, resulting in measurable social, ecological, economic and environmental benefits. Specifically, the project proposed and piloted a goat-biogas-mango-based ecological circular agriculture model, and explored the potential of an goat-earthworm-mango model and a goat-biogas-lychee model. The application of these tailored models effectively promoted the integrated use of manure waste and biogas, contributing to the improvement of local environmental health, agricultural productivity and farmers' livelihoods. The livestock-biogas (earthworm)-crop circular model was identified as a feasible model in Hainan and relevant production specifications were formulated. A 100 mu goat-biogas (earthworm)-mango demonstration operation was established in Beiling village, Yazhou district, Sanya city. Thirty agricultural extension workers were trained via a dedicated training of trainers (TOT) course. Fifteen farmer field schools (FFS) were also organized in four counties and cities in Hainan, with each FFS involving at least 30 participants over six sessions. In total, 450 farmers, comprising 237 men and 213 women, were trained in FFS. A project technical handbook on green agriculture and a guideline for FFS was developed during training and more than 1 000 farmers in adjacent communities received technical information material. Training materials for TOT and FFS were also compiled by the project.

Implementation of work plan and budget

All project activities were implemented. Delays in training and demonstration activities caused by restrictions related to the COVID-19 pandemic led to a request for a no-cost extension. This was granted and the project ended in December 2021. All activities were completed within the original budget of USD 211 000.

A Project Steering Committee was put in place, consisting of representatives from all stakeholders, including the budget holder in FAO China, the Lead Technical Officer, MARA and Hainan Provincial Department of Agriculture and Rural Affairs, as well as national consultants. Led by the National Project Coordinator and deputy director of the Hainan Provincial Department of Agriculture and Rural Affairs, a project management office (PMO) was established within Hainan Agricultural International Exchange and Cooperation Centre when the project was launched. The Centre and the PMO were responsible for the day-to-day management and implementation of the project. For each project task, a work plan was designed and strictly observed during implementation. These measures ensured the effective management and delivery of the project and eliminated any envisaged risks, such as a lack of project management, inappropriate production technology, the inaccessibility of key inputs and inadequate staff training.

Follow-up for government attention

To ensure the long-term sustainability of project impact, the competent authorities of agriculture in Hainan Province should enhance policy and institutional arrangements for the participatory demonstration and extension of agricultural technologies and allocate special funds to this end.

SUSTAINABILITY

1. Capacity development

Green circular agriculture has been identified as a way to develop a modern agriculture system that produces ecological, economic and social benefits. Both MARA and the people's government of Hainan Province have been improving the functions and services of the agro-ecosystem for the sustainable development of the agriculture sector. The project is in line with the commitment of MARA and Hainan Province to develop circular agriculture. The Hainan Provincial Department of Agriculture and Rural Affairs and other agricultural authorities paid special attention to project progress and allocated a special fund to support project activities, which ensured the sustainability of project technologies and of its extension.

The PMO will continue to operate after the project. The Environment and Plant Protection Institute of Chinese Academy of Tropical Agricultural Sciences, as one of the project's implementation partners, will apply the project results in follow-up extension activities. The PMO will also maintain contact and cooperate with agricultural extension authorities at city and county levels for the subsequent application and extension of the project results. The project is thus embedded in organizational structures that are likely to survive beyond the project and that are committed to the sustainability of results.

The project brought together the Hainan Provincial Department of Agriculture and Rural Affairs, the Hainan Agricultural International Exchange and Cooperation Centre, the Environment and Plant Protection Institute of Chinese Academy of Tropical Agricultural Sciences, competent authorities of agriculture in Haikou city, Santa city, Dongfang county and other places, and agrotech extension units in townships in order to form a project implementation alliance. The alliance not only facilitated the smooth delivery of the project, but also strengthened the follow-up application and extension of the project's results.

Following the project, the TOT and FFS trainers and trainees have taken the lead in its subsequent application and extension. The livestock-biogas (earthworm)-crop circular model will be further extended, and training and information campaigns will be organized in other areas of Hainan Province.

2. Gender equality

The priorities of women and men beneficiaries and stakeholders were to increase efficiency and raise their income. The green and circular agriculture technologies integrated in the project have enabled them to achieve higher yields and to produce green vegetables and fruit, promoting efficiency and raising incomes.

The gender perspective was incorporated in the project design. During implementation, both female and male TOT participants played an equal part in formulating the FFS work plan and scheme, and in field practice at the demonstration base. As over half the farmers in Hainan are female, ensuring equal participation enables better overall extension support for introduced technologies and training models during and after the project, strengthening the sustainability of project results.

3. Environmental sustainability

Green planting was integrated into both project technology development and training. This raised the awareness of trainees and beneficiary groups with regard to the influence of farming on the agro-ecosystem and highlighted opportunities to adopt more sustainable agricultural practices. The beneficiaries and beneficiary groups applied green and circular agrotechnologies in planting, which protected the environment in the project area and brought environmental benefits. The project also increased the efficiency of production and income of beneficiaries and beneficiary groups. The environmental and social impacts of the project were well specified and managed during project implementation. The information and knowledge generated by the project will be shared among all stakeholders through demonstration training after the project.

4. Human Rights-based Approach (HRBA) – in particular Right to Food and Decent Work

The work plan and scheme were formulated through the joint discussion of project team members. Trainees were consulted when formulating the TOT and FFS training schemes, and not only enjoyed the benefits and rights established by the project, but also took on the obligation of extending the technological model introduced. The model, which can increase yield and improve the quality of fruit, provided markets with more high-quality fruit and increased farmers' income. The expansion of fruit planting area resulted in an increasing demand of labour force. Traditional crop planters also began to plant fruit trees for economic benefit. The two phenomena created gainful employment and entrepreneurship opportunities for rural people. The livestock-biogas (earthworm)-crop circular model introduced under the project could reduce the use of traditional and poisonous chemical fertilizers, and shorten fertilizing time, improving occupational safety and reducing hours of work.

5. Technological sustainability

The technology used in the project integrated existing and new technologies according to the planting situation in Hainan and was adjusted on the basis of practice in the demonstration site. The technology is thus appropriate for use in Hainan. It is also flexible enough to be adapted by farmers according to local conditions.

In the innovative FFS, relevant institutions increased their capacity to develop new technologies, and to design, implement and assess agrotech extension plans. The project also developed the beneficiaries' capacity in public communication and promotion.

Through production practice and technical training, stakeholders and beneficiaries learned safe and productive planting technologies and the new participatory training model. Most trainees are agrotechnicians and large-scale growers, and are willing to share new technologies and training models. They are thus able to pursue project activities without further technical assistance.

6. Economic sustainability

Hainan Provincial Department of Agriculture and Rural Affairs allocated a special fund of CNY 300 000 for each year from 2020 to 2021. Sanya Nanfan Science and Technology Research Institute provided CNY 330 000 for facility construction.

The beneficiaries received free training and technical services under the project. A demonstration site was also built with financial funds. The beneficiaries will not have to resort to external funding. The introduced technologies are also affordable for ordinary rural households.

DOCUMENTS AND OUTREACH PRODUCTS

- **FAO.** *Illustrated technical information note for farmers*. 39 pp.

ACHIEVEMENT OF RESULTS - LOGICAL FRAMEWORK

Expected Impact	**Enhanced agriculture production, improved environment and increased household income for the local farmers in the tropical Island in Hainan**			
Outcome	A "Livestock-biogas-Crop" ecological circular agriculture model, which enables the use of livestock and poultry manure resources for energy and fertilizers purposes by means of biogas generation, storage and residue management, resulting in remarkable social, ecological, economic and environmental benefits			
	Indicator	A "Livestock-biogas-Crop" ecological circular agriculture model developed and extended.		
	Baseline	0		
	End Target	1		
	Comments and follow-up action to be taken	A goat-biogas-mango-based ecological circular agriculture model was proposed and piloted under the project. In addition, a goat-earthworm-mango model and a goat-biogas-lychee model were explored. The application of these tailored models effectively promoted the integrated use of manure waste and biogas, contributing to the improvement of local environmental health, agricultural productivity and farmers' livelihoods.		
Output 1	Biogas and its residue management technology optimized			
	Indicators		Target	Achieved
	Number of technologies and implementation plans for biogas and its residue management.		1	Yes
Baseline	0			
Comments	The technical specifications for nutrient management of local biogas slurry were developed.			
Activity 1.1	Determine the biogas liquid storage design			
	Achieved	Yes		
	Comments	The biogas liquid storage design was adjusted according to the local situation.		
Activity 1.2	Prepare the annual work scheme for stable utilization of biogas slurry and biogas residual nutrients			
	Achieved	Yes		
	Comments	Annual work schemes for the stable utilization of biogas slurry and biogas residual nutrients were developed.		
Activity 1.3	Identify the technologies for reducing and intercepting toxic and harmful substances from biogas slurry and biogas residue to ensure safe farmland use			
	Achieved	Yes		
	Comments	The components of biogas slurry and biogas residues were identified, and the technologies for reducing and intercepting toxic and harmful substances from biogas slurry and biogas residue were developed.		
Activity 1.4	Conduct experimental studies and demonstrations to determine the optimal technical parameters and the optimal comprehensive scheme			
	Achieved	Yes		
	Comments	Experimental studies and demonstrations were carried out to determine the optimal technical parameters and the optimal comprehensive scheme.		
Activity 1.5	Prepare the technical specifications for nutrient management of biogas slurry and slag based on the applied research results and expert recommendations			
	Achieved	Yes		
	Comments	Technical specifications for the nutrient management of biogas slurry and slag in local settings were prepared.		
Output 2	Technical regulations for using biogas slurry/organic fertilizer to improve the land fertility and production capacity of agriculture in target regions			
	Indicators		Target	Achieved
	A set of technical regulations will be made to help the land capacity improvement.		1	Yes
Baseline	0			
Comments	A set of technical regulations was developed for using biogas slurry/vermicomposting to improve land fertility in mango orchards.			
Activity 2.1	Conduct nutrient level and component analysis of biogas slurry/organic fertilizer			
	Achieved	Yes		
	Comments	The nutrient level and components of biogas slurry/organic fertilizer were analysed and reported.		

<table>
<tr><td rowspan="3">Activity 2.2</td><td colspan="3">Analyse the nutrition demand patterns for crop growth and high yield</td></tr>
<tr><td>Achieved</td><td colspan="2">Yes</td></tr>
<tr><td>Comments</td><td colspan="2">The nutrition demand patterns for mango growth and high yield were analysed.</td></tr>
<tr><td rowspan="3">Activity 2.3</td><td colspan="3">Evaluate the application effect of biogas fertilizer, organic fertilizer and their combined application schemes on crops so as to determine the optimum amount and best time for the high-efficient application of these inputs</td></tr>
<tr><td>Achieved</td><td colspan="2">Yes</td></tr>
<tr><td>Comments</td><td colspan="2">The application effect of biogas fertilizer, organic fertilizer and their combined application schemes on crop was evaluated, and the optimum amount and best time for the high-efficient application of biogas slurry and organic fertilizer were identified.</td></tr>
<tr><td rowspan="3">Activity 2.4</td><td colspan="3">Finalize the technical regulations for soil fertility improvement using biogas slurry/organic fertilizer in the crop field</td></tr>
<tr><td>Achieved</td><td colspan="2">Yes</td></tr>
<tr><td>Comments</td><td colspan="2">The technical regulations for soil fertility improvement using biogas slurry/organic fertilizer in the crop field were developed.</td></tr>
<tr><td rowspan="3">Output 3</td><td colspan="3">Local capacities increased in terms of the use of the “Livestock-biogas-Crop” model</td></tr>
<tr><td>Indicators</td><td>Target</td><td>Achieved</td></tr>
<tr><td>– Areas of demonstration on the “Livestock-biogas-Crop” model.
– Number of people trained.</td><td>– 40 ha
– 1 480</td><td>Partially</td></tr>
<tr><td>Baseline</td><td colspan="3">0</td></tr>
<tr><td>Comments</td><td colspan="3">A goat-biogas (earthworm)-mango demonstration base of 100 mu was built in Beiling village, Yazhou district, Sanya city and a livestock-biogas (earthworm)-crop circular agriculture model began to take shape. During the project, the integrated utilization rate of biogas slurry and biogas residues in the demonstration base reached 100%. The model significantly improved the physiochemical properties of the soil and increased mango yield, and farmers’ income. Thirty local technicians graduated from a three-session TOT and 15 FFS were organized to train 450 farmers. A project technical handbook on green agriculture and a guideline for FFS were also developed.</td></tr>
<tr><td rowspan="3">Activity 3.1</td><td colspan="3">Establish a demonstration field of 40 ha for experimental observation and demonstration of the proposed circular economic model</td></tr>
<tr><td>Achieved</td><td colspan="2">Yes</td></tr>
<tr><td>Comments</td><td colspan="2">A goat-biogas (earthworm)-mango demonstration base of 100 mu was built in Beiling village, Yazhou district, Sanya city.</td></tr>
<tr><td rowspan="3">Activity 3.2</td><td colspan="3">Organize a three-person international study tour on circular agriculture</td></tr>
<tr><td>Achieved</td><td colspan="2">No</td></tr>
<tr><td>Comments</td><td colspan="2">The activities could not be implemented because of the COVID-19-related restrictions.</td></tr>
</table>

Activity 3.3	Organize the Training of Trainers (ToT) for 30 local technicians and cooperative representatives	
	Achieved	Yes
	Comments	Thirty participants from the City Bureau of Agriculture and Rural Affairs, Agricultural Service Centre, associations and companies of Haikou city, Sanya city, Dongfang city and Wenchang city, respectively, participated in the TOT session. The training was organized in three phases, lasting for 25 days from October to November 2021. The training covered the following key aspects: – Basic knowledge of circular agriculture. The model and characteristics of circular agriculture, the characteristics and key aspects of the "livestock-biogas (earthworm)-crop" model, analysis of the economic, ecological and environmental benefits of the circular agriculture model. – Basic knowledge of agro-ecosystems. Concepts and characteristics of agro-ecosystems, factors of agro-ecosystems and their interactions, rapid agro-ecosystem analysis. – Biogas production and comprehensive utilization technology of biogas slurry and residues. Biogas production process, key technologies for biogas production, sanitary treatment of livestock and poultry manure, technologies for utilization of biogas residue, and biogas slurry on fruit trees and vegetables. – Vermiculture and vermicompost production and utilization technology. Biological characteristics and farming techniques of earthworms, vermicompost utilization techniques, vermicompost in substitution of chemical fertilizers, protection and utilization of natural enemies. – Ecological planting techniques for tropical fruit trees such as lychee, rice and vegetables. Biodiversity conservation, rational application of fertilizers and biogas residue and slurry and vermicompost application in replacement of chemical fertilizer, conservation and utilization of natural enemies. – Skill improvement and team building. Skills include observation, communication, systematic planning, presentation, speech delivery and management. – Practice FFS. TOT participants organize FFS. – Participatory assessment. Daily/stage assessment, pre/post-training test, opening ceremony, graduation ceremony, interview, presentation, poster exhibition, etc.
Activity 3.4	Organize 15 FFSs for 450 local farmers, including one third women and young farmers, on improving soil fertility in crop cultivation with biogas slurry/organic fertilizer	
	Achieved	Yes
	Comments	In total, 15 FFS were organized in Haikou, Sanya, Dongfang, and Wenchang from October to November 2021. 450 farmers, comprising 237 males and 213 females, graduated from the FFS. Each FFS hosted 30 farmers for six sessions of training. The training covered the following key aspects: – Basic knowledge of circular agriculture. The model and characteristics of circular agriculture, the characteristics and key aspects of circular agriculture, and analysis of economic, ecological and environmental benefits of the circular agriculture model. – Basic knowledge of agro-ecosystem. Concept and characteristics of agro-ecosystem, agro-ecosystem factors and their interactions, biodiversity utilization technology, and comprehensive utilization of crop straw. – Comprehensive utilization of biogas residue and slurry. Harmless treatment of livestock and poultry manure and application of biogas residue and slurry on fruit trees and vegetables. – Earthworm farming and vermicompost production and utilization technology. Biological characteristics and breeding technology of earthworms, and fertilization with vermicompost in replacement for chemical fertilizer. – Skill improvement and team building. Observation, communication and presentation skills. – Participatory assessment. Stage assessment, opening and graduation ceremony.
Activity 3.5	Organize information and communication campaign for outreaching to 1 000 farmers in the adjacent communities and cross visits for policy-makers and technicians for exchange and capacity enhancement	
	Achieved	Yes
	Comments	A project technical handbook on green agriculture and a guideline for FFS were developed during training to enable TOT and FFS trainees to quickly understand, learn and use relevant technologies of green and circular agriculture. More than 1 000 farmers in adjacent communities received technical information notes.
Activity 3.6	Summarize the experience of technological integration and demonstration of ecological circular agriculture to provide guidance for future practice	
	Achieved	Yes
	Comments	The experience of technological integration and the demonstration of ecological circular agriculture were summarized at the project final review workshop on 14 December 2021.

Partnerships and Outreach
For more information, please contact: Reporting@fao.org

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