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Exotic Pangas and Tilapia Farming in Bangladesh: Status, Constraints and Potentials

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ABSTRACT

In Bangladesh, the farming of exotic pangas (*Pangasianodon hypophthalmus*) and tilapia (*Oreochromis niloticus/O. mossambicus*) has gained significant importance over the last three decades. This study was conducted across Mymensingh, Bogura, and Cumilla regions, where a substantial number of fish farmers engaged in production, utilizing both primary data from face-to-face interviews with 180 respondents and secondary data from relevant literature to explore the farming techniques, constraints, and potential opportunities of these fish farming. The rise of exotic fish farming, marked by the introduction of improved varieties of these fish, had led to the predominance of polyculture systems, where pangas was preferred as the primary species by 83.33% of respondents, compared to 16.67% for tilapia. Polyculture involving a diverse range of co-species and varying stocking densities, farmers tended to utilize more diversified supplementary feeds in pangas farms compared to tilapia farms, thereby facilitating the selection of pangas as the primary crop. Despite notable potentials, the sector continues to grapple with challenges, including financial constraints, a lack of institutional support, and the need for quality aquafeed to ensure competitiveness in the global market. The findings highlight the need for targeted policy interventions to realize the full potential of aquaculture in Bangladesh and meet future demand.

Introduction

Aquaculture is the fastest-growing food production technique globally (Anderson et al, 2017). In terms of supplying a protein food source for human consumption, this industry has grown significantly and is becoming more important (Ha et al, 2020). In 2018, it was reported that the demand for aquaculture was 46% of the total fish production and was expected to account for 62% of global production by 2030 due to rising demand brought on by population growth. Global aquaculture production experienced a 609% increase from 1990 to 2020, with an average annual growth rate of 6.7%. Between 1990 and 2000, the average annual growth rate was 9.5%; however, between 2010 and 2020, it fell to 4.6% (FAO, 2020b).

Asia leads the globe in fish production, with the Americas and Europe following (FAO, 2022), and within this landscape, China emerges as a

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major player in aquaculture production worldwide (FAO, 2020; Ha et al., 2020). Specifically, Vietnam stands out as the leading producer of pangasius globally (FAO, 2023), while China also holds the title of the top tilapia producer, followed closely by Indonesia, Egypt, and Bangladesh (FAO, 2020a). China, the world's largest producer of tilapia, maintained a stable supply to global markets. Indonesia is developing supply systems to meet the increasing global demand for tilapia. Vietnam has implemented best practices in aquaculture and views the production of pangas as a crucial component to increase revenue from the export of premium fish (FAO, 2023). Bangladesh came in fifth place overall in aquaculture production in 2022 and third in inland fisheries, after China and India, according to the State of World Fisheries and Aquaculture (FAO, 2022).

The fisheries sector of Bangladesh can be distinguished into three main sectors, viz., inland capture fisheries, inland culture fisheries, and marine capture fisheries (DoF, 2023). In 1992-1993, the production from culture fisheries was 2.38 lakh MT, whereas the inland and marine capture was 5.32 lakh MT and 2.50 lakh MT, respectively, and total production was 10.21 lakh MT. In 2022-2023, the production from culture fisheries was 27.46 lakh MT, whereas the inland and marine capture was 13.29 lakh MT and 7.06 lakh MT, respectively, and total production was 10.21 lakh MT. In Bangladesh, from 1993 to 2022, this culture fisheries increased 11.54 times, whereas inland and marine capture fisheries increased only 2.50 and 2.82 times, respectively (DoF, 2023). Fisheries sector of Bangladesh contributed 2.43% and 22.14%, respectively, to the national and agricultural GDP (BER, 2023).

Exotic species like *Pangasianodon hypophthalmus*, generally known as pangas/pangasius and *Oreochromis mossambicus/Oreochromis niloticus,* called tilapia, were introduced to boost productivity, marking the beginning of a production revolution in Bangladesh (Khan et al., 2018 a) and had a lot of potential for both production and export (Dhar et al, 2021). According to Uddin et al. (2018), among other foreign species, pangas and tilapia are unique due to their rapid growth, soft flesh with minimal bone, excellent flavor, and strong ecological adaptations.

Approximately 90% of aquaculture production takes place in poor countries, where it serves as a primary source of animal protein for diets and either directly or indirectly increases food security through export-driven economic growth or local consumption (Anderson et al., 2017). However, the rapid expansion and frequently unplanned development of aquaculture in these nations has sparked a contentious discussion about the industry's potential to improve rural communities and reduce poverty (Filipski & Belton, 2018), as well as environmental issues that have painted aquaculture in a negative light (Menezes et al., 2017, Khan et al., 2021). After being consumed domestically, Bangladesh has a competitive advantage in exporting pangas and tilapia fish to the US, Europe, the Middle East, and other countries in the form of fillets, dressed fish, and entire fish. The export of pangas and tilapia from Bangladesh is hampered by several factors, including the lack of high-quality raw fish supplies and the threat posed by exchange rate appreciation (Dhar et al., 2021) and neglecting sustainability (Haque et al., 2021) alongside robust food safety measures.

The research will provide actionable recommendations for policy development, drawing attention to the need for enhanced government support, credit access, and infrastructure development in the pangas and tilapia farming sectors. The results will be crucial for aligning aquaculture policies with sustainable development goals and rural economic growth.

By combining an in-depth analysis of status and current challenges with a vision for future potentials, the study provides novel insights that will help to drive the development of Bangladesh’s aquaculture industry.

Methods

The nature of the study was mixed, allowing for an in-depth exploration of participants' experiences and perceptions within the context of fish farming practices and quantitative information for culture characteristics and production data. Both primary and secondary sources of information were used in this investigation. Secondary data was gathered from literature and scientific research that had been published in a variety of media (such as journals, periodicals, and official and non-official websites). The following keywords were used to gather the data: “Tilapia and Pangas Production,” “Culture System,” “Introduction of tilapia and pangas,”

"IUCN," "Fishbase," and "Opportunities and challenges." Additional data was gathered by visiting various pertinent institutions, such as the Bangladesh Fisheries Development Corporation (BFDC), the Ministry of Fisheries and Livestock (MoFL), the Department of Fisheries (DoF), the Bangladesh Bureau of Statistics (BBS), and WorldFish (FAO), to ascertain the current situation and production figures.

For primary data, field-based interviews were conducted from180 respondents through a semi-structured questionnaire, and three FGDs (focus group discussions) and twelve KIIs (key informant interviews) were taken to understand the culture systems, constraints, scopes, and related factors of pangas and tilapia farming in Bangladesh during July 2023 to March 2024 from three districts of Bangladesh (Mymensingh, Bogura, and Cumilla). Each focus group discussion (FGD) consisted of eight to ten participants, facilitating an in-depth exploration of the relevant topics. Additionally, key informant interviews (KIIs) included hatchery owners, feed traders, fish traders, fisheries officers, and researchers, all of whom contributed valuable insights to the study.
For the analysis of the data, both Microsoft Excel (version 16) and the IBM SPSS (version 25) were employed. The collected data underwent a thorough review and synthesis, ensuring that only the most relevant information was utilized in the final analysis.

Results

Introduction of pangas in Bangladesh

Widely distributed throughout south and southeast Asia, pangas catfish provide enormous aquaculture potential and have thirty species under five genera within the pangasiidae family (Ferraris, 2007). The only species that exists naturally in Bangladesh's river ecology is *Pangasius pangasius* (Hamilton, 1822). Pangas farming first started in 1950 in Viet Nam in closed ponds with fingerlings collected from wild and the pangasius aquaculture has been expanding rapidly since the end of the 1990s (Anh, 2014). Moreover, *P. hypophthalmus* has been cultivated in Thailand since the 1950s. However, the FAO received the first production report from Vietnam in 1997 (Lutz, 2024).

Table 1 explains the historical background of pangas introduction in Bangladesh. The country has imported pangas (*Pangasius sutchi*) from Thailand for research purposes by the Bangladesh Fisheries Research Institute (BFRI) in 1990. After three-year culture and rearing, researchers became successful in induced breeding of Thai Pangas (Daily New Nation, May 29, 1993; Ali et al., 2014). Due to the failure in induced breeding of local pangas (*Pangasius pangasius*) and after long trials and practices, now two strains of pangas are cultured frequently in Bangladesh, viz., Thai pangas (*Pangasianodon. hypophthalmus*) and Vietnami Pangas (*P. hypophthalmus*) (Haq and Rahman, 2021). For faster growth and good adaptation to adverse ecological conditions, these fish have become popular among the aquaculturists of Bangladesh (Khan et al., 2018).

Introduction of tilapia in Bangladesh

Table 1 represents the historical development of tilapia introduction in Bangladesh. The exotic fish known as the Mozambique Tilapia (*Oreochromis mossambicus*) was introduced to Bangladesh from Thailand in 1954 (Rahman, 2005). However, due to its early maturation and frequent spawning behavior, causing overcrowding and slow growth rates, the farmers did not find this species to be suitable. After that, the Chitralada strain of Nile Tilapia (*Oreochromis. nilotica*) was exported from Africa by UNICEF (United Nations International Children's Emergency Fund) in 1974, which was reintroduced by BFRI (Bangladesh Fisheries Research Institute) in 1984 to solve these problems (Alam et al, 2012; Rahman, 2005).

Table1. Developmental history of pangas and tilapia aquaculture in Bangladesh (Source: Fishbase, The IUCN Red Book of Threatened Species, Rahman (2005), Uddin et al (2021) and Field study)

Species	Common name	Origin/Native	Introduction in Bangladesh	Distribution	Status in Bangladesh	Global status (IUCN)
Pangasius pangasius, Hamilton, 1822	Yellowtail catfish	Bangladesh	____	Large rivers of Indian subcontinent and Myanmar	Not cultured	LC
Pangasius sutchi, Fowler, 1937 *Pangasianodon hypophthalmus*, Sauvage, 1878, (Thai strain)	Stripped catfish, Sutchi catfish	Thailand	BFRI in 1990 in lab and 1993 at field level production	Chao Phraya rivers and Mekong basin in Asia	Culturing	En
Pangasianodon hypophthalmus, Sauvage, 1878 (Vietnamese Strain)	Iridescent shark catfish, Siamese shark catfish, stripped catfish	Vietnam	Hatchery owner, 2011	Mekong, Chao Phraya, and Mae Klong basins. Introduced into others river basins for aquaculture	Culturing	En
Pangasianodon gigas, Chevey, 1931	Giant pangas, Mekong giant catfish	Vietnam	BFRI	Endemic in Mekong basin and become rare due to overexploitation.	Experimental stage for induced breeding	CR
Oreochromis mossambicus (Peters, 1852)	Mozambique tilapia	Africa	From Thailand in 1954, BFRI in 1987	Worldwide, introduce for Aquaculture about 94 countries	Culturing	Vu
Oreochromis niloticus (Linnaeus, 1758)	Nile tilapia	Africa	From Thailand in 1974 by UNICEF, BFRI in 1988	Worldwide	Culturing	LC
Hybrid of *O. mossambicus O. niloticus*	Red Tilapia	Africa	From Thailand in 1988 and from Asian Institute of Technology (AIT), From Thailand in 1998 by BFRI	___	Stop culturing due to fail to attain consumer acceptance for its red color	LC
Genetically Improved Farmed Tilapia (GIFT) from Nile Tilapia	GIFT Tilapia or Mono-sex Tilapia	Selective breeding between farmed and wild strained of Nile Tilapia	World Fish Center and BFRI in 1994	Worldwide	Culturing	_

LC = Least Concern, En = Endangered, CR = Critically Endangered, Vu = Vulnerable

Ignorance of biology and management techniques made Nile Tilapia a difficult fish to cultivate and made it difficult to draw people who were passionate about carp production, which was quite common in Bangladesh. After a continuous attempt to make popular this fish, a new hybrid, red tilapia (*O. mossambicus* × *O. nilotica*) imported by BFRI from Thailand in 1988 (Gupta, 1992). This tilapia also failed to be popular because of its red color. After that, the WorldFish Centre (formerly the International Centre for Living Aquatic Resources Management, or ICLARM) created a synthetic strain of *O. niloticus* known as Genetically Improved Farmed Tilapia (GIFT). BFRI improved this GIFT by further research and introduced it in Bangladesh in 1994 (Uddin et al, 2021). In comparison to other tilapia, the GIFT strain performed significantly better in several dimensions (Hussain, 2000). Further research was then carried out to make all male GIFT tilapia to avoid its prolific breeding, which is now commonly known as mono-sex tilapia (ADB, 2005; Hussain, 2000).

After the introduction of hormonally treated mono-sex tilapia, it has become a popular fish in different culture techniques, including cage culture, because of its unisex nature for a prolonged period, facilitating faster growth and good test.

Aquaculture of pangas and tilapia in Bangladesh

Pond aquaculture plays a critical role in national fisheries production in Bangladesh. In 2022-2023 production year, total fish production was 4914715 MT, whereas pond aquaculture was 2272667 MT which 46.24% of total production in 2022-2023 and contribution of this sector was 79.68% of total culture fisheries in Bangladesh (DoF, 2023). Specifically, 97.10% of total pangas production is sourced from pond culture, reflecting the dominance of this method for this species. Similarly, pond aquaculture contributes 80.61% to the total tilapia production (DoF, 2023). These figures underscore the significant reliance on pond-based systems for sustaining and enhancing the fisheries sector in the country. The widespread adoption of pond aquaculture has thus become a cornerstone for meeting the growing demand for fish in Bangladesh.

Fig. 1 illustrates the trend in the contribution of pangas and tilapia within pond aquaculture in Bangladesh over the years. From 2001 to 2010, the production share of both species remained relatively unsatisfactory, reflecting a period of limited growth. However, from 2011 to 2016, there was a notable upward trend in their production share, indicating significant improvements in aquaculture practices and output. In contrast, the years 2017 to 2024 experienced a downward trend, suggesting potential challenges or shifts in the production dynamics of pangas and tilapia during this period.

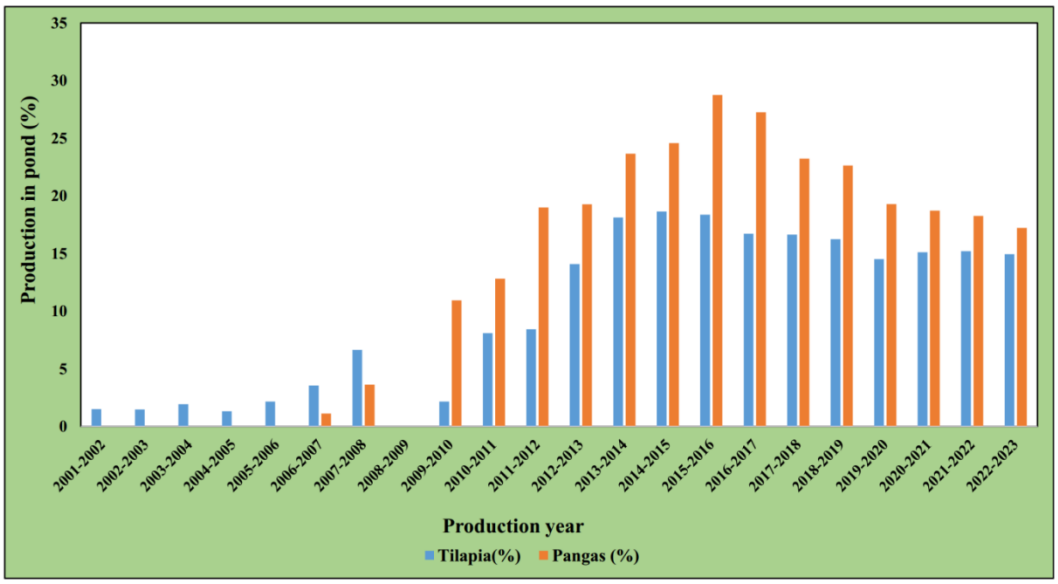

Fig. 1. Production of pangas and tilapias from pond aquaculture in Bangladesh of three decays, (pangas data was unavailable before 2007, online data of 2008-2009 was unavailable) (Source: DoF, 2023).

Culture system of pangas and tilapia in Bangladesh

Table 2 illustrates the production calendar for pangas and tilapia in Bangladesh. Tilapia, being a more frequent breeder than pangas, provides fries year-round, with peak breeding occurring between January and March (Admassu, 1996). For pangas, overwintered juveniles, locally referred to as "Chaper mas", were observed in certain ponds, where they were stocked at high densities with minimal feeding. Tilapia was generally stocked from March to April and harvested after four to six months, allowing farmers the potential for double harvests due to the extended availability of fries. In contrast, pangas were generally stocked in July and harvested in November for a single yield, though double yields were possible using overwintered fry. Double-cropped pangas farming was more prevalent in the Cumilla region compared to Bogura and Mymensingh, gaining increasing popularity due to its higher and faster return on investment. Farmers typically avoided stocking fish between December and January due to extreme cold temperature and unfavorable ecological conditions.

Among 180 respondents, (83.33% preferred pangas as their primary crop, while only 16.67% chose tilapia (Fig. 2 (a)). In recent years, several farmers have transformed from tilapia to pangas farming due to the increasing prevalence of disease outbreaks in tilapia populations and better adaptation of pangas with diversified co-species. Fig. 2 (b) illustrates the adoption of co-species in pangas farming, where carps, catfish, and tilapia were recognized as eco-friendly complementary species. Farmers selected either single or multiple types of fish as supplementary crops, with 31.1% adopting both carp and catfish, 26.67% incorporating only carps, and 16.11% integrating carps, catfish, and tilapia. The inclusion of co-species was motivated by their reliance on natural food within the pond ecosystem, enhancing sustainability in farming practices.

Table 2. Production calendar of pangas and tilapia, and co-species in polyculture technique (Source: Field survey, FGDs, KIIs, 2023-2024).

Culture activities	Practiced months											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Pond preparation												
Nursing												
Overwintered fry												
Stocking												
Culture (single crop tilapia)												
Culture (Double crop tilapia)												
Culture (single crop pangas												
Culture (double crop pangas)												
Carp culture												
Catfish culture												

Shaded areas represent the duration of practiced activities.

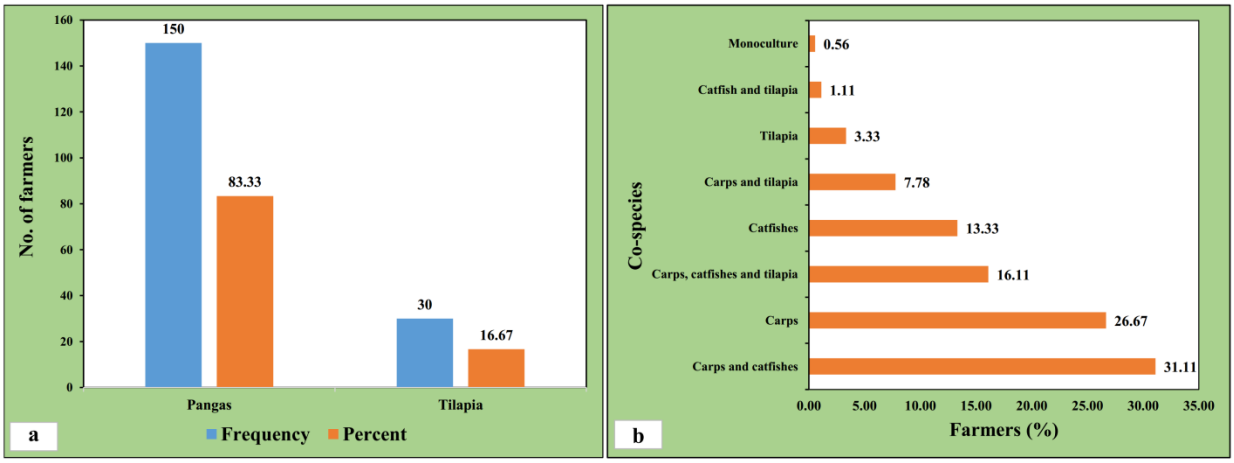

Fig. 2. Farming strategies in the study areas (n = 180), (a) Farmers' species selection as a main crop, (b) Co-species of pangas/tilapia farm selected by the farmers.

Farmers exhibited variability in stocking density across pangas and tilapia farms considering stocking density as number of fishes per decimal (d^{-1}) instead of water volume (m^{-3}). Among pangas farmers, 49% stocked between 101 to 200 d^{-1} of pond area, while only 8% farmers stocked over 300 d^{-1}. In contrast, tilapia farms showed a tendency towards higher stocking densities compared to pangas farms, where 27% of them stocked over 300 d^{-1} and only 13% stalked 101 to 0 200 d^{-1}, as depicted in Fig. 3 (a). Additionally, farmers integrated co-species alongside the primary fish species, adjusting their selection based on feeding strata and overall fish biomass within the pond ecosystem. The figure 3 (b) illustrates the distribution of supplementary feed types used by farmers in pangas and tilapia farming. A total of 39% pangas farmers and 53% tilapia farmers used feed from registered companies. Most of the pangas farmers (45%) and less tilapia farmers (33%) used farm-made feeds, and 14% pangas farmers and 13% tilapia farmers used a combination of farm-made and registered company feeds. Only 1% pangas farmers relied on poultry droppings/litter as supplementary feed, with no tilapia farmers using this method. Combination of poultry-dropping and farm-made was the least common, with only 1% pangas farmer adopting it, and none among tilapia farmers. Overall, the figure suggests that pangas farmers predominantly rely on farm-made, while tilapia farmers demonstrate a stronger preference for registered company feeds.

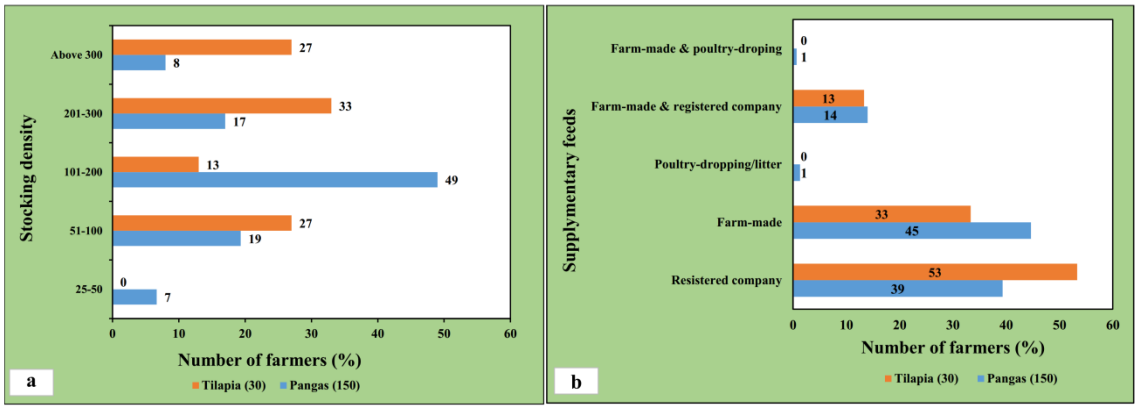

Fig. 3. Farming techniques in the study areas (n = 180), (a) Stocking density (per decimal) in pangas and tilapia farms, (b) Types of supplementary feed applied by the farmers.

Potentialities of pangas and tilapia farming

The pangas and tilapia aquaculture industry in Bangladesh exhibited significant strengths and opportunities, addressing its weaknesses and external threats (Table 3). The study identified several strengths within the pangas and tilapia aquaculture industry of Bangladesh, highlighting its potential for continued growth and sustainability. Notably, the sector benefitted from a skilled workforce, which ensured efficient farm management and operations. The availability of high-yield fish varieties of these fishes had also contributed to the significant production capacity. Furthermore, the presence of diversified farming systems, such as integrated aquaculture practices, added resilience and flexibility to the industry by optimizing resource use and enhancing productivity.

Despite these strengths, the study also revealed significant weaknesses that might hinder the full development of the aquaculture sector. Among the most pressing issues was the lack of access to fish health professionals locally termed "fish doctors" and field-based laboratories, which limited the ability to promptly diagnose and manage disease outbreaks. Additionally, there were challenges in obtaining high-quality feed, which was essential for maintaining fish health and achieving optimal growth rates. Many farmers also struggled with insufficient access to capital, which might constrain their ability to invest in improved infrastructure and technologies. Moreover, substandard hygiene practices across the production chain posed risks to both fish health and product quality, potentially undermining market competitiveness.

The study identified key opportunities for further expansion and innovation in the sector. There was potential to underutilize water bodies for aquaculture, which would increase production without the need for significant new investments in land. The rising interest among youth in

Table 3. SWOT analysis for the pangas and tilapia culture expansion in Bangladesh (Source: Field survey, FGDs, KIIs, 2023-2024).

Strength • Available workforce • High yield variety and hatchery • Continuous research on high-yield variety • Training on modern and good aquaculture practices • Adoption of highly intensive farming technology • Strong biological straits • Easy and diversified farming systems • Low production cost • Technology of live fish transport • Experienced farmers • Easy excess to aquaculture information	Weakness • Lack of fish doctor • Lack of sufficient field-based lab • Scarcity of quality feed and feed ingredients • Lack of capital • Unhygienic fish landing site • Lack of awareness about hygiene practices • Multiple use of pond • Lack of registration system for farm • Influence of middlemen • Scarcity of special schemes for marginal and new farmers • Lack of risk minimization support • Lack of awareness among hatchery owner to avoid inbreeding depression
Opportunities • Availability of underutilized water bodies • Interest of youth generation in aquaculture • Women involvement • Open information sources about culture techniques • Countrywide and overseas demand for pangas and tilapia • Excess to overseas market • Demand for value-added products • Online marketing • Good communication facilities	Threats • Extreme temperature in summer and winter • Flash flood • High prize of inputs • Export dependency for raw materials and modern equipment • Sudden disease outbreak • Over fluctuation of fish market • Conversion of agricultural land • Intrusion of sludge and other pollutants in the natural water • Loan/debt dependency of marginal farmers

aquaculture, coupled with increased involvement of women, presented an opportunity to expand the workforce and enhance socio-economic development in rural areas. The growing availability of open information sources, including digital platforms and training programs, could also facilitate knowledge dissemination and the adoption of best practices among farmers.

However, the industry faced several significant threats that could impede progress. Extreme temperatures and flash floods, exacerbated by climate change, posed ongoing risks to aquaculture operations. The sector was also vulnerable to rising input costs, particularly for feed and other essential materials, which squeezed profit margins. Dependency on export markets for inputs exposed farmers to fluctuations in global demand and price volatility. Moreover, the risk of sudden disease outbreaks remained a constant challenge, compounded by inadequate health facilities. Market fluctuations and land conversion for non-agricultural purposes further destabilized the industry. Finally, loan and debt dependency among marginal farmers left many vulnerable to financial instability, creating barriers to long-term sustainability.

Major constraints and possible solutions of exotic pangas and tilapia farming in Bangladesh

The present study on pangas and tilapia farming in Bangladesh identified several key constraints that impeded the smooth expansion of aquaculture for these highly demandable species (Table 4). These issues included inadequate formal training for farmers, which limited their ability to adopt best practices and improve productivity. Additionally, insufficient documentation of farming activities and practices hindered effective monitoring and knowledge sharing within the sector. Limited access to financing posed a significant barrier for farmers, restricting their ability to invest in advanced technologies and infrastructure. Quality assurance challenged further undermine efforts to maintain consistent standards in fish production, while concerns over safe food production highlighted the need for improved hygiene and regulatory oversight. Finally, issues related to environmental sustainability underscored the need for responsible aquaculture practices to minimize ecological impacts, which could ensure the long-term viability of the industry. Addressing these constraints is crucial for the sustainable development of pangas and tilapia farming in Bangladesh.

Table 4. SWOT analysis for the pangas and tilapia culture expansion in Bangladesh (Source: Field survey, FGDs, KIIs, 2023-2024).

Problems	Constraint issues	Possible solutions
Lack of formal training	Farmers are not interested in participating in long-term training. Lack of manpower to conduct field-based training. Farmer's engagement in multipurpose activities for income security.	Field-based training with regular supervision
Lack of license of farmers	The database of farmers is not updated. Quality/certified aqua-food production cannot be ensured. Supervision of the farming process cannot be made available. Departments of fisheries has no policy to ensure license.	Engage root-level block supervisors to ensure quality and capability.
Lack of capital	Inadequate special scheme for entrepreneurs' development. Lack of incentives for the affected farmers. Lack of insurance for the sudden risk management.	Introduce special loan with minimum interest rate and relax collateral by the banking sector

	Lack of arrangement to enforce banking sector to invest in agricultural sector at low interest especially for the new farmers. Lack of contact farming.	
Lack of quality feed	Local crushing machines are not suitable for making floating feed. Using old, date-over, lower-quality feed ingredients. Lack of storage system to preserve the feed ingredients. Lack of farmer's knowledge of feed formulation. Using date-over feed to save money.	Community storage system. Farmers' capacity building through field demonstration. Formal inspection to monitor feed quality
Low quality of fry	Unconsciousness of hatchery owner in case of brood selection enhances inbreeding depression that causes lower quality of fry production.	Training and supervision
Lack of good aquaculture practices	Lack of farmers' awareness regarding hygiene practices. Over-dependent on farm workers. Anxiety about diseases enforces excess and unusual uses of agrochemicals and drugs. Over concern about profit rather than quality aqua-food production. Lack of supervision regarding fish quality by the fisheries department.	Compelling the fish farmers to participate in half-yearly training. Monthly monitoring of pond and fish health, and farming actions.
Traditional farming techniques	Lack of modern equipment Reluctance of efficient farmer's adoption of new techniques. Inadequate equipment support by the regarding bodies.	Establishment of local lab and expertise
Lack of proper record keeping	Lack of records of stocking Lack of records of feed and chemical use Lack of records of investment	Training on record keeping with pre-designed record book.
Least concern regarding environmental issues	Unconsciousness about agricultural land conversion Establishment of embankment on the natural water and aquatic animal passage Discharging farming polluted water and sludge in the natural waterbodies	Establishment of community waste discharging unit Reuse of bottom sludge and polluted water in agriculture

Pangas and tilapia farming in attaining SDGs in Bangladesh

Table 5 explains the contribution of fish farming to attaining SDGs. Huge amounts of employment opportunities are created by farming expansion. About 2 crore people, with 14 women, are engaged directly or indirectly in the fisheries sector in Bangladesh (DoF, 2024). Pangas and tilapia farming is creating employment opportunities for the farmers, their family members, the youth generation, day laborers, businesspeople, traders, input and output suppliers, and consultants in its value chain. Employment helps to remove poverty (SDG-1) and promote socio-economic advancement. Due to its high profit margin, pangas have become the second most popular fish after 'Rui' (*Labeo rohita*) (DoF, 2022). Pangas have become popular fish among low-income groups due to the shrinkage of the abundance of open-water fish in Bangladesh (DoF). Moreover, this low-cost fish enriched the affordability of fish protein. The fish is enriched with omega-3 fatty acids and micronutrients. This less bone and better test fish is contributing to the

access of essential nutrients to children, especially for the poor community (SDG-2, 3). People are engaged in pond construction, pond preparation, feeding of fish, fish harvesting, fish transporting, fish selling, and security of the farm. Diversified inputs demand enhancing business expansion in Bangladesh. Thus, the economy of Bangladesh has improved by the expansion of pangas farming and created decent job opportunities for the people (SDG-8). However, due to less concern about environmental degradation, land conversion, habitat destruction, pollutant loads in natural waterbodies, and less adoption of improved farming technology, pangas farming hampers attaining the SDGs-12, 14, 15. If good aquaculture practices (GAP) can be ensured to get good quality of raw fish and fish products in a sustainable way, Bangladesh will be able to contribute a good share of pangas supply in the world market (SDG-17).

Table 5. Role of pangas farming in attaining Sustainable Development Goals (SDGs) in Bangladesh (Source: Nasrin and Hossain, 2025)

SDGs	Relationship with Study	Contributions
SDG 1: No Poverty	The study addresses the socio-economic impacts of pangas farming, particularly its role in poverty alleviation for rural farmers.	○ Improves household income and livelihoods through increased production efficiency and market access. ○ Provides employment opportunities in rural areas, reducing poverty levels.
SDG 2: Zero Hunger	Examines the role of pangas farming in ensuring food security by increasing fish production.	○ Enhances food availability and nutrition through affordable fish protein. ○ Supports sustainable aquaculture practices to meet growing food demand.
SDG 3: Good Health and Well-being	Considers the health implications of improved nutrition from increased fish consumption.	○ Contributes to better health outcomes by providing a rich source of protein and essential nutrients.
SDG 8: Decent Work and Economic Growth	Analyzes the economic benefits of pangas farming and its impact on rural economies.	○ Promotes sustainable economic growth by creating jobs and boosting local economies. ○ Encourages entrepreneurship and investment in aquaculture.
SDG 12: Responsible Consumption and Production	Focuses on sustainable farming practices and their environmental impacts.	○ Promotes responsible production methods that minimize environmental degradation. ○ Advocates for efficient resource use and waste management in pangas farming.
SDG 14: Life Below Water	Investigates the environmental consequences of pangas farming on aquatic ecosystems.	○ Aims to mitigate negative impacts on water quality and biodiversity. ○ Supports sustainable aquaculture practices to protect marine resources.
SDG 15: Life on Land	Explores the broader ecological footprint of pangas farming, including land use and biodiversity.	○ Highlights the need for sustainable land management practices to prevent habitat destruction. ○ Encourages conservation of terrestrial and aquatic ecosystems.
SDG 17: Partnerships for the Goals	Emphasizes the importance of collaboration between stakeholders for sustainable development.	○ Facilitates partnerships between farmers, researchers, policymakers, and international organizations to achieve shared goals. ○ Promotes knowledge exchange and capacity building for sustainable aquaculture.

Discussion

Tilapia, introduced in 1954, experienced a production boom at the start of the 21st century, while pangas, was introduced in the 1993, saw a similar surge in production contemporaneously with tilapia (Rahman, 2005; DoF, 2023). The production trajectory for both species showed an upward trend between 2001 and 2016, followed by a decline in recent years (DoF, 2023).

Most of the farmers (83.33%) have adopted pangas as their primary species due to its easier culture techniques, lower mortality rates, and production efficiency (Fig. 2 (a)). Pangas catfish is recognized as one of the most lucrative aquaculture species, owing to its high market demand, simplicity of cultivation, and suitability for the regional climate (Rahman, 2005; Rahman et al., 2012). Farmers employed diverse supplementary feeds and varying stocking densities with co-species (Fig. 3). Ahmed et al. (2010) observed different farming intensities in polyculture systems, ranging from intensive farming using commercial feeds, semi-intensive farming with limited feeds, to extensive farming without feed, combining pangas with both tilapia and carp. Due to the unavailability of fry, pangas stocking typically occurred later than tilapia. As a monsoon breeder, pangas has a breeding season from early June to September in pond environments (Sah et al., 2018), contrasting with tilapia's peak breeding season from January to March (Admassu, 1996). This challenge of late culture was mitigated using over-wintered fry, which enabled double cropping within a single production year (Table 2). Traditional feed formulation techniques have also bolstered the adoption of pangas farming in Bangladesh.

Despite the vast potential of pangas and tilapia farming in Bangladesh, farmers faced significant constraints, particularly in skill development, financial assistance, and technical support, which hinder their production (Table 4). Similar socioeconomic and technical challenges were reported among fish farmers in India (Pandey et al., 2014) and tilapia farmers in Bangladesh (Uddin et al., 2021).

Tilapia has become increasingly popular among both small and large-scale farmers due to its rapid growth, favorable texture and taste, and adaptability to diverse ecological conditions. With strong consumer acceptance, tilapia is now the third most important cultured species in Bangladesh, following *Labeo rohita* (rohu) and pangas. Its significant role in food production has earned the nickname "aquatic chicken" (Perschbacher, 2014), highlighting its potential as an affordable source of animal protein like chicken. This versatility allowed tilapia to thrive in various water environments, including freshwater, brackish water, and saltwater (Rahman, 2021), further reinforcing its reputation as "everyman's fish" (Smith, 1984). Tilapia's ability to endure low water levels and poor water quality, despite fluctuations in salinity, temperature, and rainfall, was a key factor in its successful cultivation. Due to these ecological advantages, tilapia contributes significantly to annual aquaculture production and played a vital role in Bangladesh's economy by providing food, nutrition, sustainable livelihoods, and income for farming households and associated communities. Additionally, it generated earnings from exports, further enhancing its economic impact (Rahman, 2021).

The pangas and tilapia farming sectors in Bangladesh have significant potential to bolster the country's aquaculture industry and improve food security. Focus group discussions (FGDs) revealed that the local economy was heavily reliant on fish farming, with most farmers choosing pangas and tilapia due to their easy cultivation methods. A significant number of residents were engaged in fish farming, either as part-time or full-time employees, and over the past decades, this increase in employment raised real labor wages by nearly 25%, improving rural livelihood outcomes through advancements in aquaculture (Faruque, 2007). These species, characterized by their rapid growth, adaptability, and tolerance to high stocking densities, can substantially increase food supply, promote sustainable livelihoods, and enhance agricultural practices. However, to fully unlock this potential, it is crucial to implement effective governance throughout the value chain, explore export opportunities, ensure feed quality and hygiene, and enforce biosecurity measures through coordinated efforts by the Department of Fisheries (DoF), the Bangladesh Fisheries Research Institute (BFRI), and NGOs (Uddin et al., 2018).

Pond-based aquaculture has become the dominant system in Bangladesh, playing a critical role in food security, nutrition, income generation,

and livelihoods along the aquaculture value chain (Haque et al., 2014; DoF, 2017). Additionally, fish farming has made substantial contributions to both primary and secondary job creation, enhancing local economic stability in the study areas. Consequently, the aquaculture industry in Bangladesh is a key driver of the local economy, providing employment opportunities and fostering commercial initiatives through its links with upstream and downstream businesses.

The study was limited to only three districts in Bangladesh and lacked direct observation of pond environments. Much of the data relied on discussions from FGDs and KIIs. Further research is required to more accurately assess the extent to which various constraints are impacting the production efficiency of pangas and tilapia farming in Bangladesh.

Conclusion

The farming of striped catfish and tilapia in Bangladesh has emerged as a vital component of the country's aquaculture industry, contributing significantly to food security and rural livelihoods. The study has highlighted the status, culture techniques, constraints, and prospects for the expansion of these species. Both pangas and tilapia exhibit favorable biological traits such as fast growth rates, high tolerance to stocking densities, and strong market demand, making them suitable candidates for intensive aquaculture. Polyculture systems, particularly with pangas as the primary species, have proven to be more profitable than monoculture, allowing for greater production efficiency. However, challenges such as disease outbreaks, sub-optimal feeding practices, and limited access to both financial supports and technical expertise continue to hinder the full potential of pangas and tilapia farming. Addressing these constraints through improved extension services, better access to quality feed and training, and stronger government support could unlock further opportunities for sustainable aquaculture development in Bangladesh, enhancing both economic returns and food security in the country.

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Authors' contribution

Conceptualization, MYH and KN; Methodology, MYH and KN; Data collection and analysis, KN; Writing- original draft preparation, KN; Writing-Review and editing, MYH. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors have no conflict of interests.

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