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Challenges for Pokkali ecosystem-Multistakeholder perspective

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Abstract

The Pokkali integrated farming system is a unique agro-ecosystem that combines traditional rice cultivation with fish and prawn farming in the brackish water fields of Kerala. This sustainable farming practice, predominantly found in Ernakulam, Alappuzha, and Thrissur districts, follows a cyclic pattern where rice is cultivated during the low-salinity phase, and aquaculture is practiced during the high-salinity phase. However, this system faces numerous challenges threatening its economic viability and sustainability. It has witnessed a drastic decline from 25,000 ha to less than 5,000 ha due to various reasons. This study identifies and ranks these challenges based on farmers' and other stakeholders' perceptions in Ernakulam district, as it holds 64% of Pokkali land in Kerala. Primary data was collected from 320 respondents, including 200 farmers practicing different farming systems and 120 respondents from different stakeholder groups, and data were analyzed using R software. Developmental activities were identified as the most significant threat to the Pokkali ecosystem conservation. In Pokkali rice cultivation, the purple moorhen attack was identified as a major threat, while viral diseases posed the greatest challenge to prawn/fish farming. The pokkali rice-fish integrated system was impacted by low profitability and land and water management issues. Addressing these challenges through targeted interventions is crucial for the sustainability of this unique agro-ecosystem. Policymakers and stakeholders must focus on improving management strategies for fish and prawn farming, as well as mechanization and market access for pokkali rice, to enhance the resilience and profitability of this traditional farming practice.

Keywords: Pokkali, perception, purple moorhen, challenges, climate change, Ernakulam

1. Introduction

The saline, waterlogged fields spread across the coastal regions of Central Kerala, South India, are popularly known as the Pokkali Lands. This unique landscape hosts Pokkali farming, an ancient, eco-friendly, and organic Rice-Fish Integrated Farming System (IFS) that thrives in the Ernakulam, Alappuzha, and Thrissur districts of Kerala. The Pokkali ecosystem is classified as AEU 5 (a special agro-ecological unit) under Kerala's delineation based on soil quality and climate factors. This traditional farming system follows a cyclic pattern: paddy cultivation occurs during the low-salinity phase (June to October), while prawn, fish, or crab farming takes place during the high-salinity phase (November to April).

The Pokkali rice variety, cultivated for over 3,000 years, is celebrated for its distinctive flavour and medicinal properties. Notably, it is one of the most salt-tolerant rice varieties, capable of thriving in highly saline conditions (Jayan and Sathyanathan, 2010) [8]. Following the rice harvest, traditional prawn infiltration, locally known as *Chemmeen Kettu*, is conducted in these fields. Pokkali farming is a prime example of sustainable agriculture, where rice and fish farming complement each other to maintain ecosystem stability and productivity.

However, this traditional practice now faces multiple threats, including ecological, socio-economic, and anthropogenic challenges, leading to a decline in cultivation, and the cultivation has reduced drastically from 25000 hectares to less than 5000 hectares (Vikas *et al.,* 2018) [27]. Recognizing the urgent need to preserve this vital agro-ecosystem, the present study aims to analyze the challenges confronting Pokkali farming and recommend corrective measures for its conservation. By addressing these concerns, stakeholders can contribute to safeguarding this unique and invaluable agricultural heritage.

2. Methodology

The Pokkali regions of Ernakulam district were selected for this study, as the district holds the largest area of Pokkali land (64 per cent). Within Ernakulam, these fields are spread across 28 Panchayats, three Municipalities, and one Corporation. To ensure comprehensive data collection, sample respondents were chosen from various panchayats, including Varapuzha, Kottuvally, Kadamakkudy, Ezhikkara, Chittatukara, Njarackkal, Kumbalanghi, Nayarambalam, Chellanam, Pallipuram, Kuzhippilly, Edavanakad, Elamkannupuzha, and Kumbalam.

Primary data for this study was collected during the period of 2023–2024 from diverse stakeholders involved in the Pokkali ecosystem in Ernakulam district. The sample included farmers engaged in various farming systems, such as rice-fish integrated farming and rice-prawn integrated farming, as well as those practicing fish-alone and prawn-alone farming on Pokkali lands. Fifty respondents were

randomly selected from each of these farming categories, resulting in 200 farmer respondents.

In addition to farmers, data was also collected from 30 randomly selected respondents representing four stakeholder groups: residents living near Pokkali fields, farm labourers working in Pokkali fields, Agricultural Officers, and Fisheries Department Officers working in Pokkali areas. This brought the total sample size to 320 respondents. The responses were collected through a personal interview method employing a structured and pretested interview schedule. Data collection focused on five key themes:

1. Challenges to Pokkali ecosystem conservation
2. Pokkali rice cultivation
3. Fish farming
4. Prawn farming
5. Pokkali rice-fish integrated farming

The collected data was analyzed employing standard statistical tools like frequency distributions. The analysis was conducted using R software version 4.4.1 for enhanced clarity and presentation.

3. Results and Discussion

3.1 Challenges to Pokkali Ecosystem Conservation

The major share of Pokkali fields is in and around the Kochi Corporation, which is known as the industrial capital of the state. Kochi**,** also known as the "Queen of the Arabian Sea," is a vibrant port city, a major commercial centre, and home to the Cochin Port, one of the largest ports in India. The average population density of the district is 1,072 individuals per square km. The rapid urbanisation and spread of the city to neighbouring landscapes have exerted high pressure on the land, leading to massive conversions from traditional land uses. Apart from this, many *Anthropogenic and Ecological* factors act as drivers of Pokkali land conversion and shifting from traditional farming culture (Dipson and Nair, 2012; Shamna and Vasantha, 2017) [4] [19]. Our study further goes deep into this from a stakeholder perspective (Table 1; Figure 1).

Table 1: Drivers of Decline of Pokkali Ecosystem

Challenges to Pokkali Ecosystem Conservation	Frequency	Percentage	Rank
Developmental activity	53	23	I
Water pollution	52	23	II
Urbanization	42	19	III
Sea-level rise	32	14	IV
Artificial deepening of pokkali fields	17	8	V
Mangrove infestation	16	7	VI
Parasitic weed infestation	14	6	VII

Note: Percentage is calculated to the total number of responses.

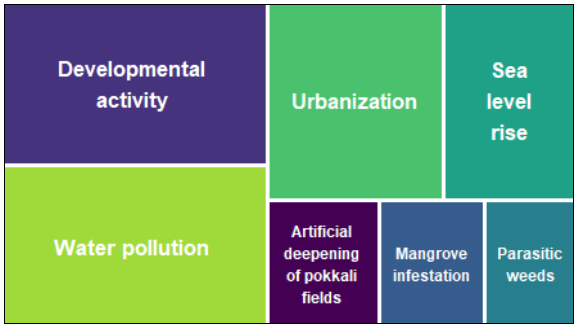


Fig 1: Drivers of decline of Pokkali Ecosystem

The majority of respondents identified developmental activities as the most significant challenge to conserving this unique agro-ecosystem. This concern emerged as the top-ranked issue, indicating that a substantial portion of the participants perceived developmental activities as having the most severe impact. Rapid infrastructure growth, expansion of residential and commercial spaces, and industrial projects are likely contributing factors that threaten the ecological balance of the area.

Ernakulam, the commercial hub of Kerala, has witnessed considerable wetland destruction over the past few decades due to various development projects. Kochi, being one of the fastest-growing regions in the state, has experienced rapid residential and commercial expansion, particularly over the last two decades. Industrial growth, along with the establishment of ports, harbours, resorts, and hotels for tourism, have been responsible for the shrinking of traditional rice-fish farming. Being in an economically viable area, Pokkali fields have been acquired for large-scale infrastructure projects, including the Vallarpadam container terminal road and railway link. Additionally, projects such as the metro rail, high-speed rail corridor, Smart City initiative, and the bridge connecting Vypeen Island to the mainland have directly or indirectly impacted the Pokkali ecosystem. The presence of three national highways (NH-47, NH-17, and NH-49), the Cochin Seaport-Airport Highway, and proposed development projects such as the International Ship Repair Facility (ISRF) of Cochin Shipyard Ltd. (CSL) and the LPG import terminal of Indian Oil Corporation Limited (IOCL) at Puthuvypeen may further threaten the ecosystem. These development activities have disrupted the natural tidal water flow into Pokkali fields, affecting traditional prawn farming. Moreover, the growth of the tourism sector and increasing development pressures have accelerated the conversion of Pokkali lands for non-agricultural purposes.

Kerala has a substantial immigrant population, which has driven societal transformations in the state, along with an exceptionally high cost of living. As one of the most urbanized districts in Kerala, Ernakulam, particularly the Kochi metropolitan area, has become a key destination for economic investments across multiple sectors. Kochi is also experiencing a surge in the IT and IT-enabled services (ITES) sector, leading to a sharp rise in the migrant population alongside general population growth. For instance, the population of Ernakulam was recorded at 3,282,388 in 2011, compared to 3,105,798 in the 2001

census, reflecting a 5.69% increase over the decade. Based on available projections, the district's population is estimated to reach approximately 3,480,000 by 2025, with figures for 2022, 2023, and 2024 projected at 3,450,000, 3,460,000, and 3,470,000, respectively (Table 2). The rapid urbanization of Ernakulam has resulted in the conversion of Pokkali fields into residential and commercial developments. Rising land prices, fuelled by rapid urbanization, have encouraged many farmers to abandon cultivation and sell their fields. Multinational corporations and real estate developers have acquired a considerable portion of pokkali lands.

Urbanization was also cited as a key concern, with expanding urban spaces encroaching on agricultural lands and natural habitats, further diminishing the area available for traditional farming practices.

Table 2: Projected population of Ernakulam district

Year	Projected Population
2011	3,282,388
2021	3,440,000
2022	3,450,000
2023	3,460,000
2024	3,470,000
2025	3,480,000
2026	3,490,000
2027	3,500,000
2028	3,500,000
2029	3,510,000
2030	3,510,000
2031	3,510,000

Source: (Population Census, 2011) [7]

Water pollution emerged as a major issue, possibly resulting from industrial discharge, agricultural runoff, and improper waste disposal, which can degrade soil quality and water resources vital to the ecosystem. Industrialization and urban expansion contribute to pollution in nearby water bodies, affecting water quality in Pokkali fields. Waste dumping and chemical contamination can deteriorate soil and water, reducing productivity. The pollution of backwaters in Ernakulam is due to indiscriminate effluent discharge from factories, oil spills from board engines of boats and the wastes from nearby urban areas, which negatively affect Pokkali rice farming and raise concerns about its organic nature. Moreover, "Kettukalakkal" is the final prawn harvest celebrated at the end of the prawn cultivation season, i.e. during the end of April. Recently, it has been celebrated as a part of tourism as well. During the festival, boating and fishing were permitted in the fields. It also polluted the fields and the surrounding areas.

Rising sea levels were recognized as another pressing threat, likely driven by climate change. This phenomenon can lead to increased salinity in the soil and water bodies, jeopardizing the sustainability of local agriculture, particularly the Pokkali farming system. Sea Level Rise (SLR) is considered one of the effects of climate change. A rise in mean sea level in the last few decades with variations in the rate of rise has been reported around the world (Menendez and Woodworth, 2010; Mudersbach *et al.*, 2013; Weisse *et al.*, 2014; Feng *et al.*, 2015) [12, 13, 28, 5]. Rise in the mean sea level (MSL) is observed by studies in India also (Unnikrishnan *et al.*, 2006; Kumar, 2006; Church *et al.*, 2006; Palanisamy *et al.*, 2014; Chowdhury *et al.*, 2015) [25, 10, 2, 14, 1]. Regarding Kerala, a higher rise in sea level of 170 mm (2.66 mm/yr) along the coastal area of Kochi during 1939-2003 was reported by Kumar, 2006 [10]. The observed rise in sea level has been more consistent since 2004. Recent studies based on Kochi tide gauge data show a sea level rise of 1.8 mm per year (Sreekesh *et al.*, 2018) [20]. As sea levels rise, low-lying Pokkali fields may become permanently inundated, leading to a reduction in cultivable land. Further, Saltwater intrusion into freshwater sources can make land unsuitable for cultivation over time.

Pokkali farming lost its economic importance in the 1990s and was partially replaced by intensive fish farming, which required less labour. However, many Pokkali fields have remained fallow since the 1990s, allowing mangroves to take over. The unchecked expansion of mangroves can encroach upon Pokkali fields, reducing the cultivable area. Strict conservation laws prohibit farmers from clearing or managing mangrove growth, leading to conflicts over land use. Farmers may face legal restrictions if their fields are near protected mangrove zones.

Parasitic weed infestation was reported as a significant problem. Such invasive species compete with native plants, deplete soil nutrients, and reduce crop yields, posing a direct threat to the productivity of the agro-ecosystem. Further, it also impacts the agricultural operations too. The proliferation of aquatic weeds, such as water hyacinths (*Eichhornia crassipes*), in the fallow lands also acts as a hurdle for this farming system and retrieval of lands for cultivation. The extensive spread of water hyacinth has made cultivation impossible in several stretches. One of the major concerns is the obstruction of tidal flow caused by these invasive weeds. Additionally, respondents pointed to mangrove infestation as a notable issue. Although mangroves play a vital role in coastal protection, excessive and unregulated growth along the periphery of Pokkali rice fields hinders traditional agricultural practices or alters water flow patterns.

The artificial deepening of Pokkali fields was also seen as a concerning factor. While such interventions may improve drainage or water flow, they often inadvertently disrupt the natural ecosystem balance, affecting soil fertility and aquatic biodiversity. Farmers are deepening their fields to enhance prawn and fish farming; this modification makes the land unsuitable for paddy cultivation in subsequent seasons. Additionally, fish farming in Pokkali fields requires a license issued for five months, i.e. November to mid-April, from the Department of Fisheries. There are two types of licenses for fisheries activities in Pokkali fields: seasonal licenses, valid for six months, and year-round licenses, valid for 12 months. The 12-month license is granted to those fields with greater depth where rice cultivation is impossible. To qualify for this year-round license, some farmers artificially increase their fields' depth.

The combined impact of these challenges underscores the need for comprehensive conservation strategies that balance developmental needs with ecological sustainability. Integrating scientific research, community involvement, and sustainable land-use practices will safeguard this unique agro-ecosystem for future generations.

3.2 Challenges to Pokkali rice cultivation

There are several reports on paddy cultivation in Kerala, which reduced from 7.11 lakh ha in the 1960s to a mere 1.91 lakh ha in 2022 (Prasad and Kuruvilla, 2024) [15]. However, the decline in Pokkali rice farming has been much higher. The reasons attributed to this fall, based on the stakeholders' responses, are presented in Table 3; Figure 2.

While some of the reasons are the same as those for the general challenges in paddy farming in the state, there are very specific reasons that are attributed to Pokkali rice farming. The most frequently reported challenge is the presence of the purple moorhen, which is considered the primary threat to rice cultivation in the region. This is followed by the lack of mechanization during the rice production process, poor market access and pricing, climate change, low yield, seed unavailability, high labour costs, labour shortages, lack of export potential, an ageing farming population, sediment deposition in Pokkali fields, lodging effects, and difficulties in obtaining organic certification**.**

Table 3: Challenges to Pokkali rice cultivation

Challenges to pokkali rice cultivation	Frequency	Percentage	Rank
Purple moorhen	61	13	I
Lack of mechanization	60	12	II
Poor market access & pricing	58	12	III
Climate change	54	11	IV
Low yield	50	10	V
Unavailability of seeds	49	10	VI
High labour cost	45	9	VII
Labour shortage	41	8	VIII
Lack of export potential	18	4	IX
Ageing farmer population	18	4	IX
Sediments deposited in pokkali fields during 2018	12	2	X
Lodging effect	11	2	XI
Organic certificate problem	8	2	XII

Note: Frequency includes multiple responses. Percentage is calculated to the total number of responses.

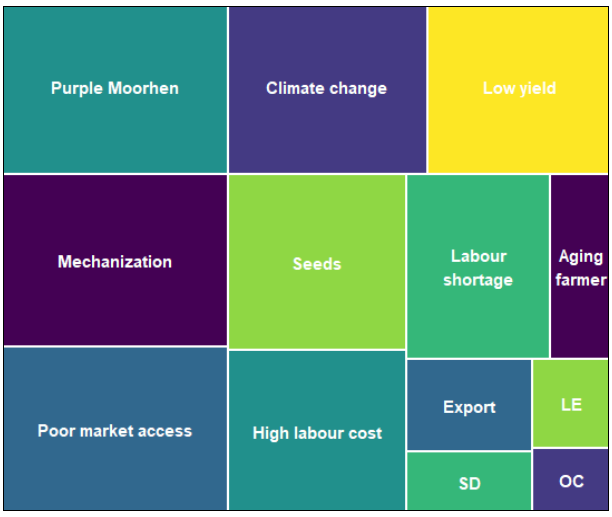


Fig 2: Pokkali rice cultivation

One of the major challenges, and a very specific one in Pokkali rice cultivation, is the damage caused by the Purple Moorhen (*Porphyrio poliocephalus*), also known as the grey-headed swamphen. These migratory birds belong to the avian family *Rallidae* and are commonly found in wetlands, including paddy fields, marshes, and lakes, where they thrive in large communities. Rice paddies serve as crucial feeding and nesting grounds for these birds. The primary reason for their intrusion into paddy fields is food scarcity and the loss of their natural habitats. They also seek shelter and breeding grounds within rice fields due to the dense coverage provided by rice plants. The Purple Moorhen primarily damages rice crops during two critical growth stages: vegetative and maturity. These birds attack crops in flocks, often destroying entire fields within days or even hours. Recently, it has become a serious threat to paddy cultivation across various parts of Kerala. Reports indicate that the bird is frequently spotted in rice fields near water bodies, with the extent of damage ranging from 10% to 50%. It also poses a significant threat to Pokkali rice farming and was reported as a major problem in Chellanam panchayat in 2011 (The Hindu, 2011) [23]. These birds damage Pokkali rice crops by cutting seedlings at ground level and consuming the soft inner portions of the plants. They can also create bald patches in the fields. While they are most active during the day, they can also cause destruction at night. Their presence is most noticeable from June, right after the seeds are sown, until the harvest season in November. Preventive measures during the early stages of rice growth, such as sprouting and growing, can reduce the damage caused by purple moorhens. The management of this bird pest is a major challenge as it is. However, since the bird is protected under the Wildlife Protection Act of 1972. In 2021, a group of farmers petitioned the Kerala High Court to classify the Purple Moorhen, locally known as 'Neela Kozhi,' as vermin, similar to rats, mice, fruit bats, and crows, which are recognized as crop-destroying pests. However, it was not permitted for legal reasons.

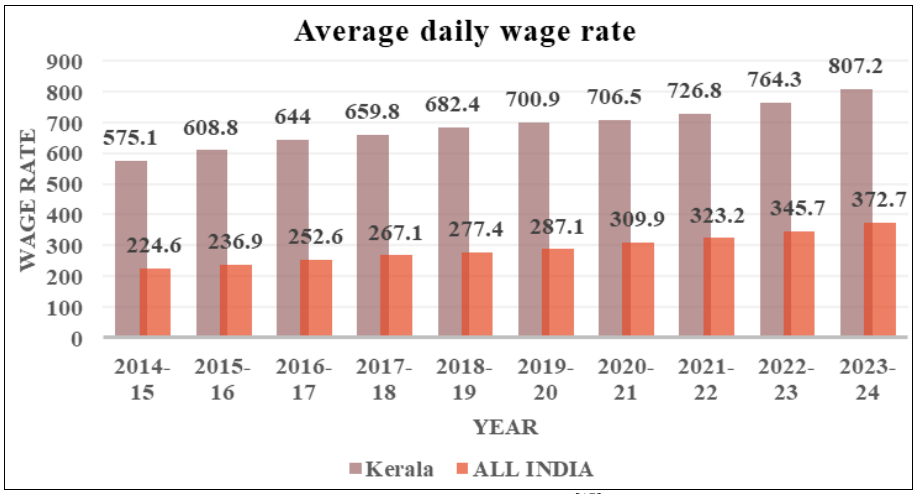
Mechanisation has significantly transformed India's agricultural sector, reduced cultivation costs and addressed labour shortages. In Kerala, technology, institutional support, and policy initiatives have successfully curbed large-scale conversions of paddy fields while promoting their restoration (Manjula and Devi, 2020) [11]. However, Pokkali cultivation has not benefited from mechanisation due to the unique waterlogged conditions of its fields, which render conventional machinery impractical. One major challenge is the absence of suitable equipment for land preparation. The marshy nature of Pokkali fields prevents the use of standard machinery, requiring farmers to rely on manual labour with long-handled spades.

Harvesting presents another difficulty, as the paddy plants remain partially submerged in water, making conventional harvesting equipment ineffective. Consequently, manual harvesting is still the norm, with women labourers working while standing in water. Despite sustained efforts by the government and Kerala Agricultural University, Thrissur, to develop appropriate machinery, no viable solution has been identified. As a result, Pokkali rice cultivation remains highly labour-intensive. This heavy dependence on manual labour not only drives up production costs but also reduces overall efficiency. Furthermore, Kerala's persistent labour shortages and high labour costs exacerbate these challenges, adding to the financial strain on Pokkali farmers.

Pokkali cultivation is a labour-intensive practice that demands substantial manpower for various tasks, including

land preparation, bund formation, sowing, transplanting, harvesting, and transportation. The shrinking agricultural workforce has compelled many farmers to abandon Pokkali cultivation or switch to less labour-intensive alternatives. One of the most pressing concerns is the shortage of workers for harvesting, which must be performed while standing in water. Compounding the challenge, labourers can only work until noon due to the physically demanding conditions.

The absence of mechanisation, coupled with the lure of better-paying jobs in urban industries, has driven many young people away from agriculture. Consequently, numerous Pokkali fields have been left fallow and overrun by mangroves. Additionally, crop yields or market prices do not sufficiently offset the high labour cost, rendering Pokkali farming financially unsustainable for many farmers. In 2023, the daily wage for agricultural labourers in Kerala was ₹764.3, more than twice the national average (figure 3). Data indicates that this trend has persisted annually since FY15. The combination of labour shortages and rising wages to attract workers has significantly escalated the cost of cultivating Pokkali.



Source: RBI Handbook of Statistics of Indian States, 2024 [15]

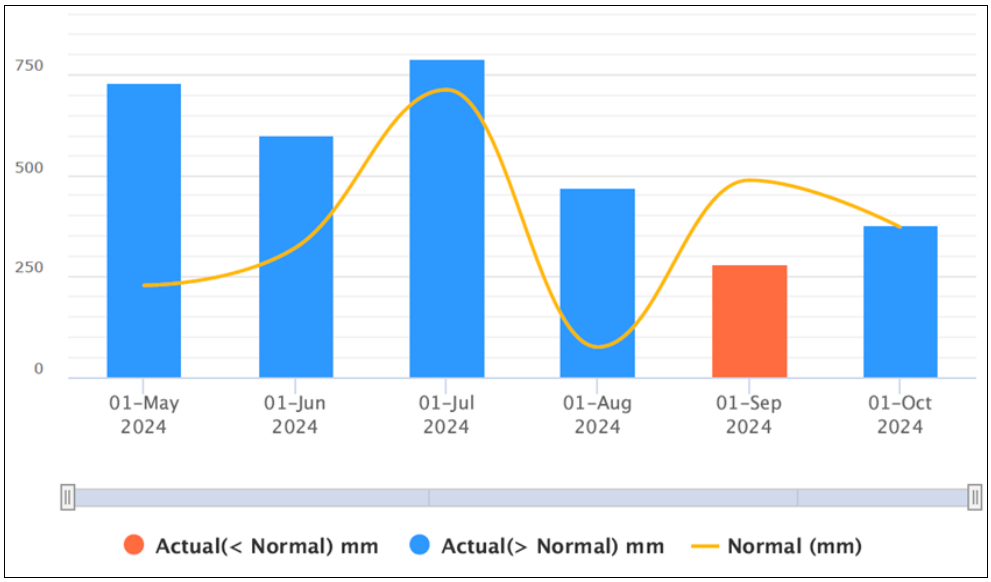
Fig 3: Comparison of the average daily wage rate of India and Kerala

Pokkali rice was granted a Geographical Indication (GI) tag in 2008, recognizing its agricultural heritage, traditional cultivation practices, and distinctive qualities due to its unique geographical characteristics. While the exceptional quality and taste of Pokkali rice make it appealing, there is no dedicated premium market for Pokkali rice and its value-added products. Pokkali rice faces competition from conventionally grown rice varieties that are more affordable and widely available. Kerala government offers Paddy a minimum support price of Rs. 28.32 per kilogram. It is difficult for pokkali rice farmers to opt for that because organically produced rice is so under-priced. The average cost of production of Pokkali paddy is ₹ 1,09,310 per ha, while that of other types is ₹ 78,792 per ha (GoK, 2025) [18]. Farmers demand a premium price for pokkali rice. Despite consumers willing to pay over ₹100 per kilogram for Basmati rice, organic rice like Pokkali struggles to gain traction in the broader market. Although the Kerala government has introduced several initiatives to promote Pokkali cultivation, it has yet to establish a successful business model for effectively marketing Pokkali rice (Radhika and Raju, 2021) [16]. Pokkali rice has export potential due to its unique taste, high protein content, and medicinal value. There was also a lack of appealing export policies in the state to promote this GI-tagged product.

Pokkali, Vellapokkali, Choottupokkali, and Cheruviruppu are the traditional rice cultivars in this region. Additionally, improved varieties (VTL-1 to VTL-8) have been developed by the Rice Research Station, Vyttila, under Kerala Agricultural University. Seeds are primarily obtained from the Rice Research Station or directly from farmers. However, traditional Pokkali seeds and farming methods are on the brink of disappearing. Due to low crop yields, farmers struggle to preserve seeds for the next season. The survey revealed that most farmers no longer cultivate the traditional rice varieties. Instead, they have shifted to high-yielding varieties such as Vyttila 6, Vyttila 8, Vyttila 9, and Vyttila 10.

Traditional and some high-yielding varieties have lodging effects, severely affecting harvesting and reducing yields. Increased pest attacks, particularly from birds like the Purple Moorhen, have been reported to cause damage to the plants, leading to lodging (Shamna and Vasantha, 2017) [19].

Pokkali cultivation relies strictly on natural systems and the climate. Climate change issues like uneven rain patterns, changes in the onset of southwest monsoon, increased salinity, high water temperature, and rising sea levels affect the traditional cycle of pokkali cultivation to a very high extent, and many farmers end up losing. Pokkali paddy requires salinity levels below one ppt for germination and early growth stages but can tolerate salinity levels up to 5 ppt or even more during later growth stages. The planting season begins in the first week of June, aligning with the onset of the monsoon, which helps flush out soil salinity through runoff water. However, many changes have been recorded in the patterns of summer rains and the onset of monsoons during the past decade (Gopakumar *et al.*, 2011) [6]. Delayed rainfall can increase salinity stress, affecting germination and early growth—excess rain after sowing washes away the seeds. Figure 4 shows the uneven rainfall pattern in Ernakulam district from May 2024 to October 2024.



Source: WRIS, 2024 [29]

Fig 4: Monthly rainfall pattern of Ernakulam district from May 2024 to October 2024

Table 4: Blockwise rainfall for Ernakulam from May 01, 2024, to Oct 31, 2024

Block	Normal (mm)	Actual (mm)	Deviation
Vypin	2207.2	2939.3	33.2%
Paravoor	2151.5	2932.8	36.3%
Palluruthy	2242.5	2968.8	32.2%
North Paravoor (m)	2076.1	2908.8	40.4%
Kochi (c)	2255.8	2985.6	32.4%
Kalamassery (m)	2255.3	3014.7	33.7%
Aluva (m)	2252.8	3075.5	36.5%

Source: WRIS, 2024

Another significant challenge is Pokkali's low yield of only about 1.5 tonnes per hectare, compared to 4-5 tonnes per hectare in other paddy fields, achieved by high-yielding rice varieties such as Uma and Jyothi. This low yield, combined with labour shortages and a lack of mechanisation, further contributes to Pokkali cultivation's declining profitability.

During the study, it was observed that most Pokkali farmers were elderly, with only a few young individuals continuing this traditional practice. This trend highlights the younger generation's declining interest in agriculture, as many prefer white-collar jobs. A lack of awareness or appreciation for the cultural and ecological value of Pokkali cultivation has further contributed to this shift.

Pokkali farmers from Varapuzha panchayat noticed that sediments were deposited in the pokkali fields after Kerala's flood in 2018. After this devastating flood, many agricultural lands, including Pokkali fields, experienced considerable sediment deposition, including silt, sand, and muddy soil. This altered the physical and chemical properties of the soil in Pokkali fields, potentially affecting nutrient availability and soil structure (Unni and Sreelatha, 2021) [24].

Even though Pokkali rice is naturally organic, obtaining organic certification is emerging as a problem because of water pollution in these continuous stretches of fields.

3.3 Challenges to fish and prawn farming in pokkali fields

Although the fisheries sector constitutes a major source of income from Pokkali agroecosystems, it has faced several challenges recently. Tables 5 and 6 highlight that diseases were the most frequently reported issue in fish and prawn farming within Pokkali fields. Other significant concerns include water pollution, low survival rates of fingerlings, declining yields, rising feed costs, elevated water temperatures, canal blockages, limited availability of high-quality fingerlings, threats from pests and predators, unauthorised fishing by outsiders, and the spread of aquatic weeds (Figure 5).

Table 5: Challenges to fish and prawn farming in pokkali fields

Challenges to fish farming in pokkali fields	Frequency	Percentage	Rank
Diseases	76	19	I
Water pollution	58	15	II
The low survival rate of fingerlings	52	13	III
Declining yield	42	11	IV
High feed cost	37	9	V
High water temperature	31	8	VI
Blocking of canal way	28	7	VII
Unavailability of good quality fingerlings	26	7	VIII
Pest and predators	18	5	IX
Fishing by outsiders	17	4	X
Aquatic weeds	11	3	XI

Note: Frequency includes multiple responses. Percentage is calculated to the total number of responses

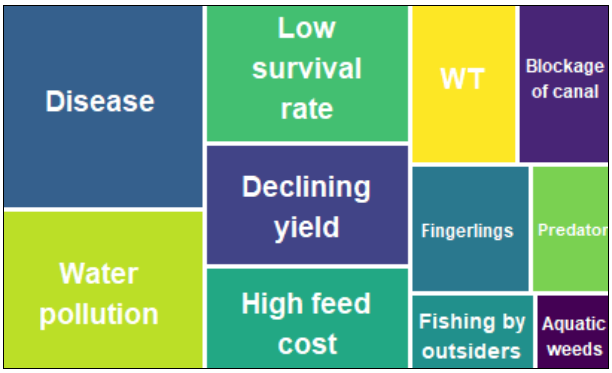


Fig 5: Challenges for fish farming in pokkali fields

The losses incurred in Pokkali rice farming are typically offset by prawn farming. However, due to the widespread White Spot Syndrome (WSS) viral infection, prawn farming has become unprofitable. Various other infections such as Yellow Spot, EHP (Enterocytozoon Hepatopenaei), Loose shell syndrome and White faecal syndrome also impact prawn farming. Discontinuing Pokkali rice farming would have severe consequences for prawn farming, as juvenile prawns rely on the high-protein nutrients derived from decaying rice stubble, which makes them vulnerable to many diseases. Without Pokkali cultivation, the soil in these fields becomes more acidic and experiences reduced oxygen availability, creating unfavourable conditions for prawn farming (Das and Stigter, 2005) [3].

Most Pokkali tracts are situated near the Vembanad and Kochi backwaters, both of which suffer from severe pollution due to the unchecked discharge of industrial effluents, oil spills from boat engines, and various types of waste from Kochi city and surrounding towns. For instance, pollution from the Eloor industrial area affects the Periyar River, impacting rice and prawn farming in Varappuzha panchayat. The deteriorating water quality of the Periyar and its tributaries has significantly affected the livelihoods of fish and Pokkali farmers in Varappuzha. The presence of harmful chemicals in the water has led to a substantial decline in yield in recent years. Additionally, the contamination has negatively impacted the health and survival of crustaceans, fish, and molluscs. The polluted water, along with sudden freshwater inflows, has also resulted in the mortality of fingerlings.

Neerkakka (or "water dog") is a local term used to describe predatory water creatures or large fish-eating birds. These predators challenge fish farming in Pokkali fields by preying on the stocked fish/prawn fingerlings, reducing yields and affecting farmers' income.

Farmers have faced difficulty sourcing high-quality fingerlings (juvenile fish or prawns) in recent years. The high risk involved in selecting suitable stock, frequent diseases, water body pollution, and the unavailability of high-quality seeds results in a low-yielding system. Climate change issues like rising water temperatures affect fish/prawn farming by reducing the survival rate of fingerlings.

Canals play a crucial role in facilitating the movement of prawns and fish between the fields and adjacent water bodies like backwaters and rivers. Canals are blocked due to siltation, weeds, improper maintenance, and other anthropogenic activities. As a result, the natural infiltration of prawns from nearby estuarine waters into the Pokkali fields is reduced, affecting stocking density and productivity. Additionally, poor drainage and water stagnation further hinder prawn infiltration.

Floating weeds like *Salvinia molesta* and *Eichhornia crassipes* (water hyacinth) form thick mats on the water surface, restricting movement and food access for fish species such as *Etroplus suratensis* (Pearlspot), which is commonly reared in Pokkali fields. This limited mobility results in slower growth rates. Additionally, dense weed overgrowth obstructs fish harvesting activities and hampers oxygen exchange between the air and water, affecting the growth of fishes.

Farmers often supplement with commercial feeds such as pelleted feed (floating or sinking pellets) and extruded feed to ensure optimal growth. The rising cost of formulated fish and prawn feed raises production expenses by increasing input costs, thus, in turn, reducing profitability.

Unauthorized fishing led to disputes between farmers and poachers, creating social tensions. Farmers investing in prawn and fish culture suffer financial losses when outsiders illegally harvest their stock.

Table 6: Challenges to prawn farming in pokkali fields

Challenges to prawn farming	Frequency	Percentage	Rank
Viral disease (white spot)	131	32	I
Blocking of canal way	53	13	II
Low survival rate of fingerlings	40	10	III
Declining yield	35	9	IV
Water pollution	33	8	V
Unavailability of good quality fingerlings	30	7	VI
Pest and predators	26	6	VII
High cost of feed	26	6	VII
High water temperature	19	5	VIII
Aquatic weeds	8	2	IX
Fishing by outsiders	6	1	X

Note: Frequency includes multiple responses. Percentage is calculated to the total number of responses.

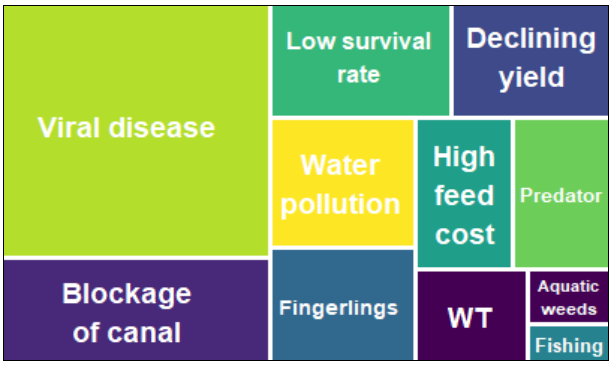


Fig 6: Challenges to prawn farming in pokkali fields

3.4 Challenges to pokkali rice-prawn/fish integrated farming

Most respondents identified low profitability as the primary challenge in Pokkali rice-prawn/fish integrated farming. Since more number of respondents acknowledged the severity of this issue, it was ranked as the most pressing concern. This was followed by challenges related to land and water management, higher returns in prawn farming, lack of interest among the younger generation, and the

monoculture of prawns (Table 7; Figure 7).

Table 7: Challenges to pokkali rice-prawn/fish integrated farming

Challenges to pokkali rice-prawn/fish integrated farming	Frequency	Percentage	Rank
Low profitability	91	28	I
Land and water management issues	89	27	II
High returns in prawn farming	67	20	III
Disinterest of the younger generation	45	14	IV
Monoculture of prawn	36	11	V

Note: Frequency includes multiple responses. Percentage is calculated to the total number of responses.

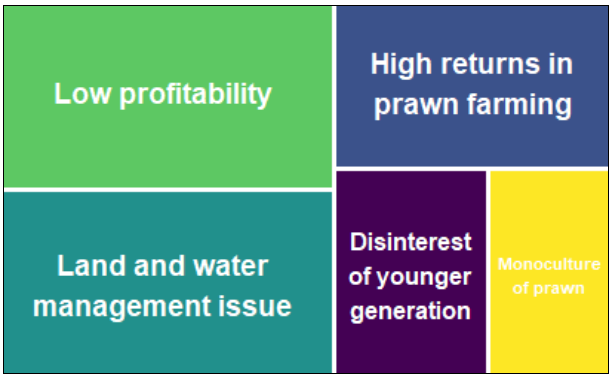


Fig 7: Challenges for Pokkali rice-fish integrated farming

Due to the low market price of Pokkali rice, many farmers are shifting towards prawn monoculture. Although the State Government has directly intervened by making the monoculture of prawns illegal, an increasing number of fields are being converted to fallow-prawn and prawn-prawn systems (Jayan and Sathyanathan, 2010) [8].

The higher profitability of prawn farming has led many farmers to prioritize stocking prawns in Pokkali fields. While this approach provides short-term gains, it is proving to be unsustainable in the long run due to deteriorating soil and water conditions, which ultimately affect prawn production in the subsequent years (Krishna *et al.*, 2006; Vijesh, 2006) [9, 26].

Lower productivity of pokkali rice in the range of 1.5 t/ha for traditional varieties (pokkali, chottupokkali) and 2.5 t/ha for high yielding varieties such as Vytila series (vytila-8, vytila-9, vytila-10) along with higher cost of cultivation of pokkali rice making the integrated system as a low profitable one (Sreelatha *et al.*, 2022) [21]. The comparatively low profits from Pokkali farming have led to a paradigm shift in traditional practices, with more farmers opting to use their fields exclusively for prawn harvesting to maximize returns. This shift has disrupted the traditional integrated farming system.

There are increasing conflicts between rice farming and fish/prawn farming on account of the timings. The rice farming is to begin by the first week of June to ensure economic returns. However, most often the prawn/fish farmers continue to harvest, without leaving the land for rice cultivation on time (April 15). Though there is legal directive to this effect, most often it is poorly followed. As the conflict is between unequals (the richer prawn/fish farmers) and the relatively poor (rice farmers), the action by the fish farmers often lead to obstructions in timely rice cultivation.

The average age of farmers involved in Pokkali cultivation falls between 50 and 60 years or older, with little to no participation from the younger generation. Many young people are opting for urban job opportunities, and are moving away from traditional Pokkali farming.

4. Conclusion

Pokkali rice-fish integrated farming, a centuries-old agricultural practice unique to Kerala, faces multiple challenges. While rapid urbanization and expansion lead to direct impacts such as land conversion, the indirect impacts include the shift of agriculture labourers and farmers to other sectors and pollution of the ecosystem as well as blocks to the natural flow of water. The invasion of Purple Moorhen and high disease prevalence in prawns further compound these difficulties. The declining interest of the younger generation in Pokkali farming, combined with ineffective marketing, has further weakened the resilience of this traditional system. Given the current challenges, it is crucial to take action to safeguard this traditional farming practice before it fades into history. Many Pokkali fields that once thrived with organic paddy and prawn production now remain abandoned. The only way to revive Pokkali cultivation and restore its past glory is by ensuring higher income per unit area, making it a more attractive and viable option for farmers. To ensure the survival of Pokkali farming, a multi-faced approach is required—stringent regulations, improving mechanization, enforcing sustainable land and water management practices, promoting value-added products, and strengthening market linkages.

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6. References

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