Promoting Biogas Development through South-South Cooperation and Communication

—Lessons learned from a small-grant project under Global SSDC Project

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Content

1. Background

1.1 About Global South-South Development Center Project

The China South-South Development Center Project (China SSDC Project) was officially launched in 2008 jointly by CICETE and UNOSSC, with an aim to support South-South cooperation between China and other developing countries for sustainable development. Over the past ten years, the China SSDC Project has been successful and effective in supporting South-South knowledge and expertise exchange, resource mobilization, and public-private partnership building, as well as facilitating cooperation between China and other developing countries in the economic and technical domains. According to the State of Intent between the Ministry of Commerce of China and UN Office for South-South Cooperation (UNOSSC), the project has been upscaled as Global SSDC in June 2019. Going forward, the Global SSDC project will, as always, position itself as a platform and global knowledge hub for South-South cooperation to make contribution to the UN Sustainable Development Goals and a community of shared future for mankind.

1.2 Challenges and opportunities of biogas in developing countries

In developing countries, agriculture is an important part in the economic structure, characterized by scattered farming and a large rural population which accounts for 60% of the national population. Besides, more than 30% of municipal solid waste is undisposed of and agricultural waste is almost not treated at all. Limited access to modern energy such as kerosene, liquefied gas and electricity led to deforestation, water loss and soil erosion, with over 600 million people around the world relying on unsustainable biomass like firewood for cooking. In this circumstance, people in developing countries are seeking affordable, reliable, environment-friendly high-quality energy, which is part of the United Nations goals for sustainable development, along with poverty reduction, sustainable cities and communities and mitigation of climate change.

Luckily, most developing countries are endowed with climates suitable for anaerobic fermentation and are rich in biomass resources. Biogas technology has been widely concerned because of its environmental, economic, health and social benefits. During the process of biogas digestion transferring waste to energy and to organic fertilizer, people’s living conditions have been improved, which in turn attracted women's participation in applying the technology as a substitution for those low-value labor such as the collection of firewood and cow dung for cooking.

Based on the common goal to tackle the climate change and energy shortage, some countries have independently or jointly developed biogas. After the oil crisis in the 1970s, the demand for biogas as a renewable energy began to increase, and its environmental benefits were widely concerned. Fuel for cooking and lighting is the most common use for small biogas plants. Being used as a domestic fuel is popular in developing countries such as India, Nepal and Vietnam. In industrial application, biogas boiler has been mature and reliable. With the expansion of large biogas, high value-added products have been explored, including centralized biogas supply for villages and towns, biogas power generation for cogeneration of heat and power, bio-methane as vehicle fuel, bio-fuel cell and application of digestate.

As natural environment and social conditions differ from region to region and country to country, the purpose and degree of biogas development are different as well. For example, Germany and other European countries have advanced biogas fermentation equipment, circular farming models and comprehensive subsidy policies, while in Southeast Asia, black-sheet lagoon is popular for palm oil treatment. And in Africa, decentralized biogas systems are more to be seen.

After decades of development, the focus of China's agriculture and rural development has changed from insufficient production to green development. The utilization of agricultural waste resources, environmental treatment and other issues have become the key issues restricting the green development of agriculture in China. As a clean and renewable energy, biogas has made important contributions to the development of rural energy, rural ecology and the improvement of farmers' livelihood in China. Based on the local demand and the knowledge sharing from other countries, biogas has scaled up from household to large and medium scales and then to bio-methane plants in China with multiple benefits.

It can be seen that each country and region has developed a suitable biogas technology for its own needs and characteristics. What will be beneficial to all is to learn from each other by sharing, mobilize the knowledge resources by training and assess the adaptability of the technology by piloting. Therefore, South-South cooperation on biogas may lead to mutual progress and win-win results.

1.3 About BIOMA

Biogas Institute of Ministry of Agriculture and Rural Affairs (BIOMA), P.R. China, established in l979, affiliated to the Chinese Academy of Agricultural Sciences (CAAS), has grown into a national-grade professional research institute engaged in scientific research, technical development and training related to micro-biology, biogas and biomass technologies for waste treatment, energy recycling and environmental protection. It has established technical services and achievements transformation platforms including Key Laboratory of Development and Application of Rural Renewable Energy of Ministry of Agriculture and Rural Affairs, Food and Agriculture Organization of the United Nations (FAO) Reference Center for Biogas Research and Training, Agricultural Special Trade Skill Testing Authority, etc. Since 1981, BIOMA has organized 125 international capacity building training courses on biogas-related topics, sponsored by Chinese government and international organizations including UN organizations and NGOs, and trained more than 2700 participants from all over the world. Besides, BIOMA has held more than 50 domestic trainings for over 3000 Chinese participants, and the tests for national biogas technicians granted by the Ministry of Human Resources. Pilot projects were built in other developing countries as technical demonstrations. See below tables for project information.

Tab. 1 Overseas training courses and pilots completed by BIOMA

Country	Time	Sponsor	Content	Participants	Pilots
Cuba	1998-1999	MOFCOM	Household digester	50	30
Rwanda	2004-2008	MOFCOM	Household digester	80	1
Guinea Bissau	2005-2006	MOFCOM	Household digester	40	3
Mauritania	2016	MOFCOM	Household digester	25	1
Laos	2017, 2018, 2019	MOFCOM	Household digester	230	1
VN	2018	MOFCOM	Household digester	30	
Jordan	2019	MOFCOM	Household digester	25	
Cuba	2019	MOFCOM	Household digester	25	
Philippines	2019	MOFCOM	Household digester	25	
Lesotho	1984-1985	UN-FAO	Household biogas	100	5
Benin	1986-1987	UNDP	Household biogas	100	10
Ethiopia	1994-1995	UNDP	Household biogas	30	4
India	2016	Pan Hymalaya Grassroots	Household biogas	25	275
Philippines, Bangladesh	2018	UNDP	Glass fiber biogas digester	50	10
Cambodia	2018	UNIDO	Commercial biogas	50	
Samoa	2018	UNOSSC	Glass fiber biogas digester	22	21

Tab. 2. Trainings in China for developing countries held by BIOMA

Sponsor	Trainings	Participants	Countries
Ministry of Commerce	92	2578	128
Ministry of Science and Technology	3	45	5
Ministry of Agriculture and Rural Affairs	4	71	13
UN-ESCAP	1	10	1
APEC	1	13	9
UN-FAO	3	47	21
UNDP	5	95	5
SNV	1	9	2

Tab. 3. Typical Cooperative projects for research and demonstration

No	Title	Time	Supporter
1	Biogas for electricity generation on chicken farm	1998-2005	UNDP, Tunisia Ministry of Hydro and Electricity
2	Biogas plant on distillery factory	2006-2007	Bangladesh Government
3	Biogas plant for sisal processing wastewater	2007-2008	UNDP, Tanzania Ministry of Agriculture
4	Regional and economic cooperation in DPR.Korea	2010.07 -2012.09	UN-ESCAP
5	Research on the hybrid fermentation of sludge from sewagement treatment plant and vegetables	2010-2012	Romania Electric Engineering Institute
6	Straw biogas fermentation	2012.03-2014.02	Germen BEB Biomass Co.
7	Cooling system for the surplus heat at biogas plants	2012.07-2013.07	AIT
8	Biogas development strategy	2016	Moldova Ministry of Agriculture
9	Microbial separation and cultivation	2018-2019	Japan Institute of Industrial Chemistry

1.4 Story behind

The training participants are like seeds that BIOMA seeded for the technical dissemination in the world. Mr. Sala Sagato is a good example. He was one of the participants of a capacity building training on biogas held at BIOMA in 2016. The lectures and fields trips during the training left him deep impression and aroused his interest in developing biogas in Samoa. Working as the coordinator of Samoa Farmers' Association (SFA), he assessed the demand for biogas from farmers and worked out a feasibility study on the application of fiber plastic digester in Samoa villages where clean energy and building materials are both lacking. He succeeded in establishing a sub project under the framework of a Global Environment Facility (GEF) project implemented jointly by UNDP and Samoa government.

1.5 Project in 2018

In October 2018, to implement the GEF project, SFA invited BIOMA, as the overseas technical supporter for its 14-day training project "Hands-on training on fiber reinforced plastic biogas digester in Samoa". The project was part of a sub project untaken partly by SFA, entitled "SAMOA MULTI-SECTORAL MANAGEMENT OF CRITICAL LANDSCAPING", which was under a Samoa/UNDP GEF Funded Program. GEF supported the procurement of digesters and auxiliary parts, and China SSDC Project supported the two BIOMA staff to travel to Samoa to do consultancy work.

The project was to demonstrate sustainable agriculture practices through critical landscape management, to make the livestock industry profitable, sustainable and environmental friendly by promoting packets of technology to manage animal waste

to be a benign product (resource) by value-adding and to cope with the crises of climate change. One of the strategies is to institutionalize the biogas technology in the local households by emplacing local people to be pioneers as trainers of future trainees of the country.

SFA identified 19 farmers who were verified by BIOMA for willingness, location and sustainability as the recipients of the 21 digesters. BIOMA contacted China-Samoa Agricultural Technical Aid Project (CSATAP) which in fact worked as a local supporter to this project and provided classroom for lectures and venue for on-site demonstration. CSATAP also helped to invite local media to report on the whole event, which approved to have brought exact influence in Samoa.

The project outputs are shown below:

Number of digesters shipped to Samoa: 21
Number of digesters installed in Samoa: 17, of which, 4 installed by the trainees and SFA after training
Number of participants: 22, of whom, one third were trained to be able to install digester installation independently.

2. Revisit in 2019

Organized by UN Global SSDC Project, a group consisting 9 people from 5 Chinese institutions paid a visit to Fiji for the "Pacific Island Development Forum (PIDF)" during July 28-31, and visited Samoa for the inspection on the above-mentioned project. Three BIOMA staff joined in the revisit to Samoa.

2.1 Objectives

The trip firstly dropped in Fiji to attend the leaders' summit of the Pacific Islands Development Forum held in Nadi for communication with the agricultural and energy extension agencies about circular agriculture and comprehensive utilization of biogas, introducing China's experience in promoting biogas technology in the Pacific so as to strengthen bi-lateral and multi-lateral cooperation.

Secondly, visit to Samoa was to be paid to investigate the current situation and policy of biogas and human settlements management, and to explore the possibility to carry out the follow-up project.

Thirdly, a revisit to the pilot households for 2018 biogas project was to make inspection on the operation and effect of the first phase and to plan for the second phase.

2.2 AGENDA

Date	Time	Activity
July 28		Departure
July 29	am	Arrival in Fiji, Mr. Wang Dengshan, Deputy DG of BIOMA delivered a speech on biogas cooperation in Pacific
	pm	Attend Pacific Island Development Forum (PIDF) summit
July 30		Attend PIDF summit
July 31	am	Attend forum of PIDF leaders
	pm	Fiji-Samoa
Aug. 1	am	Visit Ministry of Natural Resources and Environment, Ministry of Agriculture, Ministry of Finance
	pm	Visit Science Research Organization of Samoa (SROS)
Aug. 2	am	Visit Samoa Trust Estate Agency Visit Charlie Westerlund banana farm
	pm	Visit the demonstration farm of CASATAP Visit the first digester of 2018 project at Aleisa Agriculture area located at north central of Upolu Island, Mr. Aukuso Nanse and Mr. John Walter
Aug. 3	am	Revisit a households of 2018 biogas project located at remote Northeast area of Upolu island, Mr. Leau Onosai of Uafato Fagaloa and Church Community of Samamea Fagaloa, managed by Reverend Fililagi
	pm	Visit a failed biogas project initiated by Ministry of Natural Resources and Environment at Piu Falealili, south of Upolu, to provide scientific and technical support. It was for the Samoa Farmers Association to consider if possible to share available resources and BIOMA to consider a new biogas system design.
Aug. 4	am	Exchange ideas with SFA on lessons learned and experience gained from project phase one, discussed about the implementation of project phase two in 2019 and the ways to the scale-up of the biogas projects in Samoa.
	pm	Samoa-Fiji
Aug. 5		Return

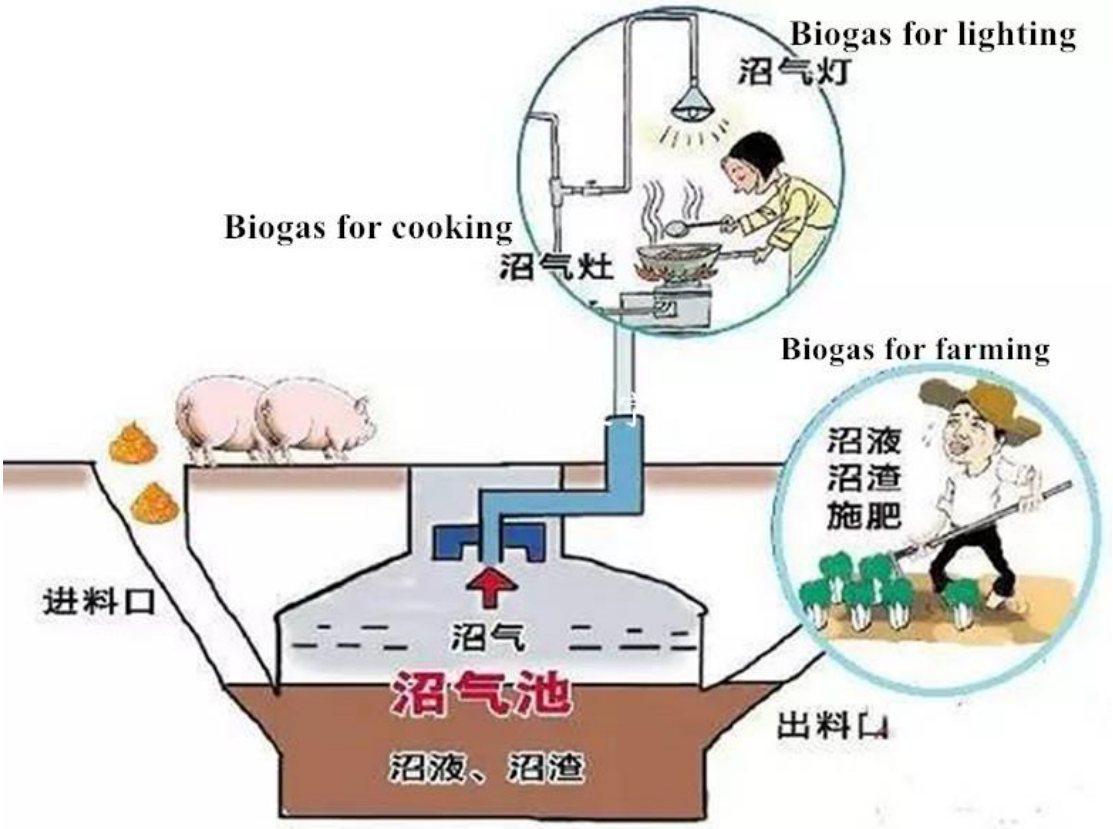
2.3 ACTIVITIES

2.3.1 Mr. Wang Dengshan, Deputy DG of BIOMA delivered a speech on the PIDF leader's summit entitled "Promoting Biogas Development in the Pacific through Cooperation and Communication", and introduced China's contribution to South-South cooperation in the Pacific, which was much highlighted by the moderator and concerned by the participants. As a result of the General Assembly, the PIDF published the Nadi Gulf Declaration on Climate Change in the Pacific.

2.3.2 In Samoa, the BIOMA group firstly visited government sectors and discussed with officials from Ministry of Natural Resources and Environment, Ministry of Agriculture and Ministry of Finance to learn that Samoa plans to increase renewable energy generation by 50 percent by 2025 in the face of climate change. It is hoped that biogas technology could play a role in achieving this goal. During the visit to the Scientific Research Organization of Samoa (SROS), it was found that the laboratory has some basic research on biogas composition analysis and anaerobic fermentation with basic equipment, but the facilities were far from enough to do in-depth experiments.

2.3.3 A revisit was paid to four demonstration digesters installed jointly by BIOMA and Samoa Farmers Association (SFA) in 2018. The 2018 project had achieved the expected results and the following effects were verified. The revisit this time in 2019 had the following findings which verified the survey partly (shown in Tab. 1).

Ministry of Natural Resources and Environment requested the team for assistances and advise on their failed biogas community project at Piu Village. The project was meant to supply electricity to the grid and biogas for cooking for eight households.



Tab.4 Instigation on the operation of digest

No.	Feedstock	Feeding	Activation	Gas pressure	Biogas supply	Digestate application	Cost saving	Problem	Solution
1 Jim Liu	Swine manure from 4 hogs out of 20 pigs in turn	Flushed with water through manure collection tunnel	5 weeks	8 KPa	Sufficient for three meals for five people, and used to cook Kava for community committee meetings	Fertilizing banana, coconut and breadfruit. The banana trees turned green faster than before	Totally replace LPG by 69 Tala per month (US$25)	The batteries in biogas stove were removed for fear that children play with fire. Stove was ignited with match.	Change to automatic igniting in the project Phase II
2	Swine manure from 3 hogs out of 15 pigs in turn	Flushed with water through manure collection tunnel	8 weeks	8 KPa	Sufficient for two meals	Fertilizing banana, coconut and breadfruit.	Totally replace LPG by saving 69 Tala per month (US$25)	The connector of gas pipe has leakage.	SFA technician will come to replace the connector and install a protection cover on it.
3	Swine manure from 4 hogs	Flushed with water through manure collection tunnel	8 weeks	8 KPa	Sufficient for two meals for 7 people	Fertilizing banana, coconut	Replace 2/3 LPG by saving 46 Tala per month (US$16)		
4	Cattle dung, goat manure and toilet sewage	Animal manually collected , toilet drainage connected to digester outlet	15 weeks	6 KPa	Sufficient for one meal especially breakfast	Fertilizing grassland and taro	Replace 1/3 LPG by saving 23 Tala per month (US$8)	The biogas yield is quite low as the quantity of toilet sewage is quite high.	Stop feeding toilet sewage and goat manure.
5	Swine manure (2 hogs), grass	Flushed with water through manure collection tunnel	2 weeks	6 KPa	For demonstration	Fertilizing vegetables	ND	The grass clogged the outlet and formed a layer of scum	Cut grass before feeding

3. RESULTS

3.1 CONSTRUCTION AND OPERATION OF DEMONSTRATION DIGESTERS

After the training in 2018, Sala Sagato, Coordinator of SFA, the partner of BIOMA, made operation assessment on all the demonstration farmers by telephone survey. It was shown that all the digesters were in normal operation without liquid leakage, and the shortest activation time for biogas production was one week after digester installation and feeding. Digestate was applied for fertilization.

3.2 KNOWLEDGE ACQUISITION

The capacity building training in 2018 focused on standard installation of digesters and application of biogas and digestate. As the farmers strictly followed the guidance, the risks that might be caused by misuse or mal-operation were not found. Besides, farmers have mastered the basic knowledge of biogas digester operation and management, and can skillfully carry out a series of activities to collect feedstock, feeding, utilizing biogas and fertilizing with digestate.

3.3 BENEFICIARIES

The revisited farmers were generally satisfied with the digesters, among them, one uses biogas instead of LPG, one serves to cook morning tea for community activities besides self-use. Only one household has not enough biogas as the amount of water from toilet is too large, and goat manure which is too dry is another reason for the low biogas yield. Solutions have been found respectively.

(1) Economic benefit

The farmers generally reflect that after using biogas, the cost of LPG was greatly reduced, and the average monthly cost of cooking fuel is saved by 69 Tara (about US$ 25). After the application of biogas fertilizer, the banana leaves turn green more quickly, indicating that digestate improves the efficiency of agricultural production. One farmer is giving biogas slurry to its neighboring farmers for nursery and the demand for biogas is increasing due to free organic fertilizer, thus it can be seen that the project of 2018 achieved the effect of saving expenditure and increasing income from agricultural products.

(2) Benefit to women

As LPG is costly, half of the cooking depends on firewood and coconut shells before, which brings about serious deforestation and air pollution. After the digester construction, women in the families are freed from hard work of firewood collection in forest and the smoke of burning coconut shells.

(3) Education to children

Children in some villages like to play with piglets as the piglets ran everywhere when the hogs went up to mountains in day time. Disease transmission might easily occur to harm their health. After the animal pen was built to keep hogs, the piglets change to be with the hogs in the pen. Then children have fewer chances to be close to pigs.

Some children have learned that animal waste and leaves can provide gas for energy and they are interest to learn more about it.

Besides, in some households, children are taught by their parents to manage the feeding by flushing water in the tunnel so that the manure can be fed to digesters.

Giving the knowledge about clean energy is helpful for the future education on children.

(4) Animal welfare
Before digester construction in 2018, the farmers were required to modify the animal pen from an open yard to a closed pen, and a manure collecting tunnel was installed along the edge of each pen. In this way, the animals manure can be flushed by water to the manure collecting tunnel and then the animal pen turned leaner and the animals might not eat food in manures.

(5) Win-win cooperation
The project in 2018 is the first cooperation between SFA and BIOMA which gives a chance for both sides to know about and learn from each other more.

To BIOMA, the solidarity of communities in the villages of Samoa is the institutional base and the key factor for the awareness establishment and project implementation. The pre-assessment and lobbying about the benefits of biogas undertaken by SFA tells BIOMA the significance of demand-driven basis for the sustainable operation of a project. And during the operation of digesters, the failure in biogas production from toilet sewage and goat manure shows the importance to modify the biogas system according to the local situation that BIOMA ignored at the beginning. The crack in the connector of the gas pipe requires security maintenance and risk control that should be emphasized in future projects.

To SFA, the knowledge sharing with BIOMA is a shortcut for rapid biogas development and SFA could establish its own talent pool by contacting local stakeholders and resource person so as to develop into a leading biogas institution engaged in training, research and technical extension in Samoa.

4. FOLLOW-UPS

4.1 SAMOA PROJECT PHASE II

The second phase of SFA's biogas project is to be implemented within 2019. SFA has asked BIOMA for quotation for equipment procurement and consultancy. In the second phase, 24 digesters will be transported and installed in Samoa, among which, 11 made of reinforced fiber plastic, and 13 of soft polymer with shelter plastic plates.

4.2 JOINT RESEARCH

The interest in biogas has been raised at Science Research Organization of Samoa (SROS) after BIOMA's visit in 2019 and in the participants who attended the training in 2018. BIOMA provided a list of equipment that are essential to do research on biogas, and shared ideas of the directions that they might explore in biogas research such as the research on biogas production potential from various substrate including tropical plants, and on the comparison of biogas production with digesters of different building material in Samoa.

4. 3 TECHNICAL MODIFICATION

The success of the project in 2018 attracted the attention of Ministry of Natural Resources and Environment (MNRE) of Samoa. During the visit to Samoa, BIOMA experts were invited to an uncompleted project for trouble shooting. The project was funded by GEF and the fund was run off on design, equipment procurement and

installation, including a black film biogas digester, equipped with a biogas gas storage bag, a generator and a gas pipeline network. It planned to supply gas to nearby communities by transporting agricultural waste from dairy farms and vegetable farms, use the excess biogas to generate electricity. However, the gas production after the completion of the project is very small. BIOMA experts found the major problems come from insufficient feeding and the quality of black film which has got cracking already. BIOMA experts thus gave suggestion that the digester should be rebuilt with fiber plastic instead of soft polymer. MNRE accepted the suggestion, invited BIOMA experts to join in and began to look for funds.

5. Findings

5.1 Adaptability of biogas technology in Samoa

Agriculture is an important part of the economic structure of the Pacific Islands, and the utilization of agricultural wastes for biogas production will play an active role in dealing with environment pollution and climate change and achieving environmental, energy and economic benefits. The land application of digestate is effective to replace chemical fertilizer for the sustainable development of organic farming and green economy.

5.2 Significance of project partner for technical extension

In view of the fact that the equipment cannot be manufactured locally, a cooperative partner such as SFA seems important in coordinating with the local stakeholders, organizing trainees, identifying recipients and surveying on the result. It is a vital factor which leads to the successful implementation of a project that one or more institutions should be mobilized to play comprehensive roles.

5.3 Cooperation center

The funds on Samoa side were very limited to support continuous technical extension. The basis for future cooperation was paved owing to the implementation of the training in 2018 which raised interest from the local stakeholders. However, to promote a technology requires systematic support including capacity building, technical demonstration, joint research and policy environment from government. Therefore, a cooperation center might work as a platform to conduct all the activities among the people involved to set up the center with equipment and facilities for research and demonstration. The cooperation center should have the following capacities:

(1) A group of people from government, research institutes and technical extension agencies can be fixed and given trainings from primary to advanced levels, so as to become professional trainers for future trainees.
(2) Certification mechanism should be set up to certify qualified biogas professionals.
(3) Necessary equipment and facilities can be provided and deepened researches can be conducted, so that the people of the center can be capable of implementing research, design and construction work for sustainability of the center.
(4) Standardization system for the construction of biogas system should be developed so as to regulate the demand-supply chain.

5.4 RECOMMENDATIONS

Despite the popular concern and active promotion, biogas development in developing countries has been restrained by varied factors:

(1) Objective factors
In most developing countries, the animal feces and crop straw could only be collected manually, which is not easy at all. Besides, due to the migration of rural population to cities, the number of domestic cultivation and household decentralized farming is reduced, which is a major feedstock for digester fermentation. Easy availability of fire wood, natural gas, LPG and electricity restricted the farmers' interest in biogas.

Recommendation:
Multiple benefits of biogas should be recognized and emphasized by government, as energy access is just part of its function, environment protection and fertilization application may play an exhilarating role in a long-term sustainable plan. To solve the feedstock shortage, food waste, waste from intensive farming and industrial waste may be explored.

(2) Social and cultural impact
Interest of biogas plant owners and implementing agencies is restrained as stakeholders' participation is not enough in many regions, which might be caused by cultural barrier of using the waste. The age and educational level of the head of household or village are also the influencing factors of biogas promotion.

Recommendation:
Male heads of household usually have sole decision-making power, so the male will be active in the digester installation if he has related knowledge or interest in promoting new technologies.

The case in Samoa can be of reference for awareness raising among people. Firstly, even though average farmers in Samoa can more or less afford LPG as domestic fuel for cooking, they are interested in biogas owing to the propaganda from Samoa Farmers Association ever since one year before the biogas project implementation. Second, what is the same important, recipients of digesters in Samoa were well selected. The selection criteria include firstly, being highly reputed in a community, such as village heads or family member of a former premier, or the owner of a largest vegetable farm; secondly, having pigs or cattle to raise; thirdly, being able to hire labor to do excavation and installation for digester construction; fourthly, the people have an open eye to accept novel things.

For example, in the most remote village where no signal was connectable, the soil was very rocky, and it took two weeks for the local farmers to excavate. It might be mission impossible if there was no strong power and impact from the community head, who had a degree in National University of Samoa and was invited by the village as a priest. Being a member of the village for twenty years, he keeps his interest in getting new knowledge to better the livelihood of his village members.

(3) Policy support
As biogas brings indirect benefits, it is ignored to be involved in the top-level design of the policy making by governments. Specific promotion programs were rare to be found in government annual plan. In the countries active in legislation establishment, publicity on the national biogas plan was not clear to all, or biogas development program is not currently integrated with other production activities, therefore, biogas plans are just plans. Besides, standards that regulate the production of biogas appliances and design and construction of biogas systems are not stipulated in many countries.

Recommendation:
Government sectors including agriculture, environment and energy should be integrated to identify the deficit gap in green farming, energy and environment, and the feasibility to apply

biogas technology. In Samoa, a number of government sectors are well aware of each other's plan in biogas and active to work together to help reach mutual goals.

(4) Financial issue
Affordability is the primary consideration of farmers without relying entirely on the assistance of governments and international organizations, as government's share of the gas subsidies for biogas is changing and the international funds are never fixed. High cost of self-funded biogas digesters under non-governmental projects have discouraged farmers which requires sustainable capital investment on building materials, labor, equipment and so on. Besides, some types of the biogas system are not movable from place to place along with the household moving, farmers need to consider the long-term ownership of land before deciding to build the digester.

Recommendation:
Technology financing mechanisms (subsidy, loans and grants) could be a solution. Public - private joint venture mode for the technical promotion remains to be explored. Additionally, land can be used as mortgage to apply for bank loan to pay for the construction of biogas digesters.

Taking Kenya as an example, women take the lead in applying for financial loans in Kenya for biogas projects, accounting for 78 per cent of the borrowers. In addition, in the operation and maintenance of digesters and the technical training of the digestate application, the female participants account for 48%. The participation of women's users and the improvement of the technology cognition have promoted the popularization of biogas.

For example, the bottleneck of the development of biogas in Namibia is the lack of government-level incentives, management, related knowledge and technology reserves, and high cost of construction of biogas. Nevertheless, Namibia's biogas development has its advantages, as the human development index of Namibia is high (referring to the overall development level of the population in terms of social and economic indicators), which means that Namibia is able to rely on its own power to implement biogas construction.

(5) Gap in technical capacity and research innovation
Poor skills in design and construction and low services of repair and maintenance led to failures in the previous biogas project and the loss of interest among people. Lacking knowledge, farmers find no way out to activate the failed digesters. Technical capacity gap in medium to large biogas digesters (> 200 cubic meters) needs to be filled. Research innovation which relies on capacity building of personnel and equipment remains to be seen.

Recommendation:
Specialized institutions responsible for biogas development and management should be established with multiple supports, which is to be empowered with specialized outreach and technical personnel. Trainings for professionals should be held, being as training to trainers. The exchange of information and popular science education should be enhanced among resource institutions to the establishment of a peer-to-peer partnership.

Annex 1. List of Government Officials
Annex 2. Photos of the revisit to Samoa

Annex 1. List of Government Officials visited

1.0 Ministry of Natural Resources and Environment
*Vanda Faasoa Chan Ting, Assistant Chief Executive Officer (Renewable Energy)
*Moafanua Tolusina – Assistant Chief Executive Officer (Forestry Division)
*Levaopolo Ricky Faatonu – SMSMCL Project Coordinator

2.0 Ministry of Finance
*Sione Foliaki – Assistant Chief Officer

3.0 Ministry of Agriculture and Fishery
*Moafanua Tolo Iosefa

4.0 Sciemtific Research Organization of Samoa
*Annie Poasa Tuisuga - Manager Environment and Renewable Energy
*Faafetai Kolose – Principal Researcher for Renewable Energy

5.0 Samoa Trust Estate Corporation
*Patea Malo Setefano – Chief Executive Officer

Annex 2. Photos of the revisit to Samoa

Digester 1: rain storage

Digester 1: children flushing manure into digester using the rain water

Digester 1: igniting biogas stove with a match

Digester 1: applying digestate to bananas

Digester 2: biogas replaced LPG by 100%

Digester 2: pigsty with manure collection tunnel

Digester 3: SFA is interview the head of the community on the biogas utilization

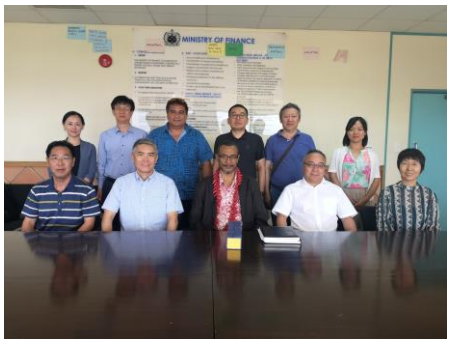
Digester 3: crack in pipe connector

Digester 4: digester link with toilet sewage and fed with goat and cattle manure, biogas yield low

Digester 4: biogas replaced 1/3 LPG

Visit Ministry of Natural Resources and Environment (Renewable Energy, Forestry and Land Management Divisions (MNRE)

Visit Ministry of Agriculture and Fisheries (MAF)



Visit Ministry of Finance – Energy Division

Visit Scientific Organization of Samoa (SROS)

Digester 5 at China agricultural demonstration center: outlet clogged by grass

Visit the idling biogas project with MNRE

Sustainable Development Goal Targets: