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Financial Performance of Biogas-Driven Pump-Based Integrated Farming System

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Abstract

The biogas-driven pump-based integrated farm with a total land area of 1.08 ha is located in Bakir, Bagabag, Nueva Vizcaya, Philippines. The farm owner was primarily practicing monoculture with rice as the product. Originally, the annual income of the farmer is Php 66,087.51. With the introduction of the biogas-driven pump-based integrated farming system (IFS), the income of the farm owner has increased to Php 196,940.13. The farm is now engaged in rice, vegetables, swine, and fish production. It was found out that both systems have a positive net present value; therefore, they are financially viable. However, biogas-driven pump-based IFS has a higher net present value of Php 601,461.41 compared with monoculture (Php 116,040.11). For the internal rate of return, biogas-driven pump-based IFS has a higher rate than the monoculture. Concerning the return on investment, the biogas-driven pump-based IFS has a rate of 25%, which is higher than the monoculture (13%).

***Keywords**:* integrated farming system, biogas, monoculture

1. Introduction

Agriculture needs to be intensified to meet future demands for commodities and to avoid further expansion to marginal lands and encroachment on fragile ecosystems. Increased use of external inputs and the development of specialized production and farming systems tend to increase the vulnerability to environmental stresses and market fluctuations. Therefore, there is a need to intensify agriculture by diversifying the production systems for maximum efficiency in the utilization of local resources while minimizing environmental and economic risks (United Nations Conference on Environment and Development, 1992).

Sometimes referred to as integrated bio-systems, integrated farming system (IFS) refers to agricultural systems integrating live-stocks and crop productions or integrate fish and livestock. In this system, an interrelated set of enterprises is used so that the waste from one component becomes an input for another part of the system, which reduces cost and improves production and income (Caribbean Agricultural and Development Institute, 2010). Aside from increasing the production, IFS is also advantageous because it utilizes natural resources and photosynthetically active radiation more efficiently; resists pests' epidemics better; produces more varied and nutritious food; and contributes more to economic stability (Parreño-de Guzman *et al*., 2015).

Biogas is a derived fuel that can be used in internal combustion engines. It is low-cost and discharges low carbon emissions compared with other secondary fuels. It can be supplemented to liquefied petroleum gas (LPG) and compressed natural gas (Ray *et al*., 2013). The biogas can be used as a substitute to expensive gasoline as fuel for engine to run a water pump. Thus, it can resolve irrigation water shortage especially in rain-fed areas and contain detrimental effects of greenhouse gas emission.

Studies have proven that there are many advantages of IFS and biogas technology. In the study of Ansari *et al*. (2013), it was revealed that the performance of all components was better in the improved IFS than conventional farming systems (CFS). Mel *et al.* (2014) found out that profit margin of 11% and a return rate of investment of 12% may just be lucrative enough for a company after the 8.2-year payback time. However, the economic evaluation of the interaction effects of these technologies has not been fully investigated; hence, the conduct of this study.

This study was funded by Commission on Higher Education – National Agriculture and Fishery System (CHED-NAFES) which was implemented to build entrepreneurial and resilient farming communities. The main objective of this project was to facilitate the transfer of environmentally sound technologies for agricultural water systems and integrated farming systems. The implementation of this project was focused on people living in areas having limited access to irrigation water. The water system made possible the implementation of an integrated farming system in the village.

2. Methodology

2.1 Setup of the IFS

Figure 1 shows the setup of the IFS. The initial stocks were 30 heads of swine, which supplied the manure needed by the biodigester. The biogas produced by the digester was used as an alternative to gasoline to run the engine, which was likewise utilized as a prime mover of the water pump. The water pump yielded water from a shallow tube well and supplied the elevated water tank and the fishpond. The water from the tank was used to run the drip irrigation system to supply water in the vegetable area. The water tank also supplied water to the fishpond and piggery as the pigs' drinking water and as cleaning water for the pigpen. Serving as irrigation water, the displaced water from the ponds flowed to the adjacent rice fields. The digested sludge coming out from the digester was diverted to the rice field and vegetable areas and serve as organic fertilizer.

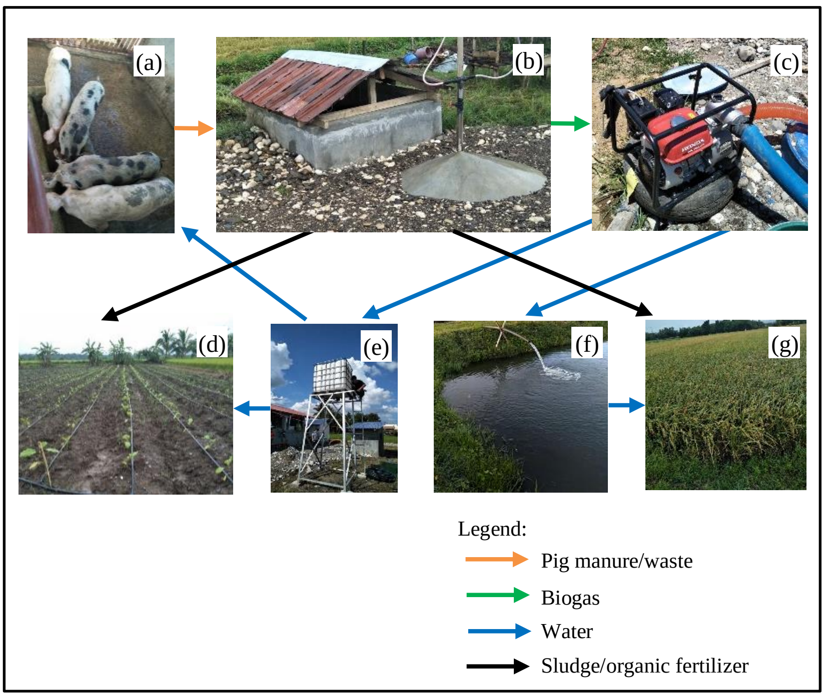

Figure 1. Setup of the biogas-driven pump-based integrated farm – piggery (a), biodigester (b), biogas-fed engine (c), vegetables (d), elevated water tank (e), fishpond (f) and rice field (g)

2.2 Description of the Biodigester

The biodigester was designed to accommodate the waste from 30 heads finishing pig (PAES 413:2001) with a retention time of 30 days. The design and volume of the biodigester were based on the Philippine Agricultural Engineering Standard (PAES 413:2001) (Department of Trade and Industry, 2001). The biodigester is fixed type (Figure 2), closed digester with an immovable, a rigid gas chamber, and a displacement pit. The mixing chamber is a component of the biodigester where the manure is deposited, and the desired amount of water is mixed before loading to the digestion chamber as slurry. In the digestion chamber, the slurry is treated by anaerobic bacteria that produce biogas. The biogas is deposited in the gas chamber before conveying into the engine. It is in the displacement pit where the digested sludge is temporarily deposited before it goes to the digester. The displacement pit is an important component of the biodigester because it gives pressure to the gas chamber necessary for the biogas to flow through the piping system going to the engine.

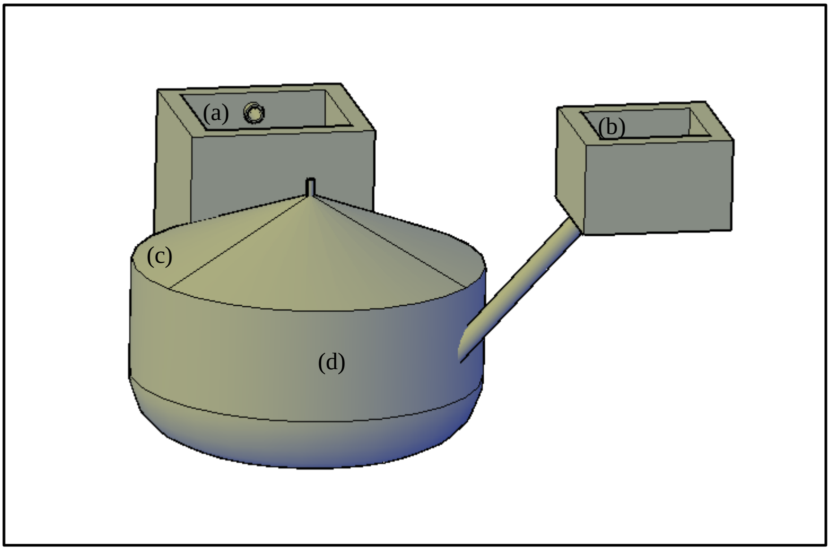

Figure 2. The exterior of the biodigester with its components – outlet/displacement pit (a), inlet/mixing chamber (b), gas chamber (c), and digestion chamber (d)

The dimensions of every component of the biodigester are shown in Figures 3 and 4. The average biogas production of the digester is 8.20 m^3 per day.

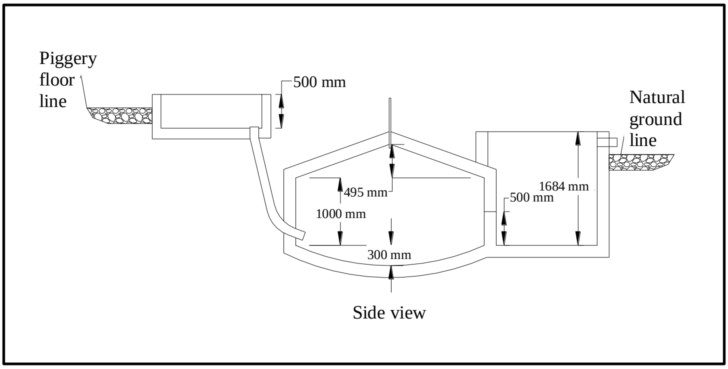

Figure 3. The side view of the biodigester

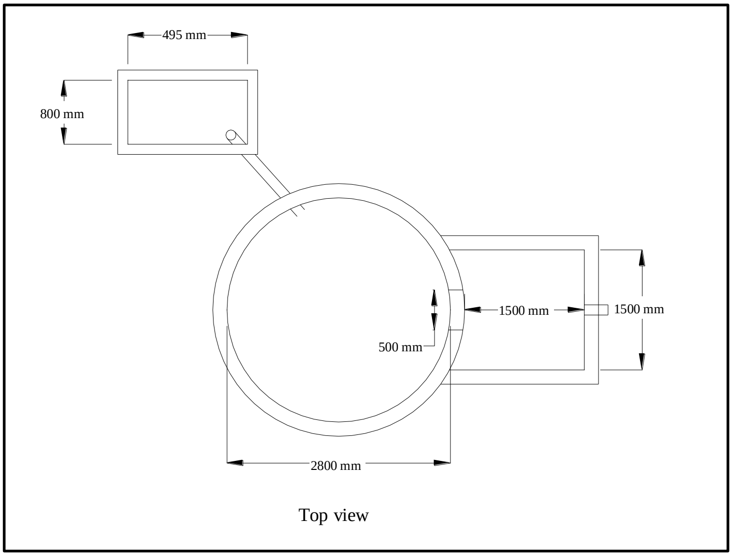

Figure 4. The top view of the biodigester

2.3 Description of the Water Pump

The water pump (Figure 5) is a 3” x 3” centrifugal type and self-priming. The water pump is run by a 5.5 horsepower gas engine. The engine is started with gasoline fuel, preheated within 3 min and shifted to biogas afterwards. No modification was made to the engine aside from the biogas supply hose that is placed in the air cleaner. The amount of biogas entering into the engine is controlled by the operator through a ball valve. The average flow rate of the water pump is 160 L per minute.

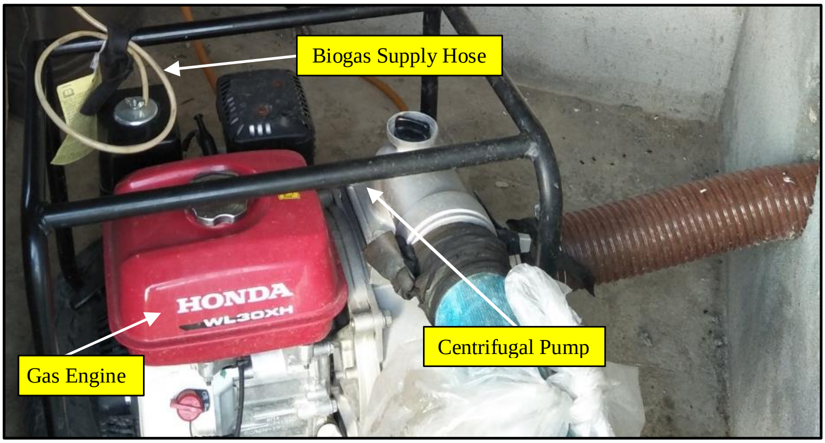

Figure 5. Setup of the biogas driven water pump

2.4 Location and Area of each Land Uses

The location and area of the new land use in the farm were determined using global positioning system (GPS). To give a clearer view of each land use, the image of the farm was downloaded using the most recent version of Google Earth maps. Each land uses were digitized using geographic information systems (GIS) application.

2.5 Management Practices

The management practices implemented in the farm were documented through an interview with the farm owner and actual observation of their farming practices during the study.

2.6 Financial Viability and Profitability of the Project

The financial viability and profitability of the project were assessed using financial and strength, weaknesses, opportunities, and threats (SWOT) analyses. The outcome of the study was evaluated through financial analysis in which the owner's or the farmer's perspective was taken into consideration. In this perspective, market prices and taxes were included. This measured the profitability of the project on the part of the investor. Results were assessed using SWOT analysis comparing the monoculture approach and the biogas-driven pump IFS.

2.7 Formulas Used

Equation 1 was used to allocate the cost of a tangible or physical asset in the project over its useful life.

$$\text{Depreciation} = \frac{\text{initial cost-salvage value}}{\text{service life}} \tag{1}$$

Equation 2 was utilized in determining the current value of all future cash flows generated by a project including the initial capital investment.

$$\sum_{t=1}^{n} \frac{\text{net cash inflow}}{(1+r)^t} \tag{2}$$

where:

n = number of periods or years
t = time in years
r = interest or discount rate

Equation 3 was applied to estimate the project's breakeven discount rate or rate of return, which indicates the project's potential for profitability.

$$\text{Internal rate of return} = \sum_{t=1}^{n} \frac{\text{Net cash inflow}}{(1+r)^t} - \text{initial investment cost} \tag{3}$$

Equation 4 was employed to compare the present value of all benefits with the cost and investments of a project. If a project has a benefit-cost ratio greater than 1.0, the project is expected to deliver a positive net present value.

$$\text{Benefit-cost ratio} = \frac{\text{discounted value of benefits}}{\text{discounted value of costs}} \tag{4}$$

Equation 5 was used to measure the gain or loss generated by the project relative to the amount of money invested.

$$\text{Return on investment} = \frac{\text{net profit}}{\text{investment}} \times 100 \tag{5}$$

Equation 6 was used to estimate the amount of time it takes to recover the cost of an investment in the project.

$$\text{Payback period} = \frac{\text{investment cost}}{\text{annual cash in flow}} \tag{6}$$

The salvage value used in computing the depreciation of the different assets in the farm was 10% (Bank, 2018). The discount rate of interest used for discounting bills of exchange was 5% (Central Bank of the Philippines).

3. Results and Discussion

3.1 Location of the Study

The farm is located at Barangay Bakir, Bagabag, Nueva Vizcaya approximately 437 meters away from the Nueva Vizcaya- Ifugao Provincial Road. It is located in the northeastern part of the province with a GPS coordinates of 16° 38’35.33” N and 121° 13’45.59” E with an elevation of approximately 220.32 m.

3.2 Farm Information

The farm has a total area of 1.08 ha. Before the introduction of the project, the farm owner was practicing monoculture with rice as the product. Now, the farm is divided into four land uses tilapia, vegetable, rice, and swine production area (Figure 6). Table 1 shows the area covered by each land use. The location of each land use is shown in Figure 6.

Table 1. Utilization of the area of the farm

Name	Total Area (m^2)
Fishpond	681
Vegetable Garden	1,885
Rice field	7,039
Others Swine house Farm house Pump house Biogas digester Inlet tank Outlet tank Water tank Pathways	1,235
Total	10,840

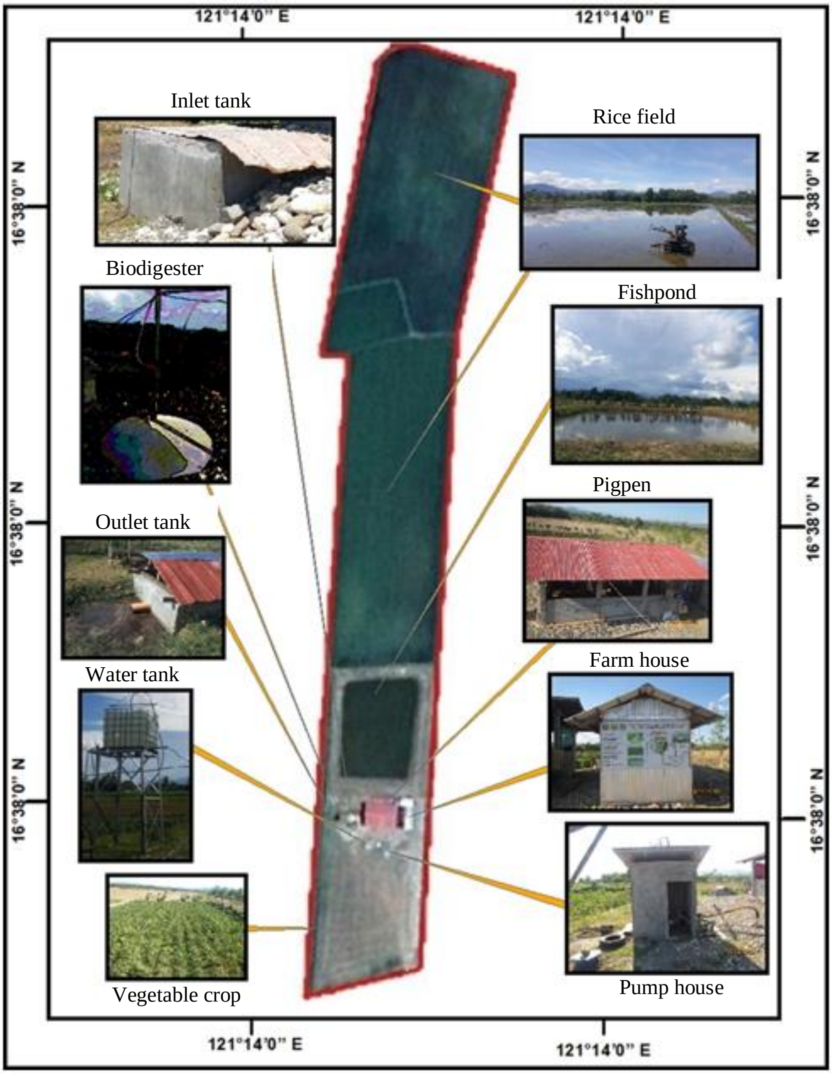

Figure 6. New land use map of the farm

3.2.1 Management Practices

The initial stocks were 30 heads of swine and 4,500 fingerlings. The crops planted were improved, inbred variety of rice, eggplants, peppers, and string beans.

3.2.2 Water Supply

The water pump run by a biogas-fed engine supplies water to the fishpond and the excess water flows to the rice fields. The pump also supplies water, utilized as pigpen's cleaning and pigs' drinking water, to the elevated water tank. The tank also provides water to the vegetable production area through drip irrigation. The water pump operates twice a day at 3 h per operation.

3.2.3 Swine, Fish, Rice and Vegetable Production

The pigs are fed twice a day at 7:30 AM and 4:30 PM. The food given depends on the number of feeds that the pigs can consume. For one-month-old pigs, starter feed is fed, and for pigs aged two to four months and above, grower and finisher/fattener are given, respectively. The animals are bathed only during the dry season – twice a day (10:30 AM and 3:00 PM) to regulate the body temperature. Vitamins and vaccines are induced bimonthly to the pigs by a veterinarian or farm technician.

Intensive culture is practiced since the tilapia is placed in a freshwater fishpond by adding supplementary feeds usually in the form of dry pellets to integrate the food naturally available in the pond allowing higher stocking density and production per area. Feeds are given to the fish until they are full. Feeding time is twice a day at 8:00 AM and 4:00 PM.

A totally of 60 kg of Triple 2 (NSIC Rc-182) rice seeds – an inbred variety of rice was used. The fertilizers utilized are 17-0-17, ammonium phosphate (16-20-0) and urea (14-20-0). The rice plants are sprayed with insecticides and pesticides seven times within the production cycle, broadcasted with inorganic fertilizers three times and weeded two times in every cycle.

The vegetable plants are sprayed with insecticides and pesticides once a week. Inorganic fertilizer is applied three times per cycle and weeded once a week. The fertilizers used are (17-0-17), ammonium phosphate (16-20-0) and urea (14-20-0).

3.2.4 Cropping and Stocking Season

The fish and pigs are disposed after four months. The eggplants and green pepper are harvested once a week while the string beans are gathered twice a week. The rice are harvested after four months. An additional or new set of swine animals are placed after a month upon the disposal of the grown ones while fingerlings are stocked in the pond according to the season suitable for fish growth that induces high survival rate. The crops are planted according to the cropping calendar (March and October).

3.3 Financial Viability and Profitability of the Farm

The economic evaluation of the farm was done through financial analysis using a 10-year projection. Table 2 shows the breakdown of the methods used in determining the financial viability and profitability of the farm.

Table 2. Comparison of the net present value and internal rate of return of IFS and monoculture

	Net Present Value	Internal Rate of Return
IFS	Php 601,461.41	25%
Monoculture	Php 116,040.11	13%

Table 2 displays the net present value and internal rate of return of the two farming systems, namely IFS and monoculture. As shown in Table 2, the net present values are both positive which means that both investments exceed anticipated costs; thus, the investments are profitable. However, the net present value of the integrated farming system is higher than the monoculture making it a more desirable investment.

The internal rate of return of both farming systems is positive indicating that both systems are financially viable and profitable. However, the IFS has a higher internal rate of return implying that the project is more advantageous to undertake.

3.4 Net Income and Return on Investment

Table 3 shows the net income and return on investment of the two farming systems. Results show that the net income for the IFS is higher by approximately 250% than the net income of the monoculture. This implies that the project is more profitable than monoculture.
Table 3 discloses that the net income of IFS (Php 187,329.80) is higher than the monoculture (Php 69,391.89); it is higher at about 270%, indicating that IFS is more profitable than monoculture.

Both farming systems have a positive return on investment, thus making them financially viable. However, the return on investment of the IFS (29.95%) is higher compared with monoculture (23.13%), signaling that IFS is more efficient and a better option in selecting the best choice in agricultural farming systems.

Table 3. Comparison between the net income and return on investment of IFS and monoculture

	IFS	Monoculture
Average sales	1,169,893.68	265,780.00
Operation and maintenance cost	963,106.54	196,388.11
Depreciation	19,457.34	-
Total Cost	982,563.88	196,388.11
Net income	187,329.80	69,391.89
Return on Investment	29.95%	23.13%

3.5 SWOT Analysis

Table 4 shows SWOT analysis of the two agricultural production systems. The systems were compared to identify and analyze the internal and external factors that can have an impact on the viability of the project.

Table 4. SWOT analysis of monoculture and IFS

	Monoculture	IFS
Strengths	Easy management Simplicity	Energy-saving Generates continuous income all year round Enhances productivity Induces greater profit
Weaknesses	Seasonal Lacks biodiversity Production requires large amount of water.	Requires larger amount of investment. Requires higher management level
Opportunities	Easy to modify ways in increasing production of the crop Continuous knowledge and technology assistance by government extension program	Intensifies crops, agricultural crop rotation and allied enterprises Provides opportunity to promote soil health Reduces pollution
Threats	Distress sale due to disaster Changing and uneven monsoon rainfall have great effect on production. Many competitors in the market	System malfunction can affect production of agricultural commodities.

3.6 Other Uses of Biogas

Other uses of the biogas aside from as fuel of the gas engine it is also use for cooking and lighting (Figure 7) in the in the farm house.

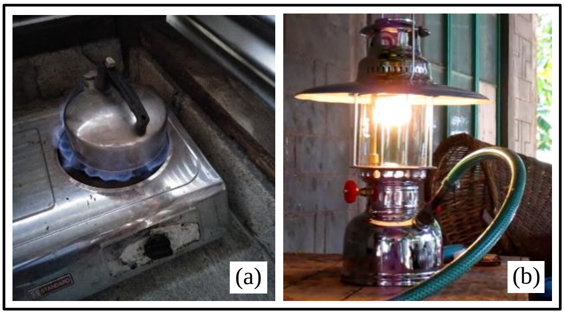

Figure 7. The biogas for cooking (a) and lighting (b)

4. Conclusion and Recommendation

Aside from being an effective waste treatment facility, the biogas technology also helped in lessening the expenses of and saving energy from the farm. Also, the transformation of the farm from monoculture to the IFS requires a considerable amount of investment. However, IFS generates higher productivity and income. The biogas-driven pump-based IFS is likewise financially viable and profitable than the monoculture. Transforming the farm from a monoculture system to a biogas-driven pump-based IFS is highly recommended to farmers.

5. Acknowledgement

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