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Integrated Multi-Trophic Aquaculture (IMTA) as a solution for shrimp aquaculture side effects on Northern Coast of Java, Indonesia

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ABSTRACT

Along the northern coast of Java, Indonesia, shrimp aquaculture has been one of the main sources of income for coastal communities. Considering its benefits, not only does these aquaculture activity invite stakeholders to establish large-scale aquacultures, but it also triggers local people to set up family-scale aquaculture on their house yards. This practice, however, gradually aggravates the environmental and ecological aspects of the coast as there is no significant environmental impact assessment either by the players or by the municipality. Meanwhile, Integrated Multi-Trophic Aquaculture (IMTA) has been suggested to be able to overcome environmental and ecological side effects of aquaculture activities. In addition, IMTA can be beneficial for local people as the use of lower trophic organisms, such as mussels and seaweed in this method can be a source of livelihood. Pursuant to these facts, the implementation of IMTA is crucial for the environment, ecology and economic states of aquaculture in the northern coast of Java.

Keywords: Integrated Multi-trophic Aquaculture (IMTA); shrimp aquaculture; environmental

BACKGROUND

Environmental issues

There have been many reports suggesting that aquaculture activities, particularly shrimp farming, have exacerbated water quality of the northern coast of Java, from Banten to East Java Province. Research conducted by Hidayat (1), for instance, suggested that the water quality of the coast in Central Java is somewhat polluted. There were also other similar studies proving that regions such as Karawang, Subang, Gresik, Semarang, Rembang, Tuban, Cirebon, Indramayu, Cilacap, Sukabumi, etc., have been found to be polluted as a result of this aquaculture activity (Aliah, 2013; Handiani et al, 2017; Sachoemar, and Yanagi. 2001; Kawaroe at al, 2001; Bappeda Subang, 2010; Vatria, 2010; Rudianto, 2014; Wulandari et al, 2014; Nurhajarini et al, 2017; Ekosafitri et al, 2017). Even though anthropogenic wastes were also considered polluting the coast, shrimp farming and other aquaculture-related activities were found to contribute the most on degrading the environmental state of the coast as the organic waste from the aquaculture sites was directly expelled to the ocean without pre-treatment (Deptan, 1994; Ongkosono, 1990; Ongkosono, 1992; Praseno, 1995; Nurdjana, 1997; Rudianto, 2012).

The organic waste originated from shrimp farming not only elevates ammonia, carbon dioxide (CO_2), hydrogen sulfide (H_2S), nitrite, nitrate, phosphorous, turbidity and sediments in the coast, but it also suppresses dissolved oxygen (DO) and sunlight penetration which are essential for life-supporting factors for aquatic organisms (Hidayat, 2018; Handiani et al, 2017; Vatria, 2010; Rudianto, 2014; Wulandari et al, 2014; Suwarsih et al, 2016;, Suadi, 2007; Radiarta, et al, 2011; Muslim, et al, 2004). Despite its deteriorating effect on the coast, the authority seems to be hands-off toward these aquaculture activities, considering its contributions to coastal community income as well as Gross Domestic Product (GDP) of the municipality (Sachoemar, and Yanagi. 2001; Ismayani, 2017; KKP, 2013). Indeed, the complexity of regulation will somewhat deter stakeholders and local players to continue these businesses, thus enforcing them with the so-called complex regulation is somehow not the best approach to choose.

Ecological issues

Shrimp farming is also suggested to aggravate the ecological state of the coast. The expansion of shrimp farming along the northern coast of Java has enforced mangrove forest logging (Handiani et al, 2017). In West Java alone, more than 60% of mangrove forest was destructed for the sake of establishing these aquaculture businesses (KKP, 2013). Consequently, numerous species of aquatic organisms no longer have supporting ecosystems, as the destruction of mangrove foresta eliminates their habitat (Muhammad et al, 2017). The fact that shrimp farming activity results in ecosystem degradation are obvious from Banten to East Java Province.

The coral reef is another ecosystem that is affected by massive sedimentation of organic wastes originated from this aquaculture activity (Vatria, 2010; Suadi, 2007). While in East Java, the destruction of coral reef reaches 60%, there are around 33% and 20% of destructed coral reef found in West Java and Banten Province, respectively (KKP, 2013). Seagrass ecosystems are also damaged owing to organic wastes causing high turbidity and interfering sunlight penetration to the coast (Suadi, 2007; BPLHD, 2008). As reported by Handiani et al. (2017) last year, there was a completely no longer seagrass ecosystem in Subang, and they assumed that it was due to anthropogenic activity, particularly shrimp farming and other aquaculture related activities. The organic wastes from shrimp farming deteriorate the ecosystem balance in the coast as the carrying capacity of the coast cannot cope with the huge amount of organic compounds (Aliah, 2013; EKosafitri et al, 2017; Rudianto, 2012). One species that is affected is *Perinereis* sp. This Polychaeta is commonly utilized by shrimp farmers as the main food source for their bloodstock (Wibowo, 2018). However, over the years, shrimp farming activity results in unfavorable water quality conditions for this Polychaeta to reproduce, thus making the shrimp farmers try to obtain the species from other cleaner areas and consequently increasing the production cost (Handiani et al, 2017; Wibowo, 2018).

Economic issues

In fact, organic waste from shrimp farming is also directly related to shrimp production as well as catches by fishermen. For example, in Karawang, the production of shrimp has been declining from 4 tons/ha to only less than 1 ton/ha for a decade as a result of unsustainable management of environmental impact assessment toward the aquaculture practice (Aliah, 2013; 30). Poor water quality from the coast that is used for production introduces various diseases and is unfavorable for optimum growth for the shrimp that eventually leads to the decline in production (Aliah, 2013; Widigdo and Sumardi, 1999). In addition, the continuously ecological degradation will eventually inflict a financial loss on local communities. The ecological degradation results in dwindling numbers of catches on the coast, thus making fishermen struggle to go more forward toward the ocean to get more catches (Rudianto, 2014; BPLHD, 2008; Redjeki, 2013; Triarso, 2004; Darmawan and Masduqi, 2014).

Previous measures

Considering this having detrimental impacts on environmental, ecological and economical states, many recommend the need for recovering water quality in the northern coast of Java. For instance, the idea of mangrove integration with shrimp farming has been introduced to balance the impact of shrimp farming on environmental as well as the ecological state of the coast (Rochana, 2010; Indrayanti et al, 2014). The mangrove forest is a life-supporting ecosystem and nursery ground for numerous aquatic organisms such as macrobenthos, shrimps, crabs, fish, etc., and it also prevents the abrasion occurring in the coast due to the sedimentation of organic wastes originated from aquaculture sites (Vatria, 2010; KKP, 2013). Nevertheless, this solution is suggested to deplete the productivity of fish/shrimps because the water condition is somewhat unfavorable for fish/shrimps due to the turbidity interfering with the gills to work properly (Handiani et al, 2017; KKP, 2013).

IMTA AS THE ALTERNATIVE SOLUTION

Among approaches that can be taken to tackle the issues, IMTA appears to be somehow promising as the best solution. IMTA is considered as a green technology due to its zero-emission or waste-free concept (Chopin, 2006; Neori et al, 1989; Troell et al, 2003). The principle is basically somewhat similar to integrated farming with mangrove, as discussed earlier. However, the difference is that IMTA will be more economically important than the integration with mangrove as the lower trophic organisms used can be a source of income (Handiani et al, 2017). So far, lower trophic organisms that may suit the implementation of IMTA according to research are seaweeds and mussels.

The idea is that the waste coming from shrimp farming will be utilized by seaweeds or mussels as a food source, which will reduce the shrimp farming's side effects on the environmental and ecological states of the coast. Mussels are a filter feeder that utilizes organic compounds in the water as a food source, and it is also economically important (Radiarta et al, 2011; Sachoemar, 2010). Organic compounds can also be decomposed by microorganisms to become inorganic compounds, and this process will produce a huge amount of CO_2 and consume oxygen (Muslim et al, 2004). The availability of inorganic compounds and CO_2 is beneficial for supporting seaweed's life as this species utilizes inorganic compound and CO_2 to produce energy and dissolved oxygen (DO), which will eventually benefit surrounding heterotrophic organisms (Aliah, 2013; Sachoemar, 2010).

There have been numerous studies suggesting that the use of mussels and seaweed together with shrimp or fish farming will increase the productivity as this method will increase the carrying capacity indicated by better water quality and thereafter lead to ecosystem balance (Chopin et al, 2004; Goldman et al, 1974; Ryther et al, 1975, Huguenin, 1976; Neori, et al, 2004; Gordin, 1993; Shpigel, 1993; Neori and Shpigel, 1999; Neori et al, 2001). In fact, it is also suggested that the implementation of IMTA is expected to be able to increase productivity up to 3-4 times (Aliah, 2013) compared to the monoculture that is considered to prone to economic loss (Ellis, et al, 2003).

THE FEASIBILITY OF IMTA IMPLEMENTATION

Even though several mussels and seaweed aquaculture sites exist along the northern coast of Java, they are not intended to be integrated with shrimp aquaculture (KKP, 2013). In terms of oceanographic considerations, mussels and seaweed farming are suitable to establish along the northern coast of Java. For instance, in Cirebon, Gresik, Indramayu and Bekasi, local people have been successfully farming green mussels (*Perna viridis*) (KKP, 2013). Radiarta et al (2011) in their study, attempted to characterize the suitability of areas in Cirebon toward mussels farming, and it turned out that 98% of the coast is suitable for mussels farming.

Local people farm mussels because they are easy to farm, and they can be a source of livelihood if fishermen do not obtain sufficient catches (Radiarta et al, 2011; FAO, 2011). In addition, mussel farming is regarded as eco-friendly farming, and productivity will not be limited by organic pollution (Ellis et al, 2002; Crawford et al, 2003; Ysebaert et al, 2009; Shumway et al, 2003). A similar situation also goes for seaweed, where the monoculture practice of this species spread in some regions of Java (KKP, 2013).

However, unlike mussels farming that suit most areas on the northern coast of Java, seaweed farming is somewhat impossible in certain areas due to its high turbidity (Hidayat, 2018). Hence, it is better to establish seaweed and mussels farming at the same sites to reach the optimum result as mussels will control the organic compounds while seaweed will take over the inorganic compounds in the coast.

ECONOMIC AND SOCIETAL ADVANTAGE OF IMTA

The culture of seaweed and mussels farming as an IMTA with shrimp farming can also be a livelihood for coastal communities. Various species of seaweed and mussels can be cultured along the northern coast of Java. *Gracilaria* sp. and *Eucheuma cottonii* are the most common farmed seaweed in the region (KKP, 2013). Kadi (2004) suggests that other types of seaweed are suitable to be cultured in the region, such as *Gelidium* sp. and *Sargassum* sp. According to a report from the Department of Fisheries and Marine Affairs Central Java, with only a few seaweed aquaculture sites in Central Java, the seaweed production can reach up to 11,555.6 tons that are equal to 7 billion rupiahs.

On the other hand, the most common mussels that can be found on the northern coast of Java are green mussels (*Perna viridis*). Prasetya et al. (2010) suggest that Asian moon scallop (*Amusium pleuronectes*) or Malaysian cockle (*Anadara granosa*) can also be options since these species have a higher price in comparison to other types of mussels. In 2011, in only some regions in West Java, the production of green mussels could reach 7 tons that are equal to more than 4 billion rupiahs (KKP, 2013). Java has approximately 1,500 km of the northern coastline, and most of it is used for either brackish or seawater aquaculture (KKP, 2013). Therefore, a solution to the implementation of IMTA by using seaweed and mussels as the lower trophic commodities will benefit both family-scales as well as the state-scale status of the economy in the northern coast of Java.

CONCLUSION

IMTA can be the best solution for problems encountered due to aquaculture activities established along the northern coast of Java. Not only can it recover the environmental and ecological aspects, but it can also be a source of people's income, which will be beneficial for the economic state of the coastal community and the municipality. Still, it cannot be neglected that there is a need for proper and significant environmental impact assessment for aquaculture activities, in this case, shrimp farming, running around the coastal areas and also the need for sustainable aquaculture practices. The study of how aquaculture activity influences the carrying capacity of the coastal areas and to what extent IMTA can support the carrying capacity needs to be a concern for the local government, stakeholders as well as local communities so that the implementation of IMTA is not like a trial and error approach. However, it should be professionally managed by discovering various considerations.

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