

A Review on Freshwater Pond Fish Farming in Cambodia

Chhim Kim I^{1*}, Serey Mardy²

¹Graduate School, National University of Battambang

²Faculty of Agriculture, Svay Rieng University

Corresponding Author: Chhim Kim kimichhim@gmail.com

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ABSTRACT

In addition to producing fish, freshwater fish pond farms preserve biodiversity, serve as important aquatic ecosystems, and enhance and maintain of the quality of the ecosystem, provide services for a range of recreational activities, are crucial to the management of water and landscape, and aid in the preservation of cultural heritage. The evaluation of reviews of the literature from all pertinent sources. Review findings indicated that high-value species are the most common fish farmed in Cambodia's ponds and cages such as snakehead (*Channa micropeltes*, *Channa striata*), Pangasius catfish (*Pangasianodon hypophthalmus*) and hybrid catfish (*Clarias batrachus* and *C. gariepinus*) and introduced fishes such as Nile tilapia (*Oreochromis niloticus*), Chinese carps (silver, bighead and grass carp). The prospects of Cambodia's aquaculture industry are called into question by these findings, as it is currently organized, to make a significant contribution to employment, food and nutrition security, and rural economic development. We propose actions to increase sector sustainability and contribute to desired development outcomes

INTRODUCTION

Aquaculture is the world's most diverse farming system in terms of species, farming methods, and farm locations (Hishamunda & Ridler, 2002; Harvey et al., 2007; FAO, 2009). According to estimates, global fish production increased by 24% between 2006 and 2015, reaching 167 million tons (on average between 2013 and 2015) (OECD/FAO, 2017a). Total fish production for human consumption was 147 million tons (approximately 88% of total in 2018), with aquaculture accounting for nearly 50% of total consumption. Aquaculture-derived fish are expected to account for 57% of all fish consumed by 2025. Aquaculture production will primarily drive future growth in fish consumption. Aquaculture's average annual growth rate is expected to slow from 5.4% to 3.0% between 2015 and 2025 (OECD/FAO, 2017a, b). Aquaculture has enormous potential to expand and intensify sustainably in order to meet fish demand in 2050, as the human population is expected to grow for the next 40 years before stabilizing at a minimum of 9 billion people (Godfray et al., 2010). It should be noted, however, that aquaculture exhibits a high degree of diversity in terms of aquatic environments, systems, technologies, and cultured species across the globe. Freshwater provided 62% of global aquaculture production in 2015 (56% by value), with carp and other cyprinids accounting for 65.9% of this total. Carp and other cyprinids are mostly cultured in ponds using semi-intensive methods such as water fertilization with inorganic and organic fertilizers and supplementary feeding with low-protein materials (Bostock et al., 2010; FAO, 2017). Freshwater pond aquaculture, the most common method of fish production in Asia, is also prevalent in some Eastern European countries, including Cambodia. Even if there are obvious climatic, hydrological and other differences between Asian and Eastern European aquaculture, the drivers of development are very similar. Aside from environmental factors (resource availability) and economic factors (satisfying market demand and profit), the importance of social factors is growing in both developed and developing countries (Stead, 2005; Bueno, 2008; Krause et al., 2015). In Asia, where the majority of the world's aquaculture production comes from, fish ponds are mostly freshwater or brackish water, and rarely marine. Fresh water species have traditionally dominated pond culture in China and the majority of the Indian subcontinent. Fish ponds in Southeast Asia are mostly brackish water, with milkfish and penaeid shrimp grown in polyculture or monoculture (Satia, 1989).

Freshwater pond fish culture is a subset of aquaculture that has always been inextricably linked to rural life, combining the social, ecological, and economic dimensions of fish farming activity. These dimensions are referred to collectively as ecosystem services. Currently, there is a particular need to consider the multifunctionality of pond ecosystems during management development (Millennium Ecosystem Assessment Board, 2005; Landuyt et al., 2014). In addition, the government of Cambodia estimated that 2,053,000 tons of aquaculture were produced there in 2017. Fish farming in freshwater, such as cage culture, pond culture, and fish culture in rice fields, dominates aquaculture in Cambodia. Despite the fact that the aquaculture subsector is still small in comparison to capture, aquaculture's contribution to total fish production in the

country has steadily increased from 10.9% in 2010 to 24% in 2017. Aquaculture in coastal ponds and marine cages accounts for only a small portion of total aquaculture production (FAO, 2023).

LITERATURE REVIEW

Ponds play an important role in the landscape, particularly in areas where there are no lakes (Turkowski & Lirski, 2011). In general, the high fertility of ponds promotes abundant plant growth, which provides habitat for a wide variety of animals. Ponds, as a result, provide ideal conditions for the preservation of diverse fauna and flora. People benefit from biodiversity conservation in a variety of ways, including their economy, culture, knowledge, and social behavior (Turkowski & Lirski, 2011). Fish ponds provide food and water, aid in local flood control, help to preserve biodiversity, and provide cultural services by enriching our knowledge and providing spiritual and aesthetic experiences. One of the reasons that these nonproductive services provided by fish ponds are not adequately recognized by the general public or state and local government institutions is that they are difficult to express in monetary units (Turkowski & Lirski, 2011).

According to FiA data, the total aquaculture production in Cambodia in 2008 was 39,025 tons, or 11% of the total production from inland fisheries. Approximately 4,500 cages are used in inland cage culture in Cambodia, which accounts for 70–80% of the nation's aquaculture production. There are also approximately 4,500 cages on the Mekong River (33%), Tonle Sap River (17%), Bassac River (7%), and Tonle Sap Lake (43%) (So & Haing, 2007; Viseth & Pengbun, 2005). The remaining portion is produced by pond-based systems. Between 1993 and 2009, there were 56,234 ponds in use for aquaculture, up from 3,455 ponds in 1993. However, because large, low-input homestead fish ponds typically have low productivity, ponds' overall production contribution is still somewhat restricted (So, 2009b). Fish and seed production are concentrated near cities with well-developed communication and market networks: Kandal province and Phnom Penh produce 49% of total aquaculture output and 57% of fingerling production (FiA, 2007). This market-oriented aquaculture makes use of semi-intensive and intensive culture systems, as well as high-value species such as snakehead (*Channa micropeltes*, *Channa striata*), Pangasius catfish (*Pangasianodon hypophthalmus*) and hybrid catfish (*Clarias batrachus* and *C. gariepinus*) and introduced fishes such as Nile tilapia (*Oreochromis niloticus*), Chinese carps (silver, bighead and grass carp), common carp, and Indian carps (catla, rohu and mrigal) (So et al., 2005). The impoverished in rural Cambodia are usually unable to use these production systems because they need a significant initial investment as well as access to inputs and markets.

The Main Aquaculture Systems in Cambodia

Freshwater Pond Culture - Smallholder

Pond aquaculture is not a traditional activity in Cambodia, owing to the abundance of wild fish. However, since the 1990s, donors and non-governmental organizations (NGOs) have made significant efforts to promote pond-based fish culture - on individual farms, in community ponds, and in rice fields. These initiatives have been accompanied by the introduction of a variety of Chinese and

Indian carps, tilapia, and hybrid catfish, all of which have well-developed breeding technology. While care was initially taken to keep these exotic introductions out of the Great Lakes and Mekong river systems, they have since been widely introduced across the country, and there is some evidence that some species, such as common carp (*Cyprinus carpio*), are breeding in the wild. Silver barb (*B. gonionotus*), walking catfish (*Clarias batrachus*), river catfish (*Pangasianodon gigas*), and *Leptobarbus hoeveni* are all native species. According to reports, the number of ponds used for fish culture increased from 3,455 (239 ha) in 1993 to 56,234 (962 ha) in 2009-2010, with 40,500 farmers operating them. According to reports, the number of ponds used for fish culture increased from 3,455 (239 ha) in 1993 to 56,234 (962 ha) in 2009-2010, with 40,500 farmers operating them (So et al., 2007; So et al., 2005; Viseth and Pengbun, 2005).

Freshwater Pond Culture - Small and Medium-Sized Enterprises

Intensive Pangas (*P.hypophthalmus* and hybrid catfish) farming in ponds has recently increased significantly, owing in part to expatriate Vietnamese farmers seeking better water quality, biosecurity, lower wages, and cheaper feed ingredients (particularly "trash" fish). Productivity is extremely high (several hundred tons/ha/year) due to intensive feeding with pellets (usually at the beginning and end of the production cycle), rice bran, trash fish, and a variety of other ingredients. The majority of farmers mix and prepare their own feed mixture, resulting in home-made pellets. Low-cost fresh fish can be purchased in bulk and semi-fermented with rice bran for several months. This type of aquaculture is mostly found near Phnom Penh and Kandal. Furthermore, there are now large areas of nursing ponds primarily for imported Pangas seed, such as to the north of Phnom Penh. In intensive culture systems, pond sizes can vary from a few hundred square meters to 10,000 square meters (average 2,400 square meters), with a depth of two to three meters and continuous access to a water supply. For *Pangasius*, the culture period lasts 8-12 months, while hybrid catfish cultures last 2.5-3 months, with an average of 3 cycles annually. Because pangas are cheap, some of these pangasius farmers are branching out to grow *Clarias* catfish, *Anabas* (climbing perch), sand goby, and other species like featherback. The majority of farmers hope to be able to raise snakehead (So et al., 2007; So et al., 2005; Viseth and Pengbun, 2005).

Intensive Pond Culture

In intensive culture systems, pond sizes can vary from a few hundred square meters to 10,000 square meters (average 2,400 square meters), with a depth of two to three meters and continuous access to a water supply. The predominant species raised in the ponds surrounding Phnom Penh is the pangasianodon hypophthalmus catfish. The culture period is 8-12 months, and the stocking density is 9 individuals/m² on average. Dried fish and rice bran make up the feed. With an average of 67 tons per hectare, yields range from less than 20 tons to 100 tons, with a feed conversion ratio (FCR) of 4-5:1. Employed laborers also run ponds for the most part. Even though small-sized fish are still the primary feed, hybrid catfish gained a lot of popularity after the farming of snakeheads was outlawed in 2004. With an average fish size of 7 cm, the stocking density ranges from 10 to 188 fish/m², depending on the size of the ponds and fish stocked. Farmers raising hybrid clariid catfish can expect two to four

crops/harvests annually, depending on pond management practices. The range of yields is 8 to 300 tons/ha/year (So et al., 2007; So et al., 2005; Viseth and Pengbun, 2005).

Extensive Homestead Pond Culture

The most popular method of raising fish for food security and livelihood improvements is this one, which is supported by donor projects and non-governmental organizations. Largely, homestead ponds (80-300 m²) are used to raise carp polyculture, tilapia, *Pangasius catfish*, silver barb (*Barbonymus gonionotus*), walking catfish (*Clarias batrachus*), and climbing perch (*Anabas testudineus*). The depths are maintained at >2 m. Fish raised on farms that yield less than 100 kg/100 m² are fed crops like duckweed and rice bran. Ponds are primarily rain-fed, with fish stocked from May to October during the rainy season and the final harvest determined by a water scarcity in March or April. Farmers mostly use wild seed to replenish their ponds, and the majority of the harvest is used for domestic use. Large-scale fish culture has also been conducted in communal or collective ponds, such as pagoda, village, or school ponds (So et al., 2007; So et al., 2005; Viseth and Pengbun, 2005).

Challenge Facing

To raise fish for small-scale aquaculture, you usually need a pond. The estimated cost of building a small pond, less than 300 m², is between 200 and 300 USD (So, 2009b). It can be difficult to get access to water, and buying a water pump and gasoline to run it might cost extra. Poor farmers might not have enough land for a pond to be dug, or they might not have access to enough money for the pond's supplies and running costs. For instance, it might be too expensive to purchase fingerlings for each growth cycle and fertilizer for pond preparation (since most farmed species do not spawn in ponds, which often dry out during the dry season). Since food produced on the farm might not always be available, fish require extra feeding. In this situation, farmers will have to buy feed or gather alternatives (duck weed, insects, etc). Before farmers think about fertilizing their fish ponds, agricultural crops must first be fertilized with inputs like organic fertilizers. Because there is less investment and risk involved, farmers may even prefer to use a pond that is readily usable for stocking fingerlings caught in rice fields or for the temporary holding of wild fish. Rice transplantation and harvesting are two of the more varied wage labor opportunities that the rainy season offers impoverished households, and farmers typically choose other revenue-generating options over fish culture (So et al., 2007; So et al., 2005; Viseth and Pengbun, 2005).

Problems in Pond Culture

The majority of pond water is stagnant, and summertime fish kills are a major consequence of inadequate water availability. Farmer knowledge of feeds and feeding technology; high-value culture species seed unavailable from hatcheries. Catching or purchasing trash fish is a major source of feed, and imported commercial feeds (pellet feed) are costly. Lack of communication to share ideas or techniques is the result of an unfunctioning aquaculture cooperative or society (So et al., 2007; So et al., 2005; Viseth and Pengbun, 2005).

Fish Diseases

Disease is a major problem in aquaculture worldwide. In the 1980s, epizootic fish disease spread throughout Southeast Asia and posed a serious threat to both freshwater and wild fish culture. The 1990s saw the region's ongoing struggles with bacterial and viral diseases as the primary cause of the collapse of Cambodia's shrimp farming industry. The marine finfish farming sector in the region is currently beset by chronic illness problems. Although these diseases are naturally occurring, overconcentration and harsh cultural conditions frequently exacerbate outbreaks (So et al., 2007; So et al., 2005; Viseth and Pengbun, 2005).

Fish Feed Supply

At the time of the survey, Cambodia had no fish feed mills in operation; however, in 2020, a single local feed mill started manufacturing floating pellets. At the time of the survey, all floating pelleted fish feed available in Cambodia was imported from Vietnam and Thailand. Six brands of major feed companies' imported floating pelleted fish are sold through a network of retailers. Feed is mostly sold by retailers between July and December, when farming is at its busiest. They usually sell 20 tons of feed apiece during this period, though there may be significant variations (1.5 to 91 t). A contract that roughly half (45%) of feed retailers have with feed manufacturers specifies a minimum annual sales target. The best-selling products are pangasius and walking catfish feeds, which range in price from USD 0.61 to USD 0.87 per kg. Compared to Thailand and Vietnam, which are nearby, this is a little higher, but it doesn't seem excessive given the transportation and transaction costs involved in importing feeds. The existence of six international brands actually indicates a convenient market for foreign suppliers operating on a large scale in neighboring countries, resulting in a reasonable level of competition, given the relatively small size of the aqua-feed market in Cambodia. However, key informant respondents indicated that in order to produce fish at a price point that could rival imported fish, they would need to purchase feed at a cost per kilogram of about USD 0.50, which is comparable to the prices of pangasius feed in Vietnam. The other relative benefits that Vietnamese farms have, such as economies of scale, are not included in this estimate (So et al., 2007; So et al., 2005; Viseth and Pengbun, 2005).

Future Problems and Challenges

The communities surrounding Tonle Sap Lake are highly reliant on the aquatic resources found in the area, making them susceptible to both short- and long-term changes in the weather. Some examples of these variations include variations in the amount of rain that falls, the duration and level of floods, and the extent to which flooded forest areas expand (Navy et al. 2006). Similar changes can also be brought about by human activities like building dams, clearing forests, using pesticides in aquaculture, and developing new land (Navy et al. 2006). Fisheries and aquatic resources are subject to both natural and man-made changes, which may have immediate effects such as decreased fish size, lower fish catch per unit effort, and extinction of specific species (Navy et al., 2006) (Bonheur and Lane, 2002).

METHODOLOGY

This study is an article based on literature research. The methodology used combines a descriptive analytical method with a qualitative approach. Journal articles, books, reports, policies and regulations, and news from online media are the sources of the data. This study is an article based on literature research. The methodology used combines a descriptive analytical method with a qualitative approach. Journal articles, books, reports, policies and regulations, and news from online media are the sources of the data.

RESULT AND DISCUSSION

The government of Cambodia estimated that in 2017, aquaculture production in the country was 205300 tons. Fish farming in freshwater, which includes pond, cage, and rice field culture, is the predominant form of aquaculture in Cambodia. For hundreds of years, Cambodia has been the home of cage culture. Even though the aquaculture subsector is still tiny in comparison to capture, its share of the nation's total fish production has increased over time, rising from 10.9% in 2010 to 24% in 2017. The majority of the country's aquaculture production is derived from aquaculture in marine cages and coastal ponds (FiA, 2017). A small portion of the nation's aquaculture production is produced through aquaculture in coastal ponds and marine cages. The Great Lake, the Mekong, the Tonle Sap, the Bassac, and the related floodplains are home to the world's most productive wild capture fisheries. 745 065 tons are thought to be the yearly yield of all fisheries, including fish and other aquatic organisms (FiA, 2014). About 120 055 tons of this total supply come from aquaculture (FiA, 2014), and its share is rising yearly. Aquaculture in Cambodia is separated as freshwater and marine, and is subdivided as small-, medium- and large-scale. Pens, ponds, and cages are the main methods. When compared to capture fisheries, aquaculture production is still comparatively low, and the majority of aquaculture practices are small-scale.

In Cambodia, pond fish farming is the least advanced technique. It makes up a little less than 20% of the total production of freshwater aquaculture, or about 1000 tons annually. While small-scale systems are used more widely, intensive culture systems are primarily used in the areas surrounding Phnom Penh and Kandal Province. The main native fish species that are raised in large quantities are *Pangasianodon hypophthalmus* and hybrid catfish. Some exotic species such as: *Clarias gariepinus* and *Hypophthalmichthys molitrix* are also cultured intensively. Small-scale aquaculture has been actively promoted by the Department of Fisheries for food security in upland areas with support from various development organizations. The majority of this output is produced in impoundments behind tiny dams, some of which are connected to rice fields. Since most of the fish used in this aquaculture are imported species, their escape could pose a major threat to the biodiversity of the area. Since 1970 at least 15 alien species have been brought to Cambodia, including four large Chinese carps. silver carp (*Hypophthalmichthys molitrix*) bighead carp (*Aristichthys nobilis*) Grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*) three Indian major carps: Rohu (*Labeo rohita*); Mrigal (*Cirrhinus mrigala*) and Catla (*Catla catla*), Java tilapia (*Oreochromis mossambicus*), Nile tilapia (*Oreochromis niloticus*), red

tilapia (*O. niloticus* x *O. mossambicus*), African catfish (*Clarias gariepinus*), and the Giant gourami (*Osphronemus gouramy*). In pond environments most alien species can adapt well and grow quickly.

The main objective of pond fish farming, which also attempts to increase the production of food fish, is to improve the productivity of water, land, and related resources. Agroforestry, fish, poultry, crops, and other products can all be a part of fish-based integrated farming systems. *Trey pra* was the species most frequently cultivated by pond and cage farmers. It was fed a combination of low-value fish and rice bran, with *Trey riel* (*Henicorynchus* sp.) being the predominant low-value fish species. Rice bran dominated the diet. Following the ban, the price of low-value fish and rice bran has gone up. Before the ban, farmers who cultivated giant snakehead saw a decline in their harvest's profits in comparison to earlier times. The majority of these farmers began growing *Trey pra*, a species with a lower market value than Giant Snakehead, in place of Giant Snakehead after the ban. This could account for the lower profits. Following the ban, the farmers' supply of low-quality fish for local consumption has declined. Natural fluctuations or increased use of low-value fish (both in aquaculture and consumption) could be the cause of this. Even so, after the ban, the household economy has improved for many cage farmers and for the majority of pond farmers. The prohibition has some somewhat beneficial effects, but since there are still low-value fish used as fish feed and the problem is so complicated, there are other options. More research is needed regarding the movement and use of low-value fish, along with enhanced cooperation and control systems.

CONCLUSION

In addition to producing fish, pond farms, a vital component of the rural economy, are valuable wetlands that maintain and improve the quality of ecosystems, manage water resources and shape the landscape, serve a variety of recreational needs, and support the preservation of cultural values. The operation of multifunctional fish farms in Hungary demonstrates unequivocally that diversifying fish farming operations presents favorable prospects for the advancement of sustainable pond farming.

Sustainable pond fish farming involves maximizing the use of natural resources, reducing the negative effects on the environment, producing goods for the public, and generating revenue for the farmers (SustainAqua, 2009; Bosma & Verdegem, 2011). However, preserving the advantages of traditional pond fish farming while simultaneously increasing production and employment opportunities without sacrificing sustainability is a significant problem in the development of pond fish farming. When the creative and traditional functions of a pond fish farm are methodically combined into a complex system that, among other things, operates by applying the concepts of resource use efficiency and circularity, multifunctional pond fish farming becomes one of the solutions. By promoting environmentally conscious farming and utilizing environmentally friendly fish production techniques, pond fish farming helps to preserve natural values and improve environmental conditions. As a result, actively promoting these techniques remains a task of particular importance for the future. Pond farming is still developing in one of the directions of activity diversification and

utilization of multifunctionality's opportunities. Nonetheless, it's also necessary to encourage pond managers' openness to innovation and their desire to grow, as well as to improve the conditions for multifunctional farming, implement targeted support programs, and gain a better understanding of its traits and the relationships between the various functions.

RECOMMENDATION

Since NGOs and other IOs realized that pond fish farming could play a significant role in subsistence farming, they have made significant contributions to the growth of aquaculture and the management of aquatic resources in Cambodia. Under collaboration with numerous NGOs, IOs, and other organizations involved in rural development projects, the FiA has been implementing a number of initiatives to promote aquaculture in all potential areas. Family-scale fish farming operations require high-quality seed that is readily available year-round, so the FiA has worked with a variety of NGOs and IOs to establish public sector hatcheries in various provinces and to help establish private sector hatcheries in numerous rural areas. Beyond the establishment of hatcheries, all cooperating NGOs/IOs have helped to build the capacity of the fisheries staff and farmers through short-term training courses, supported the production of aquaculture extension materials for farmers to use, and in certain cases, research was done in the fields and at fish seed production stations due to a lack of trained human resource to carry out extension activities. Nonetheless, a number of obstacles stand in the way of aquaculture's growth, including a lack of funding for the construction of ponds and cages, a lack of a credit system or poor credit availability due to the lack of subsidies, a seasonal nature of the pond, competition from other agricultural operations for farm resources, and a lack of aquaculture extension systems and research centers. Therefore, the following suggestions are put forth.

In order to promote aquaculture development, the Royal Government of Cambodia should focus on and assist the following initiatives through the MAFF, especially the FiA, and other development partners like NGOs, IOs, and other institutions:

- 1) To create high-quality brood stock in government hatcheries or the Center for Aquaculture Research and Development, which will then be supplied to private or farmer-managed hatcheries to create high-quality fish seed for aquaculture farming

- 2) To create a sub-research center for the development of aquaculture in Cambodia and provide extension services in all areas with a high potential for this industry

- 3) To increase the capacity of already-existing farmer networks that produce fish seed and to build more farmer hatcheries throughout all provinces—a process known as Cambodia's "fish seed production decentralization"

- 4) To improve the current good aquaculture practice (GAP) guidelines and legal requirements for aquaculture farming and fish marketing

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