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Transforming aquaculture in Cambodia through introduction of improved tilapia

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Contents

Introduction	5
Assessment methodology and forecasting scenarios	6
Status of tilapia aquaculture and challenges and opportunities for future growth	7
Seed production	7
Tilapia production and marketing	8
Opportunities for the tilapia sector	9
Pathway to aquaculture development: Tilapia as model to improve the seed sector	10
Scenario for development of the tilapia sector by 2024	11
Recommendations for improvements and innovations	11
Addressing constraints and limitations	15
Concluding remark	17
Further reading	18
Notes	18
References	19

Introduction

Fish is the main source of animal protein in the Cambodian diet; Cambodians consume an average of 52 kg of fish per person each year, one of the highest levels of fish consumption in the world (Hortle 2007).

In the past, the demand for fish and fisheries products in Cambodia was largely met from freshwater capture fisheries. However, in recent decades, a growing demand for affordable fish from both rural areas and fast developing urban centers has resulted in increased fishing pressure, which poses a major threat to the sustainability of Cambodia's capture fisheries. Although official statistics indicate that production of capture fisheries is stable in terms of tonnage, several studies shows a possible decline in the quality of fish caught (Baran et al. 2001; Baran 2005; Hortle and Bamrungrach 2015; Ngor et al. 2018). Development of aquaculture is thus vital to both meet the growing demand for fish and manage the country's fisheries resources sustainably.

Aquaculture production in Cambodia has grown by an average 20% per year over the past decade according to official statistics, increasing from less than 50,000 metric tons in 2008 to 207,443 metric tons in 2017.

The National Strategic Plan for Aquaculture Development in Cambodia (NSPAD) (2016 to 2030) (Fisheries Administration, 2017) outlines key priorities and future investment requirements in aquaculture. However, knowledge about the current status of the sector is lacking. Anecdotal field observations and the few existing studies depict a sector with unsophisticated technology, low efficiency and low competitiveness against imports from neighboring countries. Limited availability of quality inputs and services is a major constraint to the growth of the aquaculture sector. Fingerling production, in particular, is insufficient and the quality of fingerlings produced too low to support the industry. This has resulted in imports of poor-quality seed from neighboring countries.

To address these knowledge gaps, in 2017 the Department of Aquaculture Development of the Cambodian Fisheries Administration and WorldFish undertook a rapid assessment of the aquaculture sector. This study used tilapia aquaculture as a model to identify specific needs and entry points for strengthening the aquaculture sector as a whole. This brief presents the findings of the assessment, from fingerling production to the operations of wholesalers and retailers, as a contribution to efforts to strengthen the development of a sustainable aquaculture sector in Cambodia.

The first section describes the approach used in the assessment. This is followed by a summary of the key findings of the assessment of the tilapia sector, including key entry points to strengthen the structure and functioning of the sector. The third section presents a pathway for development of the aquaculture sector in Cambodia, using tilapia as a model. The final section presents the conclusions in summary form.

Assessment methodology and forecasting scenarios

In 2017, the Department of Aquaculture Development, Fisheries Administration and WorldFish undertook a rapid assessment of the tilapia sector in Cambodia. The assessment addressed the whole value chain, from the breeding nucleus producing high-quality brood fish to wholesalers and retailers, and included hatcheries, nurseries and grow-out farms. It also included key informants to the sector, such as extension services, the Department of Aquaculture Development and feed retailers and importers. The assessment covered the main aquaculture producing areas in Cambodia: the southern floodplain (Takeo), peri-urban areas around Phnom Penh, Tonle Sap floodplain (Kampong Thom, Battambang, Siem Reap, Pursat) and north-west Cambodia (Beantay meanchay) (Figure 1).

The results of the assessment were presented and discussed during a multistakeholder workshop to validate the results and to develop a plan for the future of tilapia in Cambodia up to 2024. This brief presents the main results of assessment and planning exercise.

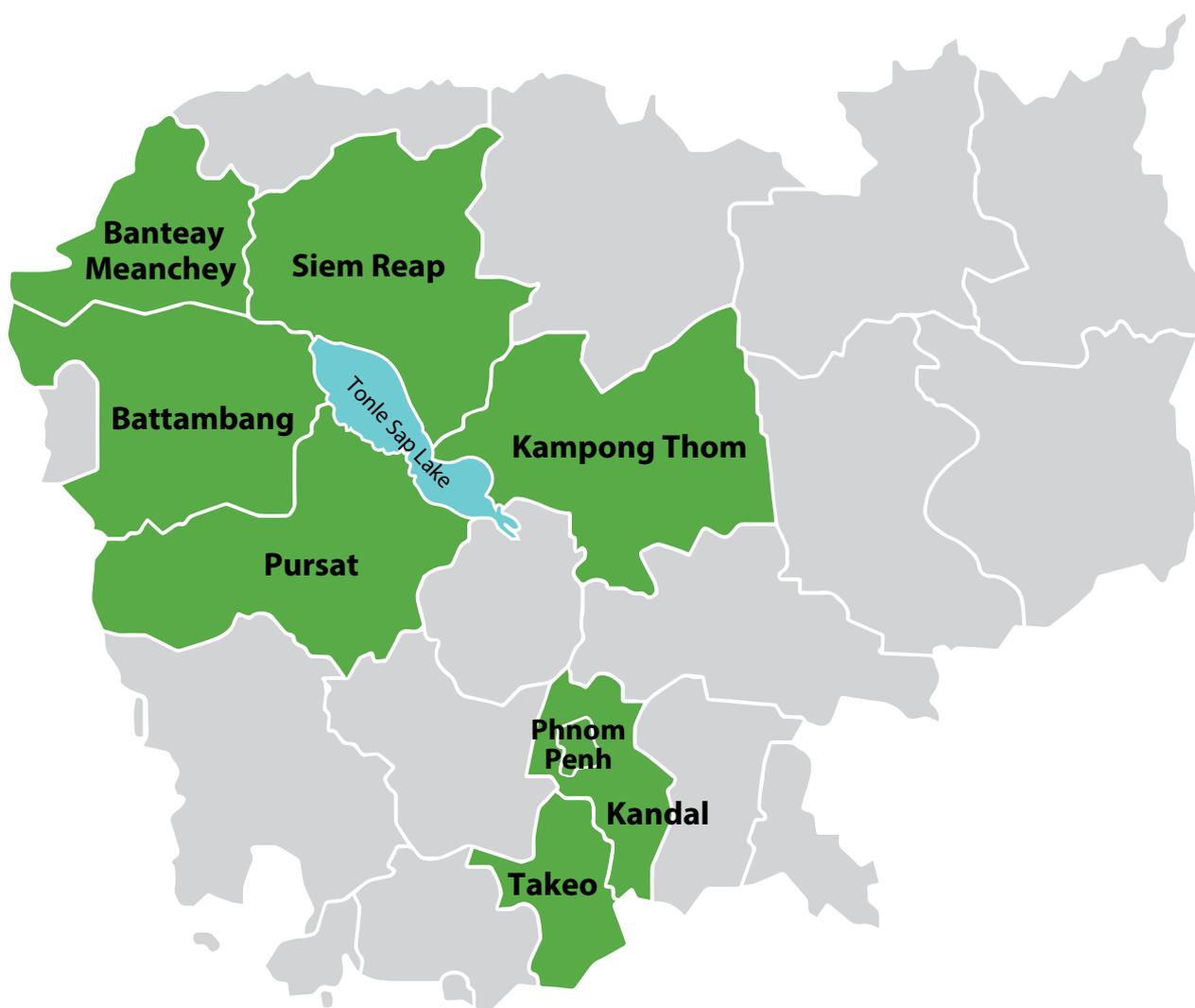


Figure 1. Location of the rapid assessment of the tilapia sector. Provinces shown in green were included in the rapid assessment.

Status of tilapia aquaculture and challenges and opportunities for future growth

In Cambodia, freshwater aquaculture (160,000 metric tons in 2016) accounts for 90% of national aquaculture production. It is dominated by snakehead (*Channa* spp.), which accounts for about 40,000 metric tons per year. More than 69% of the production is concentrated within seven of the country's 25 provinces, with Kandal, Kampong Thom and Phnom Penh provinces reporting 22,000 to 25,000 metric tons of aquaculture production per year. Production occurs in both ponds and cages.

Tilapia culture spread within the country in recent years as a result of increasing demand for both Nile tilapia (*Oreochromis niloticus*) and red tilapia (*O. niloticus* × *O. mossambicus*) (Box 1). Although Cambodians generally prefer wild-caught fish, tilapia is now widely accepted. The tilapia sector is dependent on fingerlings of unknown source and quality imported from neighboring countries, and production practices are generally poor.

The assessment revealed numerous constraints to the sustainable development of the tilapia sector along all segments of the value chain, from seed production to marketing of the fish (Figure 2).

Seed production

Breeding nucleus sites

There are 14 public hatcheries across the country. Two of them, located in Kandal and Prey Veng provinces, have the infrastructure and staff capacity to become a breeding nucleus. Both have ongoing programs to

domesticate indigenous species. Both also produce and market fingerlings of different species, including red tilapia.

Multipliers and private hatcheries

Tilapia fingerlings are widely produced in Cambodia. Mixed-sex tilapia fingerlings sell for US\$ 0.14–US\$ 0.19 each. Small-scale hatcheries produce from a few thousand to 250,000 fingerlings per year. Market demand for fingerlings is oriented toward small sizes (less than 3 cm). Only high-input farms purchase high-quality, larger-sized fingerlings; small-scale farmers do not have the appropriate technology and infrastructure needed to reduce the financial risk of investing in high-quality fingerlings.

Hatcheries face competition from nurseries that import fingerlings from Viet Nam at lower price. These imports are of unknown quality but are popular among farmers because of their low price and their availability at all times of the year. The assessment estimated that more than 5 million red tilapia fingerlings are imported each year.

There is no breeding nucleus in Cambodia that is currently providing high-quality brood fish to hatcheries. Most brood fish come from Viet Nam or Thailand and are of unknown genetic quality and level of inbreeding. Hatcheries do not regularly change their brood fish, with most hatchery operators selecting their brood fish from within their own pool of fingerlings. Few hatcheries are producing all-male

Box 1. Current tilapia production in Cambodia

- Nile tilapia and red tilapia are farmed in 12 provinces in Cambodia.
- Total production is estimated at 12,000 t of Nile tilapia and 3,000 t of red tilapia.
- Tilapia production accounts for between 5% and 30% of aquaculture production in the provinces where it occurs.
- Phnom Penh, Takeo, Kandal and Pursat provinces are the largest producers of tilapia (1,800 to 4,500 t in 2016).
- Significant amounts of tilapia are imported from Viet Nam and Thailand. Siem Reap province alone imports an estimated 12,000 t per year.
- Two grades are distinguished:
 - BBQ fish (live fish) – 800 g, KHR 5,500–KHR 9,000/kg (USD1.35–USD2.22/kg)
 - Table fish – 300–700 g, KHR 5,000–KHR 8,000/kg (USD1.23–USD1.97/kg)

tilapia fingerlings because of limited labor capacity and limited demand from farmers. Monosex culture of male tilapia is preferred to a mixed-sex system because males are substantially larger than females. In addition, early onset of sexual maturity in this species also results in rapid overcrowding and feed competition in mixed-sex production ponds, with consequent poor growth and small individual size of fish.

There is no biosecurity control in existing breeding nucleuses, multiplier hatcheries or nurseries and there is little or no control of fingerling quality. In addition, the regulatory framework to support such control does not exist yet.

Existing public hatcheries (and potential future breeding nucleuses) do not have contracts with multipliers and have no plans for the dissemination of quality brood fish. They also have no proper business plans to allow them to recover the operational costs of breeding, putting their financial sustainability at risk.

In provinces where aquaculture development projects have been deployed (in Takeo and Siem Reap provinces, for example), multipliers are part of a hatchery network that exchanges both brood fish and information regarding market conditions. In spite of this, there are limited value chain linkages and interactions between breeding nucleuses and multipliers. In contrast, multipliers have strong (and long-lasting) market relationships with fish farmers, providing fingerlings to farmers located in several provinces.

Tilapia production and marketing

In Cambodia, fish farmers raise tilapia in ponds and cages. The level of intensity varies from small-scale extensive ponds to more-intensive production systems managed as commercial farms. Farmers mostly purchase their fingerlings from nurseries around Phnom Penh and in Takeo province, which often source fingerlings from Viet Nam. According to farmers interviewed during this study, the quality of the fingerlings is a key issue in tilapia farming in Cambodia; most fingerlings available are of mixed sizes and low genetic quality, resulting in slow growth.

Pond and cage management is also usually suboptimal. For example, farmers commonly feed their fish farm waste and byproducts or trash fish mixed with rice bran rather than quality feed pellets. In addition to suboptimal feeding practices, pond management is often poor, with no management and monitoring of water quality, no use of fertilizer and no records of inputs used. The reason for this poor management is the farmers' limited knowledge of aquaculture and the absence of effective private and public support systems to provide guidance and training to farmers. Access to high-quality feed and other inputs is also limited. Recently, more high-quality feed has become available on the market and there is increased competition between feed producers. However, the cost of feed (US\$ 0.53–US\$ 0.89/kg) remains a major constraint to farmers.

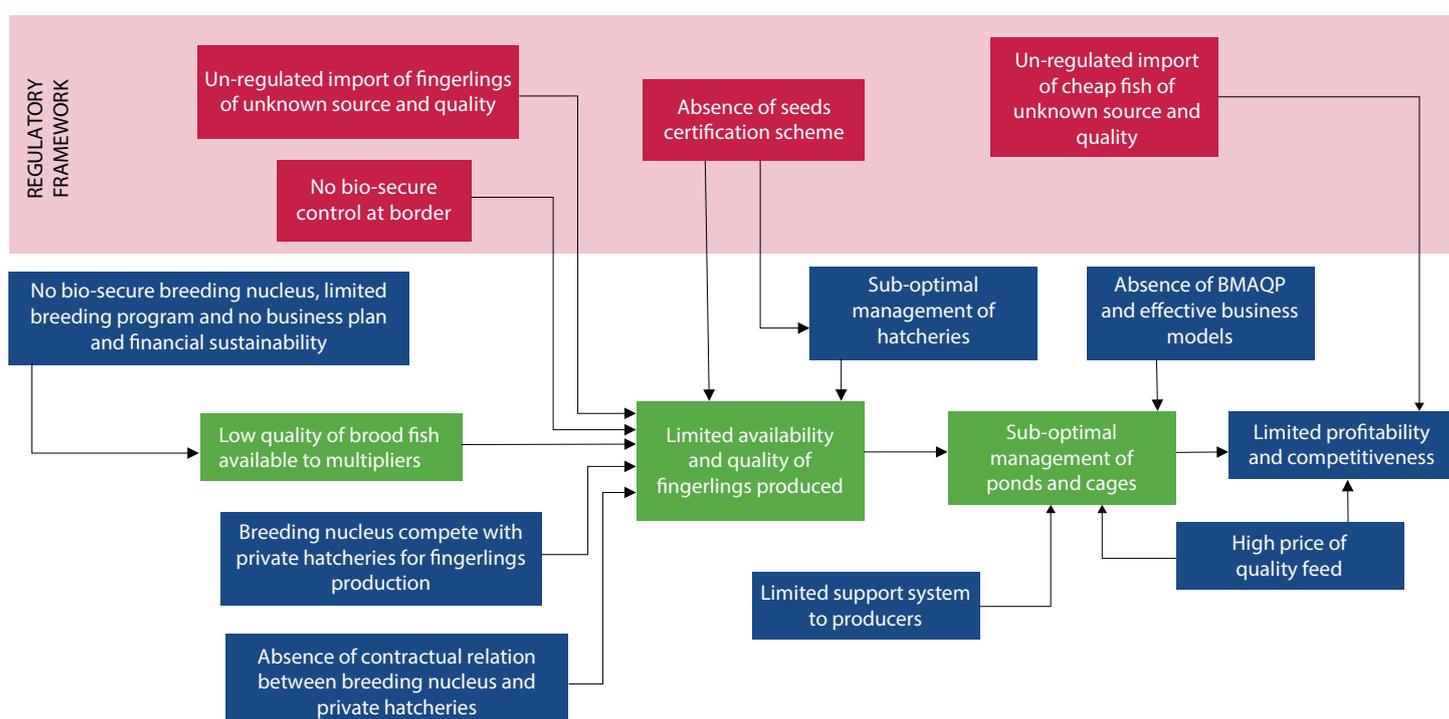


Figure 2. Constraints affecting the tilapia value chain in Cambodia.

Poor management results in low yields, estimated to be around 1.5–2 kg/m² in high-input ponds and less than 1 kg/m² in low-input systems. High-input cages perform better than ponds, reaching 38 kg/m³; however, feed management is suboptimal in most cases.

Economic returns from aquaculture are limited, although differences in marketing strategies influence the financial performance of the different production systems. Small-scale farms retail their production locally, harvesting fish selectively as they reach market size over a period of several months, while larger-scale, more-intensive farms target the wholesale market, managing their ponds so that all the fish reach market size at the same time. However, wholesale markets face competition from imported fish sold at very competitive prices.

Traders complain of difficulties in sourcing market-size tilapia locally. Local producers often fail to meet market requirements and volumes, forcing traders to buy tilapia from Viet Nam or Thailand. This is hampering development of domestic tilapia production.

Opportunities for the tilapia sector

Stakeholders identified the growing market demand for tilapia as a significant opportunity for the

development of tilapia farming. Specifically, market demand for easy-to-process fish (i.e. consumed as a filet or barbecued whole) is increasing rapidly in urban centers and tourism hubs.

The assessment also found that past project interventions had succeeded in developing a network of producers and hatcheries, leaving behind an informal, but still active, network a few years after the end of the intervention. These networks offer a base on which to build future networks of producers, create linkages between multipliers and producers and facilitate transfer of knowledge and information. The multiplier hatcheries act as an “information hub.”

Past interventions supporting fingerling production improved the capacity of local multipliers and breeding nucleus technicians, who acquired knowledge of tilapia sex-reversal techniques. The government hatcheries in Kandal and Prey Veng provinces have adequate infrastructure and could support breeding programs and proper maintenance of quality brood fish, and thus have potential to become breeding nucleuses.

From the institutional dimension, the revision of the current Fisheries Law will provide the opportunity to create a legal basis to develop the regulatory framework needed to control the quality of inputs used in aquaculture, which is currently missing.



Facilities in a private hatchery in Takeo Province.

Pathway to aquaculture development: Tilapia as model to improve the seed sector

In November 2017, the Fisheries Administration invited stakeholders in the aquaculture sector, including the private sector, researchers and representatives of development agencies, to participate in a workshop to

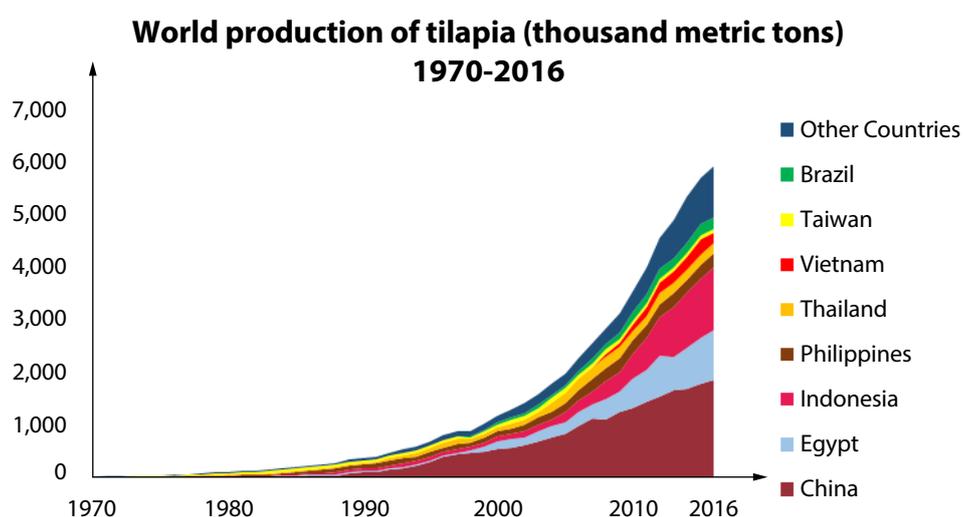
develop scenarios for the dissemination of Genetically Improved Farmed Tilapia (GIFT) in Cambodia up to 2024. The outputs of this workshop are summarized here.

Box 2. Why Genetically Improved Farmed Tilapia

Tilapia has had decades of public- and private-sector investment in research and is now a key species in the aquaculture sector worldwide. More than 5 million metric tons of farmed tilapia are produced each year, and Nile tilapia (*Oreochromis niloticus*) is ranked fourth in terms of total global production, behind three carp species (FAO 2018a, FAO 2018b). China, Egypt and South East Asia are the largest producers of farmed tilapia (Figure 3).

Genetically Improved Farmed Tilapia (GIFT) is a faster-growing strain of tilapia that is suitable for both small-scale and commercial aquaculture. It was bred by a collaborative research effort involving five research institutions, including WorldFish (then ICLARM), that was implemented in the Philippines from 1988 to 1997.

The GIFT strain grows twice as fast as the fish used at the beginning of the breeding program (WorldFish, 2015). As a result, farmers are able to produce up to three harvests a year, compared with only one with unimproved fish. It is also able to thrive in a wide range of environments. Because of its robustness, fast growth and low production cost, GIFT has become a key genetic asset to support aquaculture development in developing countries, from small-scale to commercial farms, and to support the transition from small-scale farming to small and medium enterprise development. GIFT has been disseminated to 16 countries.



Source: FAO (2018a)

Figure 3. World production of tilapia from 1970 to 2016.

Scenario for development of the tilapia sector by 2024

The scenario developed at the workshop envisaged that introducing high-quality GIFT seed in 2018, together with appropriate technical support, would result in widespread adoption of GIFT by farmers. Production of GIFT would increase from 12,000 metric tons in 2018 to 35,000 metric tons by 2024, accounting for more than 70% of tilapia produced in the country (Figure 4). This increase in production would be driven by an increase in the number of farmers raising tilapia and an increase in productivity.

The scenario envisions a large number of small-scale farmers producing about 30% of the volume, 50 medium-scale farms¹ producing 50% of the volume and five large-scale commercial farms² producing 20% of the total volume. By 2024, the number of farmers adopting GIFT technology is projected to increase to more than 2,000. Most of these will be small-scale farmers but these will account for only 5% of the total volume produced. Productivity is increased due to incremental innovations: more and more farmers adopt two culture cycles per year, stocking density increases from 3 to 5–7 fish/m² in ponds and yield reaches 10 metric tons per cycle per hectare. Farmers aim to produce fish weighing 300 g for urban markets. Processing fish filets increases for the domestic market and for export.

The effort to deploy GIFT technology will first target the most suitable areas and provinces where tilapia production is currently increasing, such as Takeo, Siem Reap and Battambang. Other provinces around the

Tonle Sap Lake and near Phnom Penh will follow.

To achieve this scenario, several improvements and radical innovations are required in the sector. The following section presents the recommendations for technological, economic and institutional changes discussed by stakeholders at the workshop.

Recommendations for improvements and innovations

Participants at the workshop developed recommendations concerning the organization of the seed production system, including quality control and a certification scheme, a new approach to delivering effective support systems, and changes within the regulatory framework.

Decentralized seed production system

Fish farms in Cambodia are widely spread and many are difficult to reach. Having only a few large-scale hatcheries to deliver fry and fingerlings to a large number of small-scale farmers would result in high transport costs and high mortality of fingerlings. A better approach is to establish a decentralized seed production system (Figure 5), as has been demonstrated in Bangladesh and elsewhere. This type of organization is also more resilient, as it is not dependent on a few large-scale hatcheries. In addition, this approach allows the number of multipliers in each province to be determined by local demand. Initial efforts to establish multipliers should be aimed at key targeted provinces around the Tonle Sap Lake, Takeo and around Phnom Penh.

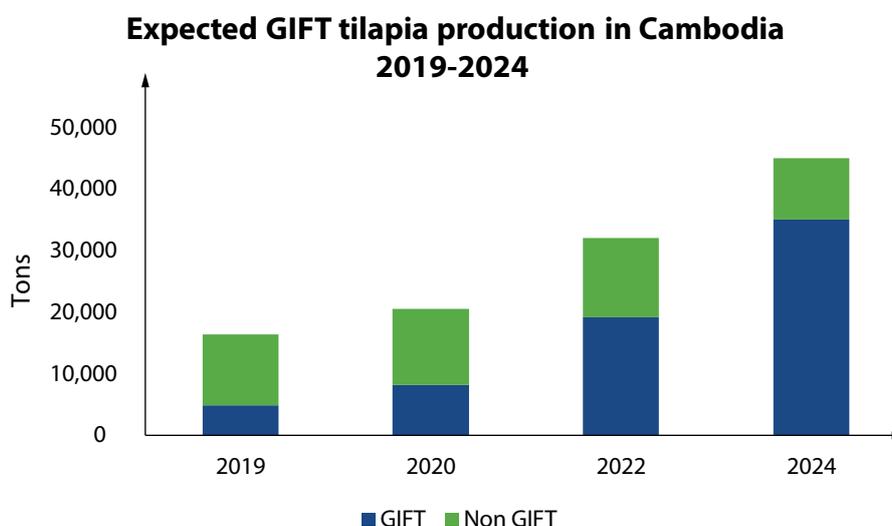


Figure 4. Projected production of tilapia in Cambodia, 2019–2024.

Biosecurity and other technical improvement of seed production

Producing 35,000 metric tons of GIFT would require about 130 million GIFT fingerlings. Producing this number of fingerlings would require a total of more than 300,000 female and 100,000 male brood fish at the multiplier level. With production limited to around 1–1.5 million fingerlings per year per multiplier, the number of multipliers adopting GIFT technology and producing all-male GIFT would need to increase from 10 in 2019 to 50 in 2024. In addition, with demand increasing, the hatcheries would have to increase their production capacity from 1 million fingerlings per year in 2018 to 3 million fingerlings per year in 2024. Private hatcheries would have to acquire quality brood fish from nucleus hatcheries. The number of breeding nuclei would need to increase from one in 2018 to three in 2024. In the initial years, the breeding nuclei would be maintained by selected public-sector hatcheries. Later, private hatcheries also could maintain breeding nuclei if they had adequate infrastructure and technical capacity.

In order to maintain or improve the genetic quality of the breeding nucleus and minimize inbreeding, hatchery staff will have to receive basic training on genetics and fish breeding. Managers of the breeding nuclei will also require support to develop business plans that ensure the long-term sustainability of their operations and access to management tools (or software) to help them plan production and manage their finances.

Such a decentralized production system would require a strict regulatory framework to control quality and biosecurity along the value chain. The breeding nucleus operations would require capacity building and infrastructure improvement to make them biosecure.³ Transforming existing small-scale hatcheries into fully biosecure hatcheries would be difficult, as it would require significant financial investment. However, improvement of current management practices with respect to biosecurity and brood-fish handling would be possible through the establishment of quarantine measures and minimal infrastructure investment.

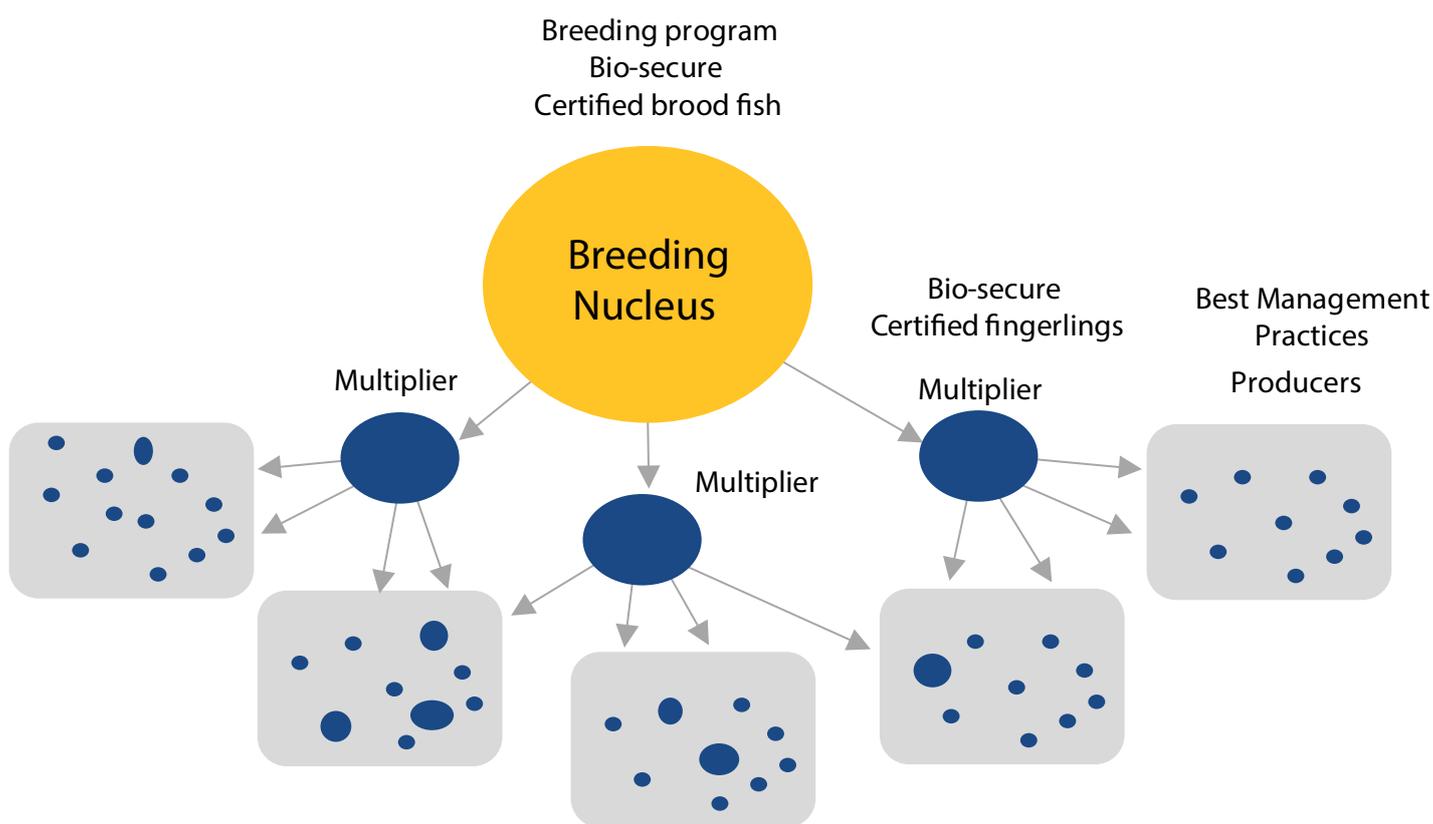


Figure 5. Conceptual framework for a decentralized dissemination system. The breeding nucleus hatchery is responsible for minimizing inbreeding, genetic maintenance/improvement and producing brood fish to sell to multiplier hatcheries. Multiplier hatcheries provide high-quality certified fingerlings to producers. Biosecurity measures to avoid disease transfer are in place at the breeding nucleus and multiplier hatchery levels, and certification systems ensure the quality of the fingerlings available to producers.

Control and regulation for high-quality fingerlings

Under the proposed decentralized system, quality control of operations and product is under the responsibility of several parties, including multipliers, nurseries and/or distributors. Making this work effectively would require specific control systems at all stages of the seed production and dissemination system.

To ensure the quality of fingerlings, the multipliers would have to have a contract with the breeding nucleus providing the GIFT brood fish that specifies the quality of fingerlings to be delivered and that addresses brood-fish and fingerling management. Therefore, to ensure the sustainability of the seed production and distribution system, breeding nucleuses would need to exercise a degree of control over the production and distribution process at two levels:

- By selecting the multipliers that participate in the multiplication program based on specific technical and managerial competencies, facility criteria and financial criteria (see Table 1);
- By contracting with multipliers and fixing the terms and conditions of the contract between the breeding nucleus and the multipliers.

Certified fingerlings: developing a brand

One requirement for the transformation of the aquaculture sector through the introduction of high-quality genetic material is the development of a quality standard or “brand.” In the past, GIFT has been used as brand name and trademark (see Ponzoni et al. 2010). Developing a GIFT brand in Cambodia would

require several key measures to be in place:

- High genetic quality of fingerlings
- Biosecurity measures to deliver pathogen-free fingerlings
- Production of homogeneous, large fingerlings (3–5 cm) ensuring fast growth, high survival rate and short cycle (less than 6 months)
- Production of all-male tilapia, with a proportion close to 100%

Novel branding can increase the value of the brand and improve perceptions of it among producers.

Branding helps promote the product by:

- differentiating GIFT from other strains;
- positioning GIFT as an innovative and novel product sold together with a technical package;
- making farmers aware of the faster growth and better returns from GIFT;
- providing opportunities to educate farmers about the importance of improved strains;
- helping to attract private-sector investment in fish seed production and dissemination and also grow-out farms.

This type of approach requires certification schemes to ensure the quality of the product and its consistency across seasons. It requires strict quality control to avoid false claims, careful management of the use of the trademark and protection for producers and users of the GIFT tilapia.

Multipliers must be selected according to specific accreditation criteria (technical and managerial, infrastructure and financial). Once accredited, multipliers would be able to purchase brood fish, but must be monitored periodically to ensure compliance with the contractual and certification criteria. The

Technical and managerial competences	Efficient and biosecure operation Management of brood fish and production of fingerlings meets quality standards (size; percentage of males; turn-over of brood fish) Technicians understand sex-reversal techniques and are able to provide technical support to farmers
Field facilities	Number of ponds; access to electricity grid; access to quality water; facilities design allows effective biosecurity measure to be implemented
Financial capability	Financial capacity to upgrade and maintain facilities, while maintaining sufficient working capital. Ability to develop a business plan and submit financial reports

Source: Adapted from Ponzoni et al. (2012).

Table 1. Criteria for selecting multipliers.

management team of the breeding nucleus or the Department of Aquaculture Development could perform the accreditation and auditing. Accreditation tools and procedures, such as a standard application form for multipliers and a standard process for verification of the information provided by applicants, would have to be developed and certifiers trained.

Accreditation would be the basis for a contractual agreement between the multiplier and the breeding nucleus. Such an agreement should include the right to produce, distribute and sell seed of specific brood stock provided by the nucleus (Table 2). It should also specify the length of fingerlings to be produced, the floor price for the fingerlings, technical criteria for fingerling quality (size, percentage of males etc...), fee calculation and payment schedule (and penalties in case of delay) and specific events that would result in the termination of the contract.⁴

Developing a pricing policy is central to the long-term sustainability of the introduction of GIFT. Therefore, government should decide to what extent they want to subsidize the breeding program, keeping in mind that providing multipliers with free or discounted brood fish will reduce cost recovery for the breeding nucleus while farmers will not necessarily benefit from this subsidy. Finally, the development of breeding nuclei and their sustainability would depend on their ability to reinvest revenue in operations and maintenance.

Upgrading production systems: a continuum approach

Other components to the production system, such as feed and pond management, need to be upgraded if

farmers are to benefit from genetically improved fish.

The sector needs assessment showed that current aquaculture production systems in Cambodia use technology suboptimally and manage ponds and cages poorly. Distribution of the improved seeds should be allied with improvements to the production system, in particular improvements in fish health and feeding. Upgrading technology and designing local best management practices will necessitate further research. On-station and on-farm trials will be required to develop, test and validate tilapia best management aquaculture practices (BMAqP) that fit the local systems, context and market requirements. The research should focus on sustainable intensification for higher productivity and profitability for small-scale farmers. The BMAqP and technical packages will need to be integrated with business models that minimize financial risk and facilitate the transition from low-input aquaculture to higher level of inputs and that also create incentives for farmers and investors to engage in aquaculture activities. Therefore, research will need to be conducted in partnership with the private sector to embed it in the dissemination process and trigger changes in how research and dissemination is conducted in the current aquaculture sector in Cambodia.

Support system and non-conventional dissemination methods

The needs assessment of the sector showed that multipliers and producers have limited support from both the public and the private sector and are largely dependent on development programs. Developing the tilapia sector in Cambodia will thus require a radical change in how support systems are designed

Breeding nucleus obligations	Multiplier obligations
Make brood stock available to multipliers	Follow technical guidelines and standards provided by the breeding nucleus and attend technical training provided by the breeding nucleus
Provide technical support to multipliers for hatchery operations and brood-fish management	Deliver reports to the breeding nucleus on financial and technical operations
Support brand development and national marketing strategy	Comply with branding guidelines (if any developed by the breeding nucleus)
Monitor performance of multipliers and enforce the provisions of the agreement	Do not compete with the nucleus by selling unauthorized brood fish

Source: adapted from Ponzoni et al. (2012)

Table 2. Obligations of breeding nuclei and multipliers.

and operated. This implies a redefinition of the role of the different stakeholders in the GIFT dissemination process. This includes the following:

- The public sector should aim at delivering research outputs that address the technical needs of the sector, such as BMAqP and breeding programs.
- The public sector should develop the regulatory framework for quality control, from production of fingerlings through production and processing. This will be crucial to the development of a GIFT trademark to differentiate the strain from other commonly used fish seed.
- The public sector should focus on producing high-quality brood fish for use by private-sector hatcheries. Private-sector multipliers should be discouraged from selling brood fish.
- Private-sector hatcheries should disseminate not only fingerlings of high genetic quality but also provide technical support to producers. Input retailers can play a similar role. Both can become “hubs” for information exchange and access to knowledge for producers. In specific areas, such as in the vicinity of Phnom Penh, where producers are geographically concentrated, supporting clusters of small-scale producers can facilitate technological upgrades and market-chain development, facilitating access to knowledge and adoption of technology and good practices.
- Public-private partnerships between breeding nucleuses and feed companies can support roll-out of BMAqP and uptake of GIFT by commercial farms.
- Increasing efficiency of the support system will also require upgrading the capacity of project development staff and nongovernmental organizations.

Thus, the support and dissemination system should be integrated within the value chain and delivered by appropriate actors within the chain. Public-sector research and development projects should support development of business models for hatcheries and producers. This implies a significant shift away from past efforts focusing on small-scale subsistence aquaculture and toward a more commercial orientation.

Institutional and policy support

Transformation of the aquaculture sector by 2024 will require an in-depth transformation of the institutional context, in particular in policy support and the regulatory framework.

At present, there is no monitoring or control on imports of either fingerlings or market-size fish. This increases the risk of importing diseased fish or stock of low genetic merit. Trade agreements within the Association of South East Asian Nations preclude restriction of such imports. However, implementation of a regulatory framework detailing quality standards for imported products would allow control of the quality of material imported.

Implementing such a framework would require establishment of quality standards, improvement in the capacity of Fisheries Cantonment officers to enforce the standards and creation of a transparent mechanism to share information about import of fish and fingerlings.

Currently, importers of fish and fingerlings are licensed for a certain volume but are rarely checked or regulated. Thus, in addition to quality control, the volumes of fingerlings and fish imported need to be better monitored and controlled.

Another aspect that would need to be addressed is access to finance. Banks and microfinance institutions do not consider aquaculture a safe investment, which limits the sector’s access to finance. Research is needed to define profitable business models adapted to the local context. These could then be used by development partners and government to inform banks and microfinance institutions about investment opportunities in aquaculture. This would contribute to enhancing access to capital for producers and private hatcheries.

Addressing constraints and limitations

The rapid assessment identified several constraints to the successful and sustainable introduction of GIFT in Cambodia, including institutional, technical and economic constraints. The following steps would have to be taken to address these.

First, development projects and private-sector bodies supporting the introduction of GIFT have to demonstrate the profitability of the production systems to farmers and hatchery owners. However, this will be highly dependent on introduction and enforcement of changes in the regulatory framework to restrict import of poor-quality fingerlings. Therefore, it is essential to involve relevant stakeholders and policymakers in the early stages of the process.

Second, the technical capacity of multipliers and producers will have to be upgraded to improve management of both hatcheries and farms. This will require significant investment in support-system capacity and a diversification of actors involved in the support systems to include feed producers and retailers.

Finally, the business relationship between breeding nucleuses, hatcheries, multipliers and farmers will have to be strengthened. This will require time and the development of a transparent and trusted framework aiming to deliver quality product.



Concrete pond for brood fish at the Freshwater Aquaculture Research and Development Center (Prey Veng Province).

Concluding remark

Increasing the productivity of the aquaculture sector requires a comprehensive and integrated approach. Upgrading only one element, such as only developing biosecure hatcheries, will not deliver sustainable outcomes and support a transformative change of the sector. The scenario outlined in this brief shows how introduction of GIFT could transform the Cambodian aquaculture sector. Although there are some issues with the introduction of exotic species in Cambodia, tilapia is already widely grown in the country and the adoption of GIFT monosex technology by farmers could overcome such concerns.

Further reading

Ponzoni RW, Nguyen NH, Khaw HL and Rodriguez BM Jr. 2012. *Considerations about Effective Dissemination of Improved Fish Strains*. Working Paper: 2012-47. Penang, Malaysia: WorldFish.

Ponzoni RW, Nguyen NH, Khaw HL, Hamzah A, Abu Bakar KR and Yio Yee H. 2011. Genetic improvement of Nile tilapia (*Oreochromis niloticus*) with special reference to the work conducted by the WorldFish Center with the GIFT strain. *Reviews in Aquaculture* 3:27–41.

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Notes

- ¹ Medium-scale farms are up to 5 ha, raising GIFT at a density of 5 to 7 fish/m² producing 1.5 cycle per year.
- ² Large-scale commercial farms are between 5 and 100 ha. They use a similar fish density to those used on medium-scale farms but produce 2 cycles per year.
- ³ We define biosecurity as “the establishment and implementation of a system or procedures to prevent the introduction of pathogens into a fish hatchery from outside the facility or into a section of the hatchery from another section in the same hatchery” (Mohamed Din and Subasinghe 2017).
- ⁴ In the Cambodian context, with its competitive fingerling market based on cheap imported fingerlings, it will be difficult initially to convince multipliers to pay royalties on sales. Therefore, the licensing agreement should initially charge only an upfront fee related to the cost of the brood fish unless royalties are subsidized by a development aid project.

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