

A Study on The Integrated Farming Approaches in Bharaliporiya Kanyaka Bahumukhi Pam and Pabhoi Greens

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ABSTRACT

This study explores the integration of pig-fish, duck-fish and paddy-fish farming systems with a focus on their economic and ecological sustainability. Conducted at two farms in Assam, India, the research evaluates the role of pig and duck manure in enhancing pond productivity through nutrient cycling. Data were collected through surveys, questionnaires, and personal interviews with farm staff and management. Key physico-chemical parameters such as pH, dissolved oxygen, alkalinity and turbidity were monitored to assess water quality. This study examines pre-stocking pond management for integrated farming systems (rice-fish, pig-fish, duck-fish). Pond preparation involved dewatering, fertilization with organic and inorganic fertilizers, and species selection based on compatibility, growth, and environmental tolerance. Duck and pig manure was used as organic fertilizer, with different application methods to enrich pond water. The rice-fish system enhanced soil fertility and controlled pests. Water quality parameters were monitored, indicating favorable conditions for fish. Fish species like *Catla catla* and *Cyprinus carpio* were used, promoting sustainable, productive integrated farming. The study concludes that integrated farming is a cost-effective, sustainable approach for rural agricultural development, with potential to enhance food security and farmer income when properly managed.

Keywords: Aquaculture, Integrated fish farming, Bharaliporiya Kanyaka Bahumukhi Pam, Pabhoi greens

INTRODUCTION

Aquaculture ranks among the world's fastest-growing food production sectors, with its commodities expected to see rising demand and greater significance in the future (Pedini & Shehadeh, 1997; FAO, 2002; Delgado et al., 2003). Asia has been the hub of global aquaculture production for decades, contributing over 90% of the total output, with China leading as the largest producer (Gangadhara et al., 2016). In India, water bodies such as ponds, lakes, and tanks suitable for

fish farming cover approximately 2.34% of the country's total land area (Kumar et al., 2022).

Integrated fish farming involves the combined management of aquaculture, agriculture, and livestock, where by-products from one sector become inputs for another (Kalita, 2017). For instance, fish waste can fertilize crops, while crop residues can be used as fish feed (Chandra et al., 2023). Animal manure added to fish ponds supports the growth of photosynthetic organisms, enhancing productivity (Saikia et al., 2020).

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Although commonly referred to as “waste,” these by-products are better considered “resources out of place” (Taiganides, 1978). However, careful management is essential to prevent the introduction of antimicrobial-resistant bacteria through manure and excess feeding (Saikia et al., 2020). Nutrients like nitrogen (N) and phosphorus (P) from livestock manure act as natural fertilizers, promoting aquatic food webs. While these elements enhance fish pond productivity, some farms also use slaughterhouse waste as fish feed for carnivorous species (Little & Edwards, 2003). Integrated fish farming offers economic and environmental advantages, being cost-effective, climate-resilient, and requiring minimal initial capital (Chandra et al., 2023).

The integrated fish farming systems combining rice, ducks, and pigs have proven to be effective and sustainable agricultural practices, particularly in regions of Southeast Asia and parts of India. These systems offer multiple benefits, such as enhanced fish production and improved soil fertility, by using animal manure as fertilizer. For example, ducks contribute by controlling pests like aquatic weeds and mosquito larvae, while their droppings serve as an important organic fertilizer for fish ponds, promoting better growth of fish and aquatic plants (Gebbru, 2021).

In Assam, integrated fish farming has gained widespread popularity. Bharaliporiya Kanyaka Pam emerged as a transformative initiative addressing regional brain drain while fostering local self-reliance. This visionary project, spearheaded by Shri Padma Hazarika, reflects a deep commitment to community development and sustainable agriculture (kanyakapam.com).

Similarly, Pabhoi Greens, also known as Lakshmi Agriculture Multipurpose Project, operates as a certified organic farm in Biswanath, Assam. Founded by Mr. Neelam Dutta, it boasts an extensive integrated fish farming system covering half its farmland. The farm breeds carp, catfish, and anabas while ensuring genetic purity through selective and single-breeding practices. With eco-hatcheries and organic fish feed production, Pabhoi Greens produces 8,000 kg of

mature fish, 8.5 million spawn, and 600,000 fish fry and fingerlings annually (pabhoigreens.com).

Despite their success, systematic studies on these farms' operations remain limited. This research aimed to explore integrated fish farming practices at Bharaliporiya Kanyaka Bahumukhi Pam and Pabhoi Greens, focusing on the role of pig manure, duck droppings, and paddy cultivation in enhancing fish growth and pond productivity.

MATERIALS AND METHODS

Study Area

The study was conducted from March to June, 2024 at two sites in the Sonitpur district of Assam, selected for their distinct agro-climatic conditions: Jamugurihat and Biswanath.

Site 1: Bharaliporiya Kanyaka Bahumukhi Pam

Located at latitude 26.6770°N and longitude 92.6984°E, about 8 km from Jamugurihat's main town, Bharaliporiya Kanyaka Bahumukhi Pam spans 800 bighas of water bodies dedicated to integrated fish farming involving ducks and pigs. The farm also operates a large dairy producing curd, milk, cream, ghee, butter, and sweets. A mini dairy plant established in 2021 improved transparency and fairness in operations.

Extensive rice and vegetable cultivation further supports fish farming, with rice waste repurposed as fish feed. The farm includes 26 large ponds, two hatching pools, and 26 nursery tanks. Under the leadership of MLA Shri Padma Hazarika, the farm has grown into a community-driven enterprise supported by stakeholders, consumers, and well-wishers. In addition, a poultry project launched to produce 20,000 eggs daily aims to create jobs and position Jamugurihat as a leading egg producer in Assam.

Site 2: Pabhoi Greens

Situated at latitude 26.8518°N and longitude 93.3389°E, approximately 18 km from Biswanath's main town, Pabhoi Greens operates as a certified organic farm promoting agro-tourism and farm stays. The farm produces organic seeds and provides free training on organic seed production to local farmers.

Pabhoi Greens maintains a gene pool of

108 indigenous rice varieties from India and Southeast Asia, producing commercial rice types such as Joha, black rice, sticky gum rice, and soft rice. Half of the farm's land supports fish breeding, featuring species like carp, catfish, and anabas. The farm has eight nursery tanks, ten rearing tanks, nine stocking tanks, six brood tanks, and eco-hatcheries.

Integrated fish farming methods include rice-fish and duck-fish systems. The farm's 38 cows and 50 ducks play essential roles in organic milk production, vermicomposting, and bio-pesticide creation, with duck waste also contributing to the fish farming system.

Survey Method

To conduct the study, formal permission was secured from the owners of both farms. Data collection was carried out using a combination of standard questionnaires and in-depth personal interviews with farm staff and management. This dual approach ensured a comprehensive understanding of farm operations, management practices, and integrated farming techniques.

Structured questionnaires helped gather quantifiable data on farm productivity, pond management, and species selection, while personal interviews provided qualitative insights into farming challenges, manure management strategies, and ecological sustainability.



Fig. 1: Detection of male and female in fishes

RESULTS

Pre-stocking Pond Management

At both farms, fishery ponds were prepared by reinforcing and trimming the dykes. Planning for integrated farming systems—rice-fish, pig-fish, and duck-fish—was based on pond size. To enhance pond fertility and remove unwanted fish species, ponds were dewatered before stocking.

Fertilization involved both organic and inorganic methods. Organic fertilizer, specifically cow dung, was applied one week after dewatering. Inorganic fertilizers, including urea, super phosphate, and potash, were added 7-15 days after the organic fertilizer application. Fish were introduced into the pond water 7-15 days after the inorganic fertilizer application.

Selection of Fish Species

Specific criteria guided the selection of fish species:

- **Compatibility:** Selected species needed to coexist well with one another.
- **Growth Rate:** Fast-growing species were prioritized.
- **Feed and Stocking Ratio:** Species combinations were adjusted according to available feed resources.
- **Disease Resistance:** Fish species resistant to common diseases and parasites were preferred.



Fig. 2: Injection of breeding hormone

- **Environmental Tolerance:** Species that could withstand high organic content and low oxygen levels in the water were chosen.

The male and female fishes are detected first based on their pectoral fin colour and texture as well as by belly pressing. Then an injection containing the gonadotropins are injected to promote breeding. Fig. 1 and 2 shows the detection of fish gender and hormone injection in Pabhoi Greens.

Construction of Duck Rearing Facilities

Most duck houses are constructed on pond dykes rather than directly over the water to reduce construction costs and simplify management. These shelters provide shade from the sun and protection from heavy rain, while allowing proper air circulation. Side curtains are essential to shield the ducks from wind-driven rain.

Locally available materials such as bamboo for the frame, bamboo matting for the floor, and straw for the roof are commonly used in duck house construction. Ducks can be housed and

fed either on floating rafts or movable structures built over the pond. In both setups, duck faeces and uneaten food fall directly into the pond, enriching the water with nutrients.

Duck houses must be well-protected against predators, with a height of 4-5 feet. The required space depends on the number of ducks, with each bird typically needing about 4 square feet of space.

When ducks are housed on the dyke, only 50-60% of their manure enters the pond water. However, housing ducks directly over the pond eliminates manure collection, storage, and transportation costs, reducing the risk of environmental pollution. Despite these benefits, duck movement can cause significant erosion of the pond's edges, leading to dyke destruction and increased water turbidity. This siltation reduces light penetration, hindering photosynthesis and affecting the pond's ecological balance. Fig. 3 shows the ducks swimming in the integrated duck cum fish culture ponds and Fig. 4 shows a typical duckery.



Fig. 3: Ducks swimming in the pond.



Fig. 4: View of a duckery

Methods of Pig Manure Application

At Kanyaka Bahumukhi Paam, pig manure is applied using two methods: direct and indirect application. In the direct application method, the pigsty is built on the pond embankment, allowing pig excreta to be washed directly into the fish pond. This method is commonly used in small-scale farms. Indirect application allows the pigsty to be constructed at a convenient location on the farm, and pig dung is collected in a large storage tank. The manure is then applied to the fish pond in controlled quantities and at scheduled intervals. This method is typically employed in large-scale farms.

No pigsty facilities were found at Pabhoi Greens.

Construction of Pigsty

The pigsty floor consists of two layers. The lower layer is made of sand, gravel, and cement for

stability. The upper layer is constructed with brick soiling and rough cement mortar for durability.

A brick-and-cement delivery pipe is attached to the pigsty, channelling waste and wash water directly into the fish pond. Feeding and drinking troughs are alternately positioned along the sidewalls of each compartment for easy access. The pigsty's sidewalls are constructed using high-quality 75.0 mm thick bricks, with iron rods reinforcing the upper sections. Each compartment has a gate allowing pigs to move in and out as needed. The roof, made of tin sheets, shields the pigs from direct sunlight. Pigs remain inside the pigsty and are fed a balanced diet to ensure proper nutrition and productivity. Fig. 5 and 6 show the inner and lateral views of a pigsty. Fig. 7 shows excreta and waste pipe from the pigsty to the fish pond.



Fig. 5: Inner view of pigsty



Fig. 6: Lateral view of pigsty construction



Fig. 7: Excreta and waste pipe from the pigsty to the fish pond

Integrated Management of Rice and Fish Farming

In the rice-fish farming system, various fish species are introduced into paddy fields, creating a mutually beneficial environment. Rice cultivation enhances soil fertility by increasing nitrogen and phosphorus content, improving water aeration, and aiding in pest control. Simultaneously, fish benefit from the nutrient-rich water and feed on plant roots, algae, and aquatic weeds.

The fish also help control mosquito larvae, algae growth, and aquatic weeds, maintaining ecological balance. In return, rice plants provide shade, reduce water temperature, and create favourable conditions for fish during summer.

To sustain fish farming during the rice harvest and dry seasons, channels are constructed within the flat paddy fields, ensuring continuous fish growth. Commonly cultivated fish species in this system include *Catla catla*, *Clarias batrachus*, and *Channa striatus*.

Preparation of Fish Feed

Fish are fed using locally available organic ingredients such as rice bran, mustard oil cake, fish meal, and molasses. These components are mixed in a specific ratio of 2:2:0.5:0.25, ensuring a balanced nutritional profile.

The prepared mixture is shaped into balls and directly thrown into the pond as feed. Another method involves cooking the mixture, packing it into small bags, and puncturing the

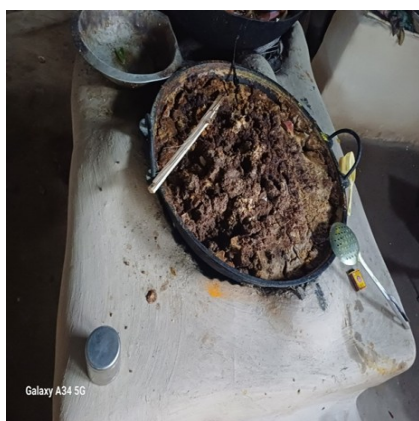


Fig. 8: Preparation of fish feed.



Fig. 9: Making of holes in the food packet



Fig. 10: Binding of the food packet with the bamboo stick in the centre of the pond

bags with holes to allow fish to access the feed. Fig. 8 and 9 show the preparation of fish feed and making of holes in the food packet. The packets are then attached to bamboo sticks placed in the centre of the pond for easy feeding, which is shown in Fig. 10.

Estimation of Excreta Produced by Ducks and Pigs in Cage Conditions

Duck droppings and pig excreta are valuable organic fertilizers commonly used in integrated fish farming systems. Monthly analyses of waste production revealed that a single duck produces between 110g and 200g of droppings per day. Similarly, a pig generates an average of 1 to 1.5 kg of excreta daily. To enhance pond productivity, a mixture of duck droppings and pig manure is prepared and applied as organic fertilizer.

Proximate Composition of Manure

The chemical composition of duck and pig manure was analysed at the farms. The duck manure was found to contain total Nitrogen 0.87%, Phosphorus 0.46%, Potassium: 0.32% and moisture Content 49.7%, while the pig manure contains total Nitrogen 1.12%, Phosphorus: 0.61%, Potassium: 0.38% and moisture content 68.2% (Fig. 11). These

nutrient-rich manures contribute to maintaining pond fertility, supporting plant and aquatic life essential for fish farming productivity.

Physico-Chemical Characteristics of Pond Water

The physico-chemical characteristics of pond water are crucial for the growth and reproduction of fish. These characteristics help maintain the equilibrium of the aquatic environment, and fish serve as indicators of environmental disturbances. Proper management of water quality is essential for the healthy development of aquatic flora and fauna. Key water parameters of both the farms are presented in Fig. 12.

3.10.1. Hydrogen Ion Concentration

(pH)

pH is a critical factor that affects the growth and reproduction of aquatic organisms. It measures the acidity or alkalinity of the water on a scale of 0 to 14, with 7 being neutral. pH is closely linked to the concentration of carbon dioxide in the water. As the timing of water sample collection can influence the pH result, accurate measurements are essential. In this study, the pH was found to be 6.5 at site 1 and

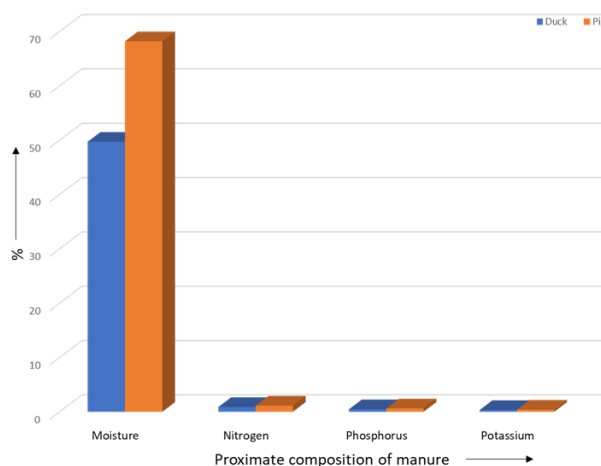


Fig. 11: Proximate composition (%) of Duck and Pig manure analysed in both Kanyaka Bahumukhi Pam and Pabhoi Greens

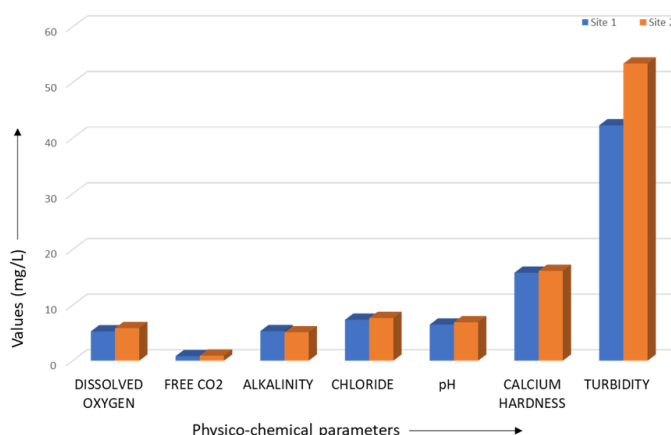


Fig. 12: Physioco-chemical parameters of pond water of both Kanyaka Bahumukhi Pam and Pabhoi Greens. Values are expressed in mg/L.

6.91 at site 2 on January 12, 2024.

3.10.2. Dissolved Oxygen (DO)

Dissolved oxygen is vital for the aerobic metabolism of aquatic organisms, playing a key role in water quality. Adequate oxygen levels are essential for the growth of fish and other organisms. At site 1, the DO was 5.28 mg/L, and at site 2, it was slightly higher at 5.86 mg/L.

3.10.3. Total Alkalinity (TA)

Alkalinity refers to the presence of minerals that neutralize acids in water, impacting the overall health of the aquatic ecosystem. Total alkalinity is measured in parts per million (ppm) or

milligrams per liter (mg/L) of calcium carbonate (CaCO_3). A healthy range for total alkalinity is between 4-200 mg/L. At site 1, the alkalinity was measured at 5.32 mg/L, while at site 2, it was 5.11 mg/L, showing similar levels.

3.10.4. Turbidity

Turbidity refers to the cloudiness of water caused by particles suspended in it. Increased turbidity reduces light penetration, which can negatively affect aquatic organisms. The turbidity level at site 2 was higher at 53.4, compared to 42.3 at site 1, indicating greater cloudiness at site 2.

Table 1: Percentage of introduction of different fish species in the three modes of integrated fish farming in both Kanyaka Bahumukhi Pam and Pabhoi Greens

Name of Fish Species	% of Introduction		
	Paddy cum Fish	Duck cum Fish	Pig cum Fish
<i>Cyprinus carpio</i>	50	15	20
<i>Labeo gonius</i> + Catfish	10	5	15
<i>Labeo rohita</i>	20	15	10
<i>Cirrhinus mrigala</i>	10	10	10
<i>Puntius sp.</i>	10	5	0
<i>Catla catla</i>	0	20	20
<i>Hypophthalmichthys molitrix</i>	0	15	10
<i>Ctenopharyngodon idella</i>	0	10	10

Fish Species in Integrated Fish Farming

Various fish species are used in the integrated systems of rice-fish, duck-fish, and pig-fish farming. The fish species involved include *Cyprinus carpio*, *Labeo gonius*, catfish species, *Labeo rohita*, *Cirrhinus mrigala*, *Puntius* sp., *Catla catla*, *Hypophthalmichthys molitrix*, and *Ctenopharyngodon idella*, each contributing to the system in different proportions. The specific names and percentages of these fish species in the various integrated farming systems are illustrated in the Table 1.

DISCUSSION

The construction of duckeries and pigsties plays a crucial role in integrated farming systems, particularly in aquaculture, where animal waste is used as an organic fertilizer for fish ponds. In the case of duck farming, duck houses are typically built on pond dykes to minimize construction costs while maximizing efficiency. These structures provide shade and protection from the rain, and the ducks' waste is directly deposited into the pond, enriching the water with essential nutrients for fish growth. According to studies, duck houses can be constructed using locally available materials like bamboo and straw, and their height typically ranges from 4 to 5 feet, providing sufficient space for each bird to thrive. However, research also suggests that excessive duck density in ponds can lead to over-fertilization, potentially harming fish stocks (Gebru, 2021).

For pig farming, pigsties are built in proximity to the pond to facilitate the direct application of pig manure into the water. The structure of the pigsty usually includes a two-layered floor made of sand, gravel, and cement, with a delivery pipe that channels the manure directly into the pond. Pig waste acts as a natural fertilizer, providing nutrients like nitrogen and phosphorus to support pond productivity (Gebru, 2021) (Sathoria and Roy, 2022). However, studies have noted that, while the use of pig manure boosts fish production, it is essential to carefully manage the quantity to avoid water contamination and

oxygen depletion (Sathoria and Roy, 2022).

In the Indian context, integrated systems such as rice-fish-pig and rice-fish-duck farming are increasingly being adopted in various states, including West Bengal, Bihar, and Assam. These practices not only help in managing organic waste but also increase the overall productivity of small farms. In the northeastern states of India, particularly in Assam, integrated farming systems are gaining popularity for their sustainability and low cost. However, the challenge lies in ensuring proper management of manure application, as excessive waste can disrupt the ecological balance of the pond and harm aquatic life (Sathoria and Roy, 2022). Our findings corroborate these observations, suggesting that while these systems offer significant benefits, careful monitoring of animal waste and pond conditions is critical to their long-term success.

The role of duck and pig excreta in integrated fish farming is crucial, as these manures serve as organic feed for many fish species. Estimating the rate of excretion from ducks and pigs is essential to maintaining a balanced fish farming system. Sharma et al. (1979) reported that one pig excretes approximately 1.6 kg of waste per day, while Jhingram and Sharma (1980) estimated duck droppings to be around 145g per day. On the other hand, Bora et al. (1990) estimated pig excreta at 0.82 kg per day. In the current study, pig excreta were found to average between 1 to 1.5 kg per day, while duck droppings ranged from 110g to 200g per day. These results are comparable to the studies referenced, with a slight increase in the amount of duck droppings noted.

The physico-chemical parameters of the pond water were observed to fluctuate considerably across different locations. Key parameters such as pH, dissolved oxygen, alkalinity, and turbidity are essential for maintaining a healthy aquatic environment. The importance of pH in determining pond productivity has been widely acknowledged (Hickling, 1971; Jhingram, 1991). Studies by Das

(1961) and Banerjee (1967) suggested that slightly alkaline water is ideal for fish production, although maintaining the desired pH levels during the monsoon season is challenging. In this study, pH levels were found to be 6.5 at site 1 and 6.91 at site 2 on January 12, 2024.

Dissolved oxygen (DO) is another crucial factor for the aquatic ecosystem, supporting the aerobic metabolism of organisms. It plays a major role in determining water quality. Similar to pH, DO levels showed variations across sites. Sharma and Das (1988) found DO levels fluctuating between 2.6 mg/L and 8.6 mg/L. In the present study, DO levels were 5.28 mg/L at site 1 and 5.86 mg/L at site 2, which is within the mentioned range.

Total alkalinity (TA) is closely linked to pH levels, as water with low pH tends to have low alkalinity. Alkalinity is important for the productivity of aquatic organisms. According to Philipose (1959), water productivity depends on its alkalinity, categorized into low, moderate, and high levels. The study found the alkalinity of the pond water at site 1 to be 5.32 mg/L and at site 2 to be 5.11 mg/L, indicating similar alkalinity levels at both sites.

Turbidity is another important physico-chemical parameter that affects fish growth. Organic and inorganic materials such as clay and suspended particles contribute to turbidity, which can impede sunlight penetration and affect aquatic life. Jhingram (1991) emphasized that excessive turbidity, particularly from silt or mud, can harm fish, while turbidity caused by plankton growth indicates a fertile pond. In the present study, turbidity was lower in the pig-treated pond at site 1 (42.3), compared to the duck-treated pond at site 2 (53.4).

In terms of fish species, various species like *Cyprinus carpio* (common carp), *Labeo rohita* (rohu), and *Catla catla* (catla) are commonly cultured in integrated rice-fish systems in India. The combination of rice cultivation and fish farming ensures mutual benefits, with fish helping to manage algae and pest control, while rice

provides food for the fish during their growth stages (Sathoria and Roy, 2022). Integrated pig-fish and duck-fish farming systems are increasingly recognized for their sustainability and productivity benefits. These systems involve the strategic use of animal manure—whether from pigs or ducks—as a natural fertilizer for fish ponds. In both pig-fish and duck-fish integration, the manure significantly boosts the growth of plankton and algae, which provide essential nutrients for fish. Studies indicate that the fertilization from pig excreta results in better growth of various fish species such as *Catla catla*, *Rohu*, *Mrigala*, and *Grass carp*, compared to systems without animal manure (Sarm et al., 2022; Cruz and Shehadeh, 1980). However, while pig manure has been shown to yield higher fish productivity than duck manure (Sarm et al., 2022), both systems help in recycling nutrients and reducing the need for synthetic fertilizers, making them both cost-effective and environmentally friendly.

In India, particularly in the states like Assam and West Bengal, integrated systems like these are proving beneficial in rural farming, providing farmers with increased yields and additional income. For instance, in Purulia, West Bengal, integrated duck-fish farming has not only improved fish productivity but also raised the economic status of farmers by reducing their dependence on external feed and fertilizers (Majhi, 2018). While pig-fish systems generally show higher productivity, careful management of manure is essential to avoid issues like over-fertilization, which can harm water quality and fish health (Cruz and Shehadeh, 1980). Our findings align with these observations, suggesting that integrated systems can thrive in smallholder farming, but success depends on proper management of animal waste and ensuring that manure levels do not overwhelm the system.

Some of the previous works on pig farming in integrated systems has often been found to be less profitable. Sharma et al. (1979) reported that the return on variable costs for pig-fish

farming was 68%, with limited profits from pig raising. Similarly, Jhingram and Sharma (1980) found the profitability of pig farming to be low. In contrast, the integrated fish farming systems in the current study showed promising results, providing substantial profits and contributing positively to the entire aquatic ecosystem.

These integrated systems have not only proven to be effective in increasing production yields but also provide significant economic and environmental benefits by reducing the need for external fertilizers and supplements. Overall, these farming models contribute to sustainable food production while improving the livelihoods of farmers, especially in rural and tribal areas where resources are often limited (Gebru, 2021).

CONCLUSION

In conclusion, integrated fish farming systems involving rice, pigs, and ducks offer a sustainable and productive approach to aquaculture, benefiting both the aquatic ecosystem and local communities. The use of organic fertilizers, such as duck and pig manure, plays a vital role in enhancing pond fertility and supporting fish growth. This study highlights the importance of estimating manure excretion rates, as well as monitoring key physico-chemical parameters like pH, dissolved oxygen, alkalinity, and turbidity, to maintain optimal conditions for aquaculture. The findings from both study sites indicate that proper management of these parameters is crucial for maximizing productivity and ensuring a healthy environment for fish. While pig farming has shown limited profitability in some previous cases, integrated fish farming systems at both sites demonstrated substantial benefits, contributing to the economic upliftment of rural communities. Ultimately, integrated farming technologies are a promising means of improving agricultural sustainability, enhancing food security, and promoting economic growth in rural regions.

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgments

The authors are grateful to the Department of Zoology, Darrang College, Tezpur, Mr. Neelam Dutta, Mr. Rakesh Bora and Mr. Pankaj Hazarika for providing support and necessary facilities to carry on the present work.

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