Rice and Coconut for Food Resilience and Environmental Conservation in Indonesia

Lina Warlina and Sri Listyarini
FMIPA, Universitas Terbuka, Tangerang Selatan, Indonesia
Email: {warlina, listyarini}@ecampus.ut.ac.id

***Abstract*—Indonesia is the third largest rice producers in the world with most wetland or irrigated fields. With the large amount of agricultural land conversion, the wetlands are increasingly reduced, especially irrigated rice fields. This can interfere food resilience. On the other hand, Indonesia is known as a coconut country, because it produces coconut. Most of the coconut trees are old, so they are less productive. Regeneration of coconut trees takes 3-4 years to start producing, consequently during that time the coconut farmers are not earning money. With the aim to increase community's income, maintain food stability by taking into account environmental sustainability, a study on rice (paddy) and coconut integration is undertaken. Certain types of rice are planted in the fields and used as inter-cropping plants in coconut plantations. The results of the study concluded that economically the integration of rice-coconut can be more profitable because it will still provide income before the coconut trees produce. In addition, rice cultivation in the fields can maintain environmental sustainability.**

***Index Terms*—coconut, rice, food resilience, inter-cropping, environmental conservation**

I. Introduction

The United States Department of Agriculture (USDA) estimates that the World Rice Production 2017/2018 will be 481.04 million metric tons. From that prediction, the five largest rice producing countries are China, India, Indonesia, Bangladesh and Vietnam. As the world's third rice producing country with 37 million metric tons [1], Indonesia is very dependent on rice. Rice can be regarded as one of the basic food needs, so that the decrease of rice production can affect food resilience.

Currently, the condition of Indonesia's food resilience is getting worse, due to the abundance of agricultural land functions. It is predicted to continue to deteriorate as the population continues to grow in Indonesia. In the future, it is predicted that there will be food scarcity caused by some things such as environmental damage, land conversion, high prices of fossil fuels, climate warming and others.

On various policies of agricultural development, efforts to achieve food resilience are mostly focused on the increasing self sufficiency of food, especially rice. In general, paddy fields undergoing conversion are a land that has high productivity such as in Java. On the contrary, newly opened land has low productivity, because it has several constraints such as physical, chemical, biological, social constraints, institutional, infrastructure and low profit. Thus, some of the newly opened rice fields can not be used optimally, so some switch to other uses, such as oil palm and rubber plantations [2].

Most rice fields in Indonesia (67.5%) consist of wetland or irrigated rice fields [2]. Dependence on irrigated rice is at high risk because of the increasingly narrow fields due to land conversion. To meet the food needs, the utilization of new technology in increasing production and productivity of wetland rice must be accompanied by technical improvement of cultivation by still paying attention to environmental sustainability. One of the solutions to improve the competitiveness of rice products in Indonesia is mechanization [3].

Based on the data at the International Rice Research Institute (IRRI), Indonesia's rice production cost in 2016-2017 is more expensive than the cost paid by farmers in Thailand, Vietnam, India and China [4]. Indonesian farmers need to be taught modern farming, which is effective and efficient.

The factors causing the high production cost in rice farming in Indonesia were related to the use pesticides and irrigation system. The farmers should not stop the common practice of excessive watering of rice fields. Pumping water to rice field cost money. Another cause of the high production cost is the use of chemicals to eradicate pests, rent of land and worker' wages [3], [4].

Rice is the second largest cultivated crop worldwide. The growing of rice is typically labor-intensive and consumes large amounts of water. With water becoming increasingly scarce for agricultural uses, alternative ways to grow rice are being explored to farm this staple food more sustainable. One of these methods being looked into is dry rice cultivation [5].

On the other hand, as an archipelagic country in the tropics, Indonesia produces coconut. Currently, the government through the Directorate of Plantation Ministry of Agriculture is promoting coconut development in Indonesia. The use of superior coconut and the application of the poly cropping system should be applied by farmers.

Based on data from the Asian and Pacific Coconut Community [6], Indonesia is the 13th copra producer in the world. However percentage contribution to National

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Export Earnings of Coconut is less than 1%. This is because the age of coconut trees in Indonesia is generally an old tree. One way of coconut regeneration is by clear-cutting. The problem with the clear-cut method is the income of farmers cut off for 4 - 7 years after the coconut old crops are felled. To prevent the loss of income farmers cultivated inter-cropping plants [7].

Coconut production is mainly coconut fruit that can be made into various products such as copra, oil, palm sugar and other derivative products. Based on Asian and Pacific Coconut Community [6], average export growth of coconut water more than 100% per year, average export growth of virgin coconut oil more than 50% per year and average export growth of coconut sugar more than 20% per year in last five years.

By combining rice plants on dry land, that is coconut land, the development of integrated agriculture of coconut is expected to improve the welfare of farmers and build food resilience of Indonesia and preserve the environment. This paper illustrates the economic calculations of this integrated agriculture and its environmental sustainability studies.

II. Materials and Methods

This study was conducted in the first semester of 2017, and the data used were obtained from Kompas [4] and [2]. The data are processed through the Focused Group Discussion (FGD) involving agricultural, economic, and environmental experts which then analyzed using simple statistic by excelling.

Year			Work activity	Need	Unit	Price per Unit	Sub Total	TOTAL
I	1		PLANTING					
		a	planting spacing					
		b	.....					
	2		MAINTENANCE					
		a	fertilization					
		b	.....					
	3		LAND TRAETMENT					Rp -
		a	ZA / Urea fertilizer					
		b	.....					
	4		PROCUREMENT OF TOOLS					
		a	sprayer					
		b	.....					
II	1		MAINTENANCE					
		a	fertilization					
		b	.....					
	2		LAND TRAETMENT					Rp -
		a	KCl					
		b	.....					
III	1		MAINTENANCE					
		a	fertilization					
		b	.....					
	2		LAND TRAETMENT					Rp -
		a	fungicide					
		b	.....					
IV etc	1		MAINTENANCE					
		a	fertilization					
		b	.....					
	2		LAND TRAETMENT					Rp -
		a	ZA / Urea fertilizer					
		b	.....					
	3		HARVEST					
TOTAL COST								Rp -

Figure 1. The example of cash flow calculation

Based on FGD, the type of rice used is a type of superior seedlings that can grow on dry land, that is the type of "Inpago". While the type of the coconut tree is a seed of type "Kelapa Genjah" and "Kelapa Dalam".

In the first step, the calculation of production costs for each type of rice "Inpago", "Kepala Genjah" and "Kelapa Dalam". In "Kelapa Genjah" harvested is sap that comes from the coconut flower, while the "Kelapa Dalam", which is harvested is the fruit. The unit price is based on the prevailing market price.

In FGD, we also calculate the cash flow of each type of coconut per year. During the first year, calculations are considered in planting, procurement tools, maintenance, and land treatment. In the next year, maintains and land treatment aspects are calculated. Start from fourth year, the harvest cost also considered, such as in Fig. 1. After that, we calculate the revenue, cost and profit or loss. As well as for rice "Inpago". Next is the calculation for integration between rice and coconut.

III. Results and Discussion

The first phase of this research is to calculate economically the cost of production of Inpago rice as shown in Fig. 2.

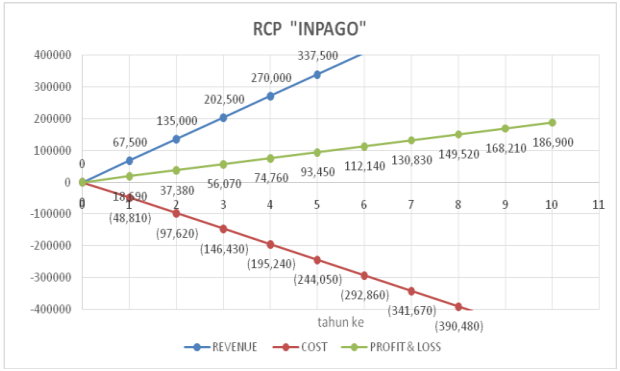

Figure 2. The RCP of "Inpago" rice

Fig. 2 shows graphs for revenue (R), cost (C) and profit or lost (P). Based on Fig. 1, profit of rice field, increase regularly. Every year, rice fields can be harvested 3 times. In the fifth year generated a profit of Rp.93.450.000,-.

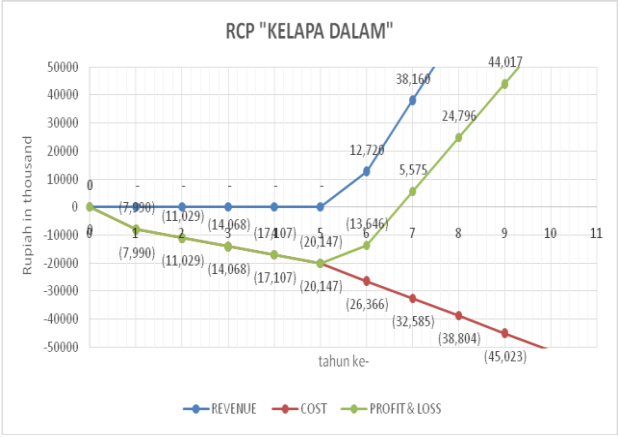

Figure 3. The RCP of "Kelapa Dalam" Coconut

Furthermore, it is calculated economically for a coconut type of "Kelapa Genjah" and "Kelapa Dalam". If the land is only planted with coconut type of "Kelapa Dalam", the result as in Fig. 3.

For the first year by the fifth year, there is no profit generated, because the coconut plant has not been produced. After the fifth year, the plant begins to produce, so there is profit generated, and increasing every year. Similarly, for the type of coconut "Kelapa Genjah" as in Fig. 4.

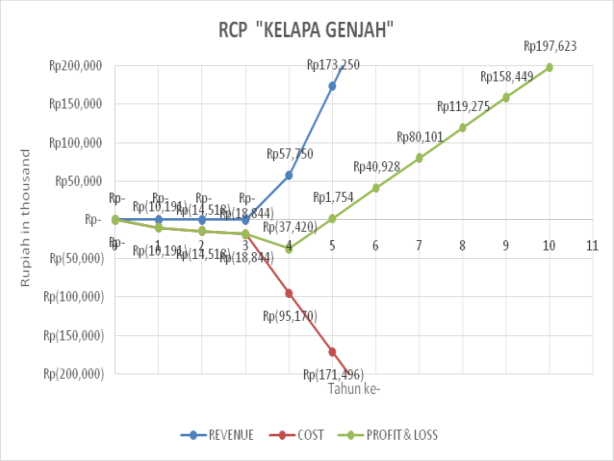

Figure 4. The RCP of "Kelapa Genjah" coconut

The difference between the RCP of "Kelapa Dalam" and "Kelapa Genjah" is the length of begin production. In "Kelapa Genjah" production begin on the fifth year, because the production comes from coconut flower, but "Kelapa Dalam" begins production in the sixth year due to production for coconut fruit.

The next step is studied for integration between rice and coconut. The economic calculation can be seen in Fig. 5 and Fig. 6.

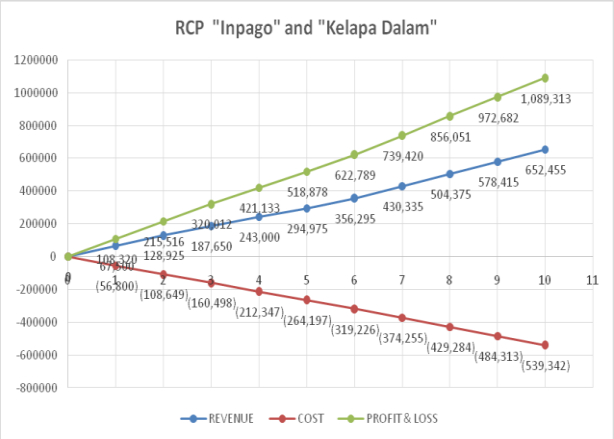

Figure 5. The RCP of "Inpago" and "Kelapa Dalam"

In Fig. 5 and Fig. 6, for "Inpago" rice with "Kelapa Dalam" and "Kelapa Genjah", there is an increase in profit from the first year until the 10th year. Although both types of coconut are superior coconut type, but the integration with "Kelapa Genjah" is more profitable than with "Kelapa Dalam". This is because "Kelapa Genjah" has been able to produce in the fifth year, while the new "Kelapa Dalam" in the 6th year [7]. "Kelapa Genjah" is a new type of coconut and the new varieties, the tree is shorter so for the level of security, "Kelapa Genjah" is harvested before the production of the fruit, which is the flower to be used as sap [7].

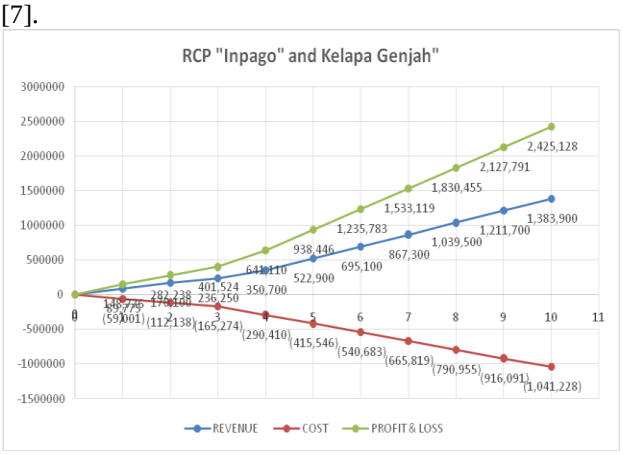

Figure 6. The RCP of "Inpago" and "Kelapa Genjah"

When examined the profit lost for "Inpago-Kelapa Dalam" and "Inpago-Kelapa Genjah" as in Fig. 7 and Fig. 8.

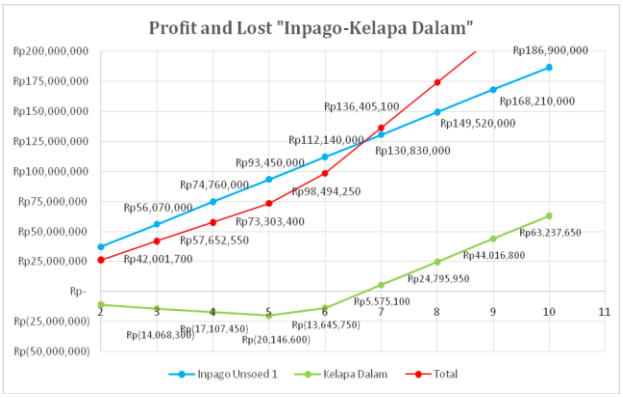

Figure 7. The Profit and Lost of "Inpago-Kelapa Dalam"

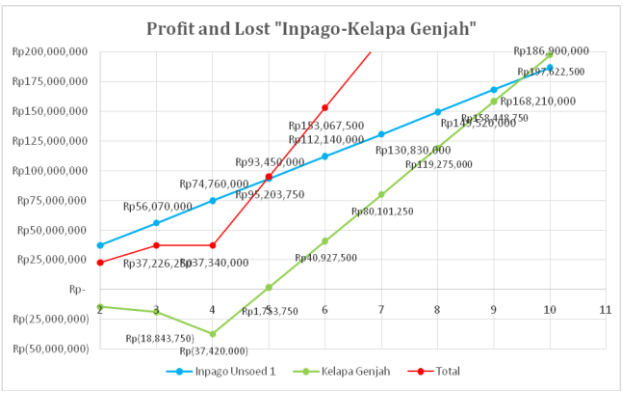

Figure 8. The Profit and Lost of "Inpago-Kelapa Genjah"

Based on Fig. 7 and Fig. 8, the profit of "Inpago-Kelapa Genjah" is bigger than "Inpago-Kelapa Dalam". The profit of Rp. 200,000,000 on the "Inpago-Kelapa Genjah" is obtained in the seventh year, whereas in "Inpago-Kelapa Dalam" in the ninth year. Increase in profits on "Inpago-Kelapa Genjah" is very significant after fourth year.

Economically, rice-coconut integration is very profitable. Old coconut trees should be regenerated. Regeneration of coconut can be done by a gradual cutting method or clear-cut method. With the inter-cropping plant, which is rice, can help increase the income of the community around the coconut plantation, because the farmers get the production of rice before the coconut trees produce.

When analyzed from the environmental side, this rice-coconut integration can preserve the environment. The change of wetland from wetland to dry land can provide several advantages, such as water supply, greenhouse gas reduction and soil health.

In wet paddy fields, irrigation is needed very much, whereas on dry land can save more water resources. If after rice harvest is followed by coconut that is more resistant to dry, so the productivity of land increase and farmer income also increase.

The intensive application of an intensive rice planting pattern of Inpago, can function as vegetative conservation of soil. Direct contact of rain water physically with the soil surface will be reduced because stuck by leaves and twigs of plants. Further, percolation of water through plant roots will increase, so that the surface flow is reduced and soil erosion can be minimized [8].

Based on research conducted by the Indonesian Center for Rice Research, Ministry of Agriculture [8], the benefits of inter-cropping crops are a) labor for planting preparation and maintenance of staple crops is reduced, b) the fertilizer residues given to the crops cultivated can be exploited by the staple crop, c) the addition of organic material from waste or food crop waste, d) better standing staple crops, e) reducing looting, f). free livestock grazing may be reduced (livestock needs to be grounded so as not to damage crops grown and livestock raising becomes more intense), and g) organic fertilizer can be used as an inorganic fertilizer substitution or as a source of other opinion when it is sold.

There is research by Chapagain *et al.* [9] about wet and dry irrigation of rice farming. This field experiment confirms that alternate wet and dry irrigation (AWDI) is a promising method in irrigated rice cultivation with benefits on water saving and maintaining the productivity comparable to conventional flood irrigation. The increased productivity of water and its resource saving aspects are likely to be the critical factors that will make farmers and other stakeholders adopt AWDI in water-scarce areas. However, it is difficult to draw general conclusions as AWDI methods adopted in a certain area may not transfer to other areas because of variability in topography, soil, and climatic conditions across the rice agro-ecological domains.

In another research [10], alternate wet and dry irrigation could be an option for reducing greenhouse gases (GHG) emissions and increasing irrigation water productivity. When the rice yield and greenhouse gas emissions were considered together, the wet and the dry irrigation system allowed for lower yield-scaled total global warming potential (GWP). It can happen, because methane (CH_4) is the dominant greenhouse gas that produced in irrigated paddy rice fields, contributing approximately 15-20% of annual global CH_4 emissions. Flooded soils generate anaerobic conditions favoring the production of as an end product from organic matter degradation. Water management is one of the most important tools for achieving high levels of production as well as a promising option for the mitigation of CH_4.

Based on the studies that have been done related to rice and dry fields, it can be concluded that in addition to economically profitable, dry fields can also preserve the environment. Especially with the integration of the coconut-rice plant.

This result is reinforced by research related coconut that conducted by Karunakaran [11], which states that coconut cultivation is highly beneficial. The average return per hectare of coconut indicated inverse relation to the size of the farm. Estimating cost and return of coconut cultivation in terms of various investment criteria revealed that this crop is profitable. The study also revealed that profitability of coconut is inversely related to the size of farm.

Besides that, Prades *et al.* [12] did the research on prospects the coconut sector. The market growth of coconut products is exponential, mainly coconut water extracted from mature or immature nuts, virgin coconut oil (VCO) cold pressed from the fresh kernel, and coconut sugar taken from the sap flowing out of the flower. This research is in accordance with the research that has been done, that is for "Kelapa Dalam" the production is fruit, while the "Kelapa Genjah" is coconut sugar.

IV. Conclusions

The results of the analysis suggest that inter-cropping rice-coconuts are economically profitable, so as to further improve the welfare of the people and ultimately increase food resilience. This is due to the planting or regeneration of new coconut will produce after 5 years, but with the inter-cropping of rice, then every 4 months the land can produce. In addition, these inter-cropping can further conserve the environment, because the use of limited water resources, can reduce greenhouse gases and soil nutrient resistance.

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Lina Warlina was born on January 7, 1961 in Padang Panjang, West Sumatra, Indonesia. She received her Bachelor in Chemistry from University of Indonesia in 1985. Her Master degree in Education from Simon Fraser University, Canada in 1990 and her Doctor in Environmental Science from Bogor Agriculture University, Indonesia in 2009.

She is currently a lecturer at Faculty of Mathematic and Natural Sciences in Indonesian Open University (Universitas Terbuka). He has served for 32 years in Universitas Terbuka. Her fields of specialization include environmental modeling and simulations. She has journal publications in Journal of Chemica Pharmatica Research, International Journal of Environmental Science and Development, Air Pollution XXIII, Jurnal Matematik, Sains, dan Teknologi, and Jurnal Organisasi dan Manajemen.

Sri Listyarini was born on April 7, 1961 in Jakarta, Indonesia. She received Bachelor in Chemistry from the Faculty of Mathematics and Natural Sciences - University of Indonesia in 1985 and Master in Management of Distance Education from the Faculty of Education – Simon Fraser University – Vancouver, Canada in 1990. She received her Doctor in Management of Environmental and Natural Resources, from Bogor Agriculture University, Indonesia in 2009. She has served for 30 years in Indonesia Open University (Universitas Terbuka) as a lecturer in the Faculty of Mathematics and Natural Sciences. Her fields of specialization include environmental and ecological system modeling and simulations, especially air pollution modeling and simulations. She has journal publication in Der Pharma Chemica, The Sustainable City, and Jurnal Matematika, Sains, dan Teknologi.