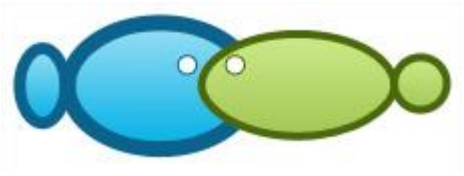

Waste management of rice husk and paddy field snails (*Pila ampullacea*) for alternative feed in fish farming: a case study in Karawang Regency, Indonesia

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Abstract. Rice mills in the Karawang Regency confront with the issue of insufficient storage space for rice husk obtained from rice production, exposing communities to a series of problems. On the other hand, the abundance of rice snails (*Pila ampullacea*) provokes disturbances in rice production. The absence of effective waste management of rice husks and paddy field snails causes losses for the community. The study aimed to analyze rice husk waste and paddy field snails damage to provide recommendations for utilization in aquaculture development. The results showed that the problem of accumulating rice husks and an abundance of paddy field snails was caused by the limited space for storing waste and the absence of effective waste management for both. An optimal management strategy for handling waste from rice husks and paddy field snails was processing them into fish feed. The nutritional composition of rice husks and paddy field snails was considered suitable for fish feed needs and were more economical than factory feed. The effectiveness of waste management of rice husks and paddy field snails can be encouraged through the role of Village-Owned Enterprises and support from related stakeholders through the implementation of co-management principles.
Key Words: DPSIR, pest control, zero waste.

Introduction. Karawang Regency is a region with high potential in Indonesia for the development of aquaculture. Based on BPS (2020a) data, aquaculture's potential area in the region in 2019 was of 25,500.58 ha, with production reaching 44,478 tonnes. The number of households involved in the aquaculture business reaches 8,049 households.

The enormous potential of aquaculture in the Karawang Regency requires the support of cultivation facilities and infrastructure, especially the availability of fish feed in sufficient quantities by utilizing local resources. One of the potential sources of fish feed to be developed in this area is fish feed resulted from the processing of rice husk waste mixed with paddy field snails (*Pila ampullacea*). This product is an innovation that is developing among local stakeholders, which is expected to encourage rural communities' economies while providing solutions to sustainability problems.

The husk is a waste that comes from processing paddy into rice, and it is often not used, while the amount is abundant (Moraes et al 2014; Padkho 2012). So far, husks have been widely used, among others, as a soil medium for vegetable crops (Baiyeri et al 2019), organic fertilizers (Angka & Herdiana 2019), energy materials (Quilang et al 2019), building materials (Abidin at al 2018). Meanwhile, paddy field snails are utilized as a raw material in food production (Sudaryati & Aji 2014; Paramartha et al 2019), poultry feed (Rondonuwu et al 2018; Kusmayadi et al 2019) and building materials (Putra et al 2019; Bakri 2009). Paddy field snails are considered an agricultural pest in rice production. Pest control generally uses pesticides that contain chemicals. The use of paddy field snails as an ingredient to make fish feed can be an alternative solution in controlling damages to paddy production and to achieve environmental balance. The combination of rice husks and paddy field snails, based on research that has been carried out, did not occur in any previous studies reported. The study purposed to analyze the

problem of rice husk waste and paddy field snails to provide recommendations for the use of both to support the development of the aquaculture sector.

Material and Method

Study time and location. The study was conducted for three months, from September to November 2020. The research location was in Sukamerta Village, Rawamerta Subdistrict, Karawang Regency, Indonesia. The area of the village is of 4.23 km^2, or 8.59% of the area of Rawamerta Subdistrict. In 2019, the village population was of 5,661 people, or 10.80% of the total population of Rawamerta Subdistrict, with a total of 2076 households. The population density reached 1,338.30 people per km^2 (BPS 2020b). The total rice field area in the village is of 300 ha or 70.92% of the village grounds. The number of rice business households is of 975 households, or nearly 50% of the total households in Sukamerta Village (BPS 2020b). The total area of potential for aquaculture in Rawamerta Subdistrict is of 84.70 ha, consisting of 29.50 ha in the form of ponds and 55.20 ha in the form of rice-fish farming systems (BPS 2020c).

Data collection. The data collected in the study consisted of primary data and secondary data. Primary data is represented by problems related to the production of rice husk and paddy field snails, and recommended management of both to be utilized as an alternative feed for fish farming. It was obtained through observation and interviews with relevant stakeholders. Besides, secondary data include the nutritional content of rice husks and paddy field snails, regional conditions, and fisheries statistics. Secondary data was sourced from the Central Bureau of Statistics and various other relevant references.

Analysis. The study generally used descriptive analysis. Furthermore, the production problems of rice husk and paddy field snails were analyzed using the Drive-Pressures-State-Responses-Impact (DPSIR) framework adopted from Baldwin et al (2016), as presented in Figure 1. The framework provides simple steps in dissecting the problem based on limited data, elaborating the causal relationships, and grouping them into five categories (Majorošová 2016; Cooper 2013; Semeoshenkova et al 2016; Martin et al 2018).

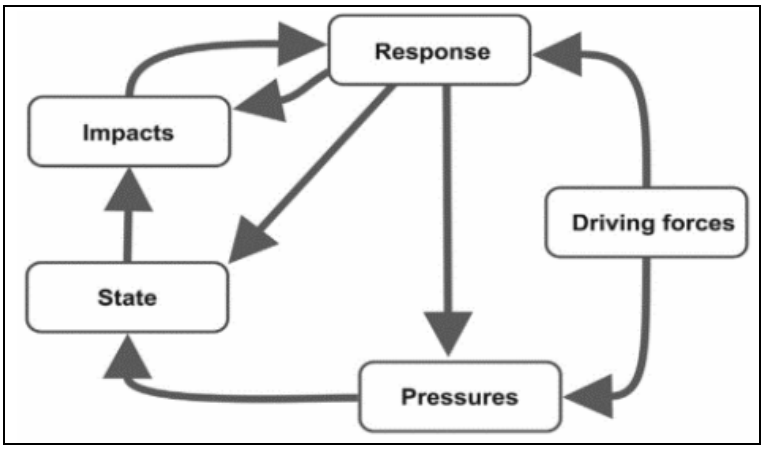

Figure 1. Schematic of DPSIR framework according to Baldwin et al (2016).

Results and Discussion

Rice husk production problems. The DPSIR analysis results of the problem of rice husk waste is shown in Figure 2. The general problem faced by the people of Sukamerta Village, that play a role as a driver, was the decrease in demand for rice husk waste for other uses. In the past, rice husk waste was mostly used as an energy source (combustible materials) to support the production of building materials, namely of bricks. In dealing with rice husk waste, rice mills did not require the cost of pulling or moving rice husks to another place. The mills can even earn income from the sale of the waste.

Transportation of rice husk waste is costly, and the rice mills support these costs. The decline in brick production is thought to be due to building materials use changing from bricks to lightweight bricks (Autoclaved Aerated Concrete). The decline in brick production resulted in a decrease in demand for rice husk waste as combustible material for brick production.

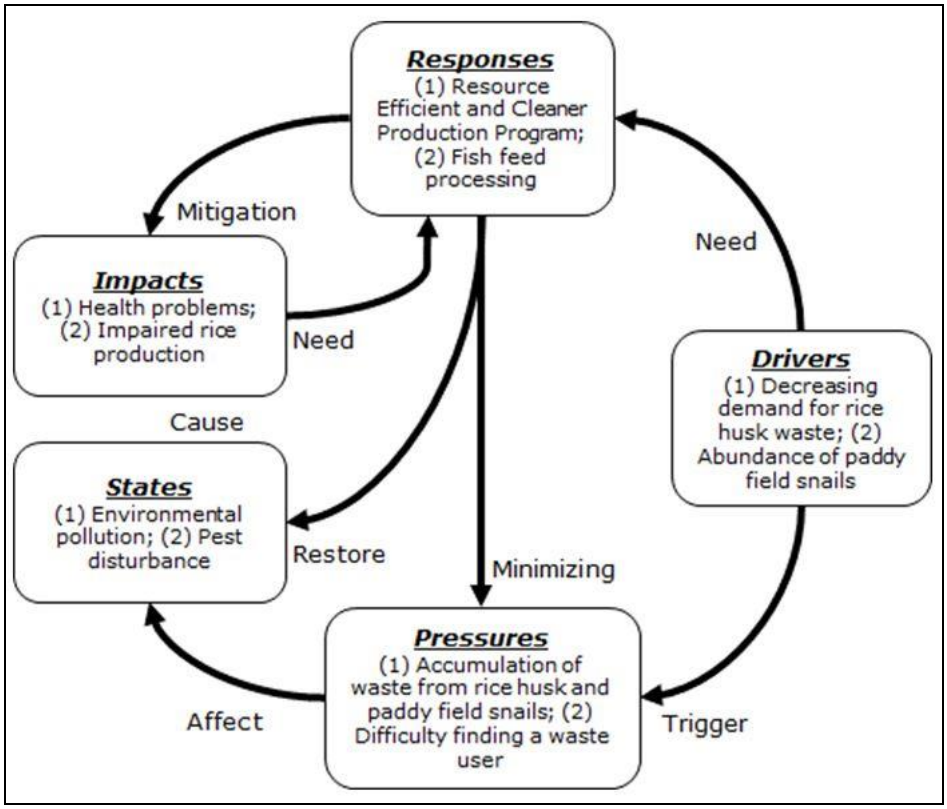

Figure 2. DPSIR framework for the problem of rice husks and paddy field snails.

In 2020, the amount of rice husk production in this village reached 1,200 tons/year. The amount was included in the large category if rice husks' storage capacity was limited, and the waste was not managed adequately (Figure 3). The limited space for storing rice husk waste, which was exacerbated by the difficulty of the rice mill in finding parties who used the waste (pressures), was an environmental problem in the village (states), so it was quite disturbing to people's lives, primarily related to health problems (impact). Based on public information, the excessive increase in rice husk waste could cause polluted and dusty residential environmental conditions and cause skin illnesses for people living around rice mills.

The government's response to addressing rice husk waste was to facilitate the Resource Efficient Cleaner Production (RECP) program. The program was the result of the collaboration between the Ministry of Environment and Forestry (KLHK), the United Nations Industrial Development Organization (UNIDO), and the United Nations Environment Program (UNEP) to increase economic work through the use of productive resources, as well as to provide environmental and social protection in the region. However, until now, the implementation of this program has not seen any real action.

Figure 3. Accumulation of rice husk waste in Sukamerta Village, Rawamerta Subdistrict.

Meanwhile, observations results showed that the abundance of paddy snails (*Pila ampullacea*) in paddy fields was also detrimental to the community because it had become a pest for rice production (Figure 4). Paddy field snails were often brought to paddy fields to reduce pest disturbances to paddy plants. Paddy field snails harvest amounts to 60 tons per year in the region. Based on the results of reference studies, rice husks and paddy field snails' chemical content can be developed as alternative fish feed ingredients (Table 1). The idea of making this alternative feed could be a solution to overcome the problem of expensive factory-made fish feed. According to Bidayani (2016), the cost of purchasing feed in the aquaculture business has the most considerable proportion of costs, which is about 70% of the total operational costs. Using waste from rice husks and paddy field snails, processing these materials is one form of implementing the zero waste component in the blue economy concept (Pauli 2010; Quilang et al 2019).

Figure 4.Catch of paddy field snails (Pila ampullacea)

Environmental sustainable management, in general, is not only related to problems in the application of science and technology but dealing with various aspects, including social problems (Eris 2009). The utilization of waste processing products from rice husks and paddy field snails requires support from various village stakeholders.

Table 1

The chemical content of rice husks and paddy snails
(*Ismail & Waliuddin 1996; **Risjad 1996)

*Rice husk**		*Paddy field snails **	
Compound	*%*	*Compound*	*%*
Cellulose	50	Protein	11.8
Lignin	25-30	Fat	2.4
Silica	15-20	Water	80
		Ash content	5.8

Management potential. Based on the preliminary study, rice husk waste and paddy field snails processing to be used as fish feed could be developed. The financial analysis results of making alternative feed from rice husks and paddy field snails, as seen in Table 2, showed that the cost of production and product prices per kilograms was only IDR 8,480 and IDR 10,000. The price was lower than the manufactured feed commonly used by the community in fish farming, especially in rearing catfish (between IDR 13,000 - IDR 25,000 per kilogram). The price of this product would be even lower if it were produced on a large scale. Also, the market potential for fish feed was very promising, considering the potential area for aquaculture development in the Karawang regency was very large. Not to mention if it could be distributed to aquaculture development areas in nearby regencies, such as Subang, Purwakarta, and Bekasi Regencies.

Table 2

Calculation of the cost of goods sold and the price of alternative feed products from waste rice husks and paddy field snails on an experimental scale

Description	*Amount*	*Unit*
The total cost of using raw materials (a)	258,000	IDR
Total direct labor costs (b)	100,000	IDR
Total factory overhead costs (c)	490,000	IDR
Total production costs (d) = (a) + (b) + (c)	848,000	IDR
Working in process of the early period (e)	-	IDR
Working in process of the current period (f)	848,000	IDR
Working in process at the end period	-	IDR
Cost of goods manufactured (h) = (f) + (e) – (g)	848,000	IDR
Initial inventory (i)	-	IDR
Ending inventory (j)	-	IDR
Cost of goods sold (k) = (h) + (i) – (j)	848,000	IDR
Total production in the current period (l)	100	Unit/kgs
Gross profit margin (m)	152,000	IDR
Cost of goods sold per unit (n) = (k) / (l)	8,480	IDR
Product price per unit (o) = ((k) + (m)) / (l)	10,000	IDR

Conclusions. The limited space for storing waste caused the problems of accumulating rice husk from rice production, the abundance of paddy field snails (*Pila ampullacea*), and the absence of effective waste management, is causing losses to the community. The study offers optimal management solutions in utilizing them by processing them into fish feed. The nutritional composition of rice husks and paddy field snails was considered suitable for fish feed needs and were more economical than factory feed. However, further research is needed on the composition of ingredients and processing methods that allow the feed to increase fish weight optimally. The effectiveness of rice husk and paddy field snails waste management can be encouraged through increasing the role of Village Owned Enterprises (Bumdes) and local role models. In addition, training and mentoring programs can be implemented through collaboration between the Rural Community Empowerment Office, the Agriculture Office, the Fisheries Office, the Environmental and Hygiene Office, and universities based on co-management principles.

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Conflict of Interest. The authors declare no conflict of interest.

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