FARMERS' RESPONSE TO THE SYSTEM OF RICE INTENSIFICATION (SRI) EXTENSION MATERIAL IMPROVEMENT EXPLORING ECONOMIC BENEFITS OF SRI, BIOGAS, AND WORM CULTIVATION INTEGRATION

Respons Petani terhadap Penyempurnaan Materi Penyuluhan SRI yang Menambahkan Keuntungan Ekonomi Menerapkan Integrasi SRI, Biogas, dan Budi Daya Cacing

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ABSTRAK

Ketersediaan kotoran sapi yang melimpah menjadi faktor penting dalam mengimplementasikan usaha tani padi organik. Penggunaan kotoran sapi dalam SRI, biogas, dan usaha budi daya cacing dapat menjadi upaya peningkatan pendapatan petani, namun informasi dan upaya ini kurang dipahami petani karena para penyuluh pertanian cenderung memfokuskan penyampaian informasi teknis bertanam organik dibandingkan keuntungan ekonomi. Kajian ini bertujuan untuk memperoleh respons petani terhadap kemungkinan memasukkan informasi perolehan nilai tambah dan keuntungan ekonomi dalam materi penyuluhan padi organik di mana kegiatannya difokuskan pada memperoleh data dan informasi nilai tambah pada rantai nilai biogas, mempresentasikan nilai tambah tersebut kepada petani dan memperoleh respons petani. Objek kajian ini adalah para petani konvensional di Kabupaten Boyolali dan menggunakan konsep nilai tambah dan respons petani. Hasil kajian menunjukkan bahwa keuntungan petani bertambah mulai dari Rp974 ribu/tahun hingga Rp5,18 juta/tahun. Respons positif diperoleh keinginan petani menerapkan integrasi SRI dan biogas, tetapi tidak untuk usaha budi daya cacing karena ketidakstabilan permintaan dan harga produk.

Kata kunci: *padi, organik, kotoran sapi, biogas, cacing, respons petani, penyuluhan*

ABSTRACT

The availability of abundant cattle waste in a village is an important factor for implementing organic rice farming practice. The utilization of cattle waste in SRI practice, biogas, and worm cultivation increase farmers' income, but this issue is not informed well to farmers because traditionally agricultural extension agent focused on delivering cropping techniques than economic advantages. The objective of this study is to assess farmers' response to the possibility of inserting the information about the economic benefits of integrating SRI, biogas, and worm cultivation in the SRI extension program. Respondents were conventional farmers in Boyolali Regency and using value added and farmers' response concept. There are three activities in this research, namely obtaining value added throughout biogas value chain, presenting the value added to farmers, and receiving farmers' response. The results shows in three parts of biogas value chain increase farmers' economic benefits from Rp974 thousand/year to Rp5.18 million/year. Conventional farmers give high positive response to the integration of implementing SRI and following biogas project and receiving value-added from installing biogas digester. However, farmers give low response to worm cultivation due to unstable demand and price volatility.

Keywords: *rice, organic, cattle waste, biogas, worm, farmers' response, extension*

INTRODUCTION

Potential of organic farming expansion in Indonesia is enormous. *Firstly*, available land for organic agriculture in Indonesia is very wide. From 188,2 million ha of available land for agriculture, only 70 million ha that has been used for various agricultural farming, and the remains of the land are potential for organic farming. Furthermore, 11,1 million ha of land is approximated as abandoned land and most of them can be used for organic farming (Mayrowani 2012). Land for organic farming needs more than two years of the conversion period before it is categorized as organic cultivation (Scialabba and Hattam 2002; Mayrowani 2012).

Secondly, organic products have a good market prospect because organic farming has chances to increase continuously and possibility to earn higher economic benefits compared to nonorganic products. Organic farming can be implemented by utilizing environmental outcomes to decrease input costs. Besides, organic product prices are higher compared to nonorganic products (Sutanto 2002; Widayanti and Yuliati 2007). *Thirdly*, the implementation of organic farming increase land, water, and air quality that impact on increasing production and human life quality (Scialabba and Hattam 2002).

Besides its massive potential, the performance of an organic farming area expansion tends to stagnate. In 2007, the organic farming area in Indonesia was 40.97 thousand ha, and increased significantly in 2008 to become 208.53 thousand ha, or increased five times compared to in 2007. However, during the period of 2008−2011, the organic farming area only grew 2.81% per year (Scialabba and Hattam 2002; Mayrowani 2012). The low growth of SRI area expansion showed that there were some problems related to the organic farming area expansion. Besides some classical problems such as certification process, other problems faced are limited market for organic products, low price (Mayrowani 2012), and the extension of SRI (Indraningsih 2013).

The availability of cattle manure became an important reason for farmers why they wanted to reduce the use of chemical fertilizers and implement the SRI practice, although not all SRI technique guides are implemented. This occurred because most of farmers were growing cattle, including conventional farmers, and the amount of cattle manure was abundant (Maulana 2015). Nevertheless, conventional farmers in this village still did not want to shift their farming practice to SRI, even though agricultural extension agents strive to inform SRI farming techniques through their extension materials. To deal with extension problem, other new extension materials are necessary to be added in extension process performed by agricultural extension agents. Inserting economic benefits knowledge of implementing SRI instead of convincing conventional farmers by technical substances can be considered as a potential substance.

The objective of the study is to assess farmers' response to the possibility of inserting the information about the economic benefits of integrating SRI, biogas, and worm cultivation in the SRI extension program. Within the context of the research objective, the following research questions are formulated to obtain farmers' responses to the new extension material. The central question of this research is how much the value-added of integrating SRI, biogas, and worm cultivation, and farmers' response to economic benefit substances disseminated by a researcher.

Specifically, this research is carried out to answer the following sub research questions: 1) How much is the value-added of implementing biogas and worm cultivation in each part of a biogas value chain? 2) What are farmers' response to the economic benefit of SRI, biogas, and worm cultivation extension materials disseminated in this research? 3) What policy recommendations should be offered to the Ministry of Agriculture of Republic of Indonesia in terms of accelerating System of Rice Intensification (SRI) area expansion?

METHODOLOGY

Conceptual Framework

The net private benefit of the conventional system is higher than SRI. However, in a condition when all labor is calculated as costs, SRI's net private benefit and also net social benefit are higher than conventional system. SRI's net private benefit when all labor is calculated as costs is Rp15.23 million/ha and for conventional system is Rp13.60 million/ha or 13% lower than SRI. Meanwhile, the net social benefit when all labor is calculated as costs, for SRI and conventional system are Rp14.96 million/ha and Rp12.55 million/ha respectively. When all labor and cattle waste are calculated as costs, the net social benefit of SRI (Rp11.97 million/ha) is also more than conventional system (Rp11.89 million/ha) (Maulana 2015).

The economic benefit that comes from reducing externalities of implementing SRI is less known by the farmers due to the lack of extension about social benefits. According to manual book of implementing SRI released by Ministry of Agriculture of Indonesia, agricultural extension agents have an obligation to counsel information stated in manual book which is the technical matters of implementing SRI, but not including the economic benefits. If agricultural extension agents do not want to increase their knowledge by themselves, economic benefits will not be delivered to farmers.

Kartasapoetra (1994) outlined that agricultural extension agents' role is very important to realize agricultural development based on people's needs. He added that agricultural extension agent's role is as a researcher who searches for mutual advices and recommendations related to knowledge and technologies, as an educator who improves farmers' knowledge, delivers information to farmers and increases farmers' working spirit, and as an agricultural extension agent who raises farmers' attitude of openness and not compulsion.

Agricultural extension agents should be able to diagnose obstacles faced by farmers, building and maintaining a good relationship with farmers, strengthen technology adoption, and prevent the decreasing adoption of technologies (Rogers 2003). Mosher (1997) mentioned that agricultural extension agents' roles are 1) educator, 2) analyzer, 3) adviser, 4) organizer, 5) needs changing developer, 6) a driver of change; and 7) builder for agricultural extension agents and farmer relationships. To support those of roles, agricultural extension agents have to master and utilize information of technology, communication, and education (Indraningsih 2013).

The researcher has an idea that the most important factor for farmers to shift from conventional farming practices to SRI is the availability of cattle manure. It means that the farmers have to raise cattle or buy cattle manure from other farmers or sellers. In order to accelerate the adoption of SRI by farmers, the extension about the social benefits of practicing SRI, the chances of obtaining government support for providing cattle for farmers, improving farmers' knowledge to raise cattle, the value-added of raising cattle, the use of cattle manure, affiliating biogas project, and the possibility of cultivating worm, in terms of increasing economic benefit, should be performed.

The first step carried out in this research is to calculate the value-added that could be obtained by the farmers along the value chain of raising 2 cattle and implementing household biogas. The value-added of each part of a biogas value chain is used as the extension materials in the study site. The extension by researchers to farmers' representative at study site is performed in order to increase farmers' knowledge and behavior of SRI.

The second step is to obtain data and information about farmers' self-awareness about SRI practice and raising cattle and farmers' response of extension materials that the researcher had already counseled. The positive response of the farmers showed the focus of extension on how to raise cattle and how to utilize cattle manure to earn economic benefit through its value-added, which is performed by an agriculture extension agent, is the main factor if the Ministry of Agriculture intends to accelerate the SRI area expansion.

Research Methods

Value-added

Value-added has different definitions in various sectors. In business and economics, unit profit is estimated as the sale value and total production cost of a product. Then, unit value-added can be calculated as the sum total of unit profit, unit labor cost and unit depreciation cost. Subsequently, the total value-added is obtained by summing all over unit value-added. The total value-added is similar to total revenue, reduced by outside materials and services purchase (Ravald and Gronroos 1996). The total value-added is also approximated as a total labor expense and operating profit plus depreciation (Dewan and Min 1996)

Added value can also be outlined by outside of business and economics definition which refers to add more features that beyond standard costumer expectations of an item of interest even though the product's price is higher for costumers. Value-added improved competitive advantage of a product. The value-added of a product can be measured and divided as parts along a value chain. A value chain is explained as a group of activities operated by a firm in a particular industry and performed in terms of transfer a valuable product or service to the market (Porter 1985).

United States Department of Agriculture (USDA) explained that the value-added in agriculture took place whenever physical form or state of an agricultural product is changed, or a production method or a handling process is adopted that leads to an improvement of customer base's product, and consumers spent their greater expenditure on the product obtained to the producer (Amanor-Boadu 2003). Concerning the ideas of USDA's explanation of value-added agriculture, the concept of agricultural value-added is not only limited to physical products, but also to services. Value-added is able to calculate at firm level and is aggregated through firms in an industry to obtain industry value-added. If value-added of all industries are summed, the value-added of the entire economy is achieved (Amanor-Boadu 2003).

Value-added at the firm level is outlined as the gross value of output minus purchased inputs and contract labor. Meanwhile, at industry level, value-added is distributed into two values, namely gross value-added and net value-added. Gross value-added can be calculated as sum of goods and services' value of a product reduced by intermediate consumption of goods and services' value. Net value-added is estimated as the total output value of a product minus intermediate and fixed capital consumption (Dewan and Min 1996; Amanor-Boadu 2003).

Furthermore, the value-added of a product can be alleged as a reward for a firm or individual who performed activities itself and other parties along a supply chain. The forms of this reward for other members of the supply chain can be enlarged market share, higher output prices, and augmented market access. The reward should be profitable, which means this reward must be higher compared to value-added activities. If this reward is lower than value-added activities, then the activities do not have a contribution of any value to supply chain or to customers, the activities cannot be qualified as value-added activities (Porter 1985).

Farmers' Response

Agricultural extension should deliver innovative messages that could alter or encourage changes so that the improvement of quality of life could be realized (Mardikanto 1993). The messages or extension materials delivered by agricultural extension to farmers consist of various forms such as information, technology, social engineering, management, economics, laws and environmental preservation. Extension materials are made based on farmers' and stakeholders' need regarding expediency and preservation of agricultural, fishery and forestry resources (Indraningsih 2013).

Extension materials for the last three decades were dominated by technology transfer aspects, oriented to project interests to reach a specific production target. Therefore, the coverage of extension materials has to be extended, not only limited to production technology, but also harvested technology, processing, packing, transportation, price and market information, and agribusiness, so that the farmers could gain more profit. Extension materials needed by farmers should be based on farmers' opportunity, willingness, and ability to implement, not only by scientific calculations that are considered beneficial (Tjitropranoto 2013). Subejo (2009) outlined that extension materials should be shifted from increasing production rate, but adapting other global issues such as preparing farmers in overcoming global climate change. Farmers need to be introduced by production inputs which have high adaptation to climate change. Moreover, extension materials must be oriented to environmental friendly farming practices, water saving, and resistant to high temperature.

In previous eras, agricultural development known as green revolution has been exploited by government interest to increase crop production, especially for rice production, to fulfill the increasing of people's food needs. In line with it, extension materials were also changed. If the extension is focused on directing farmers to implement better farming practices previously, then changed to concentrate on technology transfers to increase rice production rate, farmers become dependent, and local institutions would not function or even disappear. Therefore, paradigm change is needed, from the old paradigm that emphasis on technological transfer to new paradigms that focus on farmers' empowerment, known as "farmer first" or "changing farmers" and not "changing farmers' farming practices" (Indraningsih et al. 2013).

The main characterization of farmer first approach are (Sadono 2008; Indraningsih et al. 2013) 1) the main objective is to empower farmers, farmers group, and association of farmers group; 2) farmers are facilitated by outsiders in analyzing their needs and priority; 3) technology transfer from outsiders to farmers through some principles, methods, and a set of choices; 4) farmers are given chances to select materials they need; 5) behavioral characteristics of farmers are characterized by the application of principles, selecting a set of choices, and attempting to apply methods; 6) main product wanted to achieve by outsiders is that farmers could improve their ability to adapt and provide them with some extended choices; 7) having main extension model that is from farmers to farmers model; and 8) agricultural extension agents' role as facilitators and providers of choices.

Methods of Data Collection

To answer sub research question 1 (How much is the value-added of implementing biogas and worm cultivation in each part of a biogas value chain?), a focus group discussion (FGD) with a farmer group in Cibodas Village, Lembang District, West Java Province, was performed in order to obtain data and information about value-added of implementing biogas in each part of biogas value chain and worm cultivation. The results exhibited the economic benefit of practicing biogas and worm cultivation in each part of biogas value chain.

To answer sub question 2 (What are farmers' responses to economic benefit of SRI, biogas and worm cultivation extension materials disseminated in this research?), this study collected data from the representation of 5 farmer groups and 1 female farmer group, that have existed in Dlingo Village in Boyolali Regency, Central Java Province. The data about farmers' perceptions of raising cattle and following biogas project was collected by using a questionnaire that was distributed after extension which is conducted by researcher.

To answer sub question 3 (What policy recommendations should be offered to the Ministry of Agriculture of Republic of Indonesia in terms of accelerating System of Rice Intensification (SRI) area expansion?), interview was performed by the officials of local government and extension agents in order to discuss about the new idea of focusing extension about adopting SRI, raising cattle extension, and the biogas project compared to focus only on technical implementation of SRI. Interview with the Ministry of Agriculture officials in the central office in Jakarta and with NGO that have ever been sought in promoting biogas project namely “Yayasan Rumah Energi (YRE)” was performed to obtain further information about the possibility of giving government support for procurement of cattle for farmers and implementing biogas projects on the study site.

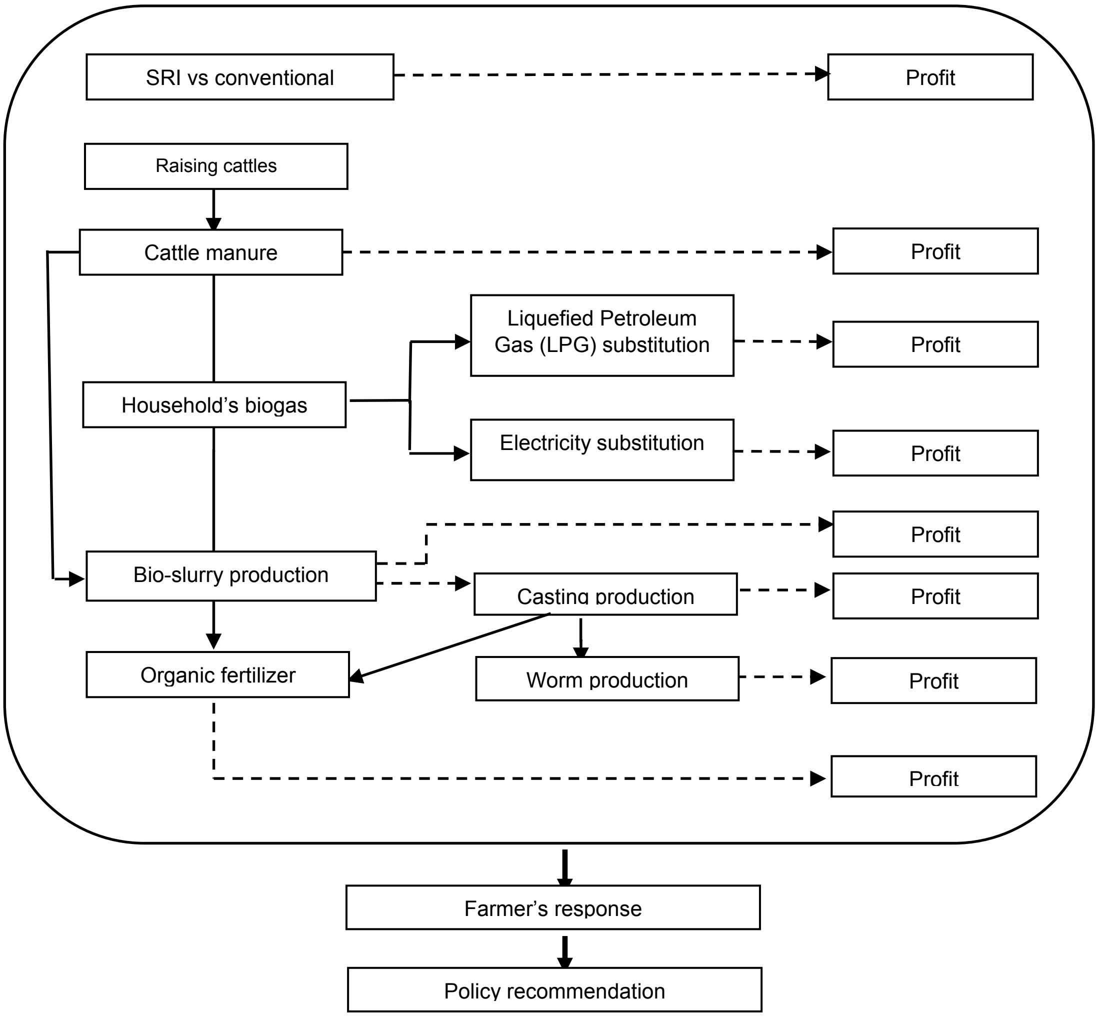

Figure 1. Conceptual framework

Study Site

The first study site was in the Cibodas Village in the Lembang District, West Java Province. This village is chosen in order to obtain data and information about the cost of building biogas installation and economic benefit of implementing biogas. It was conducted because there is no biogas project in Dlingo Village in Boyolali Regency, Central Java Province. Therefore, biogas data and information from Cibodas Village was used as extension materials in Dlingo village. In this village, one of the NGOs existing in Indonesia, namely “Yayasan Rumah Energi (YRE)” that supports building biogas installation in some locations in Indonesia, has a project, namely BIRU (Biogas for Household) in collaboration with the Ministry of Energy and Mineral Resources Republic of Indonesia. By considering that BIRU project has been going on two years in Cibodas Village with 80 households participated in this project and economic benefits of implementing biogas had been received by farmers, this research chose Cibodas Gillage to be the first study site.

The second study site was in Dlingo Village, in Boyolali Regency, Central Java Province. This location was selected because there were two different farming areas: one area were practicing SRI and the other one were implementing conventional farming system.

Data Analysis

Calculating the Profitability of Implementing Biogas

The profitability of implementing biogas was calculated by using formula explained below (Gittinger, 1986; Soekartawi, 1995):

1) $\pi = TR - TC$ (1)

$\pi = P.Q - (TFC + TVC)$ (2)

$$\pi = P.Q - \left(\sum_{i=1}^{n} TC + \sum_{i=1}^{n} P_i X_i\right) \quad (3)$$

Each notation in the formula mentioned above can be described as follows:

π = profit
TR = total revenue
TC = total costs
P = price per unit
Q = the amount of output
TFC = total fix cost
TVC = total variable cost
P_i = input price
X_i = the number of inputs used

Criteria: if $\pi > 0$ = implementing biogas is profitable
if $\pi < 0$ = implementing biogas is not profitable

2) B/C ratio or the ratio of benefit over costs.

B/C = TB/TC

Where: TB = total benefit
TC = total costs

Criteria: if B/C > 1 = implementing biogas is feasible
if B/C < 1 = implementing biogas is not feasible

Measuring Farmers’ Response

Farmers’ self-awareness about their knowledge of SRI practices and their response to the extension of the possibility of receiving value-added by implementing SRI and household biogas was measured by using a Likert scale (Indraningsih 2010; Indraningsih et al. 2013). Each representative from 5 farmer groups was asked to fill the questionnaire. Farmers answered the questions by giving check sign (√) in each statement in questionnaire according to their self-awareness about their knowledge of SRI practices and raising cattle. There were 12 statements and on SRI practice part and 8 statements in raising cattle part. After researcher gave a presentation and discussion about SRI to farmers accompanied by experts, officials, and NGO members, then a response questionnaire was used for each farmer to be filled with the same filling method. The second questionnaire asked about farmers' response to extension material delivered by researcher and their willingness to implement biogas and SRI.

Farmers' answers to each statement in the farmers' self-awareness questionnaire were grouped into 1) their knowledge of SRI practices and 2) raising cattle. Meanwhile, for farmers' response questionnaire, farmers' answer were categorized into 1) farmers' response to the possibility of increasing their knowledge in SRI practice; 2) farmers' response to the possibility of improving their knowledge in raising cattle; and 3) farmers' willingness to obtain biogas value-added.

Farmers' answer for all statements in each group was accounted and categorized as follows:

If farmers gave 1−3 check signs (√) among all statements in a group, their answers were categorized as "1"
If farmers gave 4−6 check signs (√) among all statements in a group, their answers were categorized as "2"
If farmers gave 7−9 check signs (√) among all statements in a group, their answers were categorized as "3"
If farmers gave 10−12 check signs (√) among all statements in a group, their answers were categorized as "4"

For group of statement with only 8 statements:

If farmers gave 1−2 check signs (√) among all statements in a group, their answers were categorized as "1"
If farmers gave 3−4 check signs (√) among all statements in a group, their answers were categorized as "2"
If farmers gave 5−6 check signs (√) among all statements in a group, their answers were categorized as "3"
If farmers gave 7−8 check signs (√) among all statements in a group, their answers were categorized as "4"

For group of statement with only 4 statements:

If farmers gave 1 check signs (√) among all statements in a group, their answers were categorized as "1"
If farmers gave 2 check signs (√) among all statements in a group, their answers were categorized as "2"
If farmers gave 3 check signs (√) among all statements in a group, their answers were categorized as "3"
If farmers gave 4 check signs (√) among all statements in a group, their answers were categorized as "4"

The average of all categories for each farmer is averaged. Subsequently, it is then grouped into three score groups, i.e., 1 (if the average score of all farmers is 1,00–2,00); 2 (if the average score of all farmers is 2,01–3,00), 3 (if the average score of all farmers is 3,01–4,00). The interpretation of score 1 is farmers' self-awareness and farmers' response is low, score 2 is median, and score 3 is high.

RESULTS AND DISCUSSIONS

Biogas Value-Added

This chapter provides information about the potential of utilizing cattle manure as raw material of biogas digester, cost of affiliating a biogas project, and benefits from three parts of biogas value-added. These all information will be used as extension materials by researcher in a presentation and discussion in study site in order to receive farmers' response to implementing SRI, following biogas project and worm cultivation.

Biogas is one of renewable energy types (Widodo and Hendriadi 2005; Haryati 2006) and defined as a type of gas that is produced by organic matter biological breakdown in an anaerobe process or in an oxygen deficient environment condition. Biogas contains 60% of CH_4 and CO_2, categorized as ecofriendly biofuel and used for a substitute of Liquefied Petroleum Gas (LPG), generating electricity, and as fuel for machine and automotive (Ishizuka et al. 1995; Widodo and Hendriadi 2005; Holm-Nielsen et al. 2009).

Raw materials used for biogas production are agricultural waste such as rice straw, cassava solid waste, water hyacinth (Ishizuka et al. 1995), liquid manure of cattle, pigs, goats, hens, and organic waste from food industry, market (Widodo and Hendriadi 2005), and Municipal Solid Waste (MSW) (Aprilia 2012). Agricultural waste is abundant, but its utilization for biogas production is still very low compared to its huge potential (Widodo and Hendriadi 2005).

One of agricultural waste that has huge potential to be raw material for biogas production is liquid manure of cattle. In Dlingo Village, in the System of Rice Intensification (SRI) area, a farmer had 1,64 cattle on average, or 2 cattle are rounded. Meanwhile, conventional farmers have 1 cattle for each of them in average. For goats, both types of farmers remain the same (Table 1). If each weight of a cattle is 250 kg and it can produce cattle manure (dung and urine) 8−10% of its weight (Werner et al. 1989), which is 25 kg, so for a day, each farmer has 50 kg of cattle manure. The growing season for paddy is 100 days, so that SRI farmers can produce 50 kg x 100 days = 5,000 kg cattle manure. The average land size per SRI Farmer is 0.2710 ha, while the average of organic fertilizer use is 3,980 kg/ha, so the need of organic fertilizers is only 0.2710 ha x 3,980 kg/ha = 1,079 kg. It means, SRI farmers produce 5,000 kg – 1,079 kg = 3,921 kg of useless cattle manure per each paddy season or 3,921 kg/100 days = 39.21 kg per day per farmer.

Table 1. The number of cattle and goats nurtured by farmers in Dlingo Village, 2014 (head)

No.	Types of livestock	SRI			Conventional		
		Average	Min–max value	Standard deviation	Average	Min–max value	Standard deviation
1.	Cattle	1.64	0−8	2.292	0.82	0−9	0.982
2.	Goats	2.10	0−8	3.048	1.63	0−9	3.042

The calculation mentioned above shows that there are huge cattle manure surplus. However, when cattle manure surplus is not treated and managed well, it will be a main source of land, air, and water pollution. Some main pollution risks are nitrogen and phosphorus leached nutrient, pathogen contamination, and ammonia evaporation (Holm-Nielsen et al. 2009). In addition, livestock industry produced 18% greenhouse gases, 37% methane, 65% nitrous oxide, and 64% ammonia emissions worldwide (Steinfeld et al. 2006). Some pollutants are also caused by decomposed animal waste such as biological or chemical oxygen demand, pathogenic bacteria, water pollution, and dust and odor pollution (Haryati 2006).

On the contrary, if managed properly, cattle manure surplus can be used as raw material of biogas production and organic fertilizer for paddy land. By building biogas digester, cattle manure surplus can be stored in the digester and processed to produce methane gas that can be used for replacing LPG and electricity, and bio-slurry for organic fertilizer. Furthermore, bio-slurry from the biogas process can also be used for cultivating worm. It will increase farmers' revenue.

In building a digester of biogas, a non-governmental organization (an NGO) namely Yayasan Rumah Energi (House of Energy Foundation) collaborated with the Ministry of Energy and Mineral Resources Republic of Indonesia, supported by HIVOS, SNV, Norwegian embassy, and Netherlands Government, has promoted biogas as a form of renewable energy by building biogas installation in many provinces in Indonesia. Its program name is BIRU or "biogas rumah" (household biogas or small scale biogas for household). BIRU has built 14,554 biogas reactors in Indonesia and approximately has given benefit for 72,770 people in 2009−2015 period. This is officially declared as the biggest program of building biogas reactors in Indonesia by Indonesia government.

Practically, BIRU agents collect data and information from some resources such as Ministry of Agriculture, Ministry of Energy and Mineral Resources. and Central Agency of Statistics, in order to find a potential area to implement BIRU project. Subsequently, they came to the potential area and asked farmers to participate in BIRU project. Farmers are offered a credit package for about Rp7.89 million and Rp2.00 million subsidies from BIRU project for building a 6 m^3 biogas reactor. Cost of building a 6 m^3 biogas digester in detail can be seen in Table 2.

Table 2. Costs of building a 6 m^3 biogas digester, 2015

No.	Materials/labors	Unit	Material quantity	Unit price (Rp)	Total price (Rp)
A.	General				
1.	Bricks	Pc	1.600	700	1.120.000
2.	Sand	m^3	2,4	300.000	720.000
3.	Aggregate	m^3	1,7	375.000	637.500
4.	Cement (50 kg)	Bag	16	55.000	880.000
5.	MS rod (8 mm - SNI)	kg	12	22.000	264.000
6.	Emulsion paint	L	1,5	50.000	75.000
	Subtotal A				3.696.500
B.	Appliances				
1.	Main gas pipe + accessories	Pc	1	250.000	250.000
2.	Fittings PVC	Pc	10	6.500	65.000
3.	Fittings GI 1/2 inch	m	4	-	-
4.	Gas pipe (PVC), 1/2 inch	m	12	22.000	264.000
5.	Main valve	Pc	1	150.000	150.000
6.	Water drains	Pc	1	75.000	75.000
7.	Gas tap	Pc	1	75.000	75.000
8.	Stove	Pc	1	400.000	400.000
9.	Mixer	Pc	1	175.000	175.000
10.	Hose pipe	m	1	60.000	60.000
11.	Taflon tape	Pc	2	10.000	20.000
12.	Inlet pipe (PVC) - 4 inch @ 4 m	Pc	2	100.000	200.000
13.	Manometer	Pc	1	50.000	50.000
	Subtotal B				1.784.000
C.	Manpower				
1.	Masons	Person	10	100.000	1.000.000
2.	Labors	Person	22	80.000	1.760.000
3.	Miscellaneous (Rp100.000)	LS	1	100.000	100.000
	Subtotal C				2.860.000
Subtotal (A+B+C)					8.340.500
Maintenance fee (Rp200.000)					300.000
Construction fee (Rp800.000)					850.000
Grand total (Rp)					9.490.500

Source: BIRU-NGO (2015), computed

The 6 m^3 biogas reactor technology built by BIRU is a fixed-dome reactor that is a biogas reactor technology adapted from the same reactor technology as built in Asian countries such as in Vietnam, Bangladesh, Laos, Pakistan, Nepal, and Cambodia. This reactor technology is built in underground and made of masonry and is worked by trained labors. The reactor is declared as environmentally friendly technology. The lifetime of this technology is 15 years if maintained well and it can be functioned if at least farmer has 2 cattle in order to produce enough cattle manure as raw material of biogas production to be able to generate sufficient gas to turn on 2 stoves, 1 lamp, and 1 time cooking rice by using a specific rice cooker for about 4 hours as meet their daily basic cooking and lighting needs.

The reactor consists of six main parts. Firstly, inlet or mixing tank where cattle manure is put to feed reactor. In this part, cattle manure and water with the same comparison is inserted into mixing tank and flows via pipeline to second part, namely reactor. In a reactor, also called as digester chamber, anaerobic/non-oxygenated process is occurred to separate between methane gas, which is then stored in third part, i.e., storage dome or gas storage and bio-slurry. Fourthly, outlet or divider chamber which divides bio-slurry to be stored or bio-slurry to be flown to slurry-pit. Fifthly is a gas carrier system, which will flow methane gas from gas storage to the farmer's house passes through water drain. Sixth part is bio-slurry pit or cattle manure composts pit that has been reduced of any kind of gas.

The calculation of cost and benefit for each part of a biogas 6 m^3 value chain begins with explaining building a 6 m^3 digester and detail information is shown in Table 3. The cost is Rp9.49 million and digester lifespan is approximately 15 years. Depreciation per year is 5% or Rp475.53 thousand/year. With the average number of cattle owned by a farmer is 2, and average land size 0.271 ha/farmer, based on calculation mentioned above, the cattle manure surplus is around 4 tons per farmer per paddy growing season.

Table 3. Costs and benefits of implementing 6 m^3 biogas digester and cultivating worm, 2015

No.	Type of costs, revenue, and benefit	Unit	Volume	Price/unit	Value
I.	Costs:				
1.	Building a digester:				
a.	Digester's size	m^3			6
b.	Digester's lifespan	years			15
c.	Cost	Rp			9,490,500
d.	Depreciation (5%/year)	Rp/year			474,525
2.	Building 2 racks for cultivating worm				
a.	Rack's size	m^2			7
b.	Rack's lifespan	years			6
c.	Cost	Rp			1,150,000
d.	Depreciation (5%/year)	Rp			57,500
3.	Land size for building a digester and a rack				
	Land size	m^2			21
	Opportunity cost of land	Rp/year			17,500
4.	Cattle manure		15	66,667	973,333
5.	Worm seeds	kg	4	35,000	140,000
	Total cost: Implementing biogas+cultivating worm				1,662,858
	Total cost: Implementing biogas				1,465,358
II.	Revenue:				
1.	Casting	kg	3,780	714	2,700,000
2.	Worm	kg	72	27,750	1,998,000
3.	Liquefied Petroleum Gas (LPG)'s substitution	cylinder	48	25,000	1,200,000
4.	Slurry for organic fertilizer	kg	2,520	375	945,000
	Slurry for organic fertilizer (2)				2,362,500
	Total revenue				6,843,000
III.	Benefit:				
	Casting + worm + LPGs + slurry	Rp/year			5,180,142
	Slurry + LPGs	Rp/year			2,097,142
IV.	R/C ratio:				
	Casting + worm + LPGs + slurry				4.12
	Slurry + LPGs				1.43

The first part of calculating farmer's cost and benefit on each part of a biogas value chain starts with the assumption that the farmer is only raising 2 cattle, but not installing biogas, the farmer's added benefit is only from cattle manure. Farmers can have approximately 40 kg cattle manure surplus/per day or multiplying by 365 days, a farmer obtains 15 tons of cattle manure surplus after it is reduced by the need of fertilizing his paddy land 324 tons for three paddy growing seasons in a year. The average cow dung price is Rp67/kg and farmer's benefit is 15 tons/year x Rp66,667/ton = Rp973,333/year.

The second part of biogas value-added is assuming that farmer affiliates with BIRU project and install biogas reactor. The total cost comes from depreciation cost (Rp474,525/year), the opportunity cost of land calculated by comparing land use for growing paddy and land rented to another farmer (Rp17,500/year), and cattle manure cost (Rp973,333/year). Total cost is Rp1.46 million/year.

Farmer's revenue in this second part is obtained from bio-slurry and methane gas values calculated from the value of LPG replaced by methane gas use for turning on 2 stoves, 1 lamp, and 1 time cooking rice by using a specific rice cooker for a year. The farmer harvests bio-slurry 175 kg (5 bags x 35 kg/bag) for every 10 days or 6.3 tons per year. The average price of bio-slurry is Rp375/kg and bio-slurry value is 6,300 kg/year x Rp375/kg = Rp2.36 million/year. In addition, farmers can use biogas to substitute LPG. Previously, farmer used 4 cylinders of gas per month or 48 cylinders per year, but after shifting to biogas, LPG is no longer used. The cost of buying LPG is Rp25.000/cylinder or 48 cylinders x Rp25,000/cylinder = Rp1,200,000/year. Total farmer's revenue is Rp1.2 million/year + Rp2.36 million/year = Rp3.56 million/year. Farmer's benefit in the second part is Rp3.56 million/year – Rp1.46 million/year = Rp2.10 million/year. Benefit-cost ratio (B/C ratio) is 1.43 or farmer gains 43% benefit over the cost. The third part is to enhance the biogas value chain by adding growing worm effort in order to increase farmer's benefit. Total cost is higher because farmer needs to build 2 racks for cultivating worm. Rack size is 7 m^2 and its lifetime is 6 years if it is managed properly. The cost of building racks is Rp1.15 million and its depreciation cost is 5% per year or Rp57,500/year. The racks are filled with bio-slurry from biogas digester and worm seeds to start growing worm. The farmer could buy worm seed from distributor and its price is Rp35,000/kg. Bio-slurry produced from the biogas digester as explained in the second part is 6,300 kg/year, but in the third part, it is divided into two utilization of bio-slurry namely bio-slurry for organic fertilizers (2,520 kg/year) and bio-slurry of raw material in cultivating worm process (3,780 kg/year). Bio-slurry for raw material is dried before it is used to cultivate worm. After worm is harvested and separated from dry bio-slurry, worm is sold to buyer at the price of Rp27,750/kg and dry bio-slurry is also sold at Rp714/kg. The dry bio-slurry is called casting. In a year, farmer harvests 72 kg of worm and 3,780 kg of casting.

Total production cost in the third part of a biogas value chain is calculated by adding building a digester depreciation cost (Rp474,525/year), depreciation cost of building racks (Rp57,500/year), the opportunity cost of land (Rp17,500/year), cattle manure (Rp973,333/year) and worm seeds (Rp140,000/year). Total production cost is Rp1.66 million/year. Meanwhile, farmer's revenue is obtained from selling casting (Rp2.70 million/year), worm production (Rp1.99 million/year), LPG's substitution value (Rp1.20 million/year), and bio-slurry for organic fertilizer that is not used as raw material of cultivating worm (Rp945 thousand/year). The total revenue is Rp6.84 million/year. Hence, farmer's benefit is Rp6.84 million/year less Rp1.66 million/year equals Rp5.18 million/year. The B/C ratio in this third part of a biogas value chain is 4.12 or 2.88 times higher than the second part.

The explanation above exhibits that there were a huge cattle manure surplus amounted to 39.21 kg/day/farmer that can be used as raw material of biogas digester. The cost of building a 6 m^3 biogas digester is Rp9.46 million and can be used until 15 years. The three possible benefits in three biogas value chain are showed as follows: 1) farmers only utilize cattle manure as organic fertilizer or sold, the benefit is Rp 973 thousand/year; 2) farmers install biogas digester and receive benefit from energy produced and bio-slurry production, the benefit is Rp2.1 million/year; and 3) farmers add cultivating worm business by using bio-slurry instead of energy benefit and selling bio-slurry, the benefit is Rp5.18 million/year.

Farmer's Self-Awareness and Response to Economic Benefits of Implementing SRI and Biogas

After biogas value-added is obtained from Cibodas Village in Lembang District, West Java Province, this chapter showed farmers' self-awareness and response to economic benefits of implementing SRI and biogas in Dlingo Village, Central Java Province. A coordination is built between researcher and Animal Husbandry Department officials in Boyolali Regency in order to provide SRI and raising cattle experts to support farmers' self-awareness and response on SRI practice and biogas program. Two officials, who are responsible for SRI and raising cattle, accompanied researcher in assessing farmers' self-awareness and response.

In Dlingo Village, 16 conventional farmers were gathered in one place and given an extension about SRI practices and raising cattle. Previously, farmers were asked to fill a questionnaire in order to assess their self-awareness about their knowledge on SRI practice and raising cattle. Afterwards, researcher performed a presentation about SRI practice, raising cattle, and biogas supported by officials and experts. Discussion is also carried out among farmers, researcher, and officials from Boyolali Regency. After discussion was accomplished, farmers were asked to fill a second questionnaire in order to obtain farmers' response to SRI practice, raising cattle, and biogas project.

The results showed that conventional farmers' knowledge about SRI practice was in medium level. Farmers' score was 2.1875 which was in category 2 (2.00−3.00) (Table 4). This result is not surprising considering that conventional farmers have ever received an extension and an offer to implement SR which they did not accept. In addition, farming area of conventional farmers adjoined with SRI farming area and the two areas are separated by a river, so it is easy for conventional farmers to compare their farming practices with SRI farmers.

There were 12 statements asked to conventional farmers in terms of measuring farmers' knowledge about SRI practice. All statements in questionnaire were started by stating "*Farmer knows about….*" For instance, about tillage techniques in SRI, the statement was "*Farmer knows about tillage techniques in SRI*", and so on for the subsequent statements. The percentage of farmers answered "yes" or agree with the statement, according to their self-awareness, was calculated by comparing all agree answers to the amount of statements. For example, there were only 4 conventional farmers who answered "yes" in statement 1 (about tillage techniques). The percentage was accounted 4 divided by 16 (the amount of all 16 statements) = 25%.

The highest percentage when farmers answered about SRI practices was about harvesting techniques in SRI. Subsequently, farmers mostly knew about fertilizer application, especially the organic fertilizer use which came from fermented cattle manure, and grading techniques that in this SRI case, performed by machine in rice mills.

The conventional farmers' knowledge score for raising cattle was also included in medium rate. The score was 2.1250 (Table 4). This occurred because farming area in Dlingo Village was focused on rice production and not in raising cattle so the agricultural extension agent's specialization was on paddy farming system and SRI. Therefore, information about raising cattle was quite less obtained by farmers. Conventional farmers raised cattle mostly based on their experiences and previous experiences inherited by their parents.

Most conventional farmers knew about how to keep cage sanitation and hygiene techniques and it was shown by the highest percentage of farmers answering "yes" on the statement, i.e., 87.5%. The next high percentage of farmers' knowledge about raising cattle was farmers' understanding cattle health (62.5%), followed by farmers' knowledge on cattle estrus period (56,25%) and how to select a good cattle seed (56.25%).

After counseling and discussing among attendants, conventional farmers felt that their knowledge about SRI practice was increasing. Average score of conventional farmers' knowledge was 3.0625 and was grouped in high category. All conventional farmers agreed that the extension and discussion increased their understanding of cultivation techniques in SRI. It was exhibited by 100% farmers answering "agree" with the statement. Meanwhile, increasing knowledge of post-harvest handling (75%) and product selling (75%) was also obtained from most farmers.

Conventional farmers also felt that their knowledge about raising cattle was increasing, but its score was only 2.3750. Because the extension and discussion were focused on cattle manure use for raw material of biogas digester, all farmers felt that their knowledge about the use of cattle manure was increasing significantly. It was shown by the percentage of farmers agree with the statement that reached 100%. The increase of farmer's knowledge of raising techniques also showed a high percentage (87.5%). However, most farmers felt that their knowledge did not increase enough in product selling (18.75%) and processing (35.25%).

Farmers' willingness to obtain biogas value-added had a high response by farmers, shown by the score of 3.0600. Conventional farmers want to nurture cattle with main expectation that the government will support the procurement of cattle. Farmers also want to use cattle manure mainly as organic fertilizer for their land (87.5%), and followed biogas project because a 6 m^3 biogas digester project offered a significant benefit and also there is credit and subsidy provided by BIRU project management which greatly reduced the farmers' burden in paying biogas installation costs. However, farmers still considered that credit offered should be lower or the building biogas costs are reduced.

Table 4. Farmers' self-awareness about their knowledge on SRI practice and raising cattle, and farmers' response to the extension of SRI, raising cattle, and biogas, 2014

No.	Items	Average score and percentage farmers answer "yes" on statements
Before counseling:		
I.	Conventional farmer's knowledge about SRI practices (score)	2,1875
1.	Tillage techniques (%)	25,00
2.	Selecting good seeds (%)	31,25
3.	Seedling (%)	37,50
4.	Planting method and spacing (%)	25,00
5.	Fertilizer application (%)	68,75
6.	Weeding (%)	50,00
7.	Eradicating pest and disease (%)	12,50
8.	Harvesting techniques (%)	93,75
9.	Grading techniques (%)	68,75
10.	Post-harvest handling (%)	56,25
11.	Packaging (%)	31,25
12.	Water management (%)	25,00
II.	Conventional farmer's knowledge about raising cattle (score)	2,1250
1.	Selecting cattle seeds (%)	56,25
2.	Ration techniques (%)	18,75
3.	Cattle disease treatment techniques (%)	12,50
4.	Cattle estrus period (%)	56,25
5.	Natural and artificial insemination techniques (%)	37,50
6.	Cage sanitation and hygiene techniques (%)	87,50
7.	Cattle health (%)	62,50
8.	Cattle products processing techniques (%)	25,00
After counseling:		
III.	Increasing conventional farmer's knowledge about SRI practices (score)	3,0625
1.	In respect of cultivation techniques (%)	100,00
2.	Post-harvest handling (%)	75,00
3.	Product processing (%)	56,25
4.	Product selling (%)	75,00
IV.	Increasing conventional farmer's knowledge about cattle breeding (score)	2,3750
1.	In respect of breeding techniques (%)	87,50
2.	Utilization of cattle manure (%)	100,00
3.	Product processing (%)	31,25
4.	Product selling (%)	18,75
V.	Conventional farmer's willingness to obtain biogas value-added (score)	3,060
1.	The farmer wants to raise cows (%)	93,75
2.	The farmer wants to utilize cattle manure (%)	87,50
3.	The farmer wants to install the biogas digester (%)	87,50
4.	The farmer wants to cultivate worm (%)	31,25

Furthermore, although farmers know from discussion that adding worm cultivation activity into a biogas value chain will increase farmers' benefit, but farmers doubted about worm product market even though officials from Boyolali Regency promised to help them find buyers for buying worm products and support worm processing equipment such as an oven to make worm flour.

The conventional farmers' knowledge about SRI practice and raising cattle was categorized in medium level. After new extension materials was delivered, farmers' showed positive response. Their knowledge about SRI practices was increasing and grouped into high category. Meanwhile, farmers' response to raising cattle increased but fell into medium level category. Furthermore, farmers' willingness to obtain biogas value-added received high positive response except for their willingness to cultivate worm that showed medium level.

CONCLUSION AND RECOMMENDATION

There are three parts in the biogas value chain to show the increase of economic benefits. In the first part, conventional farmer only utilizes cattle manure to receive added benefit. The farmer only receives Rp974,000/year or approximately Rp325,000/paddy season. In the second part, farmer affiliates with BIRU project and receives the added value from implementing biogas. Farmer obtains Rp2.1 million/year or Rp700,000/paddy season. In the third part, farmer installs biogas digester and cultivating worm. Farmer's benefit is Rp5.18 million/year or Rp1.73 million/paddy season.

Conventional farmers give high positive response to the integration of implementing SRI and following biogas project and receiving value-added from installing biogas digester. However, farmers give low response to cultivating worm due to unstable demand and its price volatility. It showed that government support on the procurement of cattle for conventional farmers and intensive extension about raising cattle at the same time implementing biogas will attract conventional farmers to shift their farming practice from conventional to SRI.

To accelerate SRI area expansion by attracting conventional farmers to shift their farming practice from conventional to SRI, the government is recommended to add information about economic benefit of raising cattle and implementing biogas to the extension materials of agricultural extension agents, because traditionally agricultural extension agents focus on delivering cropping techniques. Therefore, agricultural extension agents' capability in counseling about raising cattle and implementing biogas should be improved.

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