



Research Note

Mussel Farming in Kavvayi, Southwest India: Economic Analysis and Socio-Cultural Insights on Women Farmers

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Mussel farming is a breadwinning activity in the northern coastal districts of Kerala. The only species commercially cultivated in the region is the green mussel, *Perna viridis*. This study focused on the economic evaluation of mussel farming in the Kavvayi estuarine wetland. The survey analyzed the economic efficiency of mussel rack farms in the area. The benefit-cost ratio (BC ratio) was used to compute the financial viability, which was estimated as 1.56. At present, the invasion of the alien mussel species, *Mytella strigata* is a serious concern to the mussel farming sector. Proper management measures to control their invasion are yet to be identified.

Keywords: *Perna viridis*, mussel farming, Kavvayi wetland, economic evaluation, benefit-cost ratio, *Mytella strigata*

Aquaculture has gained prominence as one of the most potent food-producing sectors globally. Aquaculture not only supplies dietary essentials for human consumption but also provides significant opportunities for income generation for the unemployed and economically backward rural communities. This is a rapidly growing sector in India, with an annual growth rate of over 7% (Boyed et al., 1998). Global aquaculture production in 2020 was

122.6 million tonnes, including 87.5 million tonnes of aquatic animals. Production from capture fisheries worldwide in 2020 was 90.3 million tonnes (algae excluded). Over the past seven decades, the total production from fisheries and aquaculture (apart from algae) has increased dramatically. Aquatic animal output was expected to have decreased slightly from the all-time high of 179 million tonnes in 2018 to 178 million tonnes globally in 2020 (FAO, 2022). About 37% of the overall production was harvested from inland waters and 63% from coastal seas. India contributes 7.96% of the global fish production, making it the third-largest fish producer in the world. More than 10% of the world's fish and shellfish species are found in India's vast and diverse fisheries resources, which include deep sea, lakes, ponds, and rivers. The extensive inland resources include 3.15 million ha of the reservoir, 2.45 million ha of ponds and tanks, 1.2 million ha of floodplain lakes, and 0.27 million km of rivers and canals. Mariculture in the country has been limited to bivalve molluscs such as mussels, edible oysters, and pearl oysters (DADF, 2017).

Mussels are bivalve molluscs found attached to the hard surfaces in the littoral and sub-littoral zones. They attach themselves to the substrate by secreting long threads called byssus. Though generally sedentary, they can move from one area to another, if exposed to unfavourable environmental conditions. Mussels are regarded as one of the best candidates for aquaculture since they are filter feeders, obtaining nourishment from the lowest level of the food chain by feeding on phytoplankton, detritus, and associated microscopic flora and fauna.

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Other attributes such as fast growth, high nutritional value, and adaptability to various environmental conditions such as short periods of exposure to extreme temperatures, salinity, desiccation, and high turbidity are added advantages for selecting these species for culture. The two important species of mussels in India are the green mussel, *P. viridis*, and the brown mussel, *P. indica*. The green mussel has a wider distribution along the west and east coasts of India, including the Andaman Islands.

The Malabar Coast in northern Kerala, covering the districts of Kasaragod, Kannur, Kozhikode, and Malappuram, with its extensive network of backwaters and estuaries, has proved to be an ideal location for green mussel culture. However, continuous cultivation of mussels in the same area for a long period at a density exceeding than acceptable limits has adversely affected their growth rate. Further, frequent disease outbreaks and unpredictable changes in the climate have also negatively effected the growth and sustainability of mussel farming in this region. The green mussel is generally farmed during the post-monsoon months extending from November–December to April–May each year, when higher salinity conditions (20–30 parts per trillion) prevail in the backwater systems. Among the different culture methods, farmers in the Kannur and Kasaragod areas generally follow the rack method of culture introduced by the Central Marine Fisheries Research Institution (CMFRI). This study presents a comprehensive economic analysis of mussel culture activities carried out in the Kavvayi Estuary, located along the west coast of India in the state of Kerala. The analysis focuses on assessing the costs, returns, profitability, and overall economic viability of mussel farming practices in the region. By evaluating various financial indicators and socio-economic factors, the study aims to provide insights into the potential of mussel culture as a sustainable livelihood option for local communities especially women farmers and its contribution to the coastal economy and some challenges for the culture are also discussed in the study.

Kavvayi is the largest backwater system in northern Kerala and extends across the Kannur and Kasaragod Districts (Fig. 1). This estuarine wetland system is fed by five major rivers and several small canals and has an area of about 26.49 sq km. The depth of the wetland varies from 0.5 m and 8.9 m, while its width ranges between 155.81 m and 1754.12 m (Shiji, Kavya, & Harikumar, 2015). Aquaculture, particu-

larly artificial mussel farming contributes greatly to the economic status of the rural inhabitants in the Kavvayi wetland. Most of the inhabitants depend on both fishing and farming as alternative occupations. Mussel farming was first introduced in Padanna Kayal by CMFRI in 1996 and has since grown tremendously due to its multiple advantages.

The data for this study were collected from four Panchayats within the Kavvayi estuarine system, specifically Padanna, Cheruvathur, Valiyaparamba, and Trikaripur, over the period from 2018 to 2020. Field visits were conducted to each mussel farming unit, during which detailed observations were made. The primary survey was carried out using a pre-designed questionnaire that mainly included economic parameters such as initial establishment cost, fixed cost, operating cost, total cost of production, and profit. Mussel farming in the region involves the use of a bamboo pole-based rack system, measuring 25 sq m (5 x 5 m), which serves as the primary structure for mussel cultivation. For one mussel unit about 100 seeded ropes were hung in each site. The various stages of mussel culture within the Kavvayi system are visually represented through photographs (Fig. 2). A comprehensive survey was conducted across 216 mussel farming units spread across the four Panchayats, gathering essential data on the socioeconomic profiles of the participants. The survey also aimed to identify the socio-economic profile of women farmers in the area and the key challenges faced by the local mussel farmers.

The large bamboo poles, each longer than the maximum water depth during high tide, are driven into the bottom and connected horizontally with smaller bamboo poles. The seeded mussel ropes are hung from these racks. For seeding, mussel seeds are placed around the rope and securely wrapped with knitted cotton cloth. The seeded rope, measuring about 1–1.5 m in length, is suspended in the water. Within 2–3 days, the cloth starts to disintegrate, and the seeds get attached to the rope using the byssus threads. The economics of mussel farming were analysed using variables such as annual fixed cost, operating cost, total returns, net profit, and the benefit-cost ratio (BC ratio) (Lakshmi et al., 2019). The total cost was calculated as the sum of annual fixed and operating costs. Operating costs included all the expenses incurred during the operation of the farming, while fixed costs are those incurred even in the absence of farming activity.

Depreciation was estimated based on the expected lifespan of each item in the capital investment. The economic feasibility and efficiency of different production systems were assessed using the following formulae:

$$\text{Total cost} = \text{annual fixed cost} + \text{operating cost} \dots (1)$$

$$\text{Net operating income} = \text{total income} - \text{operating cost} \dots (2)$$

$$\text{Net returns} = \text{total returns} - \text{total cost} \dots (3)$$

$$\text{Benefit-Cost ratio} = \text{total returns} / \text{total cost} \dots (4)$$

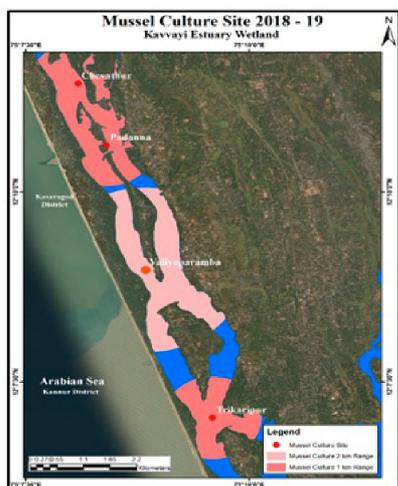
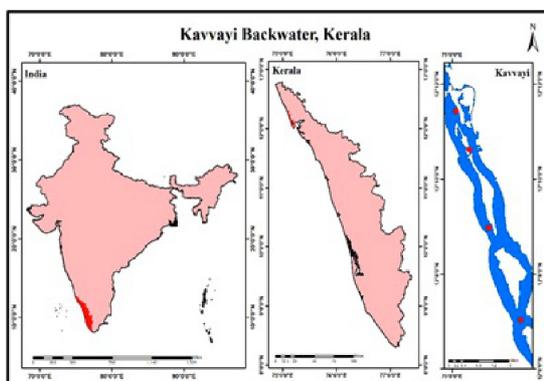


Fig. 1. The map showing the major locations of mussel farming in Kavvayi

Backwater mussel culture, being a low investment activity, promotes the potential for resource and employment generation among coastal communities, particularly among women and youth. It can stimulate healthy socio-economic development in these area. Starting in the mid-1990s, mussel



(a) Mussel spat



(b) Manual seeding



(c) Mussel bag



d) Mussel rack culture



(e) At the time of harvest



(f) Harvested mussel

Fig. 2. Mussel Farming in Kavvayi backwaters

farming in the Kasaragod region grew steadily and at present, the region is the “mussel hub” of India. The production of farmed mussels from this region peaked at 15,000 tonnes in 2008 (CMFRI, 2020). Here, farming is primarily a group-based activity, with around 500 groups currently involved in the practice. The major operational costs associated with the culture systems included annual lease, labour for rack construction, muslin cloth, mussel seeds, harvesting and marketing expense, and transportation cost. Labour charges related to stocking, rack maintenance, and harvesting also contributed to about 22-35% of the total operational cost. Transportation accounts for about 29%, while harvesting and

marketing represent around 15% of the total operational cost (Lakshmi et al., 2019). The operational cost mainly includes expenditure on rack construction, and in these studies, it ranged between Rs. 1000 and Rs. 2500 per unit involving 100 seeded strings. The annual fixed cost includes bamboo poles, nylon rope, coir rope, and nylon cages, which are the main investment in these culture systems.

The annual fixed cost was calculated by considering a 50% depreciation rate for bamboo poles, nylon ropes, and coir ropes. This higher rate of depreciation was considered based on feedback from farmers. Interest for capital investment was computed at the rate of 10% per annum. Depreciation was calculated for permanent assets, based on the life expectancy of each item in capital terms (Lakshmi et al., 2019). The cost of mussel seeds was found to be very high and varied depending on seed availability. Therefore, among the operation costs, the highest expenditure was for the purchase of seeds. There was no feed cost involved in mussel culture since the species generally utilizes the plankton available within the water column. The maximum mussel production recorded across the sampling sites was 1,450 kg and the minimum was 120 kg, with a mean production of 785 kg. In cage culture farming, the maximum production of pearl spot was 280 kg per cage, which was very encouraging and economically viable in the cage culture (Imelda & Gopalakrishnan, 2017).

The mean Benefit-Cost ratio (BC ratio) was calculated as 1.56, which ranged from a minimum of 0.33 to a maximum of 2.8. The mean annual fixed cost, operating cost, total income, net profit, and benefit-cost ratio were estimated as Rs. 4,115, Rs. 40,715, Rs. 1,17,750, Rs. 72,930 and 1.56 respectively. For different aquaculture systems, the benefit-cost ratios varied between 1.22 and 1.86 (Katiha, Jena, Pillai, Chakraborty, & Dey, 2005). The economic analysis revealed high variability in the economic variables for mussel culture in the Kavvayi wetland. However, the mean estimates for the culture operations were found economically viable and the farmers preferred to continue the mussel culture activity in the Kavvayi estuarine wetland.

The uniqueness of this cultured system is that except for some labour-intensive tasks, most of the activities in the mussel culture are managed individually by women or by women Self-Help Groups or Kudumbashree units. Kudumbashree is a poverty

eradication and women empowerment programme implemented by the State Poverty Eradication Mission (SPEM) of the Government of Kerala in 1998. It functions through a three-tier network of women's collectives, with Neighbourhood Groups at the base, Area Development Societies at the ward level, and Community Development Societies at the local government level. Self-help groups (SHGs) are informal associations of people who come together to address common issues. The SHG programme was introduced with the goal of improving the standard of living in rural areas. Through attractive schemes and positive efforts, SHGs provide mutual support and solutions to shared problems (Panackal, Singh, & Hamsa, 2017)

In Mussel culture, women are engaged in a wide range of activities such as sourcing inputs, rack establishment, seeding, farm management, and harvesting followed by post-harvest value addition and marketing. This is a highly successful and self-emerged model of rural women empowerment and is also an example of gender inclusiveness. Through this, women provide both physical and moral support to their families and society. More than 3,000 women had become owners of mussel farms along the southwest coast of India (Kripa & Surendranath, 2007). Women also play a significant role in aquaculture production in Bangladesh (FAO, 2017). They have gained knowledge in managing cage farms for seed procurement, nursery rearing of fish seed, feed scheduling, feeding, cage maintenance, and marketing, hence it has been shown that women's participation in aquaculture is advantageous for their socioeconomic empowerment (Imelda & Gopalakrishnan, 2017).

The major problem faced by the farmers is the invasion of *M. strigata*. The species has already spread in many estuarine ecosystems and brackish water lakes along the Kerala coast. (Kumar, Ravinesh, Oliver, Tan, & Sadasivan, 2019, Jayachandran et al., 2019). The rapid spread of the species may be due to the strong tropical cyclone 'Ockhi' in the Arabian sea in 2017 or the frequent movement of fishing vessels from the inshore waters to the estuaries (Kumar et al., 2019). *M. strigata* has been spotted in the Kavvayi habitat since 2018, particularly in Thayil, Kavvayi, Madakkal, Orie, Thekkekad, Vadakkekad, and Ayitti. In these areas, the growth of *P. viridis* has been reduced as a result of the spread of *M. strigata* (Communication by local people). In contrast to Rice, Rawson, Salinas, and Rosario

Table 1. Economic analysis of mussel farming in Kavvayi estuarine wetland

		Minimum (Rs.)	Maximum (Rs.)	Mean (Rs.)
A	Investment Bamboo poles (22 feet (Rs 200 /piece))	800	4600	2700
	Bamboo poles (12 feet (Rs 160 /piece))	640	3360	2000
	Nylon rope (Rs 1.20/m)	120	2272	1196
	Coir rope (Rs 8/m)	340	2528	1434
	Others (needle, thread, coir)	800	1000	900
	Total Investment	2700	13760	8230
	Annual fixed cost			
	Depreciation			
	Bamboo poles- 22feet (50% per annum)	400	2300	1350
	Bamboo poles- 12feet (50% per annum)	320	1680	1000
	Nylon rope-(50% per annum)	60	1136	655
	Coir rope- (50% per annum)	170	1264	640.5
	Others- (50% per annum)	400	500	650
	Total annual fixed cost (B)	1350	6880	4115
C	Operating Cost			
	Annual lease	200	200	200
	Labour for Rack construction	980	2500	1740
	Muslin cloth	600	1000	800
	Mussel seed (Rs 84/kg)	5880	58800	32340
	Harvesting and Marketing	1250	2700	1975
	Others	800	3000	1900
	Transportation	500	3000	1750
	Total operating cost	10210	71200	40715
D	Total cost (B+C)	11560	78080	44820
E	Production (kg or number)	120	1450	785
F	Income @ Rs. 5/number (150/kg)	18000	217500	117750
G	Net operating income(F-C)	7790	146300	77045
H	Net profit(F-D)	6440	139420	72930
I	BC Ratio	0.33	2.8	1.56

(2016), Lim et al. (2018) found that *M. strigata* may possibly outcompete *P. viridis*. They were observed in their natural habitat and were also attached to nets for cages or pens, wooden pilings, bottom sediments, bamboo poles, boat hulls, etc. The cage/pen net can break due to the heavy pressure of the species. Farmers in the vicinity suffer substantial economic losses due to *M. strigata*, which poses a serious threat to aquaculture activities.

Mytilides typically have high fecundity, fast growth rates, are filter feeders, and can tolerate a wide range of environmental conditions. Reproductive maturity

of *M. strigata* occurs at a shell length of 1.25 cm (Stenyakina, Walters, Hoffman, & Calestani, 2010). In the kavvayi backwater, the collected sample size ranged from 0.8 cm to 5 cm. The eradication of this species for reviving mussel farming is a major concern for farmers. At this juncture, a complete eradication is not conceivable. The Convention on Biological Diversity (CBD) formulated Biodiversity Target 4 to identify invasive alien species and identify their route of introduction, for developing a better management plan as a part of National Biodiversity Strategies and Action Plans (NBSAP) in 2020 (Jayachandran et al., 2019). People in the

Kavvayi region now frequently utilise *M. strigata* as food and as pet food.

The emergence of potential risk factors in mussel farming areas includes several key challenges. These include poaching and unauthorized harvesting which can significantly impact both sustainability and economic returns. Water quality plays a critical role, as poor conditions, often resulting from pollution or environmental changes, can adversely affect mussel health and growth. Disease outbreaks pose another serious threat, potentially leading to widespread mortality among mussel populations and significant economic losses. Mortality rates can also rise due to environmental stressors, poor management practices, or other unforeseen conditions. Additionally, invasive species remain a growing concern, as they can compete with mussels for resources, disrupt ecosystems, and affect the overall productivity of farming areas. Addressing these risks is essential for ensuring the long-term sustainability and profitability of mussel farming operations. The production of farmed mussels in the area experienced a steady decline after 2009. Between 2009 and 2015, production dropped by 16–43%, eventually reaching a historic low of 264 tons in 2016. The decline from 2015 to 2016 was particularly severe, amounting to a 93.8% reduction. This sharp decrease in 2016 was not limited to the Padanna Backwaters but extended to all northern districts of Kerala. Notably, in 2014, the Edayillakadu area of Padanna Backwaters suffered high mussel mortality due to poor waste flushing, which led to eutrophication of the water body. Mussel farming issues also include poor seed quality, overcrowding, reduced water flow, environmental stress (high temperature and salinity), stunted growth, high mortality, and the presence of the parasite *Perkinsus olseni* (CMFRI, 2021).

Another factor that impacts the economics of the mussel culture is seed availability. Seed prices vary considerably across the years due to the differences in natural seed setting rates and availability of good-quality seeds. These price fluctuations affected the small-scale farmers who were dependent solely on the mussel culture for livelihood. During the culture time, seeds are distributed and, after harvest, collected by middleman called agents. These agents sell the seed to farmers at a higher rate and collect the harvested mussel at low price, later reselling them at higher rate in different districts. Some women sell their products directly to the local

markets to eliminate the middlemen (Imelda & Gopalakrishnan, 2017). Some suggestions for improving mussel culture include constructing stages in a crisscross position; and using coir ropes instead of nylon rope for better attachment and development of the mussels. However, the major problem for the farmers is fluctuating seed rates and marketing issues, for which better facilities have to be utilized so that farmers can secure better price for their product and get maximum yield from the culture.

Mussel farming provides a secondary livelihood option for several coastal inhabitants. Most farmers were satisfied with the culture system. The invasion of *M. strigata* is the main threat to the mussel culture. Since there are no successful methods for complete eradication of this invasive species, it is essential to establish a framework for conservation and management that will allow for the early diagnosis and impact reduction of invasive species.

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References

- Boyed, C. E. (1998). *Water quality for pond aquaculture*. Auburn University Press.
- CMFRI. (2020). *Annual Report 2020*. Central Marine Fisheries Research Institute.
- CMFRI. (2021). *Annual Report 2021*. Central Marine Fisheries Research Institute.
- Department of Animal Husbandry, Dairying and Fisheries [DADF]. (2017). *Annual report 2016–17*. Ministry of Agriculture, Government of India.
- FAO. (2017). *National aquaculture sector overview: India*. FAO Fisheries and Aquaculture Department.
- FAO. (2022). *The State of World Fisheries and Aquaculture: Towards Blue Transformation*. FAO.
- Imelda, J., & Gopalakrishnan, A. (2017). Cage farming headed for equal opportunity in aquaculture development in Kerala, India. *Asian Fisheries Science Special Issue*, 30S, 383-387. <https://doi.org/10.33997/j.afs.2017.30.S1.026>.

- Jayachandran, P. R., Aneesh, B. P., Oliver, P. G., Philomina, J., Jima, M., Harikrishnan, K., & Nandan, S. B. (2019). First record of the alien invasive biofouling mussel *Mytella strigata* (Hanley, 1843) (Mollusca: Mytilidae) from Indian waters. *Bio Invasions Record*, 8(4), 828-837. <https://doi.org/10.3391/bir.2019.8.4.11>.
- Katiha, P. K., Jena, J. K., Pillai, N. G. K., Chakraborty, C., & Dey, M. M. (2005). *Inland Aquaculture in India: Past Trend, Present Status and Future Prospects, Aquaculture Economics & Management*, 9(1-2), 237-264. <https://doi.org/10.1080/13657300590961573>.
- Kripa, V., & Surendranath, V. G. (2007). On-bottom culture of the green mussel *Perna viridis* in Kerala. *Marine Fisheries Information Service, Technical and Extension Series*, 191, 9-10.
- Kumar, A. B., Ravinesh, R., Oliver, P. G., Tan, S. K., & Sadasivan, K. (2019). Rapid bioinvasion of alien mussel *Mytella strigata* (Hanley, 1843)(Bivalvia: Mytilidae) along Kerala coast, India: will this impact the livelihood of fishers in Ashtamudi Lake. *Journal of Aquatic Biology & Fisheries*, 7, 31-45.
- Lakshmi, N. M., Praveen, K. V., Sreekanth, G. B., Singh, N. P., Vennila, A., Kumar, R. R., & Pandey, P. K. (2019). Economic Evaluation of Different Aquaculture Systems in Coastal waters of Goa, Southwest Coast of India. *Fishery Technology*, 56(3), 231-241.
- Lim, J. Y., Tay, T. S., Lim, C. S., Lee, S. S. C., Teo, S. L. M., & Tan, K. S. (2018). *Mytella strigata* (Bivalvia: Mytilidae): an alien mussel recently introduced to Singapore and spreading rapidly. *Molluscan Research*, 38(3), 170-186. <http://dx.doi.org/10.1080/13235818.2018.1423858>.
- Panackal, N., Singh, A., & Hamsa, S. (2017). Kudumbashree and women empowerment in Kerala-An overview and theoretical framework. *Indian Journal of Commerce and Management Studies*, 8(1), 16-21.
- Rice, M. A., Rawson, P. D., Salinas, A. D., & Rosario, W. R. (2016). Identification and salinity tolerance of the Western Hemisphere mussel *Mytella charruana* (d'Orbigny, 1842) in the Philippines. *Journal of Shellfish Research*, 35(4), 865-873. <http://dx.doi.org/10.2983/035.035.0415>.
- Shiji, M., Kavya, P., & Harikumar, P. S. (2015). Sediment quality assessment of Kavvayi Wetland in South Coast India with special reference to phosphate fractionation and heavy metal contamination. *Journal of Environmental Protection*, 6(11), 1308-1321. <http://dx.doi.org/10.4236/jep.2015.611114>.
- Stenyakina, A., Walters, L. J., Hoffman, E. A., & Calestani, C. (2010). Food availability and sex reversal in *Mytella charruana*, an introduced bivalve in the southeastern United States. *Molecular Reproduction and Development*, 77(3), 222-230. <https://doi.org/10.1002/mrd.21132>.