Developing Green Feed Toward Environment Sustainability in Freshwater Aquaculture in Indonesia

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Abstract: - Environment performance is critical in freshwater aquaculture subject to fish diet formulation due to its negative impacts such as waters eutrophication and water quality. Problem on the water quality is not only impact on the fish growth itself but also will impact on the aquaculture business sustainability. Sustainability of fresh water aquaculture mainly relates to its environment performance subject to various resource management. Freshwater aquaculturist face a challenge to manage such resources to achieve their competitive advantage. The Resource-Based View (RBV) theory highlight on the firm ability to achieve their competitive advantage which dynamic capability is one of the main concern. The intensive freshwater aquaculture relied on feed as the primary factor to increase fish growth and production mainly. The feed might contribute 20 -30% waste in environment. The objective of this study is to identify in what extend green feed technology can support the environment sustainability. This study use combination of field data experimental result and semi structure interview to the fish farmers and fish agents. Developing green feed is one of the solution to gain environment sustainability. Various commercial diets have been fed on freshwater cultured fishes using both cages and ponds. As the results, low digestible diet and wasted diet has increased N and P in water, which will decline water quality at certain level. It is recommended to formulate green feed using low P and high digestible ingredients as well as any supplement material, which could increase diet digestibility. Minimize waste possible done through increasing feeding efficiency and use multiple cages, polyculture, aquaponics system in ponds, and alternative fish by-product in the diet. Technology to support the environment sustainability can be implemented by arranging the C-N ratio of the water, which will raise production of both bioflocs and bio-films. Stocking multi species different food web is recommended.

Keywords: Green Feed, Environment, Sustainability, Freshwater, Aquaculture

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1 Introduction

Freshwater aquaculture is one of the fastest growing food production sectors in Indonesia. However, most research on the freshwater aquaculture have more concern on technic- biological issues than socio- economic and institutional ones. Indeed, such activity must face great economic, social and environmental challenges. Relate to the sustainable development goals program, there has been a growing interest in the sustainability of the activity, in its economic, environmental and social dimensions. In terms of sustainability, hence aquaculture sector has much to contribute to the achievement of the Sustainable Development Goals (SDGs) and the SDGs are relevant to aquaculture development [1]-[2].

In practice, environmental sustainability becomes a question of selecting the best alternatives among different practices and procedures. The aquaculture farmers face various solutions with different environmental consequences. The best technologies are expected being able to reduce the environmental footprint which will impact on the increasing productivity [3]. Hence, various industry groups, companies, organizations, and government institutions have developed sets of good management practices that aid in making such choices. Additionally, "green label" programs sometimes balance the cost of more expensive management practices by providing price premiums or access to specialty markets for aquaculture products raised under social and environmentally responsible practices.

Despite the contribution of fresh aquaculture production systems as to food and nutrition best provider for people, as well as to develop the national economy, however, an unsustainable expansion of the industry might pose a significant threat to the global environment. Issue such as the trash fish, that are needed to feed in the farmed fish industries [4] [5] might be the most source of environmental problem in the freshwater aquaculture industry.

Fish contains high nutrient required by human for maintain their health and welfare. The Government of Indonesia encourages the people to consume fish as high as possible. In 2019, human fish consumption value achieved at 54.4 kg per capita. Aquaculture produces fish increasingly by a year for supplying human demand. It is because of availability good quality of seed, commercial diet, good water quality and fish health management. There is a tendency that the attention to how to provide healthful food from fish from aquaculture is greater than the sustainable management of aquatic resources [6]. The aquaculture activities generate waste to water environment. It is therefore, environmental management is becoming more important as the emphasis on the environmental protection. The impact of this aquaculture waste on environment sustainability becomes a public concern [7] [8]. The waste of aquaculture comes from faces and wasted diet. In the meanwhile, diet is a significantly factor to increase of production of aquaculture. Therefore, feed is a major element in realizing the ambitions of the aquaculture industry and at the same time, threatens in reducing quality of water resources [9].

In intensive freshwater aquaculture systems relying on high quality of diet for increasing fish growth instead [10] [11] [12], feed is also the major source of waste [13] [8] [14] [15] [16] [17]. The effect of wasted diet from aquaculture varies. It depends on nutrient composition, method of feed production (extruded vs pelleted), ratio of feed size to fish, quantity of feed per unit time, feeding method, and storage time [18] [17].

Study on the green feed technology which impact to the environment sustainability is limited. There is a need to have integration research between field experimental design for fish with the social research perspective as the basis of exploration study.

This study covers a broad spectrum of reviews and original research contributions in the topic of environment sustainability of freshwater aquaculture, with a particular emphasis on the environmental interactions of aquaculture activities toward its sustainability. The study aimed to understand in what extent of the green feed practice within the freshwater aquaculture in Indonesia toward environment sustainability. This study also provides an overview of the environmental impacts of production and the sustainability that it is subject to the green fed development point of view. This aims to be useful to aquaculture producers and companies to improve the competitiveness and sustainability of their activity and thus improve their well-being. It also aims to provide a snapshot of the current state of knowledge and the latest advances and practices in this area to policy makers and other stakeholders to promote the governance and sustainability of aquaculture.

2 Literature Review

2.1 Returns Resource Based View Theory

The performance of the enterprise within a particular industry might not be determined by the external environment, but internal factors. This is the essence of the theory of RBV which used as the ground theory of this study toward environmental sustainability in the freshwater aquaculture. The RBV stated that a business's performance is dependent on internal resources and capabilities [19] or practices of the firm or business. The RBV is a model that sees resources as key to superior firm performance.

The RBV model explains that it is significant to accept and fulfil external or new opportunities using existing resources innovatively. There are two types of assets in the RBV model namely, tangible and intangible assets. The tangible assets are the physical resources of the firm that are quantifiable. The tangible asset in freshwater aquaculture includes products, machinery, equipment, capital, infrastructure, etc. They can be easily acquired by competitors in identical assets and offer a less competitive advantage in the long run. Hence, concerning on green feed product as one of the material resources will impact to long term aquaculture sustainability in particular for the environmental sustainability pillar.

2.2 Environmental Sustainability

Sustainability is most often defined as meeting the needs of the present without compromising the ability of future generations to meet theirs. It has three main pillars: economic, environmental, and social. Sustainability and environmental issues are among the most pressing concerns and environmentally conscious business organizations to

promote organizational sustainability, specifically for the emerging economies [20] [21] [22]. Environmental issues mostly refer to the main category of environmental impact with emphasis on materials (including water), energy, or pollution namely emissions and toxic waste. Some popular programs developed for environmentally conscious practices are started from design for product namely eco design, environment, total quality environmental management, up to an establishment of a green product concept. Eco-design refers to environmental design of a product and /or a process [23]. It focuses on reducing or preventing the environmental effects of a product before it is produced, distributed and used. Eco-design is an approach to product design that makes special consideration of the environmental impact of the product during its entire life cycle.

According to the Food and Agriculture Organization (FAO) of Conduct for Responsible Fisheries Art.9, aquaculture is sustainable when management, fish farms locations and use of natural resources-with their social implications and institutional orientation - ensure economic viability, social equity and acceptable impacts to the environment. Significant threats to marine resources, coastal resources, and the global environment can occur if there is an unsustainable expansion of the aquaculture industry [6]. Therefore, it is a challenge to find fish feed's protein ingredients with the lowest environmental impact [24].

2.3 Green Product

A green product is one which satisfies consumers' needs without damaging the environment and contributes towards a more sustainable world. Green products can be defined as products that use less resources, have lower impacts and risks to the environment as well as prevent waste generation already at the conception stage [25]. This definition emphasizes the importance of designing products as 'green' since the conceptualization phase. Those products that are manufactured from the industry through the green technology and caused no environmental hazards are called "Green Products" [26]. Green products also can be stated as products that do not harm or pollute the environment as well as low carbon dioxide production. Green product can be distinguished based on their main environmental focus, respectively as green products focused on materials, energy, and pollution [27].

Green aquafeed product development is one of the strategies to reduce the diet waste from aquaculture. There are currently various voluntary instruments that can help freshwater aquaculture in the fishery industry to improve the environmental performance of their product and fish production processes, such as eco-design, or to encourage the purchase of products that are environmental-friendly in order to produce green product of fish feed. Freshwater aquaculture in Indonesia has been applying green product of the fish feed in particular for the small medium aqua culturists.

2.4 Aquaculture Feed Wastes

Mostly, both solid wastes and dissolved is produced from freshwater aquaculture activities. Solid wastes originates from uneaten diet and faecal of cultured fish. These solid wastes will clog fish gills and lead to death, especially for large settled particles [13]. In a properly managed aquaculture producing highly feed efficiency, the solid wastes of feed will be produced at an approximately 30 percent [28] [29]. Dissolved wastes are products of diet metabolism in fish or decomposed, uneaten diet. The dissolved wastes contain two major components of nitrogen (N) and phosphorus (P) [16]. This N and P are unable utilized by fish, but primarily component of the feed, and therefore, will lead to a high potential for environmental pollution from aquaculture [30] [17]. These nutrients enter to the systems and are eventually released into the environment as a waste [31].

The management of feed is the primary solution for managing the environmental impacts of aquaculture [8] [32]. Proper management of the inputs into the culture system to effectively reduce wastes of aquaculture can be approached using feed and feeding systems. About 20% reduction in environmental impact from aquaculture system could be performed by reducing feed conversion ratio value in a fish farm at least 30% [33].

3 Methods

This study conducted based on mixed method approach. The quantitative study is based on secondary data of various fish feed experimental study subject to the characteristics presented by the multiple case studies of freshwater aquaculture. The aim of this quantitative study is to analyse green feed technology to find the best feed fish formulation which less toxic to the environment despite the good growth of fish itself. Which feed ingredients need to be less consume for the fish feed and which material need to be replace in order to deliver good fish production without harming the surrounding ecosystem relate to the environment.

The result of this data is used as the basis to conduct an explorative-oriented qualitative method involving semi-structured interviews. The aim of this qualitative study is to examine in more detail how is the best practice of green feed technology implemented by freshwater aquacultures.

This method is used because the content is contemporary [34]. Semi-structured in-depth interviews were conducted to examine respondent experiences with sustainability strategies and practices. Other's data are gathered from various multiple forms of data, such as semi structured face to face interviews, observations, documents such as annual reports, news, official reports, research publication. This type of qualitative research is necessary because the topic is new and the subject has never been discussed with a specific sample or group of people, and the existing theory does not apply to the particular sample or group studied [35].

3.1. Secondary Data Collection

Secondary data collection is gathered from multiple fresh water aquaculture type such as fish cage, fishponds with various fish species production namely catfish and tilapia. The location of data collection is represented from potential freshwater aquaculture lands in some provinces in Indonesia such as Java, Sumatera and Kalimantan.

Semi structure interview is conducted with fish farmers and extension agents' representative respondents at various types of fish cultured. In a range of 3 to 10 respondents was required for phenomenology research [36]. The semi hearing was done at each type of freshwater aquaculture. Each informal interview lasted for about 10 minutes. The result of semi structured interview, then was compiled. Table 1 presented the list of freshwater aquaculture type used as interviewees in this study.

Table 1. Freshwater aquaculture types used in the study

Fish Species	**Fish Cages**	**Fish Ponds**
Clarias gariephinus	Fish Farmer 1a	Extension agent 1b
Pangasionodon hypopthalmus	Fish Farmer 2a	Extension agent 2b
Oreochromis niloticus	Fish Farmer 3a	Extension agent 3b

4 Results and Discussion

4.1 Results

Freshwater fish farmers (cages, ponds) raising catfish (patin catfish - Pangasionodon hypopthamus and catfish- Clarias gariepinus), common carp (Cyprinus carpio) and Tilapia (Oreochromis niloticus) realized that (a) their fish production play an important role in supplying fish for human consumption, (b) fish culture requires green water environment and feed, (c) fish culture wasted organic material in term of wasted feed and feces. Fish farmers used feed efficiency as indicator of feed quality (Table 2). The feed efficiency formula is calculated by : Feed efficiency (%) = fish wet weight gain x 100 / feed intake (dry matter). The more high feed efficiency, the more good quality of feed, the less organic waste of fish culture in water. Organic waste of fish culture being into the water environment and at certain levels will decline water quality. Annual fish death, particularly in cage placed in lake, and/or man made lake due to water upwelling bringing organic material from water bottom was observ.

Table 2. Feed efficiency (%) in various fishes raised in various captives and fed on various commercial diets

Fish species	Cage	Ponds	Concrate pond	Peatsoil pond
Catfish-lele (*C. gariepinus*)	-	100,00	100,00	100,00
Catfish - Patin (*P. hypopthamus*)	71,43		-	66,67
Common carp (*C. carpio*)	71,43	66,67	-	-
Tilapia (*O. niloticus*)	71,43	66,67	-	-

Feed contains complete and balanced nutrition required by fish. Wasted feed and feces are into waters and decomposed by microorganism to form total Nitrogen (N) and phosphorus (P). P is an important element in preparation of nucleic acids and cell membranes. Fish must obtain P from their diet because concentration of phosphate in natural waters is low. P deficiency results poor growth, poor feed effciency, and bone mineralization. Balanced and completed diet will increase feed efficiency and reduce waste, less N and P released in waters. Water pollution from freshwater aquaculture activities mostly due to using bad quality of feed. N and P are often as important nutrients for eutrophication in natural water. Table 3 shows composition of crude protein, N and P in various commercial feeds. Releasing N and P from diet depend on water stability of diet and immersion time of wasted feed and faces as well.

Table 3. Crude protein, total N and P of various commercial diet used in freshwater aquaculture

	Commercial Feed								
Feed Composistion	1	2	3	4	5	6	7	8	9
Crude protein (%)	26.00	26.40	26.40	27.32	27.35	28.25	28.33	29.13	29.46
Total N (%)	4.16	4.23	4.23	4.37	4.38	4.52	4.53	4.66	4.71
Phosphorus (%)	2.47	2.08	1.38	2.82	2.62	5.18	2.75	3.32	2.99

Fish farmers stated that about 20%-30% of total diet fed on cultured fish wasted in water bodies. In cage culture, this wasted diet was re-utilized using double or triple cages stocked with different fish species to reduce organic material waste in waters. In ponds, reducing wasted feed using polyculture system, and aqua-phonic system were observed. In catfish culture, probiotic was applied to maintain water quality in good condition. Increasing feed efficiency of commercial diet was done using supplementing micronutrient such as glutamine [37] and fermenting diet with commercial microbe (bacteria and/or fungi) [38] [39] to increase feed digestibility. Table 4 described detail condition of the environment performance based on both farmers and research extension observation. Despite the lowest environment performance on cages type, however, it still can be improved subject to green feed development.

Table 4. Environment performance in freshwater aquaculture

Performance	**Cage**	**Ponds**	**Concrete Pond**	**Peat-soil Pond**
Uneaten feed	many	Some	Few	Many
Feces	Low	Moderate	Low	Moderate
Water transparency	High	Moderate	Moderate	Moderate
Eutrophication level	High	Moderate	Non	High

4.2 Discussion

4.2.1 Environment Performance of Fish Green Feed

Waste of freshwater aquaculture activities should be concerned because of the main factor affecting on environmental sustainability subject to sustainability of aquaculture business. This relates to use feed intensively contributing in large number of organic wastes in term of wasted feed and fish feces. Those organic wastes play significantly role in eutrophication of natural water particularly water bodies such as lake and reservoirs used for setting cage culture. The eutrophication of natural waters relates to release Nitrogen (N) and phosphorus (P) in water. Feed particularly having bad quality is the main sources of N and P. According to Boyd (1982), N and P are an important nutrient in water needed in primary productivity. Over concentration of both nutrients in water bodies results in increasing water fertility. In freshwater, P is limiting factor and orthophosphate is its form being ready to be used by aquatic plants. Over supply of P from wasted feed and feces in natural water trigger algae blooming. This situation causes drop of dissolved oxygen concentration and increasing free carbon dioxide and ammonia-Nitrogen in water. Declining water quality in water body results in annual fish death in a mass. It is therefore, green water environment in freshwater aquaculture is absolutely needed.

The green water environment is an effort to guarantee that aquatic organisms live conveniently both wild organisms and cultured fish. In fresh water aquaculture, fish growth, production and productivity is the main targeted. Completed and balanced feed is a primary input production process. Fish farmers have already well known a feed quality that use feed efficiency as an indicator. Good quality of feed results in high feed efficiency and in other hand, bad quality of feed results in low feed efficiency. In practice, many qualities of feeds are used in fresh water aquaculture. It depends on price of the feed. Increasing feed price such observed in field causes fish farmers to use low quality of feed because the feed cost contributes up to 70% of total production cost. The low feed quality brings to decline water quality. This is not in line with green water environment concepts.

4.2.2 Green Feed Practice

Fish farmers have been conducting an effort of increasing feed efficiency in freshwater aquaculture. Reducing wasted diet in natural water using double and/or triple cages is observed. Different fish species was stocked in each layer cage. Wasted feed in the first cage layer will be fed on fish in the second cage, and so on. This will optimize the feed utilization and only feces will expel in natural water. Effort of greening water environment in eutrophic with restocking herbivorous fish species water bodies has been done.

Habitat destruction, water pollution, and ecological degradation are forms of environmental degradation caused by the freshwater aquaculture industry. Eutrophication, as a process that is caused by the excessive input of nutrients such as phosphorus and nitrogen, has been widely recognizing as a severe threat to the environment as well [40] [41]. It negatively affects water quality and eventually leads to ecological damage [41]. Therefore, effective green feed management strategies are urgently needed to minimize the environmental impacts of freshwater aquaculture and to ensure maximal contribution to environment sustainability.

Biofloc technology has been gaining popularity as an efficient alternative water management system [42] [43] [44] [45]. This technique is one of the green feed technology management implementation as it combines the removal of nutrients from water with the production of microbial biomass. Earlier studied has revealed that biofloc was used by the culture species in situ as feed supplements [46] [47].

Another green feed development to reduce water pollution can be implemented based on the earlier concept and practice of integrated multi-trophic aquaculture. Multi-trophic aquaculture is based on the concept that waste from one species, such as uneaten feed, faeces, and metabolic excretion, is useful for the growth of other species, thus forming a natural self-cleansing mechanism [48]. There are countries such as the Philippines, Malaysia, Vietnam, China, and Thailand, have been successfully incorporated this practice by culturing fish species in combination with seaweed to increase economic benefits and reduce negative environmental impacts from aquaculture activities [49] [50].

Based on the above effort for green feed development, it can be said that as sustainability focuses on future for which present utilization of resources is necessary, hence, a good environmental performance goes as an investment for future [51]. This is because in operational activities components cover all aspects of sustainability, taking into account materials such as raw materials, semi-finished products, end products, by-products, emissions and wastes, processes and finally technology aspects [52].

4.2.3 The Extent of Green Feed Practice

Based on the observation and interview with both fish farmers and the extension agents. Implementation of green feed practice for the freshwater aquaculture in Indonesia is in progress. Majority of the small medium scale of fresh water aquacultures have been socialized to use the new feed formulation.

In addition to the environment sustainability effort, thus it provides some support of the RBV that internal capabilities or practices improve business performance. The ability to quickly respond to reduce waste and negative environmental impacts can be an example of a dynamic capability effort.

5 Conclusion

Developing green feed is needed by the freshwater aquacultures toward environment sustainability which will impact to the fish production. In summary, the green feed practice within the freshwater aquaculture in Indonesia indicates that there is a need to further develops green feed practices, as it will affect the sustainability of environmental in line with the aquaculture sustainability goal. Green feed is one of the tools toward environment sustainability in freshwater aquaculture in Indonesia.

Green water environment should be achieved by formulating a diet with low Phosphorus (P) and increasing feed digestibility using micronutrient supplementation and fermentation, and re-utilizing wasted feed and faeces as well in nature water with applying a technology of polyculture, biofloc, and integrated multi trophic aquaculture. Finally it can be explained that the freshwater aquaculture producers might use its internal resources to renew their capabilities and expertise in order to reduce annual fish waste rate or CO_2 emissions from production environment toward environmental sustainability.

Hence, it can be concluded that freshwater aquaculture industry in Indonesia is has a tendency toward fulfilment the green feed development.

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