Bio-cycle: Implementation of Bio-Industry in Farmers' Level for Sustainable Agriculture Development

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Abstract. Indonesian Ministry of Agriculture in 2013 launched agricultural bio-industry policy for sustainable development, which is targeted in 2045. Bio-industry as the agricultural policy is interesting since bio-industry commonly associated and practiced by giant industry or a multinational corporation. Its contrasts with Indonesian condition, which the farmers only have a small land or even land-less. As a solution, AIAT Central Java developed a bio-cycle approach that accorded to the bio-industry concept and suitable under small farmers’ circumstances. The bio-cycle model was developed from the previous integrated crop-livestock systems approach. The approach was based on the following principles, i.e. (1) reduce biomass loss and external input by using all of the agro biomass as feedstock, (2) reuse residual biomass and processed waste and (3) recycling final products, waste products, and processed products. The bio-cycle approach has been implemented in Central Java Province, both in irrigated and in high land areas since 2015. The implementation of the bio-cycle approach under farmers’ circumstances was promising. Aside from the increasing of farmer’s income and farming efficiency, it is possible to develop sustainable bioenergy in rural areas through the implementation of this approach.

1. Introduction
Indonesia is well known as an agricultural country. However, since the last few years, the agricultural sector has not only been demanded to provide enough food, feed, and fiber but also to supply fuel. As a respond, Indonesian Ministry of Agriculture in 2013 launched agricultural bio-industry policy for sustainable development. This policy is outlined in the document of the Agriculture Development Master Strategy [1]. That document states that sustainable bio-industrial agriculture in the direction of Indonesia's agricultural development in 2045.

Bio-industry is the application of biotechnology in the industry. In its broadest sense, bio-industry is the application of biological techniques and engineering of organisms to make products or modify plants and animals to bring desirable traits [2]. The biotechnology tools include conventional plant breeding, microtissue culture and propagation, molecular breeding or marking selection, genetic engineering, and molecular diagnostic devices [3][4]. In further, the bio-industry term generally refers to a group of companies that produce biological products and run a supporting business. However, most bio-industry is engaged in human health and only around 10 percent focus on plants and animals [5].

Agricultural bio-industry subsequently transforms in the form of restructuring and consolidation. For example, a joint venture between Cargill, Inc. with Monsanto and Renessen, Bunge and Borne, and DuPont de Nemours. At present, there are only a few large companies engaged in the commercialization of transgenic crops as well as research and development activities to produce new products. However, the direction of Indonesia's agricultural policy toward bio-industrial agriculture is interesting since most of the Indonesian agricultural actors are small farmers in rural areas [5].
In the perspective of the Sustainable Bio-Industrial Agriculture System, it is necessary to change fundamental thought, namely: (1) agricultural organisms include all organisms, (2) agriculture is not a disturbance to the ecosystem but an ecosystem engineering, (3) industry agricultural processing must cover all biomass of agricultural products, and (4) the linkages between agriculture and processing industries are not limited through input-output material media, but also through energy media, and circular ecological functions [6]. Moreover, it is believed that bio-culture paradigm being the main key success, namely awareness, enthusiasm, cultural values, and actions (production systems, consumption patterns, and awareness of ecosystem services) to utilize biological resources for human welfare in a harmonious ecosystem [1].

Indonesian Agency for Research and Development (IAARD), Ministry of Agriculture follow up the policies by developing bio-industry models under farmer’s circumstances in 66 location located in 33 provinces. In that case, four bio-industry models located in Central Java Province. Bio-industry models in Central Java Province uses integrated bio-cycle approach, which was developed from the crop-livestock system (CLS) approach.

The concept of intensive mixed farming [7] was not new in some parts of the region. For example, farmers in various tropical and sub-tropical countries have implemented a mixed farming system between plants and livestock [8]. A mixed farming system under one management is seen as the most efficient and sustainable farming system in increasing food production [9].

Mixed farming systems provide intense interaction between crops and livestock due to the mutual relationship and mutual interactions that provide higher profits and productivity, while at the same time conserving resources [10]. In the crop-livestock integration system, agricultural waste is used as animal feed while livestock waste/manure becomes a source of nutrients/fortifier for plants [8]. The integration of plants and crops also reduces irrigation water use and diversifies farmers’ incomes [10].

A more complete picture of the resource cycle use in the crop-livestock integration system (CLS) was proposed by Wolmer (1997) [7] as well as Rota and Sperandini (2010) [11]. There are at least four interrelated components in the CLS integration, namely (a) manure as an important technological component in the initial phase of agricultural intensification, (b) agricultural waste, one of which is a source of animal feed, (c) a source of forage other feed, for example grass and legume which are also important for increasing soil fertility, and (d) livestock as a source of labor.

There are at least eight advantages of the CLS implementation [12], namely: (1) diversifying the use of production resources, (2) reducing risks of farming, (3) efficient use of labor, (4) efficient use of production inputs, (5) reducing chemical and biological energy dependency and other resource inputs, (6) ecological system is more sustainable and does not cause pollution so that it is environmentally friendly, (7) increases output, and is able to develop farmer households in a sustainable manner. In further, the application of integration systems can: (1) reduce erosion, (2) increase crop production and biological activities in the soil, (3) increase land-use intensity and profits, and (4) reduce poverty levels, the occurrence of malnutrition, and preserving the environment [11].

The concept of CLS has been widely applied in Indonesia. One of them is the integration system of paddy-beef cattle. The Ministry of Agriculture in 2002 implemented the Sistem Integrasi Padi Ternak/SIPT (Integration System of Paddy and Livestock). SIPT was developed in irrigated paddy fields in 20 districts in eleven provinces. SIPT was developed to overcome the problem of the decreasing rate of increasing rice productivity [13]. In CLS, livestock’ manure is processed into compost and used as organic fertilizer to increase land fertility. In that case, rice straw was used as cattle feed. Basically, CLS is a zero-waste approach [14], because the input comes from the agricultural system itself.

Livestock waste, in their further development, was used to produce energy (biogas) and the biogas waste (slurry) being used for organic fertilizer [15]. In addition, Basuni et al. (2010) added the use of solid waste of livestock as a worm media, liquid waste for ponds, and encourage straw fermentation processing. Basuni et al. (2010) called the production process of the paddy rice-beef cattle integration system as a closed nutrient cycle [16].

In bio-industry, SIPT was improved into a crop-livestock integrated bio-cycle. Benefit and synergy among business units in SIPT are further developed. The subsystems of the plant business are enhanced by implementing Integrated Crop Management (ICM), which is an approach in managing land, water, plants, plant-disturbing organisms (OPT), and climate in an integrated and sustainable manner.
In bio-cycle, livestock waste (feces and leftover feed) is processed into compost and feedstock of biogas as one of the renewable energy sources [17]. Biogas is used for cooking or converted into electrical energy. Biogas waste (slurry) can be separated into two parts, namely solid and liquid. Slurry solid waste is used as compost, while slurry liquid waste can be processed into liquid fertilizer or flowed into ponds for fish farming. To absorb toxic substances in biogas liquid waste, biofilter can be applied. The biofilter is equipped with activated charcoal. Bio filter also has function as a water purifier.

In bio-cycle, crops’ by-product was used as a feed and culture media. Furthermore, worm cultivation waste is considered as high-quality fertilizer for crops known as vermicomposting. Plant waste can also be used as a mushroom media. Mushroom waste is used as compost to improve the physical and chemical structure of the soil or can be used as an eel media. In addition, plant waste can also be processed into bio-ethanol as a renewable energy source. Liquid waste in the process of making bioethanol can also be processed into liquid fertilizer.

Crops biomass, for example rice husks or corn cobs, can be processed into charcoal. Husk charcoal can be used as a planting medium or applied to improve the physical and chemical structure of the soil. Husk charcoal can also be processed into briquettes or alternative renewable energy for cooking. Smoke rising from the process of making husk charcoal by pyrolysis techniques can be condensed into liquid smoke. This liquid smoke can be used for various purposes, including as a bio-pesticide [18] [19], preservation of foodstuffs [20] [21]. Based on the description, three types bioenergy can be produced from bio-cycle, which is biogas, bioethanol, and briquettes.

Local microorganisms (LOM) are developed in bio-cycle as a decomposer and fermenter in the treatment of waste process into new products. One of LOMs is made from cattle rumen. The rumen is then mixed with other ingredients (rice bran, molasses, and cassava leaves). LOM can be used as a decomposer in composting, making liquid organic fertilizer (liquid urine or slurry), or directly applied as liquid fertilizer. LOM can also be used as a fermenter both for forages and feed concentrate to improve their nutrition contents [22].

Value-added and synergy between business units in bio-cycle is in line with the main principles of bio-industrial agriculture, namely agricultural systems without waste, minimally using production inputs and energy from outside the system, processing biomass and waste into bio-products of high value, environmentally friendly and biorefinery farming systems. The concept of bio-cycle as a part of sustainable agriculture development in farmers’ level in rural areas has been implemented in Sumberejo Village, Ngablak Sub District, Magelang District. The main results of the bio cycle are presented in this paper.

2. Research Method
The development of a bio-industrial model using the bio-cycle approach was carried out from 2016 to 2019. The stages of the assessment activities included:

1. Site selection carried out jointly with the Technical Service, planners and extension agencies of Magelang District,
2. Participatory Rural Appraisal
3. Preparation of detail engineering design and technologies introduction stages carried out based on information on the potential of agricultural resources and existing institutions in the location
4. Implementation and the development of bio-cycle models,
5. Monitoring and evaluation carried out regularly together with all stakeholders

Based on the coordination and selection stages, the location of the development of the bio-cycle model was in the Sumberejo village, Ngablak Sub District, Magelang District. Accord with the location resources and characteristics, the bio cycle approach is part of an effort to integrate cattle business with vegetables. The bio-cycle model development using a participative approach involved all member of “Mutiara Organik” Farmers’ Group, from planning, implementation, and monitoring and evaluation processes.

In the implementation process, the technology component in the existing system was improved with innovations, especially the technology of waste utilization for bioenergy, local microbes using for
composting and fermentation, and developing organic agriculture. In particular, environmental aspects will also be considered in accordance with the character of upland dry lands that are sensitive to land degradation.

![Diagram of Bio-cycle concept as an improvement of the crop-livestock system][1]

**Figure 1.** Bio-cycle concept as an improvement of the crop-livestock system [23]

3. Results and Discussion

3.1. Research Site Description

Sumberejo Village is located in the mountainous area (> 1250 meters above sea level) of Ngablak Sub-district, Magelang District. It has quite a wide dry land area which is around 194.37 hectares [24]. If it is compared to total dry land area in Ngablak sub-district, it is only 4.62%. There are around 1,340 people live in the village [24]. Most people (58.40%) are farmers or have their source of income from farming, and 21.30% of the populations are farm labors. This is quite high compared to the average of farm labors in Ngablak sub-district that is only around 10.20%.
Table 1. The Characteristics of Case Study Area

| Characteristics                  | Sumberejo Village | Ngablak Subdistrict |
|----------------------------------|-------------------|--------------------|
| Elevation (m above sea level)    | 1250              | 1160.3             |
| Slope (%)                        | 30                | 39.7               |
| Dryland Area (Ha)                | 194.37            | 4,204.89           |
| Plantation (%)                   | 86.6              | 72.9               |
| Critical Land/Erosion (ha)       | 20.3              | 939.6              |
| Population (People)              | 1,340             | 29,015             |
| Farmers (%)                      | 58.4              | 80.6               |
| Farm Labor (%)                   | 21.3              | 10.2               |

Source: [24]

Farmers usually plant vegetables and rearing cattle. There are 271 head of dairy cows to produce milk and 265 heads of beef cattle for fattening purposes [24]. If it is compared to the total dairy cows and beef cattle in Ngablak Sub-district, the cattle owned by farmers in the village are only a few or consecutively around 9.65% and 4.53%. However, in term of milk production, the village has quite low productivity. From 271 head of dairy cattle, the village produces 1,092 liters per day or on average around 4.03 liter per head of dairy cow. If it is compared with the average production of milk in Ngablak Sub-district, it is only 37.76%. It should be considered that a dairy cow was new business in Ngablak. It was introduced in 2015 by the government. Ngablak village was previously known as a beef cattle production center. Therefore, the area is potential as milk and beef production centers.

Table 2. Number of Dairy Cows and Beef Cattle owning by Farmers in Sumberejo Village and Ngablak Sub district

|                | Dairy (head) | Milk Production (liter) | Beef Cattle(head) |
|----------------|-------------|------------------------|-------------------|
| Sumberejo Village | 271         | 1,092                  | 265               |
| Ngablak Sub district | 2,809    | 2,892                  | 5,853             |

Source: [24]

There are about 30 vegetable commodities grown by farmers. Limited farmers' formal education is compensated by sufficient vegetable farming experience. In fact, the area of cultivated for vegetables is not too large (averaged 1300 m²). In addition to vegetable farming, some farmers also have vegetable nursery businesses.

Not all land owned by farmers is used for organic vegetable farming. This is due to the lag time to convert non-organic farming land into organic vegetable production land, which is more than 1 year. During the transition period, farmers barely get any results/income from the land. The land must also be certified by an organic institution (for example Lesos and Inafis).

There are two main reasons for farmers to switch to organic vegetable farming. Firstly, is to improve the condition of soil structures that are starting to decline and secondly as a save production costs strategy. The savings in farming production costs can be enjoyed after the transition period ends. Farming costs can be reduced because fertilizers and pesticides can be made by themselves since the raw materials are available in their surrounding environment. Even vegetable seedlings can be made by themselves or bought from their neighborhood so the price can be reduced.

The development of a bio-cycle in Sumberejo Village is also based on the condition that existing vegetable and cattle farming tend to be run independently and have not been optimally integrated as in other vegetable center locations [25]. Another consideration was the presence of blood test results in the Ngablak Sub district which previously showed that pesticide poisoning has occurred in farm families [26][27] which resulted in the deaths of 9 residents in Kanigoro Village, Ngablak District, Magelang in July 2007 [28].

3.2. Description of the bio-cycle model in Sumberejo Village

The concept of bio-cycle in Figure 1 could be implemented both by big or profit-oriented farming scale or in small farmers’ circumstances. However, in practice no small farmer eager to apply all of the
activities presented in the concept due to their limited resources. Farmers apply some parts or units that depended on their needs and resources. Farmers in the highlands, as in Sumberejo Village, focus more on vegetable commodities. They treat cattle as part-time. Conversely, some farmers were focused on livestock business and slightly intense in vegetable farming. In that case, the vegetable farmer is only interested in the unit or activity that supports the vegetable farming, while the beef cattle farmers are only interested in the units that are directly related to the livestock farming.

At the beginning of the activity, the concept of bio cycle (Figure 1) was offered to farmers. They then chose the units or activities that suit the needs and conditions of agricultural resources at the site. Bio-cycle models that are considered suitable for farmers in the site are shown in Figure 2.

Through the implementation of a bio cycle technology, there is a possibility to integrate vegetables and beef cattle farming. By integrating both commodities, farmers can gain quite high benefits and reduce potential risks. Vegetable farming that previously required and used high external inputs, can be reduced along with the technology application. In fact, the chemical residues of fertilizers and pesticides have been poisoned farmers, polluted the environments, and degraded land plantations. Those could have caused low production and productivity in the future. Therefore, the development of organic fertilizer and bio-pesticide, which supports organic farming are strategic. In that case, livestock waste is a potential raw material for organic fertilizer, while on the other hand, the cattle fattening needs high quality of feed. The complete feed technology could be implemented to increase production and productivity of beef cattle farming by using vegetable waste as a feedstock of complete feed.

![Figure 2. Bio-cycle model of vegetable-cattle farming in the upland of Sumberejo Village, Ngablak Sub District, Magelang District [23]](image-url)
The bio cycle model, which integrated vegetables and cattle commodities, combines three components such as biomass, nutrient, and energy cycles. The biomass cycles utilize the waste of vegetables and the feces (dung) and urine of the cattle.

3.3. Local Micro-organism as fermenter and decomposer

The initial step carried out in the bio-cycle was to make Local microorganisms (LOM). LOM is needed to make complete feed fermentation for cattle and decomposers in making liquid and solid organic fertilizer. LOM was made from rumen as the main raw material. Other ingredients were molasses, rice bran, and cassava leaves. In the next occasion, farmers add some other ingredients.

The results of microbiological analysis of the initial LOM and farmers’ LOM aimed for complete fermentation of feed and decomposers in making POC can be seen in Table 1. It can be seen that LOM formulated by the farmer is quite good. The result showed that there are relatively no significant microbiology characteristic differences between LOM formulation from farmer and AIAT Central Java (Table 3).

| Microbe            | AIAT Central Java formulation | LOM for complete feed fermentation | LOM for liquid fertilizers | Farmers’ liquid fertilizers |
|--------------------|------------------------------|-----------------------------------|---------------------------|-----------------------------|
| Cellulolytic       | 7.80 x 10^5                  | 3.55 x 10^4                      | 6.05 x 10^5               | 1.05 x 10^4                 |
| Proteolotics       | 5.50 x 10^3                  | 3.45 x 10^3                      | 1.35 x 10^4               | 6.15 x 10^3                 |
| Amylolyltic        | 1.50 x 10^2                  | 4.60 x 10^2                      | 7.10 x 10^2               | 9.45 x 10^2                 |
| Nitrogen fixation  | 7.83 x 10^3                  | 1.19 x 10^4                      | 4.20 x 10^3               | 4.70 x 10^3                 |
| Total Plate Count (TPC) | 7.36 x 10^6                  | 7.95 x 10^5                      | 1.47 x 10^5               | 7.00 x 10^5                 |

Source: Hermawan et al. (2017)[29]

It is interesting that liquid fertilizer made by farmers also contain quite complete and active microbes. The microbial content of farmers’ fertilizer is also quite high. This shows that the application of liquid fertilizer in vegetables in the field will have a positive impact on the environment. In further development, farmers are encouraged to make liquid fertilizer with certain high nutrient content, i.e. high Nitrogen, Phosphate, and Potassium nutrient content. This is due to the high variety of vegetables cultivated by farmers. Some vegetables are harvested leaves (for example caisim and mustard greens), fruit (tomatoes and chili), or tubers (potatoes and beets). Each particular type of vegetable requires different concentrations nutrient content. The results of nutrient analysis at the intended liquid fertilizer are shown in Table 4.

| Nutrient      | Types of liquid fertilizer | MIX |
|---------------|-----------------------------|-----|
| Macro:        | High N content | High P content | High K content | MIX |
| N total (%)   | 0.48                  | 0.39              | 0.09              | 0.30 |
| P_2O_5 (%)    | 0.04                  | 0.29              | 0.05              | 0.06 |
| K_2O (%)      | 0.33                  | 0.30              | 0.36              | 0.34 |
| Micro:        | High N content | High P content | High K content | MIX |
| Fe (ppm)      | 20.3                  | 67.5              | 43.70             | 8.30 |
| Mn (ppm)      | 5.20                  | 30.5              | 2.90              | 1.70 |
| Ca (%)        | 0.11                  | 0.24              | 0.02              | 0.04 |
| Mg (%)        | 0.06                  | 0.06              | 0.02              | 0.04 |
| Na (%)        | 0.10                  | 0.16              | 0.03              | 0.11 |

Source: [30]
LOM for complete feed fermentation is quite good and can be accepted by farmers. Proximate analysis of complete fermented feed carried out at UGM Laboratory, Yogyakarta. The results are quite promising. Improvement of initial LOM (Moferdec), in the form of adding milk and replacing cassava leaves with Morina leaves (Mofernak RKS) can significantly increase the protein content of feed and slightly increase its fat content.

Table 5. Proximate analysis results of complete fermented feed

| LOM            | Dry matter/DM (%) | Ashes | Crude protein | Crude fat | Coarse fiber |
|----------------|-------------------|-------|---------------|-----------|--------------|
| Moferdec       | 96.08             | 23.77 | 5.54          | 3.13      | 29.87        |
| Mofernak RKS   | 93.85             | 23.70 | 10.24         | 3.37      | 28.50        |

Source: [30]

3.4. Farming Productivity

The productivity of vegetables, both before and after the bio-cycle, could be seen by comparing the output produced per land area used or output per land area used (Table 6). To note that the area of vegetable planting between before and after joining the organic farmer groups actually decreased. This is because not all farmer's land is certified and used to grow organic vegetables. The result (Table 6) showed that the development of organic agriculture increases the productivity of farmers. Increased productivity can be seen from the indicators of the number of crop commodities planted each period, the frequency of harvest per planting period and the productivity of farmers' vegetable harvests.

Table 6. The average number of harvests per period per household in one planting period (69 days)

| Description                          | Before joining the organic farming group | After joining the organic farming group | After joining Bio-cycle |
|--------------------------------------|-----------------------------------------|----------------------------------------|-------------------------|
| Vegetable planting area (m²)         | 1,247                                    | 814                                    | 1,031                   |
| Number of commodities per period     | 2                                        | 3-4                                    | 4                       |
| Harvest frequency per period (times) | 2.0                                      | 3.7                                    | 4.0                     |
| Total production (kg/period)         | 956                                      | 966                                    | 1,245                   |
| Kg / period / mtr²                   | 0.77                                     | 1.19                                   | 1.21                    |

Source:[24]

Before participating in the bio-cycle, in average farmer cultivated 814 square meters of organic vegetables. It yielded 966 kilograms of vegetables per period (69 days) or resulted the productivity of around 1.19 kg/ m². After the bio-cycle, the cultivated land area increases up to 1,031 m² per farmer with the increased production was around 1,245 kg per period. This means the productivity of vegetables due to new technology is 1.21 kg / m2. There is a productivity increase of about 1.68%.

An increase in productivity can also be seen from the increase of organic vegetable productivity of farmers who use technology in accordance with customs and introduction technology. The technology introduced is the compost tea, in the form of cattle/chicken manure that was fermented with LOM. Farmers were asked to practice the new technology and their ordinary practice in their land and compare the growth performance and their yield. Generally, crops’ yield of compost tea as new technologies was better than farmer practice. The compost tea introduction could increase the vegetable yield from 1.35% to 45.64%.
Table 7. Comparison of vegetable production between farmer technology and introduction (grams per plant)

| Farmers’ practice | Compost tea | Increasing (%) |
|-------------------|-------------|----------------|
| Beet              | 88,7        | 93,3           | 5,26           |
| Broccoli          | 349         | 383            | 9,59           |
| Cailan            | 110         | 120            | 8,89           |
| Large Cabbage     | 1,676       | 2,442          | 45,64          |
| Lettuce           | 52.5        | 53.2           | 1,35           |
| Chinese Cabbage   | 403         | 427            | 5,98           |

Source: [29]

The advantages of bio-cycle technology were also known from the fermented Complete Feed test for beef cattle. If previously the average daily weight gain (ADG) of beef cattle with the farmer feeding system reached 0.48 kg, the ADG of the cattle with the complete feed fermentation, reached 0.978 kg by using initial LOM-Moferdec and even reached 1.24 kg with an enhanced LOM (Mofernak RKS). According to microbial content analysis, LOM of Mofernak RKS contains the highest protein degradation microbes.

3.5. Economic feasibility

Bio-cycle increased farmers’ income from vegetable farming. A comparison description of organic and non-organic vegetable farming for broccoli as cultivated by most farmers is shown in Table 8. It can be seen that in general organic vegetable farming of broccoli is more profitable. As an indicator, the B / C ratio of organic broccoli (1.34) is much higher than non-organic farming (0.46), even though all costs have been accounted for.

Table 7. Financial analysis of non-organic and organic broccoli farming (IDR per 500 m²) in Sumberejo Village, Ngablak Sub District, Magelang District, 2018

|                  | Non-organic farming | Organic farming |
|------------------|---------------------|-----------------|
| I. Cost          | 2,893,491           | 2,718,750       |
| - Seed           | 208,259             | 250,000         |
| - Fertilizer     | 1,493,929           | 584,167         |
| - Pesticide/insecticide | 130,946   | -              |
| - Labor          | 1,010,357           | 1,820,000       |
| - Transport/retribution | 50,000     | 64,583         |
| II. Revenue      | 4,215,982           | 6,358,333       |
| III. Benefit     | 1,322,491           | 3,639,583       |
| B/C              | 0,46                | 1,34            |

Source: [30]

Complete fermented feed technology introduced in the bio-cycle model is also quite economically feasible. Table 8 presents both of calculating total cash and non-cash and only calculating cash revenue and expenditures (explicit). Examples of implicit expenditures are family labor, land rent, and manure.

The analysis shows that the application of cattle fattening technology introduced in bio-cycle, the period or duration of fattening can be shortened (from 12 months to 10 months), production costs are reduced, and revenue or profits can be increased. Even if all costs are taken into account, the cattle fattening with farmers' technology that was initially unprofitable (IDR -11,212,556 per head of cattle) becomes profitable (IDR +3,480,233 per head of cattle). Overall, cattle fattening efforts by introducing introduction technology can increase B / C.
Table 8. Financial analysis of beef cattle fattening within Sumberejo Village, Ngablak Sub District, Magelang District, 2018

| Item                                  | Farmers practice | Bio-cycle technology | Note |
|---------------------------------------|------------------|----------------------|------|
| Fattening period (month)              | 13.5             | 11.0                 |      |
| I. Cost (IDR/head)                    |                  |                      |      |
| • Calf                                | 9,250,000        | 8,680,000            | Cash |
| • Electricity                         | 315,000          | 216,000              | Cash |
| • Feed                                |                  |                      |      |
| - Fodder                              | 7,087,500        | 3,300,000            | Non cash |
| - Concentrate                         | 10,287,000       | 5,158,500            | Cash |
| • Depreciation                        | 2,160,556        | 1,065,267            | Cash |
| • Labor (non-cash)                    | 7,200,000        | 3,600,000            | Non cash |
| Total cost (IDR/head)                 | 14,925,056       | 11,819,767           | Cash |
|                                    | 29,212,556       | 18,719,767           | Total* |
| II. Revenue (IDR/head)                | 18,000,000       | 22,200,000           | Cash |
| III. Benefit (IDR/head)               | 3,074,944        | 10,380,233           | Cash |
|                                    | -11,212,556      | 3,480,233            | Total* |
| B/C                                   | 0.21             | 0.88                 | Cash |
|                                    | -0.38            | 0.19                 | Total* |

* Total = Cash + Non cash

Source: [30]

Improved technology will influence production directly and positively [31]. The positive impact of integrated farming and technology introduced to production and productivity is supported by other researches. For instance, study on integrated crop-livestock farming system in Nigeria found that the system could help to restore soil fertility, reduce weed population, increase yields or crop production and livestock productivity or weight gain and milk production, and substantially farmers’ profit [32]. In addition, the study of the integration between cocoa and goat in Kulon Progo District, Special Region of Yogyakarta (DIY) has proved that the integrated farming with bio-industry approach could increase the productivity [33]. In that case the utilization of dunk from goat as POP and POC to substitute inorganic fertilizer has increased cocoa productivity from 317 kg/hectares/year to 508 kg/hectares/year or increased by 60.25% [33].

3.6. Land quality improvement

The implementation of organic agriculture has a positive impact on environmental quality improvement. The results of the soil analysis of farms that are organically and non-organically cultivated (Table 9) show that the quality of organically cultivated land is better than that of non-organically managed lands. Improvement of land and environmental quality can be seen from the levels of C - Organic in the soil, nutrient levels of Nitrogen, Boron, cation exchange capacity (CEC), and availability of NO\textsubscript{3} and NH\textsubscript{4}.

Table 9. Soil analysis of organically and non-organic cultivation farmland in Sumberejo Village, Ngablak Sub District, Magelang District, 2018

|                   | Organic farm land | Non organic farm land |
|-------------------|-------------------|-----------------------|
|                   | 0-20 cm | 20-40 cm | 0-20 cm | 20-40 cm |
| C-Organik (%)     | 3.72     | 3.33     | 2.55     | 2.55     |
| N-Kjeldahl (%)    | 0.49     | 0.42     | 0.36     | 0.36     |
| KTK cmol(+)/kg-l  | 32.61    | 34.69    | 23.89    | 37.05    |
| Boron (ppm)       | 0.87     | 0.78     | 0.46     | 0.47     |
| NO\textsubscript{3} available (ppm) | 45.27 | 45.66 | 27.92 | 26.57 |
| NH\textsubscript{4} available (ppm) | 17.57 | 6.00 | 5.86 | 5.04 |

Source: [29]
3.7. Biogas as renewable energy in the bio cycle

The dung and urine are used as a feedstock for biogas. Biogas is an important component in biocycle. There are two types of digester that were introduced, i.e. fixed dome and portable digester. Fixed dome digester with a capacity of 9.0 m³ suitable for six cattle, while portable digester with a capacity of 5.3 m³ is more appropriate for three cattle [34].

Portable digesters made from polyethylene plastic. This digester was originally designed by AIAT Central Java researchers. In 2008, it was commercialized by private parties (CV. Prima Utama Semarang) [34]. The investment cost of a portable digester is cheaper than a fixed dome digester. The fixed dome investment cost currently around US$ 2,000-2,200 while the price of the portable digester is US$ 1,250. The fixed dome is also needed wider space since this installation consists of three parts, namely the inlet, digester, and outlet. The biogas could be used for cooking, lamp, and electricity. As an illustration, the biogas that was produced by portable digesters is equivalent to 2 liters of kerosene. If the price of kerosene is US$ 0.75 a liter, then one day of biogas saves US$ 1.5 or US$ 45 per month [34].

The potential for biogas development in rural areas is quite high. However, since farmers generally only have 1-3 cows per family, smaller, cheaper, and durable of portable digester development technology are still needed. The high population density in highland rural areas causes the portable digester is more appropriate, as developed in Jordan [35]. In fact, biogas development requires government subsidies or assistance from other parties, as suggested by Vorley et al. (2015) [36].

Sumbererejo Village locates in the highlands. Gas formation of the portable digester in highland is not only slow but the gas production is also low. To overcome the low efficiency, surrounding portable digester was covered with paddy husk, aside of Karimov and Abid (2007) which solved the problem by adding heaters [38].

In biogas, slurry as a by-product can be used directly as plants fertilizer. The relationship between livestock and plants in biogas is the use of slurry to fertilize plants [36]. The problem of transporting slurry to the cropland with tanks [36][39] was constrained by high operational costs since cropland is located far from the road. As a solution, the slurry was separated into two parts, i.e. liquid and solid biomass. Solid waste could be directly used to fertilize plants, while liquid biogas waste was processed into liquid organic fertilizer. Nutrient levels in liquid fertilizer can be increased by adding ingredients from other agricultural wastes and fermentation using LMO.

The waste from vegetables is not only utilized to feed cattle, but could be utilized to produce liquid organic fertilizer, solid organic fertilizer, and bio-pesticide. Therefore, the outputs produced in the biomass cycles will be used as a nutrient for either vegetables or cattle. Liquid and solid fertilizers are used as the substitution of inorganic fertilizer. Meanwhile, biopesticides are used as the substitution of chemical pesticide. This benefited farmers as they will not be exposed with poison again and could produce high value of organic vegetables. The output of the biomass could also use in the energy cycles. The biogas produced could be used as energy for household cooking and water for cattle. As in crop-livestock system, the bio cycle model introduced is expected to produce zero waste.

4. Conclusion

Based on the implementation of the bio-cycle approach in farmer’s circumstances of rural areas in highland, the following conclusion could be drawn. Bio-cycle implementation showed that the approach is suitable under small farmers’ circumstances. The approach was developed from an integrated crop-livestock systems approach and accorded to the bio-industry concept, as an Indonesian sustainable agriculture policy targeted in 2045. However not all units of bio-cycle concept are applied by farmers. The choice of units is determined by the needs and interests of farmers as well as availability of farmers' resources. The implementation of the bio-cycle approach in highland, which was dominated by beef cattle and vegetables, is promising. Through the local microorganism propagation, as fermenter and decomposer, both commodities could be smoothly integrated. The local microorganism was used for complete feed and organic fertilizer processing. Moreover, the implementation of the bio-cycle approach increased both beef cattle and vegetable farming productivity. The technologies implementation in biocycle was economically feasible and resulted higher profit for farmers. It also improves the land quality.
Moreover, the implementation of bio-cycle makes possible to promote biogas as renewable energy in rural areas.

References
[1] Kementan 2014 Strategi Induk Pembangunan Pertanian 2015–2045: Pertanian-Bioindustri Berkelanjutan Solusi Pembangunan Indonesia Masa Depan, 2nd ed. Jakarta: Biro Perencanaan, Sekr, Jenderal, Kementerian Pertanian
[2] Kohler GA 1996 Bioindustry - A Description of California’s Bioindustry and Summary of the Public Issues Affecting Its Development Sacramento, California: California Research Bureau vol 95814
[3] ISAAA 2014 Agricultural Biotechnology ISAAA SEAsiaCenter, Los Baños, Laguna, Philippines, pp. 1–40, 2014.
[4] Zhe L, G Lifeng, and Z Xinghua 2009 Asian Biotechnol. Dev. Rev. 11(2) 29–43
[5] Sasson A 20016 Ciencia y Tecnologia 3(1) 212-220
[6] Simatupang P2015 Reformasi Kebijakan Menuju Transformasi Pembangunan Pertanian, Haryono, Ed. Jakarta: IAARD Press, pp. 61–79.
[7] Wolmer W 1997 “Crop-Livestock Integration: The Dynamics of Intensification in Contrasting Agroecological Zones: A Review,” 63
[8] Van Keulen H and H Schiere 2004 Crop-livestock systems: old wine in new bottles ?,” in “New directions for a diverse planet” Proceedings of the 4th International Crop Science Congress pp 1–12.
[9] Winrock 1992 Assessment of Animal Agriculture in Sub-Saharan Africa Morrilton, Arkansas, USA.
[10] Allen VG, E Segarra and P Brown 2007 Agron. J. 99 346–36
[11] Rota A and S Sperandini 2010 Integrated crop-livestock farming systems IFAD, Rome, Italy, pp. 1–8.
[12] Devendra C 1993 Sustainable Animal Production from Small Farm Systems in South East Asia. Rome: Food and Agriculture Organization of the United Nations.
[13] Priyanti A 2007 Dampak Program Sistem Integrasi Tanaman-Ternak Terhadap Aloka Waktu Kerja, Pendapatan dan Pengeluaran Rumah tangga Petani,” IPB (Bogor Agricultural University: Thesis)
[14] Yuliani D 2014 Crop Livestock Systems Integration to Achieve Food Sovereignty,” J. Agroteknologi, vol. 4, no. 2, pp. 15–26, 2014.
[15] Wahyuni S, ES Harsanti, and D Nursyamisi 2012 Sinar Tani 3451 11–16.
[16] Basuni R and C. Kusmana 2010 Iiptek Tanam. Pangan 5(1) 31–48.
[17] Paramita P, M Shovitri, and ND Kuswytasari 2012 J. SAINS DAN SENI ITIS 1 23–26.
[18] Thomas C 2002 Managing Plant Diseases with Biofungicides,” Vegetable and Small Fruit Gazette, no. November 2002, Virginia, p. 3.
[19] Hayes C 2013 Soil Biofungicides: Soil Biofungicide: Biological Warfare at its Finest,” Gpnmag, no. February, pp. 18–23.
[20] Dewi J, A Gani, and M Nazar 2018, “Analisis Kualitas Asap Cair Tempurung Kelapa dan Ampas Tebu sebagai Bahan Pengawet Alami pada Tahu,” J. IPA dan Pembelajaran IPA, vol. 02, no. 02, pp. 106–112.
[21] Assidiq F, TD Rosahdi, and BV El Vieria 2018 al-Kiyya 5(1) 34–41.
[22] Sudaryanto B, H Kurnianto, and R Nurhayati 2015 Pengembangan Bioindustri di Tingkat Petani, Jakarta: IAARD Press pp. 133–141.
[23] Hermawan A 2019 Konsep, Penerapan, dan Teknologi Aplikatif Pertanian Bioindustri Sapi – Sayuran di Dataran Tinggi. Surakarta: UNS Press.
[24] Hermawan A 2016 Model Bioindustri Berbasis Sapi-Sayuran Dataran Tinggi di Jawa Tengah. Laporan Tahunan Kab. Semarang pp 62.
[25] Adiyoga W, TA Soetiarsro, and M Ameriana 2008 J. Hort. 18(2) 234–248.
[26] Runia YA 2008 Faktor-Faktor yang Berhubungan dengan Keracunan Pestisida Organofosfat,
Karbamat dan Kejadian Anemia pada Petani Hortikultura di Desa Tejosari Kecamatan Ngablak Kabupaten Magelang (Semarang: Universitas Diponegoro)

[27] Prijanto TB, Nurjazuli, and Sulistiyani 2009 *J Kesehat Lingkung Indon* 8(2) 73–78.
[28] Raini M 2007 *Media Litbang Kesehat* 17(3) 10–18.
[29] Hermawan A 2017 *Model Bioindustri Berbasis Sapi-Sayuran Dataran Tinggi Di Jawa Tengah* Laporan Tahunan Kab. Semarang pp 89-92
[30] Hermawan A 2018 *Model Bioindustri Berbasis Sapi-Sayuran Dataran Tinggi di Jawa Tengah.* Laporan Akhir Tahun pp 121-129
[31] Debertin DL 2012 *Agricultural Production Economics* Second Edition N.J (USA: Pearson Education) chapter 6 pp 173–214
[32] Ezeaku IE, BN Mbah, KP Baiyeri and EC Okechukwu 2015 *African J. Agric. Res.*, 10(47) 4268–4274.
[33] Gunawan and C Talib 2016 *WARTAZOA* 26(4) 163–172.
[34] Muryanto, A Hermawan, and Sudadiyono 2015 *Biosiklus Terpadu Padi - Sapi di Lahan Irigasi* Jakarta: IAARD Press pp. 75–90.
[35] Alkhalidi AAT, K Amer, A Nawafleh, and MA Al-safadi 2019 *Recycling* 4(21) 1–10
[36] Vorley B, I Porras, A Amrein, C Rogers, and E Blackmore 2015 *The Indonesia Domestic Biogas Programme: Can carbon financing promote sustainable agriculture?* (London: International Institute for Environment and Development) pp. 35
[37] Karimov KS and M. Abid 2007 *Env. Monit.* 7(12) pp. 1–7
[38] Karimov KS and M. Abid 2012 *IIUM Eng. J.* 13(2)109–119
[39] Haryati T 2006 *WARTAZOA* 16(3) 160–169,