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System Integration of Paddy-Cattle in Wetland Areas of Merauke Regency Papua

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Abstract – **Aside from being a rice development area, Merauke Regency is also a center for beef cattle development. The more intensive the use of land for agriculture, the dependence of livestock feed supply from agricultural byproducts/waste will be greater Commodity of rice and beef cattle is very potential to be developed in Merauke Regency, because in addition to producing main products (rice and meat) also produce side products (straw, bran, manure). The cattle system integration system of paddy-cattle is one of the alternatives in increasing the production of rice, meat, milk, and increasing farmers' income. This study aims to evaluate the utilization of fermented straw fodder for beef cattle and the utilization of compost from livestock for the growth of rice crops. The results of the study indicate that paddy-cattle integration can increase farmer income by 68.42% with 1 ha and 11 cattle planting area. The integration of livestock system of paddy-cattle gives benefits to farmers, because : 1). Agricultural waste (rice straw and rice bran) is available and can be utilized as a source of quality feed through the fermentation process to reduce feed costs, and 2). Waste of livestock that has not been utilized optimally can be utilized as organic fertilizer to improve soil fertility and also as a source of income.**

Keywords – **Crop Livestock Integration System, Feed, Waste, Paddy-Cattle.**

I. Introduction

Merauke Regency is one of the rice plant development areas in Eastern Indonesia, especially in Papua Province. In 2013, rice production reached 177,581 tons, with production growth of 15.89% per year for the last five years (2009-2013), but production decreased 3.21% in the previous year due to decreased rice productivity in farmer level. One of the problems faced by farmers in rice farming is the decrease of wetland productivity due to inorganic fertilizer (chemical) use continuously and limited availability of manure. Similarly, byproducts produced after harvest in the form of rice straw have not been utilized by farmers-farmers optimally. Even rice straw produced by farmers is mostly burned in paddy fields to make it easier to cultivate the land.

Aside from being a rice development area, Merauke Regency is also a center for beef cattle development. In general, beef cattle are widely developed by farmers-breeders are Ongole Peranakan cattle (PO). To date, the development of beef cattle population has reached 33,037 heads, with population growth in the last 5 years (2010-2013) experiencing an average increase of 8.47% per year higher than the growth of beef cattle population National of 4.95% (Directorate General of Livestock and Animal Health, 2015). However, the population growth continues to experience problems, especially in the dry season, farmers are difficult to obtain forage feed, causing beef cattle become thin, followed by high mortality rates. This condition also affects the decrease in the selling price of beef cattle.

In addition, with more intensive land use for agriculture, the dependence of livestock feed supply from agricultural byproducts/wastes will be even greater. Based on these potentials and problems, it is shown that both commodities of rice and beef cattle are very potential to be developed in Merauke Regency, because besides producing main products (rice and meat) also produce byproducts (straw, bran, manure). So the problem is expected to be solved simultaneously through the application of cow-rice integration system. The system of paddy-cattle system integration is one of the alternatives in increasing the production of rice, meat, milk, and increasing farmers' income (Haryanto, et al., 2002). Organic fertilizers are needed to increase rice production, improve soil physical and chemical properties (Syam and Sariubang, 2004), and suppress the use of inorganic fertilizers (Sutardi et al., 2004). Nurawan et al. (2004) stated that organic fertilizer can increase rice yield by 0,9 t/ha compared to without organic fertilizer. Integration pattern of cattle with a crop-livestock system (CLS) is able to guarantee the sustainability of land productivity, by improving the quality and fertility of the soil by continuously giving cattle dung as organic fertilizer so that the fertility of the soil is preserved (Diwyanto and Haryanto, 2003).

The potential of these local resources is not utilized by farmers, either as forages of ruminant feed, especially for beef cattle feed in the dry season or as organic fertilizer for increasing land productivity. This is due to the limited knowledge of farmers about the technology of fermentation of hay and cattle manure processing, and the limited facilities and infrastructure needed by farmers. Rice straw feed is less preferred by livestock because it is not accustomed and low in nutrient content of straw. To optimize the potential utilization of local resources in the system of cow-rice integration should be fermented rice straw before it is given to cattle and livestock manure into compost for paddy rice growth.

This study aims to evaluate the utilization of fermented rice straw as the feed of beef cattle and compost for the growth of rice crops.

II. Methodology

The integration of paddy-cattle assessment was conducted at Marga Mulya Village, Semangga District of Merauke Regency on farmer's land through integration approach involving farmers, extension workers, and researchers. Assessment method of crop-livestock system integration of paddy-cattle is implemented through the application of rice crops processing technology such as straw and rice bran to be used for cattle as feed. While cattle dung is used as a source of organic fertilizer raw materials to improve soil quality in rice fields.

Materials and tools used in the implementation of this assessment are rice seed, adult cattle, feed (rice straw, bran), organic fertilizer (cattle dung), probion/starbio, inorganic fertilizer (NPK Ponska, SP 36), shovels, hoes, sickles, machetes, buckets, digital cattle scales, hanging scales.

The assessment method was designed in two treatment groups: integration pattern and non-integration pattern. Farmer groups that will be involved in addition to owning paddy fields also have cattle. Wetland area and the number of cattle each pattern that is integration pattern 2 ha and 11 tail and non-integration about 2 ha and 9 tail. The applied technology package can be seen in Table 1.

Table 1. Packages of integration pattern technology and non-integration of paddy-cattle

Commodities	Component	Integration pattern	Non integration
Rice	Varieties	Inpari 33	Inpari 33
	Use of seeds	2-3 stems/clumps	Pattern of farmer
	How to plant	Legowo planting distance2 :1	Pattern of farmer
	Fertilization:		
	Inorganic Fertilizer	Urea 100 kg/ha, NPK Ponska 300 kg/ha	Pattern of farmer
	Organic fertilizer	Compost fertilizer 2 t/ha	-
Beef cattle	System maintenance	Group enclosure and livestock health	Existing
	The main feed	Straw fermentation	Grass field
	Additional feed	Concentrate/rice bran	-
	Waste treatment	Rice straw and cattle waste	-

To use livestock manure as organic fertilizer for rice plants and rice straw as beef cattle feed first processed or fermented using probiotics.

CattleManagement Technology

In the pattern of integration, cattle raising is done in group cages equipped with a place to eat while drinking cow water is provided bucket. Soy straw is given as much as 7-8 kg/head/day and rice bran 1.5% of body weight. In the morning cattle are given bran, while fermented rice straw is given in the morning and evening. The remaining feed has given both rice bran and rice straw was weighed.

Livestock is weighed once a month to determine changes in livestock weight, which is calculated by subtracting the final weight by the initial weight divided by the number of days between the two weights. While in the non-integration pattern, livestock is maintained according to the pattern of farmers that is removed or tied in the garden near the house. Feed given also according to the pattern of farmers are also done weighing the livestock every month to determine the changes in body weight.

Rice Cultivation Technology

Integrated crop management is one of rice field management model, with cultivation technology component that gives synergistic, harmonious and complementary effect to get optimal yield and environmental sustainability (Sumarno et al., 2009). This Integrated crop management uses superior varieties (Inpari 33), 2: 1 jarwo planting system, utilizes livestock waste as organic fertilizer 2 ton/ha, and chemical fertilizer based on soil analysis using Rice Field Test Kit and leaf color chart.

Data Analysis

Parameters observed for rice plants include plant height, number of tillers, rice production and rice straw production; while for livestock include livestock weight gain, feed consumption, ration conversion and cow dung production. The collected data were analyzed through a descriptive and technical approach of tabulation.

To measure technological change of farmers to introduction technology was analyzed using Marginal Benefit Cost Ratio (MBCR).

III. Results and Discussion

Data on crop performance, paddy production, and rice straw production are shown in Table 2. Based on the data in Table 2 it is seen that plant height at 30 days after planting (DAP), 45 days after planting (DAP)and 80 days after planting (DAP) in the integration pattern is lower than a non-integration pattern, however, the plant height does not have significant effect on rice productivity because plant growth is an open area so there is no growth of etiolation.

The number of tillers in the integration pattern is higher than non- integration. This is allegedly caused by the integration pattern with 2: 1 jarwo planting system with regular plant spacing although the plant height is lower the formation of more saplings will affect rice productivity. The number of tillers the more likely to produce the number of panicles that many. The legowo row planting system makes all the plants or more plants become peripheral crops so as to obtain more sunlight, better air circulation, and the plants will obtain more nutrients than the way the tiles are planted (Mujisihono et al. in Yunizar et al. 2012). Sunlight is used in the process of photosynthesis, where more sunlight can be absorbed faster the plant photosynthesis process takes place and ultimately accelerate plant growth. The wide spacing on the legowo jajar system allows the plants to grow more freely so that the availability of nutrients can be absorbed more optimally by the plants. The wide spacing will also increase the capture of solar radiation by the plant canopy, thus increasing the growth of plants one of which is the number of productive tillers (Hatta, 2012). Legowo row technology can remind the number of tillers, plant growth simultaneously and easy in maintenance, in addition to high production.

In non-integration pattern with planting system that is dissipated, the density of the plant is very dense so that the plant grows high but the seeds are formed slightly, the distance of plants that are not regular and dense cause only a little sunlight that can be absorbed so that the photosynthesis process does not take good which further affects the growth plant. the number of tillers on 80 days after planting on the pattern of integration and non-integration occurs decrease, this is due to drought disaster so it affects the number of productive tillers. Audebert et al. (2013) state that drought will decrease the number of tillers, changes in rooting patterns and flowering delays.

Tabel 2. Rice productivity in integration pattern and non-integration.

Agronomic performance and productivity	Integration pattern	Non integration
Plant height (cm)		
30 DAP	52.3a	64.0b
45 DAP	73.0a	75.1b
- 80 DAP	80.6a	79.9b
Number of tillers (stem)		
30 DAP	14.9a	8.2b
45 DAP	24.0a	8.7b
80 DAP	14.6a	7.8b
Production (ton/ha)	3.5a	2.8a
Rice straw production (ton/ha)		
Fresh production	11.3a	10.4a
ProductionDM	5.1a	4.7a

The data in Table 2 also shows rice production in the integration pattern with the recommended fertilizer (Urea 100 kg /ha + NPK Ponska 300 kg /ha) plus manure of 2t/ha gives higher yield (3.5 ton /ha) compared to non-integration patterns (2.8 tons /ha). In the non-integration pattern the fertilizer doses given by farmers consist of NPK Phonska 50 kg/ha + Urea 200 kg/ha and SP 36, 100 kg/ha. Higher production is due to the effect of manure whose function is to improve the soil, fertilizer, nutrient source for plants and also as microbial nutrients so that nutrients are available in sufficient quantities. Thus, rooting plants freely absorb nutrients available for growth and productivity of plants. In addition, the addition of organic fertilizer to the soil, which in this case cow manure will improve the soil biological properties of increasing the amount of soil microorganism activity that will support the growth and development of plants (Sutejo, 2002).

In addition, there is a tendency that the more a growing number of tillers the number of panicles is also increasing. This is due to the increasing number of alleys in the legowo row planting system resulting in the intensity of sunlight that reaches the leaf surface, especially on the edge of the aisle thus increasing the efficiency of photosynthesis (Abdullah, 2000). The rate of nutrient uptake by plant roots tends to increase with increasing intensity of sunlight, Fagi and De Datta (1981); Darwis (1982).

However, paddy production is still lower than previous research results reported rice production of Inpara 22 varieties with 2: 1 jarwo planting system with Urea fertilization dose 200 kg /ha + SP36 100 kg /ha + KCL 75 kg /ha reaches 6.75 tons /ha. The low production of rice is caused at the time of the formation of panicles drought caused by the dry season. In the generative phase, there are three stadia that are very susceptible to drought, namely (1) stages of panicle formation, (2) pollination/fertilization, and (3) filling of seeds (Akram et al., 2013). Furthermore, it is said that water shortage in the forming stage of interest will decrease the amount of grain formed or decrease the number of grain per panicle. In stadia pollination /fertilization the lack of water increases the amount of empty grain. This is because the pollen becomes barren so there is no conception. Water shortage in seeding stadia will reduce the weight of 1,000 seeds because the grain is not fully filled or the size of the grain is smaller than normal. If the plants experience drought stress in one of the three stadia then it will certainly result in a decrease in yield. The drought strain occurring in the panicle initiation phase decreases the panicle's length dramatically, but it does not matter if drought stress occurs during anthesis or panicle filling. Drought stress at the time of panicle initiation decreases the dry weight of panicles and the number of grains per panicle, which affects grain yield decline. This is thought to be caused by the decline of photosynthesis thus reducing the assimilation production for panicle growth and grain filling. Djazuli, (2010) states that drought stress not only suppresses growth and yield but also causes the death of plants.

Production of Rice Straw

Production of rice straw in both patterns (Table 2), indicates that the pattern of higher integration of fresh material production and dry matter production (DM) compared to the non-integration pattern. Fresh straw production in 11.3 ton /ha /planting season, with DM production in integration pattern of 5.1 ton /ha (DM 45%). The average consumption of DM fermented rice straw is 5.28 kg /head /day so that each hectare of rice field can be used for 2-3 cows /year of feed. If in one year there are 2 growing seasons it can meet the needs of feed 4-6 tail/year. This is in accordance with the statement of Haryanto et al. (2002), that each hectare of rice field produces fresh straw 12-15 t/ha/season, and after fermentation process yield 5-8 t/ha, which can be used for 2-3 cows/year feed. During this time not many farmers who use rice straw as cattle feed, rice straw is left to accumulate in the rice fields and burned, whereas with the season conditions in Merauke extreme rice straw is very potential to be used as a feed reserve in the dry season.

Feed Consumption

Observations on feed consumption, daily body weight changes and feed conversion are shown in Table 3. At the beginning of the activity, livestock given fermented rice straw was not all consumed because they were not used to it. But on the second day, all the cattle were able to consume rice straw given.

Table 3. Beef cattle production pattern of integration and non integration

Description	Integration pattern	Non integration
- Average initial body weight (kg)	302.1	275.3
- Average final body weight (kg)	336.9	297.9
- Changes in body weight (kg/head/day)	0.39a	0.25b
- Consumption of feed DM (kg/head/day)	8.93	Td

Description	Integration pattern	Non integration
- Fermented rice straw	5.28	Td
- Rice bran	3.64	Td
- Feed convertion	20.9	Td
- Manure production (kg/head/day)		
- Fresh production	10.83	Td
- Production DM	4.89	Td

The data in Table 3 shows that the consumption of DM fermented rice straw is 5.28 kg/head/day, whereas the consumption of bran is 3.64 kg/head/day. Total consumption of DM in this study amounted to 8.93 kg/head/day. When viewed from the needs of DM for PO cattle already meet the needs of the need for DM cattle PO is 8.90 kg/day (NRC, 1984 cit Priarso, 2005). Recommendation of a requirement of DM feed according to Parakkasi (1999), where cow mother and stud with body weight 315 kg with body weight gain 0.2 – 0.4 kg consumption of DM minimum about 6.7 – 7.2 kg/day, hence consumption DM the feed on this study is already above the minimum recommended DM requirement.

The results of this study were lower when compared with the results of the Endrawati (2010) study, which stated that the consumption of dried beans (DM) of PO cows consuming forages and concentrates was 10.95 ± 1.03 kg, but higher when compared with Priarso (2005), that the consumption of PO cow 6.93 ± 1.06 kg /head /day at the farm in Probolinggo.

Nevertheless, the results of this study were higher than those of Hasbullah (2003), which reported that the consumption ofPO cattle at farmer level in Bantul District was 5.31 ± 1.35 kg, low feed intake at farmer level was caused by feed is sober, so that consumed nutrients are also low.

The difference in consumption of feed DM is thought to be caused by consumed feed ingredients, palatability rate and age or body weight of livestock. The consumption of beef cattle ration is affected by body size, environment, and feed conditions and forage consumption correlates with in vivo digestibility of dry matter and organic matter (Minson, 1990). Further explained Davies et al. (1990) that usually high digestibility gives high consumption. Consumption of feed DM is determined by body size, type of ration, age, and condition. The consumption of dry matter rations usually decreases with the increase of the digestible ingredients.

Yudith (2010) adds that the factors that influence feed consumption rate are: 1). Feed factors, including digestibility and palatability, and 2). Livestock factors, which include age, nation, sex and livestock health conditions. Further Parakkasi (1999), explained that the palatability of feed is one of the factors that influence the amount of feed consumption and the ability of livestock to consume the DM contained in the feed and related to the physical capacity of the stomach and the condition of the digestive tract. High low consumption of feed on ruminant livestock is influenced by environmental factors as well as feed ingredients.

Fast slow-motion feed rate in the rumen will affect the consumption of feed. The limited capacity of the gastrointestinal tract almost always suppresses feed consumption, so the incoming feed is always lower than it should be (Church, 1982). Low feed digestion will last longer in the digestive tract so it will slow the feed rate in the rumen and will lead to decreased feed intake.

Changes in Body Weight of Cattle

Data on cow body weight changes are shown in Table 3. Based on the data in Table 3 it is seen that the average daily gain (ADG) cattle in the integration pattern is higher (0.39 kg/head/day) than non-integration (0.25 kg/ head/day). The application of integration pattern was increased by 0.14 kg /day compared to non-integration. This is thought to be due to the pattern of integration of feed consumption (rice bran + fermented rice straw) to meet the need for livestock for nutrients rather than non-integration where the livestock is removed and feed depends only on natural availability. The long dry season in Merauke District has an impact on the availability of forage so that it affects the change of livestock body weight that its maintenance system is released in the garden or infested. This proves that the maintenance of livestock with integration systems with rice plants provides benefits for both livestock and the crop itself. Special District Merauke, with the new paddy field printing program then the land for grazing livestock will be reduced. However, the positive impact is with the wider field of rice fields, rice waste (straw and bran) will be abundant, which is potential for animal feed, especially in the dry season due to limited feed forage. On the other hand, cattle raised in groups /individuals, the waste can be collected and used as organic fertilizer for rice crops so as to minimize production costs.

The increase of body weight in integration pattern during 3 months maintenance was 38.42 kg (11.53%), while non-integration pattern was 22.6 kg (8.19%). The weight of the parent body of cattle on the pattern of integration and non-integration during the observation did not change significantly. In the pattern of ADG integration of cattle ranged from 0.30 to 0.45 kg/head/day while in the non-integration pattern of the ADG only ranged from 0.22 to 0.28 kg/head/day, resulting in an increase of 0.08 to 0.17 kg/tail/day or about 36 - 60%. Although the ADG difference in the integration pattern is relatively small compared to non- integration, the increase is relatively small but it will greatly affect the selling value of livestock, which according to the farmers in the dry season due to the condition of the skinny livestock resulted in the decrease of livestock prices. Feed consumed in both quality and quantity will greatly affect the ADG, although the genetic potential of livestock is good if it is not supported by the availability of feed then the livestock cannot display its genetic potential.

The results of this study are lower than those of Basuni et al. (2010), which reported that intensive cattle management with regard to the feeding aspect (concentrate and fermented rice straw), collective cages and healthcare increased the ADG 0.89 kg /head, while the farmer pattern is only 0.29 kg /head /day. The existence of this difference is thought to be due to the concentrate give is a complete concentrate mixture of nutrient content, while in this study only given bran. However, the core of this study is not only high ADG but how livestock can utilize rice straw that has not been utilized optimally so that in the end can reduce production costs and environmentally friendly because no waste is wasted.

Feed Convertion

Convertion of feed is one of the benchmarks to assess the level of efficiency of ration use on the increase of livestock body weight. The data in Table 4 shows that the feed conversion rate in this study is 20.9. The feed conversion rate obtained in this study is quite high, meaning that to form ADG 1 kg requires more feed so that it can be said that the consumed feed is less efficient. Siregar (2008), stated that the good feed conversion rate for cattle is 8.56 - 13.29. Conversion of feed is influenced by the condition of livestock, digestibility, gender, nation, quality, and quantity of feed and also environmental factors. Campbell et al. (2006) state that the efficiency of feed use is influenced by several factors such as the ability of livestock in digesting feed ingredients, the adequacy of feed substances for basic living, growth, body function and type of feed consumed.

However, the rate of feed conversion obtained in this study is still lower than that of Widyaningrum et al. (2013) who reported the conversion rate of male Balinese cow feed consuming basal feed + supplements (energy source: protein, ratio 30: 70) was 39.9 ± 4.5; but higher than that of Usman et al. (2013), where the conversion of Aceh cattle feed males who consume forage feed and concentrate 4.60 – 9.55. The difference in feed conversion rates is thought to be caused by consumed feed ingredients (quality and quantity), livestock conditions and environmental factors.

Production of Livestock Manure

The average yield of fresh feces obtained from this study was 10.83 kg/head/day, but the production of manure obtained was 4.89 kg/head /day (assuming of DM 45%). So from the maintenance of 11 cows for 3 months will produce manure about 4.84 tons or 4,800 kg. The need for manure is 2 t/ha, so the maintenance of 11 head of cattle for 3 months can meet the requirement of cow manure of 2.4 ha.

Analysis of Cattle-Rice Integration System

The results of the analysis of cattle-paddy farming management in the LembuNdanu Farming Group, Marga Mulya Village, Semangga District are seen in Table 4.

Table 4. Analysis of cattle-beef rice integration

Description	Rice farming (a)	Cattle farming (b)	Rice farming (a + b)
Cost (Rp)	6,025,000	115,166,668	121,191,668
Reception(Rp)	14,000,000	189,109,000	203,109,000
Income(Rp)	7,975,000	73,942,332	81,917,332
R/C			1.7

Total income of integrated farming system (1 ha of rice field + 11 cows) is Rp 81,917,332, - Rp 203,109,000, - and Rp 121,191,668, with R/C ratio 1.7 (Table 4). In addition to additional income, the availability of organic fertilizers can be more assured and the dependence on inorganic fertilizers can be reduced. In addition, livestock also obtains food sources from rice waste so there is environmentally friendly livestock farming system because there is no waste that is wasted (zero waste). According to Priyanti et al. (2001), small-scale crop farming in irrigated rice fields with 0.30-0.64 ha of land management and the average number of cows 2 households can increase the average household income by Rp 852,170/month with business contribution petitions to total household income reached 40%.

Analysis of farmer costs and earnings on integration and non-integration patterns is shown in Table 5. Based on the results of the analysis (Table 5), a cattle-rice integration system can increase R/C revenue and value. The integration pattern is much higher in revenue (Rp 80,999,332,-) than non-integration (Rp 47,680,000,-). Increased farmer income from non-integrated system to system integration amounted to Rp 33,319,332 or about 69.88% with R/C value increased by 12.092%. According to Kusnadi and Prawiradiputra (1996) in Chaniago (2015), integration of livestock and crops can increase income from 14.9-129.4%. It can be said that the pattern of cattle plant integration is feasible to be developed because it can increase farmer's income and reduce production cost compared to farming activities that have been done by farmers.

Table 5. Analysis of farmer costs and revenues on integration and non-integration patterns

No.	Description	Rice farming	Cattle farming
1.	Cost (Rp)	121,191,668	97,620,000
2.	Reception (Rp)	202,191,000	145,300,000
3.	Income(Rp)	80,999,332	47,680,000
	R/C	1.7	1.5
	MBCR	1.4	

The result of cost equilibrium analysis obtained MBCR value 1.4, it means every additional cost in applying technology equal to Rp 1,000, - can increase acceptance Rp 1,400, -. This means that the integrated system of paddy-cattle farming is feasible to be developed on a wider scale. The system of livestock integration in farming is one of the efforts to achieve the optimization of agricultural production. According to Pamungkas and Hartati (2004), the livestock integration system is significantly able to provide added value to farm yields as well as to livestock production. Integrated farming can reduce production costs, especially on the provision of forage, as a source of labor and can contribute to the cost savings of fertilizer.

IV. Conclusion

The farming pattern of cow-rice integration is an efficient and highly relevant farming system with limited land tenure. The integration of cattle-paddy farming can increase farmer's income of Rp 33,319,332 (69.88%) with the scale of 1 ha and 11 cattle. The integration of livestock system of paddy-cattle gives benefits to farmers, because

1). Agricultural waste (rice straw and rice bran) is available and can be utilized as a source of quality feed through the fermentation process to reduce feed costs, and
2). Waste of livestock that has not been utilized optimally can be utilized as organic fertilizer to improve soil fertility and also as a source of income

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