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Original Research Article

Feasible Approaches to the Sustainable Development of Rural Household Biogas in South Asian Regional Country

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Abstract

The paper work is designed based on the baseline experimental survey; and the detailed extensive and intensive analysis on countermeasures and barriers of rural household biogas in China. The potential focuses on the feasible approaches to the sustainable development of rural household biogas in China as per the former countermeasures and barriers have also been implemented in this work. During the implementation of the approaches, it has been found that the basic solution to the sustainable development of rural household biogas is to enhance the awareness about the biogas of the biogas users. Moreover, to get the auxiliary countermeasure in form of "having resolved"-- an impeccable post-installation service market mechanism can be constructed is also discussed in this research work highlighting the recent constraints in field level. The paper also dictates the comprehensive benefits of biogas and how they can play an important role in the local development of green agriculture and organic agriculture. Besides, particular representation will be notified about how the environmental pollution that can cause by the arbitrarily stacked bio-slurry can also be avoided by having its' appropriate measures.

Keywords- Sustainable Development; Establishment Mechanism; Bio-Slurry Utilization, Biogas Industry Chain; Utilization of the Comprehensive Biogas; Bio-residue Treatment; Post-installation Market Mechanism

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1. Introduction and Research Outline

To summarize the main existing problems in domestic bio-digester, while the production of biogas as shown in Figure 2, management and maintenance is still the biggest problem that should be plotted on consideration table as it has been causing the abundant dysfunction of well-constructed bio-digesters. The research is conducted in local scenario of China as a representative platform of South Asian regional countries considering all reasonable factors into account through which its' found in the past 10 years, there are 203,186 biogas digesters have been built in Yuxi, China and the biogas coverage degree/level is 47%. According to the investigation, the average size of digesters is $6.75m^3$, different volume proportion is shown in Figure 1.

According to the standard defined term of 'dysfunctional', by investigation group found: The totally dysfunction ratio in 8 Counties is 60.86%, and there are only 39.14% of the bio-digesters have been still used normally. The rate of dysfunctional plants in each County is shown in Table 1 and Table 2.

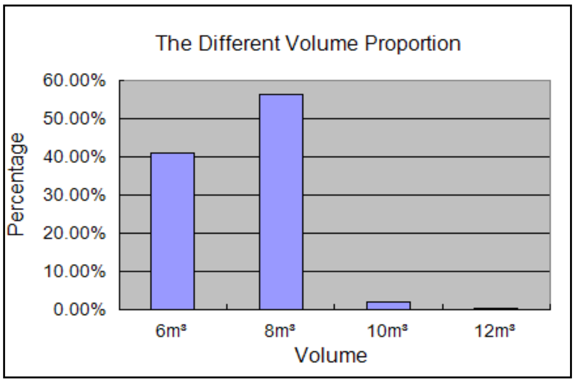

Fig.1. The Different Volume Proportion

Table 1. Rate of Dysfunctional Digesters in each County

County	E'shan	Xinpin g	Yuanjiang	Yimen	Huaning	Tonghai	Jiangchuan	Chengjiang
Number of interviewers	98	131	38	40	49	60	58	31
sfunctional Plants'Rate/ %	51.56	56.82	66.63	57.54	61.08	63.08	61.54	68.63

Table 2. Biogas Digester Condition

County	E'shan	Xinping	Yuanjiang	Yimen	Huaning	Tonghai	Jiangchuan	Chengjiang
Digesters built before 2005 /%	70.05	53.04	52.63	52.29	53.75	53.33	53.45	53.33
Types of the digesters	Concrete							

Complicated system management reasoning usually causes of such phenomenon; and all of the counting reasons can be classified as the following main factors (Table 3) through integrating every County's general biogas utilization situation. Generally, there are 5 main factors leading dysfunction, which are existed in every County and each factor accounts for different percentage.

The paper is created based on three sides;

1.) The current disruptive and complicated energy construction status in rural parts.

2.) To provide and develop some theoretical and experimental foundations, solutions and the decision making policies for the recreation or redevelopment of biogas digesters.

Usage to Bioslurry to get the sustainable development of rural household biogas.

Table 3. Factors that Cause Dysfunction in Different Counties

Place/%(Number of households)	Poor management	Poor post-installation service	Lake of basic management conditions	Quality of construction
Yuxi region/797	52.77%(421)	48.94%(390)	36.45%(291)	4.41%(35)
E'shan/190	36.94%(70)	34.36%(65)	18.23%(35)	3.97%(8)
Xinping/230	84.43%(194)	78.30%(180)	18.23%(42)	4.85%(11)
Yuanjiang/57	63.32%(36)	58.73%(34)	61.97%(35)	4.41%(3)
Yimen/70	31.66%(22)	29.36%(21)	18.23%(13)	3.97%(3)
Huaning/80	52.77%(42)	48.94%(39)	29.16%(23)	4.85%(4)
Tonghai/60	47.49%(38)	44.05%(26)	29.16%(17)	4.85%(4)
Jiangchuan/58	36.94%(21)	34.36%(20)	43.74%(25)	4.41%(3)
Chengjiang/45	68.60%(31)	63.62%(29)	72.80%(33)	3.97%(2)

The research is conducted in local scenario of China as a representative platform of South Asian regional countries considering all reasonable factors into account through which its' found in the past 10 years, there are 203,186 biogas digesters have been built in Yuxi, China and the biogas coverage degree/level is 47%. According to the investigation, the average size of digesters is 6.75m³, different volume proportion is shown in Figure 1.

The interrelation between different factors which can lead to bio-digester dysfunction is shown in Figure 2. The paper is written to highlight the factors that can cause the dysfunctional bio-digesters which can be identified based on current field condition, field survey and research outline placement as follows:

Defective Biogas Industry Chain: All industrial sectors among the industry chains completely rely on the subsidy from government through using resources efficiently and through taxing its efficient producers to pay for subsidizing inefficient ones that is found in low cost, which discourages the sustainable parameter and mode for the users' participation of biogas management and maintenance systems. In result poverty baffles the new construction of bio-digester in the under privileged rural areas cannot be completely covered if there are not the additional self-raised funds from the local households available. According to the investigation, it is visible that there are more than 45% of the households require paying more than half (around 250 EURO) of the construction fees/charges; whereas the annual net income per family is 1120 EURO, and the rest besides daily expense is only 50 ～100 Euro, which visibly states that making constructed and maintained biogas digesters by themselves certainly difficult for the local families. During the investigation processes it is found that financial constraints for designing biogas digesters are present in number of 15.5% in households. So, the mandatory financing approaches toward resolving constraints by the governmental, nongovernmental organization extending their helping hands will play a great role in properly biogas digesters placement and development Meanwhile, it's also responsible reasoning for the defective post-installation service market. Having NO mobilization from market mechanism, the post-installation service system cannot indeed leads and performs to its' service function as demanded, although many Renewable Energy Sources (RESs) [(10

Small Hydro Power, 4 wind, 3 biomass, 1 PV, 2 solar thermal] have already been established since 2004 without having proper measure and cost effective projects taken place in different regions and provinces of China but not efficiently working for rural households.

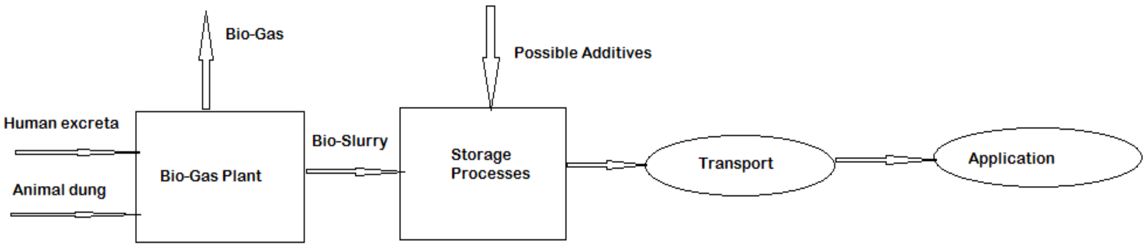

Fig.2. Bio-Gas and Bio-Slurry Production Flowchart

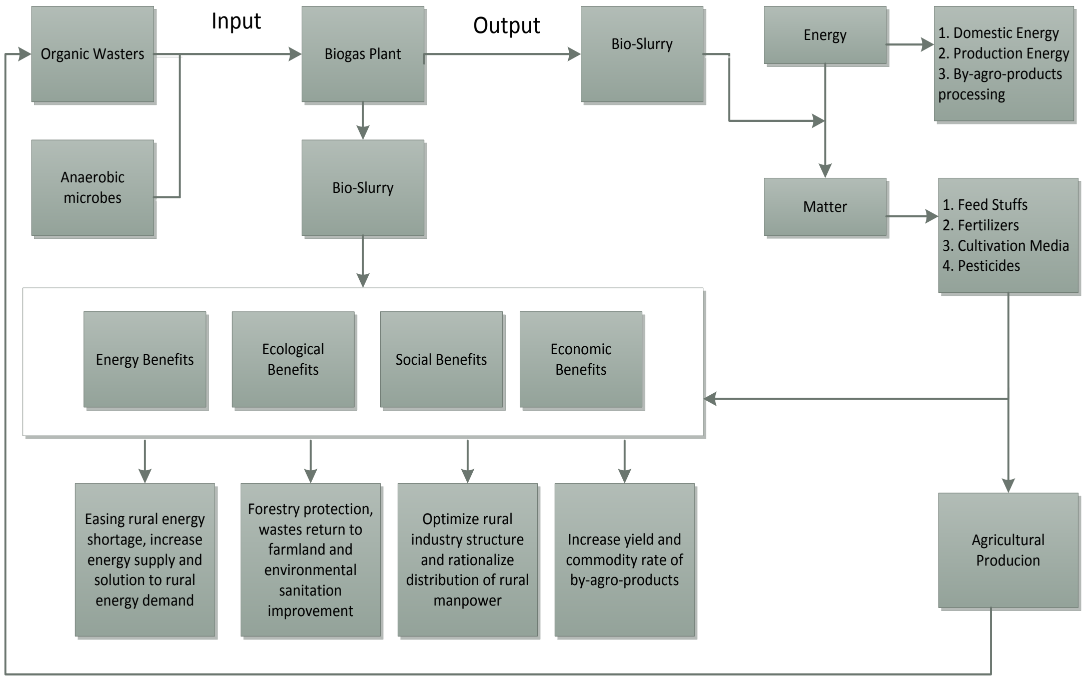

Fig.3. Bio-Gas and Bio-Slurry Beneficial Flowchart

Lacking in Bio-Slurry Utilization: Additional values of bio-slurry as shown in Figure 2 (The term bio-slurry is used here for the residue that comes out of the biogas plant as a result of anaerobic biodigestion process. Other terms sometimes used are just 'slurry', 'effluent', 'bio-manure', 'sludge', 'bio-fertiliser','organic fertiliser' and 'organic manure') use have not yet been realized or promoted in generalized form. Domestic biogas plants convert animal dung and human excreta at household level into small but precious amounts of combustible gas, known as 'biogas'. This gas can be effectively used in simple gas stoves for cooking and in lamps for lighting. The residue of the process, known as 'bio-slurry'1, can be easily collected and used as a potent organic fertiliser to enhance agricultural productivity or as food for fish in ponds. Several countries in Asia have embarked on large-scale programmes on domestic biogas like China (15 million digesters by the end of 2004), India (more than 3.5 million plants by 2004) and Nepal (more than 150,000 plants by the end of 2005). Other countries like Vietnam, Bangladesh and Cambodia are in the process to up-scale the deployment of biogas plants [3]. Biogas use and bio-slurry comprehensive use are the key concepts to arouse the vigour of domestic biogas. If only the additional values of bio-slurry utilization can be sufficiently realized-- the guidance on energy consumption choice, production method modifier, low carbon consciousness rising, and healthful lifestyle formation as shown in Figure 3 can all be well-achieved.

Weakness in Post-installation Service: Currently, Chinese government investment heavily favors construction of new biogas processors and bioslurry comprehensive utilization, with little funding remaining for comprehensive post-installation service maintenance or management to maximize use [1]. Being one of the important local partners, Renewable Energy Sources (RESs) are initiated and partially supported by the government with financing the local needs. In the past 20 years, the major tasks of these stations have been building the new bio-digesters. The buildings of new bio-digesters are being as periodic works, only few of the employees are full time in semi-government entities, and most of them are driven to find some temporary jobs during the free periods. To mobilize the enthusiasm of Renewable Energy Sources (RES) on post-installation service through market approaches will be able greatly to improve the working efficiencies of RES in solving the employment problem as well.

Weakness in Technical Training: Lack of experienced technical trainings for biogas users are still a countable factor that causes the dysfunction of constructed bio-digester. If some small problems cannot even be solved by the users themselves, the hard work cannot be beared by RES itself- even if having farmers' working interest in implementing new technology and working efficiency get improved.

According to the baseline survey from the above discussion and well in-detailed description in research method and analysis section, the local people related to this program are mainly from Dai ethnics and also the Han people as shown in Figure 4. The key point of the plans is to do the pre-event for the local biogas users explaining and introducing the significance of the sustainable development of biogas-- as well as the related knowledge on eco-agriculture and eco-environment. The plan is to realize the self-support within the community through this sustainable system in one year, and without surprise the plan gets full support of local residents. Also the ability of local staff has been improved; they can do more work individually by the implementation of the plan. They are now not only doing their maintaining works, but also are helping the local farmers to know more about the benefits of biogas residue and slurry using into the agricultural chain. It is a win-win solution for both the farmers and the local community.

2. Research Method and Baseline Survey Hypothesis

In the basis of the works that have been carried out based on hypothesis, the relative ways to check whether the plans work properly or not, required questionnaire has been designed accordingly are discussed below. In resolution, one experiment in field has been conducted and carried out as per planned algorithms, which will disclose the convincible data about the use bio-slurry and bio-residue on ground level. Lastly, approaches will be taken such like- data studies, questionnaire survey, factors analysis, statistical analysis of the data, qualitative analysis to plot the potential drives and its resulting conclusion from the conducted research

Approaches such like- data studies, questionnaire survey, factors analysis, statistical analysis of the data, qualitative analysis have been plotted and adopted in this paper.

Research Contents Hypothesis

During the investigation, five main factors have been taken into consideration:

a.) Family characteristic factors.
b.) Biogas characteristic factors.
c.) Biogas technician characteristic factors.
d.) Environmental characteristic factors in terms of Bio slurry application.
e.) Accessible transportation facilities.

The survey designed considering two

questionnaires, the first one aims at biogas users and another one aims at biogas digester technicians.

The questionnaire for biogas users included the following few aspects---

a.) The family condition of biogas users: addressing the basic numbers of living family members and livestock animals.
b.) Energy consumption condition of biogas users: addressing the amount and criteria of energy that gets consumed by the household members annually.
c.) The biogas use condition: addressing the amount and consumption rate of biogas annually by the household members.
d.) Users' awareness on biogas and bio-slurry: addressing users understanding regarding the usage of biogas and bio slurry and their functionalities.
e.) Working condition of post-installation services: addressing biogas digesters management condition and working status of technicians. Energy choices orientation of users: addressing users' preference in choosing energy resources and energy usage fields.
f.) Farming condition: addressing farmers' feasibilities to use bio slurry; and their feasibilities of using bio slurry in crops production as fertilizer and pesticides.

The questionnaire for technicians included:

a.) The working status of existing biogas service group.
b.) Master level on biogas knowledge and training status.

Satisfaction level on present salary and working mode.

Overview of the Physical Geography in the Investigation Area

The Research conducted based on China's regional Yuxi region which is located in central of Yunnan Province, in where there are interlocked distributions of mountainous, canyon, plateau, and basin regions. Therefore, there exists extremely distinct three-dimensional climate; also found that Northwestern terrain is higher than the Southeastern, the highest altitude is 3166 meters and the lowest one is 328 meters. It was reported that, in the last past 10 years, 203,186 domestic bio-digesters have been built or produced in Yuxi, which helped the Yuxi to be nominated as one of the earliest regions in developing biogas, and at the same time one of the best biogas-used regions in the Yunnan province. Furthermore, Yuxi region people has established 264 rural service networks, 10 joint-household biogas projects; and 3149 villages have been constructed with biogas digesters.

Yuxi region is in the majority plateau landform, as shown in Table 4; the 8 investigated regions are largely different in landform, which led to the relevantly different agricultural areas.

Table 4 Geography Condition of Investigating Region

County	E'shan	Xinping	Yuanjiang	Yimen	Huaning	Tonghai	Jiangchuan	Chengjiang
Population/Million	0.15	0.27	0.20	0.17	0.20	0.27	0.27	0.16
Gross Area /Km^2	1972	4223	2858	1571	1313	721	850	773
Agricultural Acreage/Km	116	182	176	68	283	112	88	81

Interviewers

Before the December 2011, the investigation questionnaire has been completed, during 2011 December to 2013 April, 8 counties in Yuxi had been investigated. And the methodologies adopted including: field survey, questionnaire, household interview et al.

3. Analysis on Research Finding and Constraints while Conducting

By the March of 2013, most contemplated activities for the plans are completed according to the scheduled timetables from 2011 December to 2013 April. Two technicians' trainings with 18 technicians in Mosha Town in Yuxi Region, China have been successfully conducted, and three sessions' farmer training courses with 830 local farmers' attendance were conducted. Furthermore, the post-installation service system is established for the sustainable development of the plan. Moreover, the construction of the market mechanism of post-installation service system is on its' way to be completed and implemented.

Through the technicians' training, the biogas technicians' working enthusiasm has been greatly stimulated and their technological implantations have been improved. Furthermore, the local farmers' understanding on biogas, eco-agriculture have been improved in a great scale, which has motivated farmers' to participate in the cooperative purposes. Besides, the establishment of post-installation service system will maximize the comprehensive benefits of the plan and will help the sustainable development of Chinese biogas in the long run [5].

3.1. Training for Technicians

Technicians are the vital role player during the whole implementation process of the plan as shown in Table 5. The working enthusiasm and working efficiency of technicians will directly affect the plan's implementation-after-effect [3]. Considering the importance of biogas technicians', the working team has been paying great attention to the capacity – building factors (capacity of the farmers' understanding about technology and on site resulting progress). It is well-understandable from the above discussion and resulting data that the smooth and sustainable implementation of this plan cannot rely solely on technologies, the strong organizational coordination among different stakeholders and the highly communication skills of technician are more important role-player. For the better technicians, deep diving into the farmers' lives and thinking are required, to better understand so that they can help farmers to solve the actual problems within the field level. However, the reality is that biogas technicians' expressing capacity, facilitation capacity, organization skills and the sense of service still are needed to be improved because of the relevant lacking in educational level, cultural background and other socio-economic restrictions as shown in Table 5. Therefore, in order to enhance technicians' confidence and improve technicians' awareness on public service, the working team has conducted twice Participatory Trainings for 18 technicians in June and August respectively to strengthen technicians' capacity-building aspects.

It has been found (as shown in Figure 4) that the biogas technicians are lack of communication skills even if they are enough-equipped with high level of biogas technologies and instruments. In order to help the technicians in solving these problems and to develop the market mechanism, the working team has conducted the second training on capacity building for technicians on 8th August, 2012. The working team has introduced normative service system and provided technicians with working requirements to avoid the irregular service which might lead to the possible losses in organization.

Besides, the working team has done a lot of works to help biogas technicians to unify and standardize the reactivation process. Firstly, the plan working team managed to plot the work-logarithms (step by step procedures to reach trainees' understanding about new technology) for biogas technicians which will keep sharp plan outlines delivered considering all the relevant factors while performing field works. Secondly, the working team has designed a reactivation work program to help technicians in establishing service standards. Additionally, the working team has distributed related references about the daily management and comprehensive utilization of biogas, having the sole purpose is to improve technicians' understandings and working efficiencies.

3.2. Training for Biogas users

Being the beneficiary and key part of the plan, biogas users' active participation in following, maintaining, managing the technology's on site implementation and post installation; and in supporting to the plan is the basic requirements to get the excellence in the accomplishment of the plan by realizing the comprehensive benefits of the plan. By February 2013, the working team had been conducting the three participatory trainings for more than 800 biogas users in Mosha Town. The farmers' enthusiasm of getting involved into the plan and to promote the comprehensive utilization of biogas and its residue has been highly appreciated and highlighted as shown in Table 5.

Table 5. Education and Training Condition

County	E'shan	Xinping	Yuanjiang	Yimen	Huaning	Tonghai	Jiangchuan	Chengjiang
Education level/year	9.8	8.4	9.0	11.4	7.8	9.0	10.0	8.7
Ratio of the trained farmer/%	50.25	2.61	56.14	47.14	50.00	13.33	41.38	4.4

3.2.1. Language

Since 90% of the local farmers are from Thai nationality whose educational level is relevantly low and less communicative with the outside world, and understands fewer Mandarin [3]. Based on these facts, the local dialect and even the Thai language trainer have been elected to deliver the training to the farmers.

3.2.2. Season

Considering the fact that the local farmers remain relatively much busier in the growing season and the harvest season, the working team arranged the training in farm slack season to assure the efficient trainings and effective outcomes in real ground from the farmers [7].

3.2.3. In Field Methodology while Training

To minimize the training unwillingness local campaigns along with pictures, videos, posters and some other multi-media training methods addressing the importance of Biogas and Bio-slurry to the sustainable development of the rural households are adopted to improve the interested and intelligent participants of the training. Meanwhile, the shared feelings and FAQ (Frequently Asked Question) about the training can strengthen the interaction between the trainers and farmers, so that the plan working team can have the best outcomes and gain from the farmers.

3.2.4. Interest-Oriented

The training contents and materials are designed based on the real-life-demands that designed based of research hypotheis and current on site constraints of the local farmers and the plan requirements, and combined with the local cultivation and animal feeding situation.

3.3. Training Effects

The random door-to-door survey helped the researcher to identify the farmers who are found interested in knowing about the sustainable development of household biogas and bioslurry implementation in field level, among them the majority of farmers- in 830 numbers of local farmers are picked and gone through the training, which are in total have 24 classes that cover throughout the 6 villages. The specific distribution of gender and ethnic nationalities are shown in the following Fig. 4.

For the overdue account of knowing whether the trainees can understand the training course very well or not, and to assess the overall training effect among the trainees, the working team managed to issue the evaluation form (Appendix I) to the participants at the end of the training. There are total 830 questionnaires who are assigned in the two training sessions, 98.07% of total farmers (among 814 farmers) are found efficient. The detailed information is shown in the following Fig.

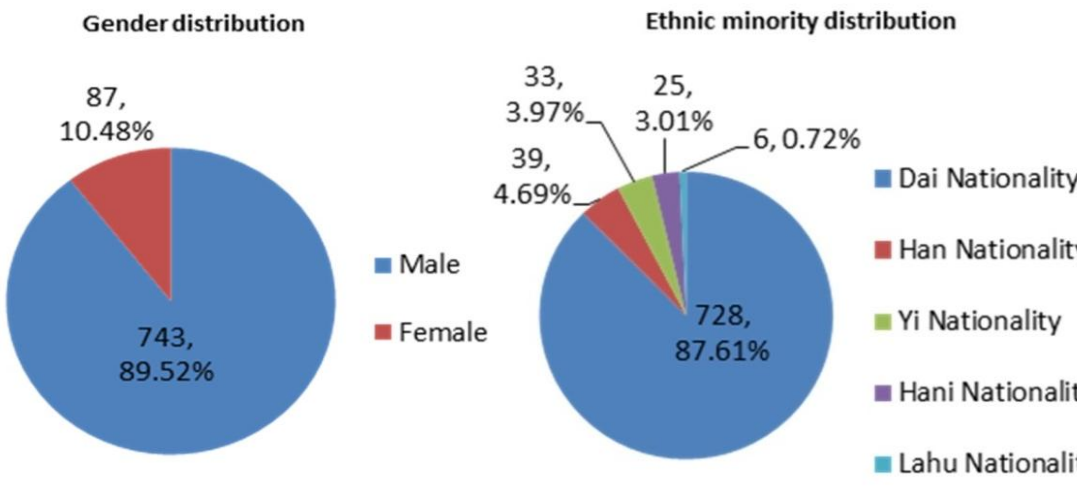

Fig.4. Evaluation - Specific Distribution of Gender & Ethnic Nationalities

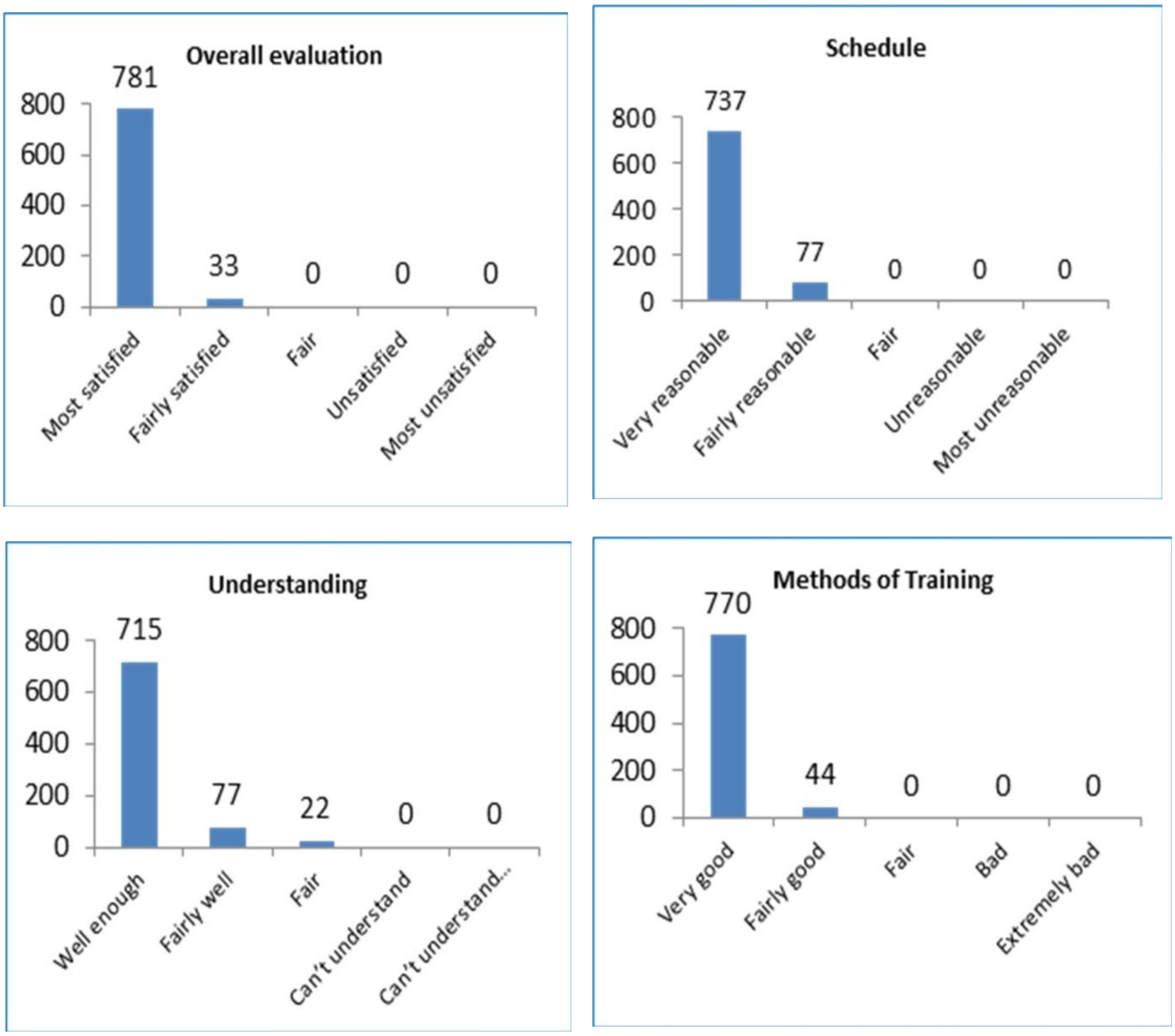

Fig.5. Evaluation -- Statistics of the “four open-ended” questions

3.4. The Demonstrative Utilization of the Comprehensive Biogas

3.4.1. Introductory Comprehensive Biogas Use

Proper improvement of the current application of bio-slurry and bio-residue can not only help the local farmers to save their cost on purchasing fertilizers and pesticides, but also help them to improve the quality of the agricultural products. Furthermore, the exertion of the comprehensive benefits of biogas can play an important role in the local development of green agriculture and organic agriculture [4]. Besides, identified resources of wastes and secondary environmental pollution that get caused by the arbitrarily stacked bio-slurry can also be avoided by using them out.

During the conduction of the research---to reach the farmers' awareness on the comprehensive utilization of biogas, and to improve the present use condition of bio-slurry, the working team did select 5 random households from the door-to-door survey which were actively performed biogas production using bioslurry to conduct the demonstrative measures of the comprehensive biogas utilization that are combined with the local agricultural characteristics.

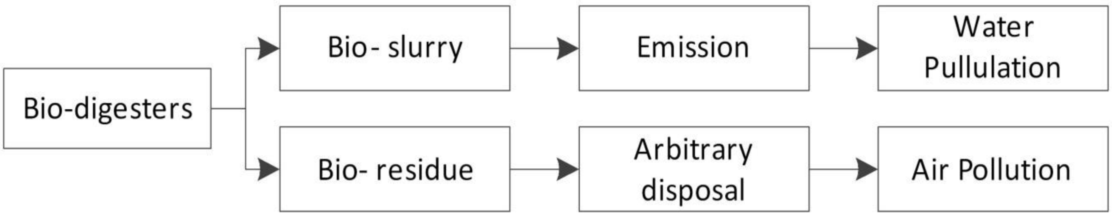

Fig.6. Flow Diagram of Bio-slurry & Bio-residue Treatment

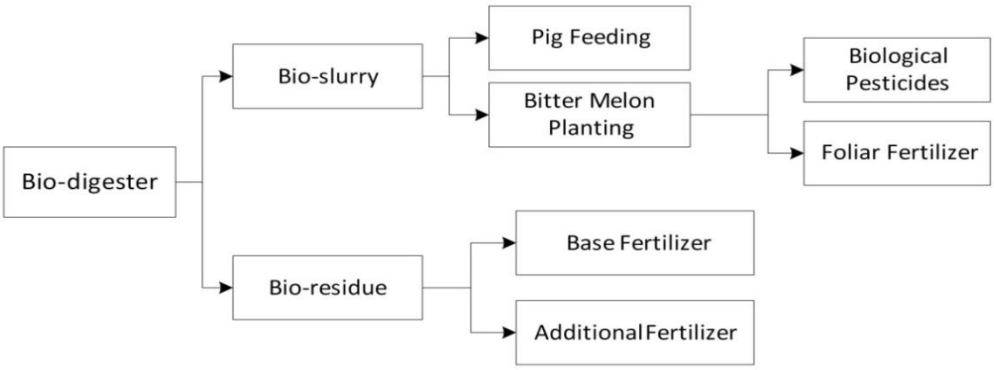

Fig.7. Diagram of Comprehensive Utilization of Bio-residue & Bio-slurry

3.4.2. The Demonstration on Field Planting

Planting bitter melon and feeding pigs are the main focuses for the demonstration of the comprehensive utilization of bio-slurry. Bitter melon, the main crops and main income source in the local village, will play an important role in effecting, when if the quality can be improved by using the bio-slurry as fertilizer. Based on this concept, such plan has been designed by selecting the two households (Household A and Household B) to conduct the demo research. The two households were required to choose two equal area fields; one was planted with the traditional chemical fertilizer and pesticide modes, another one is for the demonstration of new mode with bio-slurry. Following the way, the comparative demonstration can be found to verify and understanding the effect of bitter melon planting with bio-slurry, and the research results are shown in the following Table 6.

As shown in the above Table 6, The comparison with the fields planted with chemical fertilizer and pesticide, the bitter melon yields in field B (using bio-slurry) get the improvement significantly of 32.06% and 30.72% respectively; as well as the quality is also found improved. Besides, it can be found that the income scale is almost improved in twice, and the economic benefit of planting with bio-slurry is much higher than the planting with chemical fertilizer & pesticide.

Table 6.The demonstration of comprehensive utilization of biogas in planting

	Household A		Household B	
Planting Model	Field A(Chemical Pesticides & Fertilizers)	Field B (Bio-fertilizer)	Field A(Chemical Pesticides & Fertilizers)	Field B (Bio-fertilizer)
Planting Area	1Mu(667m^2)	1Mu(667m^2)	1Mu(667m^2)	1Mu(667m^2)
Cost of Inputs[1](CNY)	1023	0	1023	0
Production (kg)	1946	2570	1979	2587
Gross Income[2](CNY)	3892	5140	3958	5174
Net Income(CNY)	2869	5140	2935	5174

Notice:

1. The input refers to the cost of fertilizers and pesticides, which is not needed in the new model.
2. The price of bitter melon is 2 CNY/kg.

As shown in the above Table 6, The comparison with the fields planted with chemical fertilizer and pesticide, the bitter melon yields in field B (using bio-slurry) get the improvement significantly of 32.06% and 30.72% respectively; as well as the quality is also found improved. Besides, it can be found that the income scale is almost improved in twice, and the economic benefit of planting with bio-slurry is much higher than the planting with chemical fertilizer & pesticide.

3.4.3. The Demonstration on Animal Feeding

To establish the demonstration on animal feeding research has been conducted by feeding pigs with bio-slurry, there were two local households (A and B) were selected randomly following door-to door survey in where bioslurry was properly feed while conducting research, besides regular animal feeding aspects to see the particular change in output. Promotion of the demonstration results in showing in Table 7 that after seven to twelve months of field observation the rising pigs with bio-slurry have had great benefits declared from farmers' experiences and Bioiberica's Animal Nutrition Division in China's available data resources and information on animal's health,, such as good appetite, more sleep, slick fur, less disease, and grow faster etc. Additionally, it is much easier to remove the pig fur from getting slaughtered. All of the good effects of bio-slurry use come from its abundant Amino acids, Vitamin, Trace elements, Antibiotic, Lysozyme and Digestive enzymes, which can help in promoting animal growth, enhance disease resistance and improve forage digestibility [6].

Table 7. The demonstration of comprehensive utilization of biogas in breeding

	Famer A		Farmer B	
Feeding model	Pig A(General)	Pig B(Biogas slurry)	Pig A (General)	Pig B(Biogas slurry)
Slaughter Time(day)	150	120	150	120
Slaughter Weight(kg)	113	132	117	126
Forage Consumption(kg)	336	330	327	315

Before the implementation of this plan on ground, farmers didn't know that bio-slurry can have that many functions on planting and breeding. Even after receiving the trainings, most of the farmers doubted about the use of bio-slurry on planting and breeding, being afraid of income decrease that can be caused due to the lacking in related experiences. After the demonstration of the comprehensive use of biogas, a huge number of farmers in percentage of 93.5% of total farmers are found more likely interested in trying to plant and breed with bio-slurry & bio-residue, since they have seen the considerable range of economical benefits and the rest 6.5% of them are not interested to put attention on being beneficiary for their own disinterest in certain technological implementation.

On the another hand, once the farmers' have seen the economical benefits get brought by the utilization of bio-slurry, there will have a great need for bio-slurry & bio-residue in everyday demand, which can only be accounted by the outstanding management and maintenance of biogas digester. It is well notable that the demonstration of the comprehensive utilization of biogas in the working ground played an important role in motivating farmers to increase the pre-awareness about the significance of good management and maintenance for the biogas digester development. In this way, the maximum comprehensive benefits of the research can be achieved.

3.5. Establishment of Market Mechanism

Establishing post-installation service system is one of the most important goals of the plan, and it is also an important indicator to assess the plan's success. A sustainable and independent post-installation service system can not only improve the service quality and working efficiency of technicians, but also can provide a successful model for the management of nationwide rural biogas. According to the above, this plan has tried to establish a post-installation marketable operation model to promote the sustainable development of biogas, using bioslurry while biogas production .The sustainability cannot be supported or maintained by the users' enthusiasm only, mobilization from economic profits and sanction of other related profits are very imperative to bring the certain improvements in-into the real ground. Besides, equal benefit distribution among every stakeholder from the well running biogas industry chains is the key to understand the independent and sustainable development in the biogas energy promotional aspects.

Moreover, from further in-depth investigation, it's found that there were 64.80% of the interviewers who would like to pay for the recreation and reinstallation of dysfunctional biogas digesters. Therefore, the most important thing is to establish and enhance the post-installation service system, to mobilize the technicians, through raising the salary of the technicians, reassigning the duty of each technician, etc.

To establish a healthy, independent, and sustainable post-installation service market, the key necessities are basically to solve the existed technical and mechanism problems, and to modify the whole biogas industry chain systems. Mobilizing technicians' activity and carrying out the comprehensive utilization of biogas are the key points of establishing a market mechanism. By mobilizing technicians' activity, the quality of post-installation service can be improved; technical trainings and acknowledgement can be enhanced among general people about the basic management of biogas and also the benefits that they can get from comprehensive utilization of biogas. Thus more farmers would like to use biogas even if they are required to pay for the little service fee. As a result, both technicians and farmers will realize win-win effect; technicians will be more willing to work for the biogas post-installation service system, while the farmers will be more willing to use biogas using bioslurry while production as well. As an exploratory mechanism, as well as the first attempt in the world, the post-installation service mechanism should be examined in order to run the reactivation processes of

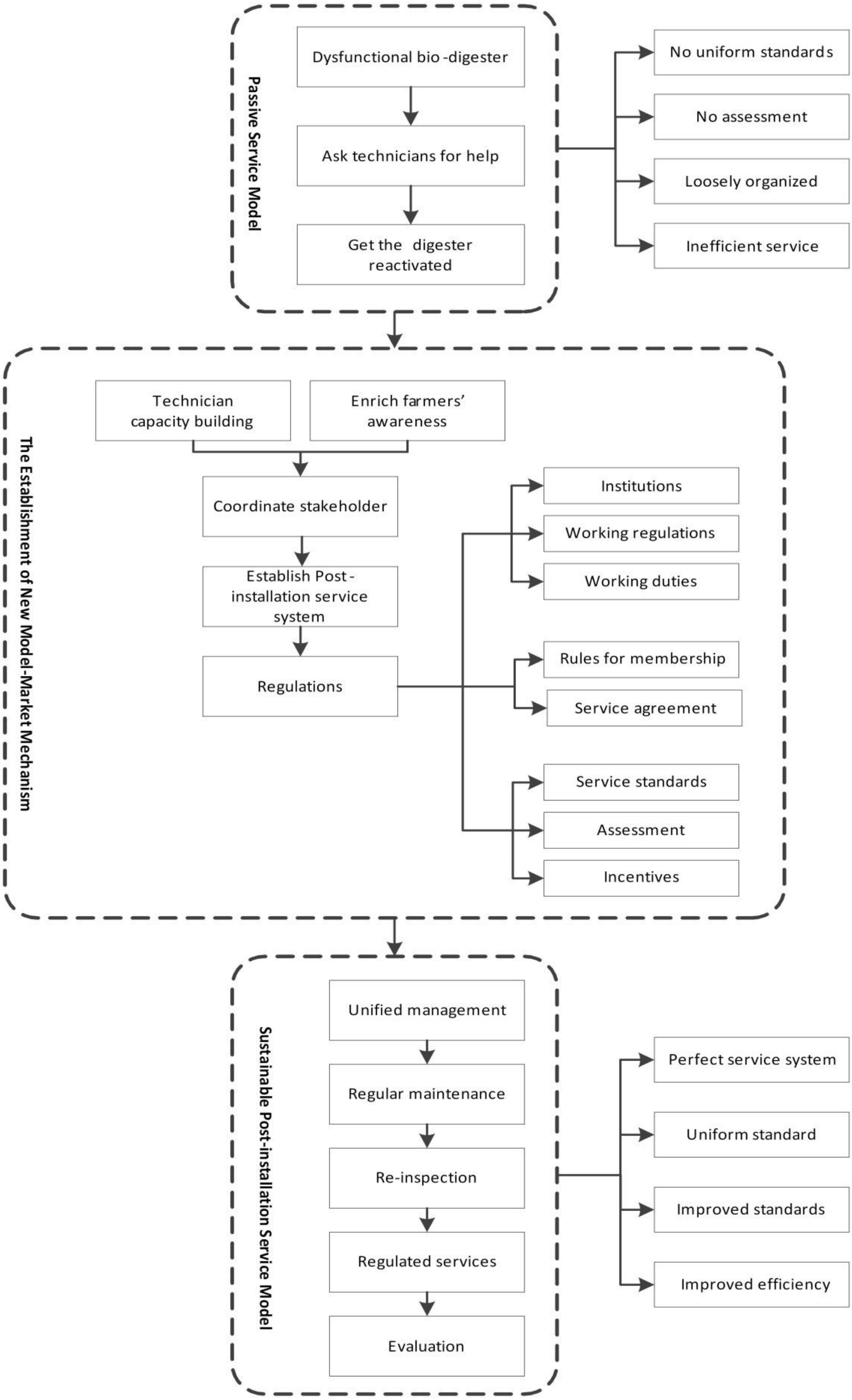

Fig. 5. The framework of post-installation market mechanism

dysfunctional bio-digesters to get more successful outcomes. The mechanism for testing the post-installation service system should include following aspects: the biogas use condition, the users' monetary contribution, the sustainability, etc. Usage of biogas condition can be measured through the record and random survey. Sustainability can only be measured after a long term running-usage of biogas digesters. Besides, through our survey, 0.6 EURO payment for annual service can be undertaken by most poor families which sound quite adequate.

In order to make necessary improvement to the current imperfect post-installation service system and unsatisfactory biogas utilization, the working team considered establishing a biogas cooperative [1]. The industrialization and commercialization of biogas cooperative will integrate the farmers and biogas technicians together, and impel all of the stakeholders actively joined in the biogas maintaining work. In one word, this will ensure the running of the post-installation service system sustainable and efficient.

The cooperative can manage the system with standardized regulations, such as establishing membership system, management regulation, financial rule, service regulation, rewarding mechanism and a series of other rules and regulations. On one hand, what biogas users need to do is just to use the biogas and bio-slurry after paying for the entirely management service provided by the technicians. On the other hand, the cooperative will be able to replace the dysfunctional devices and to re-act the biogas digester as well as to raise the technicians' salary once the stable financial income can be assured. To some degree, income security will motivate the technicians' working enthusiasm and service quality, and will improve the farmers' satisfaction. Finally, a benign market circulation can be completed. The Comprehensive Market mechanism's framework is shown in the following Fig. 5.

4. Conclusion

To begin with, all of the dysfunctional bio-digesters in the plan --- bio-digester of 2003 households in Mosha Town --- have been reactivated successfully reactivated that performed by manual usage observation following door-to-door survey and technicians help bringing smooth home production in rate of 90% during the plan period. What's more, through the technicians' training, the biogas technicians' working enthusiasm has been greatly stimulated and their technologies have been well-improved and well-maintained. As the consequence, the post-installation service system is established successfully for the sustainable development of the plan. Furthermore, the local farmers' understanding on biogas, eco-agriculture have been improved greatly, which has motivated farmers to participate in the cooperative areas. Besides, the establishment of post-installation service system will maximize the comprehensive benefits of the plan and will help the sustainable development of Chinese biogas in the long run [2]. Last but not the least, there are several lessons and challenges have been obtained during the development of the plan, which can add up valuable information for the sustainable development of the rural household biogas in China, and even to the other household biogas countries.

4.1. Lessons

4.1.1. Participatory approaches make the process easier

Participatory approaches are not the innovative initiative in this plan work, but indeed have made the conduction of plan activities easier and smoother; including-plan site-selection, scheduled design of baseline survey, interviews and action decisions.

4.1.2. Replace-ability and Marketability

After the successful completion of this plan, more than 2000 general public and local users get benefited, and the positive outcomes from, and influence of this plan will further help in affecting local governments to fund the following plan on post-installation service; instead of investing in new bio-digesters' construction

Besides, there are breakthroughs in opportunities for the independent and sustainable marketability of this plan:

1. There is found a huge market demand for biogas post-installation service, and yet there isn't any professional entity available to do this business in recent

circumstances. If the enthusiasms of biogas users and RESs are mobilized, the market demand will be stimulated in the long run.

2. The change of decision makers' is taken place and consciousness has been raised regarding the plan's future outcomes, which also involves paying attention to maintenance and management from biogas installation. It'll also be easier to obtain the policy support and even financial support from government than ever before.

4.1.3. Farmers' training should be more flexible

While conducting the farmers' first training process, the working team has encountered with some unexpected challenges, such like-- there is no electricity for the Power Point presentation, and at the beginning of the survey, they were having troubles in understanding the technical concepts having relatively low education level and technical skills which were required for formal trainer to give them training for certain period of time to make them learned. Therefore, considering these scenarios, the team members should prepare posters in the very next training, and the mode of expression should be more familiar and comprehensive to be understood—the training contents should be more understandable as well. In summary, all of the trainees' basic situation should be considered during the training process, such as-- the local customs, their education levels and the nationalities.

4.1.4. The plan works should be more focused on daily-life basis

During the plan development process, the working team found that the training and the reactivation of the bio-digester, etc. cannot be impressive to all of the farmers. Only the works which are related to their daily life and production having progressive impacts on their lives can draw their attention towards the establishment mechanism and cooperation.

4.2. Challenges

4.2.1. The low educational level of biogas holder

It is not so easy for the common biogas holders to pick up the new technology because of its complication and due to their low technical education level where there it is expected to have literacy rate 65% of total farmers to welcome and run the new technology in day-to-day life to get the targeted research output , but in real scenario the rate was found 32% [4] in most places, so basic technical knowledge in their post-secondary education is highly recomended that can be implanted through available vocational schools, community colleges, independent colleges. So the training for the next phase of this plan will be very important to improve the understanding on basic biogas knowledge to make easier correspondences and pre-awareness section emphasized.

4.2.2. Lack of comprehensive utilization knowledge on biogas

According to the baseline survey, the dates showed that most of the local farmers are having the lacking in knowledge in comprehensive utilization on biogas. This will be a mandatory challenge and obstacle in leading and carrying the plan thoroughly, especially of its' comprehensive part of biogas. Meanwhile, this can also be stated as one of the important reasons for the limited scale of comprehensive utilization on bio-slurry and bio-residue.

4.2.3. Comprehensive technologies on biogas reactivation are needed for technicians

Non-professional technicians might be the limitation for the working efficiency of biogas reactivation and also for comprehensive technologies which can be prime concerns during the plan design. Most technicians usually will have more than 10 years' of experience on biogas, but their main focus is on new bio-digesters' construction instead of post-installation service. So how to get the technicians trained in the post-installation service teams are also the mainstream breakthrough of this plan, and to have them as master in their skills by giving strong basic knowledge on it. So for the second phase of the research - the main challenges yet to consider are---culturing users and developing them into clients, implementing comprehensive technologies on biogas reactivation and maintenance, and establishing a set of relatively perfect working mechanisms.

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