Shrimp Culture in Indonesia: Key Sustainability and Research Issues

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Abstract

Indonesia is a vast country of 8.7 million km^2 with a coastline of 81,000 km. It consists of more than 17,000 islands, spreading along the equator, between the continents of Asia and Australia. Indonesia has 800,000 ha of potential area for brackish-water ponds of which 360,000 ha have been developed for aquaculture. More than 30% of ponds are used for shrimp culture.

The current key constraints to sustainable shrimp culture are: environmental degradation due to both internal and external pollutants, ineffective coastal land-use planning, technically poor design and layout of brackish-water ponds, and improper culture management. The main threats are magnified due to rapid industrial development. Efforts are being made to minimise some of these problems.

Future research activities should be established to study the following issues:

1. impacts of large-scale intensive shrimp farms and industrial and agricultural activities on coastal waters, reservoir water treatment on large-scale shrimp farms and industries, the use of gigantic plastic sheets in shrimp farms, and absorption capacity of different species of aquatic flora to treat pollutants;
2. development of high quality broodstock and fry through genetic engineering;
3. development of immunostimulants to combat shrimp diseases and development of early warning systems for shrimp diseases; and
4. an integrated approach to proper coastal land use and coastal zone management, with government and non-governmental organisations playing an important role in providing better environmental conditions for sustainable shrimp culture.

INDONESIA consists of more than 17,000 islands with a total coastline of 81,000 km, and a total land area of approximately 192 million ha (Ritung and Widjaja-Adhi 1994). The coastal area covered by mangrove vegetation was 4.25 million ha, however some mangrove areas have been converted to fishponds or other uses, bringing about the reduction of mangrove area to 3.5 million ha.

Aged brackish-water ponds constructed before 1985 were mainly designed for milkfish culture (Poernomo 1996) but, following the success experienced by some shrimp farmers, many farmers converted extensive milkfish ponds into semi-intensive and intensive shrimp ponds. Further uncontrolled development of brackish-water ponds has caused serious environment degradation and the recent failure of shrimp culture in many areas.

Efforts to overcome the problems of environmental degradation have been made by farmers, the Government of Indonesia and research institutions, but so far in many areas the farmers are still facing difficult problems. Some farmers have quit shrimp culture activities and others have converted their ponds to milkfish culture. In this paper, the efforts to solve the problems for sustainable shrimp culture are discussed.

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The Present Status of Shrimp Culture

The estimated potential area for brackish-water ponds is 800,000 ha and existing pond area is more than 360,000 ha. However, detailed data on the suitability and capability of the potential area for development of shrimp culture are very limited (Anon. 1994). Out of the total existing brackish-water ponds, more than 30% are practising shrimp culture. The sizes of ponds used by more than 100,000 farmers are classified into <2 ha (46.58%), 2–5 ha (31.37%), 5–10 ha (14.70%) and > 10 ha (7.35%). In 1993, shrimp exports amounted to 98,569 t, worth US$876 million.

The Directorate General of Fisheries recommended five levels of technology for shrimp culture (Table 1). The relatively low stocking density aims to avoid harvest failure for farmers having aged ponds with minimum improvement.

The characteristics of coastal areas vary from location to location and from one island to another. Typically, Java, Sulawesi, Bali-Nusa Tenggara, Timor and Maluku Islands are dominated by mineral soils, while outside Java, particularly Sumatera and Kalimantan, more than 50% is peat soil or affected by peat soil.

Constraints on Sustainable Shrimp Culture

Shrimp culture management

The management of shrimp culture varies from location to location, depending on the level of technology applied. However, in semi-intensive and intensive shrimp culture the constraints being faced by many farmers at present are much the same. The important factors to be considered for successful shrimp culture are water quality (pollution problems) and production inputs, such as feed, fry and culture management.

The quality of shrimp feed is determined by its nutrient composition, method of processing and storage. There are at least five different imported and locally-made artificial feeds available to farmers. There is no monitoring of shrimp feed quality at present, thus the farmers select by trial-and-error. However, Hamid (1992) tested two different artificial feeds and found that feed conversion ratio (FCR) fluctuated, ranging from 1.7 to 2.6 in one case, and 1.7 to 3.3 in others. Excessive feeding caused a drastic drop in water quality, particularly dissolved oxygen content. A. Hanafi (unpublished data) observed that under laboratory conditions, excessive feeding caused dissolved oxygen to drop to <1.0 ppm within two days, and all shrimp tested were dead. The uneaten feed and shrimp excreta settled on the pond bottom, causing an increase in the organic content, which in turn resulted in an anaerobic zone. These observations indicated that feed and feeding techniques have an important role in shrimp culture.

The success of shrimp culture also depends on fry quality. Certification to guarantee high quality fry from hatcheries seems to be impossible at the present time.

There are many different chemicals involved in culture management but they are not understood by farmers. The chemicals which are used include probiotics, fertilisers and pesticides (tobacco dust, saponin and thiodan) (Hanafi 1989). The probiotic chemicals are expensive and their effectiveness is questionable. Thiodan has a toxic effect and residues may be dangerous for shrimp. Under laboratory conditions it was observed that low concentrations significantly affected the growth of shrimp (Hanafi and Pantjara

Table 1. Shrimp culture stocking densities and the expected yields recommended by the Directorate General of Fisheries.

Technology	Size of pond (ha)	Stocking density (fry/ha/crop)	Expected yield (kg/ha/crop)
Traditional	1–4	7,500–12,000	150–240
Semi-intensive	1–2	30,000–60,000	600–1,200
Intensive	0.2–0.1	100,000–150,000	2,000–3,000
Shrimp–milkfish	1–4	1,500–9,000[a] 1,500–2,000[b]	110–180[a] 250–300[b]

[a] Shrimp [b] Milkfish

1995), hence residues affected shrimp quality and in turn the consumers. For the proper use of fertiliser, both the dosage and nutrient requirements should be studied to minimise negative effects and cost of production. The total use of fertilisers for brackish-water ponds is 8,217,000 kg of organic fertilisers and 11,090,000 kg of inorganic fertilisers, such as urea and triple superphosphate (Anon. 1994).

Environmental problems

Poernomo (1989) identified reasons for failures of shrimp culture as: improper site selection, poor design and layout of ponds, inadequate pond preparation and extremely high stocking densities. Since then, vast areas have opened up for intensive culture, e.g. in Lampung, shrimp pond area was only 1,500 ha in 1986 and increased to 13,500 ha in 1995 (Anon. 1996a). Improper planning resulted in a poor irrigation system, and many shrimp farmers faced problems in obtaining the right quantity and quality of seawater and fresh water. This situation induced the outbreak of shrimp diseases in many areas, hence the failure of shrimp culture could not be avoided. From this bad experience many farmers changed their pond management from shrimp culture to milkfish culture, or from intensive culture into semi-intensive culture, and some farmers completely stopped their activities for a period of time, e.g. in Central Java, out of 45 private shrimp farms, 40% were no longer operational (Anon. 1996b). Shrimp disease outbreaks started in 1990, with 264 ha of shrimp ponds affected, and peaked in 1995 with a total area of 4,749 ha affected.

Other factors that may reduce the quality of the environment for shrimp culture include changes in the biophysical features of the river catchment areas. Some examples are forestry activities in the upper catchment of coastal rivers, pesticide use for agricultural activities, and land disturbance by industry and mining.

Social conflicts and benefits

Many coastal zones are becoming areas of intense economic, social and biological activity, including over-exploitation of fisheries and other marine resources. Urban uses, recreation, industrial development and pollution are the major threat to the coastal zone and to shrimp culture. Local issues such as conflict between development and preservation of mangroves or conversion of paddy fields, serve to emphasise the complexity of the problems faced in planning, administrative and legislative aspects of coastal zone management. Shrimp culture has also caused conflicts with people in surrounding areas through seawater intrusion, consequent failure of certain agricultural crops and reduced quality of fresh water for daily needs.

Economic constraints

Placement of permanent fishing traps near shrimp culture areas has significantly affected the success of shrimp culture. For example, in Bone Regency, organic material from outlets of shrimp farms, crowded residential areas and agricultural activities all flush into the sea and are trapped by the relatively small mesh size of fish traps. Thus, rapid sedimentation occurs and the water becomes very turbid, causing reduced water quality for shrimp culture. However, the removal of fishing traps would create conflict with their operators.

Mining of mineral sands for metals like chromium, nickel and other heavy metals is an activity which has had a major impact on many coastal waters. Mining could alter the coastal landscape and lead to degradation of coastal ecosystems, and residues of heavy metals in fishery products (including shrimp) may be a danger for human consumption.

Legal aspects

Effective enforcement of laws for fishing in coastal waters and laws for coastal land use will help in the effective management of coastal areas and provide a better environment for brackish-water shrimp culture. The approach to sustainable shrimp culture should be integrated, rather than in a piecemeal fashion. Plans for use of the coastal environment should be carefully integrated with all institutions concerned with forestry, agriculture, plantations, mining and industry. The Indonesian Government should take action on coastal land use and develop policies for regulating coastal management. It should take strong action to strengthen the size and capability of Bapedal (Agency for Evaluation of Environmental Impacts).

Research Activities Related to Constraints

Ongoing research activities

Research is under way to characterise existing brackish-water ponds in the Pangkajene district, southern Sulawesi, to evaluate the suitability of using

different levels of technology for environmentally sound shrimp culture. The factors being studied include climatic conditions, physical, chemical and biological characteristics, and management aspects (Mustafa and Hanafi 1996).

A preliminary study on genetic variation of shrimp broodstock from different locations in waters of western and eastern Indonesia (i.e. Aceh, Madura, Bali, Sumbawa and Sulawesi) has been carried out in Gondol Research Station, Bali. The results showed that broodstock collected from Aceh is the best. In addition, a study on enzyme polymorphism in the giant tiger shrimp from Indonesia and Taiwan has been done and the results showed no differences in allele frequency between these two samples (Sugama 1993).

A study on breeding of broodstock reared in brackish-water ponds concluded that the minimum size was 60 g after 8–12 months rearing and it spawned with a hatching rate of 10% and survival rate of 0%. The hatching and survival rate increased for broodstock of two years rearing, i.e. 98% hatched and 80% survived after 1–2 months. The size of broodstock was >150 g (K. Sugama 1996, pers. comm.). Performance of tiger prawn larvae produced from wild and pond spawners was also studied by Khalik et al. (1993).

A study on the effect of external waste, mainly industrial waste, has been conducted in West Java in the Ciujung and Cisedane Rivers, in Central Java in the Tapah, Bango and Suwatu Rivers, and Porong, Surabaya, Candi, Rejoso and Curah Rivers in East Java by Poernomo (1996). The various industrial wastes caused environmental degradation, and the shrimp were stressed, stunted and their eating desire dropped drastically. This was followed by a disease outbreak. Rachmansyah and Ahmad (1996) have been studying residues of heavy metals and pesticides on different biological samples taken from coastal waters in Sulawesi.

The study on shrimp diseases has focused on identification, characterisation and prevention through improvements in the culture environment (A. Rukyani, 1995, unpublished report). Dominant shrimp diseases were caused by bacteria (*Vibrio*, *Aeromonas* and Enterobacteriaceae), viruses (yellow head disease and MBV—*Penaeus monodon*-type baculovirus) and ectoparasites (*Zoothamnium*, *Epistylis* sp.).

Research target

Brackish-water farms of Indonesia are dominated by small-scale farmers, almost 50% have less than 2 ha, and 30% have 2–5 ha. Thus, Government policy focuses on the elevation of income of small-scale farmers by introducing lower risk technology. One of the Indonesian Government projects, INTAM (Intensifikasi Tambak or Pond Intensification), recommends low stocking densities (Table 1). There are only a few private businesses operating large-scale shrimp farms, like those in Lampung Province, with an area of more than 10,000 ha (Poernomo 1996). One of these large shrimp farms is using gigantic plastic liners to cover the sediment in the ponds.

In general, Indonesian research aims to deal with the needs of aged brackish-water ponds as well as those of newly established ponds (i.e. outside Java and in eastern Indonesia). The Research Institute for Coastal Fisheries is also doing basic research.

Research dissemination

The Assessment Institute for Agricultural Technology (AIAT) is an apex body responsible for promoting and assessing technologies for the National Research Institute for Agriculture, which includes fisheries. There are 16 AIAT offices under the Agency for Agricultural Research and Development (AARD) representing the different provinces. AIAT conducts first line demonstrations for the transfer of improved technology at the farm level at selected sites. All the provinces facilitate direct linkage of research from scientists to extension workers and farmers.

The Institute of Brackish-water Aquaculture in Jepara, Central Java, is involved in education and primary extension of technology in brackish-water aquaculture, particularly shrimp culture.

Research constraints

Due to high variability in characteristics of coastal environments, the technology produced should be location specific. This condition implies that the resources of the coastal zone must be carefully evaluated for their suitability for the development of shrimp culture. At present, detailed data on coastal areas are limited. Many farmers applied technologies which were successful for other farmers, but found it could not be directly transferred to their location due to their specific problems. This is one of the reasons the Government, through AARD, established AIAT to conduct research and assess results conducted under specific conditions to establish the most appropriate technology for farmers at different sites.

Priorities for Future Research

A. Research priorities for dealing with environmental issues.

- The impact of large-scale intensive shrimp farms on coastal environments. The objectives are to characterise the causes and changes in water quality which result from high loadings of organic matter and other chemicals.
- The impact of mining, industry and agricultural activities on coastal environments. The objectives are to determine the toxicity of different pollutants, the effect on survival rates and growth rates, the levels of residues in shrimp and their distribution in the environment.
- The impact of 'wetland treatment' on discharges from large-scale shrimp farms and industries.
- The impact on the environment of the gigantic plastic liners which are used in shrimp farms in Lampung. The objectives are to determine impacts of plastic on bottom soil quality and loading of organic matter on aquatic plants and water quality.
- Absorption capacity of different species of aquatic plants to various pollutants. This study will be able to find the most effective aquatic plants for environment improvement.

B. Development of high quality broodstock through genetic engineering to produce improved seed (i.e. resistant to disease, healthy, fast growing and adaptable to environmental change).

C. Development of immunostimulants to combat shrimp diseases. Effective immunostimulants will increase survival rates and growth rates. Low cost shrimp feed will reduce production costs.

D. Identification and characterisation of coastal land in newly established brackish-water shrimp ponds, particularly those outside Java and in eastern Indonesia. The objectives are to classify the suitability and capability of the area according to the level of technology needed for sustainable shrimp culture. In this study, the physical, chemical, biological, economic and social aspects must be considered. Characterisation and evaluation of aged brackish-water ponds also need to be studied in order to restore and improve shrimp culture.

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