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## Economic and environmental aspects of Pokkali Rice-Prawn production system in central Kerala

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### Abstract

Pokkali rice-prawn farming practice is a traditional rice-fish cultivation system found only in the coastal areas of Central Kerala where the height of water column of the field increases more than 100 CM during the South-West Monsoon. This system utilizes the symbiotic relationship between rice and prawns. This is a natural system of cultivation which relies upon monsoons and sea tides. Rice residues form the feed for prawns and the excreta of Prawns formed the fertilizer for rice, which makes it ecologically stable and also reduces the input by maintaining a mutualistic approach. The study was conducted among Pokkali-Prawn, Non-Pokkali- Cowpea and Semi Intensive Prawn systems present in Ernakulum and Alappuzha Districts of Kerala. The net returns generated from these systems were estimated to be of Rs. 2.80 lakhs; Rs. 0.69 lakhs and Rs. 1.55 lakhs per ha with the Benefit Cost Ratio of 2.17, 1.45 and 1.31 respectively. Partial Budgeting exercise of sole Pokkali rice cultivation to Pokkali-Prawn Integrated system has resulted an income enhancement of Rs 3.75 lakhs and Partial Budgeting of Semi-Intensive Prawn cultivation to Pokkali-Prawn cultivation resulted an increase of income by Rs. 0.93 lakhs for every ha of cultivation. Such a profitable venture can be taken up scientifically without reducing the ecological health by an agripreneur.

**Keywords:** Pokkali rice cultivation; prawn farming; Semi-intensive farming; partial budgeting

### 1. Introduction

Rice (*Oryza sativa*) is a widely consumed cereal grain formed the staple food to the people of Asian continent. Rice is grown in all rice growing areas of India. The Major Rice producing countries in the world include China, India, Indonesia, Bangladesh, Thailand, Vietnam etc. These countries also have the tradition of practicing agriculture-aquaculture integrated farming systems in which fresh water prawns have been grown as a part of rice-fish integrated farming systems either in the same season or in the consecutive seasons<sup>[3]</sup>. Kerala holds 18<sup>th</sup> Position in terms of production of Paddy in India. But a particular traditional paddy production systems is exclusively found only in the coastal areas of the Central Kerala commonly referred to as the "Pokkali Rice Cultivation System" which is a famous practice well known in the world.

Pokkali Rice received the Geographical Indication (GI) tag during the year 2007. During the monsoon, the water height in the Pokkali Rice fields raise upto the height of 100 to 110 CM and the Pokkali Rice grows above the water height throughout the season and floats over the surface with a height of 130 to 140 CM by the time of flowering<sup>[1]</sup>. During the high tide and low tide situations, the water is let in and let out of the field through the sluice openings provided in the field. Droppings of the previous prawn culture, dead and decayed prawns etc. adds to the nutrient contents in the Pokkali Rice fields for the next Pokkali Rice cultivation. Water from the backwaters supply the additional nutrients required for the growth of Pokkali Rice. By mid-September the crop is harvested by cutting the panicle at a height of 30 to 35 CM from the top and the remaining plant part left in the water column for decomposition. This will act as the feed for Prawn cultivation<sup>[2]</sup>.

After the harvest of Pokkali Rice, the field is kept idle for the proper decomposition of the leftover of the Pokkali Rice. By Mid-October-November, the local Prawn varieties like Naran (White Prawn), Kara (Tiger Prawns) etc. will gravitate towards the field through the sluice gate openings<sup>9</sup>. Many of the Pokkali farmers cultivate Tiger Prawn and Crab along with the local Prawn varieties in the same field<sup>[10]</sup>. Prawn in the Pokkali field subsist on the organic matter from decayed stubbles and in turn the field is enriched in manure and the excreta of organic wastes from fish and prawn.

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By the second fortnight of March Prawn and Crab are harvested using “Bag Net” placed on the sluice gates. As Pokkali Rice variety is cultivated using organic farming methods, it has high export potential and medicinal value and it is produced for its special taste and high protein content as well.

Even though many attempts were made to study the Pokkali Rice Prawn system of cultivation till date, studies regarding economic and environmental aspects were very few in number. So this study was an attempt to bridge these gaps by providing the economics of Production of Pokkali Prawn system. An attempt was also made to address the environmental implications associated with Pokkali-Prawn system of cultivation as well. This study mainly focused on the following problems viz., Analyzing the economics of production of Pokkali - Rice-Fish farming system compared with other two production systems like Non-Pokkali-Cowpea system and Semi-Intensive Prawn system and studying the environmental issues related to this system and the policy implications were addressed to some extent but detailed analysis was not possible due to some inevitable constraints in collection of data.

## 2. Materials and Methods

Pokkali – Rice – Prawn cultivation system is one of the traditional system practiced in Kerala as the environmental conditions conducive to raise such crops. For that the Pokkali-Rice-Prawn cultivation which is predominant in Kerala were enlisted from the records of the Department of Agriculture and Fisheries and the potential districts in which the Pokkali-Rice-Prawn cultivation is predominant. The potential districts for Pokkali-Rice-Prawn cultivation were found to be the Ernakulam and Alappuzha Districts and hence these two districts were chosen in the First Stage.

In the second stage, North Paravur, Kochi and Kanayannur Taluks from Ernakulam District were selected for studying the Pokkali-Rice-Prawn Production system based on the maximum area of cultivation in the district. Non-Pokkali Farms and Prawn Farms were selected from the villages having similar soil conditions and climatic factors, which was

more or less similar to the area where the Pokkali farms were located. Aluva and Cherthala taluks were selected for this purpose. From the selected taluks, three villages were randomly selected based on maximum cultivation area and from these villages, 10 farmers were selected randomly in the third stage, making a total sample size of 90 Pokkali farmers, 30 Non-Pokkali-Cowpea farmers and 30 Semi-Intensive Prawn farmers following a three stage random sampling technique. Thus, a total sample size consisted of 150 farmers to represent three different production systems followed in the Coastal area of Central Kerala.

Both primary and secondary data were collected for the study to fulfill the objectives enshrined. The primary data required for the study was collected through personal interview method using a well-structured and pre-tested interview schedules. Three separate sets of interview schedules were prepared to collect details from the farmers from different categories.

The study was conducted among Pokkali-Prawn, Non-Pokkali- Cowpea and Semi Intensive Prawn systems present in Ernakulam and Alappuzha Districts of Kerala during the year 2017 and the data related to the year 2016.

## 3. Results and Discussion

Pokkali cultivation can be considered as man’s ingenuity in harnessing natural events for farming. It is a system of integrated farming, which does not affect the natural ecological processes. This system does not require any external inputs). Pokkali is a unique system which combines rice cultivation as well as prawn culture in the same field. Traditionally only one crop of rice is taken in a year; the rest of the season prawn farming is initiated in a traditional manner. The farmers use a native variety for rice cultivation known as Pokkali having duration of 120 days<sup>[7]</sup>. This variety is effectively resistant to flood and salinity. Other varieties which are being used include Chettivirippu, Vyttila-1 and Vyttila-2 varieties<sup>[12]</sup>. While discussing the Pokkali –Paddy cum Prawn Production System, the principal dates and events are to be taken note of to make the system very effective and hence these details are accessed and the results are presented in Table 1.

**Table 1:** Important dates and time to be followed in pokkali system of cultivation

S. No	Important Dates to Remember	Important Events to be Practiced
01	April Last Week	<ul style="list-style-type: none"> <li>Drying up the lands,</li> <li>Strengthening of Field Bunds</li> </ul>
02	June First Week	<ul style="list-style-type: none"> <li>Levelling the top of the Mounds and Sowing depends upon the rain</li> </ul>
03	July (After 28 to 30 Days)	<ul style="list-style-type: none"> <li>Transplanting of Rice</li> </ul>
04	August	<ul style="list-style-type: none"> <li>Weeding Should be Carried out thoroughly</li> </ul>
05	October / November	<ul style="list-style-type: none"> <li>Rice Harvesting to be carried out based on the Maturity</li> </ul>
06	First Fortnight of November	<ul style="list-style-type: none"> <li>Prawn filtration starts and Sluices fixing activity to be carried out</li> </ul>
07	Last Week of November	<ul style="list-style-type: none"> <li>Prawn siblings are to be introduced in to the Rice field</li> </ul>
08	After 70 Days of Stocking of Prawn Fry	<ul style="list-style-type: none"> <li>Harvest of White Prawn (<i>Penaeus indicus</i>) or Naran to be carried out</li> </ul>
09	After 90 Days of Stocking of Prawn Fry	<ul style="list-style-type: none"> <li>Harvest of Tiger Prawn (<i>Penaeus monodon</i>) (Kara) to be carried out.</li> </ul>
10	Before April First Week	<ul style="list-style-type: none"> <li>Final Harvest of Prawns are to be carried out</li> </ul>

Table 1 revealed the details of time bound operations to be performed in the Pokkali farms for realizing better harvest of both Rice and Prawns in the wonderful environment. This system makes the environment ecologically acceptable and environmentally supportive to the farmers who perform the different tasks of Pokkali Rice Fish cultivation system. Absence of fertilizer application and pesticide spray made the system organic and the output of the Pokkali Rice and Fish or Prawn are readily acceptable to the consumers even at higher

price per unit of the produce is an impact created by the system. Though the system is well accepted among the practitioners and the stakeholders, there were certain constraints in executing or continuing the Pokkali Rice-Fish cultivation system which are discussed in the end of the discussion.

The cultivation starts during the first week of June and the realization of output by the end of March of every year leaving the April and May months for drying the ponds

thoroughly for avoiding any infection in the cultivable zone. In general, during the low saline phase, the paddy cultivation is practiced in the Pokkali Farms and the Prawn cultivation took place during the high saline phase <sup>[13]</sup>.

Such an ecological friendly system and its establishment should be known to the young groups. The youngsters are to be motivated by highlighting the economic advantage associated with the system which permits the young entrepreneurs or farmers to enter into the system. In this circumstance, analyzing the results with respect to the objectives of analyzing the costs and returns become important. The results are analyzed and discussed in different headings which are delineated below

- Costs and Returns realizable from different Pokkali Systems

- Comparative Advantage of Pokkali Prawn Production System
- Comparative Advantage of Pokkali System to Semi-Intensive Prawn Production System
- Environmental Impact of Development Projects to Pokkali Fields
- Constraints in Pokkali-Rice-Prawn Production System

### 3.1 Costs and Returns Realizable from Different Pokkali Systems

The main objective of the study was to estimate the total cost and return realizable from the Pokkali prawn cultivation system in comparison with other two production systems. The details of analyzed information are delineated in Table 2.

**Table 2:** Costs and Returns from Different Pokkali Farming Systems

S. No	Particulars of Costs and Returns	Pokkali Rice-Prawn System	Non-Pokkali-Cowpea System	Pokkali Semi-Intensive Prawn Production System
1	Total Cost Incurred in Rupees per Ha	240000	151000	494000
2	Gross Return Realized in Rupees per Ha	521000	220000	649000
3	Net Return Generated in Rupees per Ha	281000	69000	155000
4	Output-Input Ratio	02.17	01.46	01.31

Table 2 revealed the details of costs and returns realizable under different Systems of Pokkali cultivation. The Pokkali Rice-Prawn Production System has generated a gross return of Rs 5.21 lakhs per annum in which the Rice alone generated a loss of around Rs. 63000 which was compensated by the Prawn production system. Combined together the Pokkali Rice-Prawn Production System could generate a net return of Rs 2.81 lakhs per annum with an output – input ratio of 2.17 which revealed that for a rupee of investment in Pokkali Rice-Prawn Production system, one could realize a net return of Rs. 1.17 indicated that the system is profitable. Intensive management with time bound care could enhance the profit from the system on a higher scale. Rice cultivation alone not profitable under the organic farming, but the overall Pokkali farming system is made highly profitable by including prawn cultivation in the succeeding season <sup>[14]</sup>.

Another system practiced by the farmers in the study environ is the Non Pokkali-Cowpea System. In this system, the cost of production of Cowpea was accounted to be around 77000 Rupees per ha and the system had consumed an amount of Rs. 1.51 lakhs per annum per ha and capable of providing a gross income of Rs 2.20 lakhs per annum per ha leaving a net return of only Rs 69000 Rupees per ha per annum. The output-input ratio was arrived at 1.46 only indicated that for a rupee of investment into the system, the farmer could realize only 46 paise alone as his return from the system. When one could compare the Pokkali Rice-Prawn production system and the Non-Pokkali – Cowpea production system, the Pokkali Rice-Prawn Production system found to be the highest revenue earner and hence one can resort to the Pokkali Rice-Prawn Production system.

One another system practiced by the farmers in Central Kerala is Pokkali-Semi Intensive Prawn Production system. These shrimp farms are shallow impoundments, which are utilized for culture on scientific lines involving advanced techniques so that higher doses of inputs are applied to increase the productivity. The semi intensive shrimp farms are capital intensive and require higher initial investment. Under

this system, extra care is taken in the selection, location, design and preparation of farms, seed, stocking density, fertilization, feeding (with formulated feeds), aeration, harvesting, marketing, etc. Compared to extensive farms, more controls at different stages of production could be possible under semi intensive farming.

In this study, the semi-intensive prawn production system could generate an output value of 6.49 lakhs of Rupees per annum per ha with a resource consumption value (Cost) is arrived at 4.94 lakhs of rupees per ha per annum leaving the net return of Rupees 1.55 lakhs per ha per annum. In a production function fitted to assess the resource use efficiency of semi- intensive Pokkali prawn production system, the sum of the values of the coefficients of production function fitted yielded 0.996 which indicates that almost unitary economics of scale or a constant return to scale have been prevailing under the system revealed that the system is profitable<sup>11</sup>. Beyond that the farmer is not advised to add any additional input to enhance the output of Prawn.

### 3.2 Comparative Advantage of Pokkali Prawn Production System

To highlight the advantage of one system over the other production system, normally the economists will be adopting the partial budgeting technique as their tool to assess which system has the added returns with reduced costs so that it will be advantageous to the farmers or the agripreneurs. In this context, the study has attempted to project the three systems of Pokkali cultivation and hence the author has used the Partial Budgeting technique to assess the advantages associated with the system.

The partial budgeting analysis of Sole Pokkali-Prawn Production System which is depicted in Table 3 has highlighted that an increment in the income to the tune of Rs. 3.75 lakhs for every ha of production indicating that the Pokkali-Prawn Production system is a promising Integrated Farming System giving higher returns to the farmers. The details are presented in Table 3.

**Table 3:** Partial Budgeting of Sole Pokkali System to Pokkali-Prawn Production System

Added Costs (Rupees per Ha)		Added Return (Rupees per Ha)	
Cost of Prawn Seed and Stocking	21000	Value of Prawn Output	415000
Additional Labor Cost	22000	Return from Byproduct	3000
<b>Reduced Return</b>		<b>Reduced Cost</b>	
Reduced Return due to any other inputs	00	Reduced Cost of using any input	00
Total	43000	Total	418000
Net Gain in Rupees			375000

The value of Prawn output is arrived at Rs 4.15 lakhs and the Manurial value of the byproduct is arrived at Rs 3000. Put together the value of added return is arrived at Rs. 4.18 lakhs from the Pokkali-Prawn Production System. The net gain from the Pokkali-Prawn Production over the Pokkali Rice Cultivation system is accrued at Rs 3.75 lakhs and if we combine both the production system, the venture will be profitable and hence the system is recommended for wider adoption by the young agripreneurs in that locale.

### 3.3 Comparative advantage of pokkali system to semi-intensive prawn production system

**Table 4:** Partial Budgeting of Pokkali-Prawn System to Semi-Intensive Prawn Production System

Added Costs (Rupees per Ha)		Added Return (Rupees per Ha)	
Cost of Seed	40000	Pokkali Rice Yield	65000
Additional Labor Cost	65000		
<b>Reduced Return</b>		<b>Reduced Cost</b>	
Value of Reduced Prawn Yield	6000	Pond Aeration	17000
		Prawn Feed	119000
		Application of Lime	2000
		Value of Organic Fertilizer	1000
Total	111000	Total	204000
Net Gain in Rupees			93000

Table 4 revealed that the Pokkali-Prawn production system has yielded a net gain of Rs 93000 over the Semi-Intensive Production System indicating that the Pokkali Prawn Production system has a clear advantage over the semi-intensive prawn production system.

### 3.4 Environmental impact of development projects to pokkali fields

When one could examine the environmental impacts of developmental projects to the Pokkali fields, the Pokkali cultivation is under threat. The potential benefits of Pokkali cultivation is not appropriately examined by the Socially–Politically Important persons in the Kerala state. In the recent

By adopting semi-intensive farming, shrimp can be produced at low costs compared to extensive system of farming. Highlighting the importance of semi-intensive farming <sup>[4]</sup>, It is observed that "the search for efficient operating levels has taken the farmer operating with extensive system to semi-intensive systems <sup>[8]</sup>. Similarly, the intensive farmer has also shifted to semi intensive systems. The end result is more consistent production with less risk. In this circumstance, the economic gain associated with the system need to be assessed and hence a partial budgeting technique is employed for that purpose and the results are presented in Table 4.

history of Kerala especially in Kochi, the most important milestone was the establishment of International Container Trans-shipment Terminal (ICTT), otherwise known as the Vallarpadam Terminal, which has paved the way for increased connectivity in goods transportation through new bridges, national highways, Rail links and through waterways. Due to these, the Pokkali fields are directly and indirectly affected because of these development projects <sup>[5]</sup>. The structures established in these areas like pillars etc. hinders the natural flow of water to the Pokkali fields and as a result, artificial water management became necessary in these environment. These details are analyzed and the results are presented in Table 5.

**Table 5:** Environmental Impact of Development Projects to Pokkali Fields

S. No	Environmental Challenges	Number of Farmers (Multiple Responses)	Percentage to Total
01	Threat due to the Establishment of Vallarpadam Terminal	82	54.67
02	Linking of Vallarpadam Terminal through Railways and Waterways	62	41.33
03	Natural Flow of Marine Water gets Affected	104	69.33
04	Real Estate Threats to Pokkali Fields	95	63.33
05	Loss of Wetlands resulted in Ecological Imbalance	89	59.33
06	Water Logging permits indirect Health Disorders	108	72.00
	Total Responses	150	

The permanent structures like establishment of Vallarpadam Terminal is one of the biggest constraint to Pokkali Cultivation. It affects directly or indirectly. All other challenges listed between 3 and 6 are mainly because of the terminal which was linked through Highways, Railways and Waterways which has hampered the Pokkali cultivation

drastically. Construction of Vallarpadam Terminal Road and its linkages with waterways and railways hindered the natural flow of tidal waves into the Pokkali fields, which is the backbone of Prawn farming. The indirect effect accounts the booming of land prices in the nearby areas of Vallarpadam Terminal due to the artificial demand created by the real

estate investors, promoters and Multi-National Corporations. This real estate motivation encourages many farmers to stop the practice of Organic Pokkali-Rice cultivation. Acquiring of land in the Pokkali areas and embarking the area becomes water logged and the area becomes polluted. These waterlogged, swampy fields could not put for any other use other than real estate developments. The huge loss of wetlands also disturbs the ecological balance. As a consequence, the dream of food security for the state will not be realized with the destruction of Pokkali fields in the name of development.

The cultivation of Pokkali Rice-Prawn production systems is significantly different from normal wetland cultivation of paddy. Gravitating water in and out of the fields during the high tide and low tide conditions respectively is considered as the major difference between the systems. Water parameters are affected by this water exchanging process. Presence of Nitrous Oxide in the water sample taken from the Pokkali field occurs only when an oxidized condition is maintained in the system [6]. Continuous exchange of water during high tides and low tides throughout the production period helps to maintain sufficient amount of Oxygen in the fields and it helps to create an oxidized condition in the production system rather than a reduced condition.

Methane (CH<sub>4</sub>) emissions will reach to the peak only when proper reduced condition is attained in the system or in the absence of Oxygen. So through practicing this Pokkali – Prawn system, the farmers are reducing the load of Methane gas emission, thus reducing the contribution of Green House Gases (GHG) from these environment.

Discontinuing Pokkali cultivation will greatly affect the Prawn farming practices. The juvenile Prawn lack the high protein supplement from the decaying stubbles and vulnerable to many diseases. Without Pokkali farming, the flooded land becomes more acidic less oxygen availability, which is in turn detrimental to prawn farming.

Another threat of monoculture of Prawn without practicing Pokkali rice cultivation will lead to loss of livelihood to many of the rural women, who work in the paddy fields. Discontinuation of Pokkali and Monoculture of Prawn and Shrimp will lead to disturbances in the ecological balance of Pokkali rice fields leading to loss of biodiversity. Monoculture of Prawn will give higher yield in the early periods but eventually the yield will come to decline shortly (Vijesh, 2006). So practicing this unique production system is important not only from the ecosystem perspective but also from the environmental sustainability point. With these prelude, the environmental impact actually created were analyzed in the study environment and the same are analyzed and the results are presented in Table 5.

Table 5 revealed that for all the challenges enlisted and documented, the core challenge was found to be the Erection of Vallaradam Terminal and its linkages through highways, railways and waterways. Most of the farmers were of the opinion that the natural water flow gets affected and water logging takes place which indirectly promotes some health disorders. Any project and its implementation for economic and social advantage, the same should be subjected to Environmental Impact Analysis. Due to many of the constraints, the total area under Pokkali cultivation of 25000 ha has been reduced to a mere 5000 ha. Such erosion had taken place in the last few decades [12]. Further studies are needed in that direction to restore the Pokkali Practices in Kerala and its socio-economic incentives.

### 3.5 Constraints in Pokkali-Rice-Prawn Production System

Beyond certain challenges, the Pokkali – Rice – Prawn Production system is also facing certain production constraints also. Though these constraints are manageable, it hinders heavily during the season which are analyzed and the results are presented in Table 6.

**Table 6:** Constraints Faced By the Farmers of Pokkali-Rice-Prawn Production System

S. No	Particulars of Constraints	Number of Respondents	Percentage to Total
01	Lack of Farm Labor for Pokkali Farming Practices	128	85.33
02	Absence of Seasonal Rain	78	52.00
03	Higher Distance between the Harvest Zone to Processing Centre	99	66.00
	Total Respondents	150	

Table 6 revealed that the Pokkali farming practices has few production constraints. Among the three production constraints, lack of farm labor for Pokkali farming practices found to be the foremost constraints which was reported by 85 per cent of the respondents whom are practicing the Pokkali cultivation followed by higher distance between the harvest point to processing center because of the wet condition of the rice, it should be taken immediately to for drying and cleaning for distribution to the consuming units. Periodically the harvested panicles need to be brought to the drying floor or threshing floor on small lots and hence it become a constraint because of the inundated water. For that also labor requirement is more and it is not available on time and however it is being managed by the farmers and the practicing of Pokkali Rice-Prawn production is a continuous one. Great applause to the farmers of Central Kerala for doing such a service to the humanity through serving the food and fish and ensuring the food security.

### 4. Conclusion and policy implications

The study has focused on the economic and environmental aspects of Pokkali –Rice – Prawn production system in comparison with other two systems like Non - Pokkali-Cowpea Production system and Semi-Intensive Pokkali Prawn Production System. There was much difference in terms of cost and returns in the three production systems identified. Among the three, the Pokkali-Rice-Prawn Production system alone is capable of fetching highest net return over the other two systems and found to be economically viable enterprise. When the environmental aspects were examined, the Presence of Nitrite nitrogen in the water samples from Pokkali fields indicated that oxidized condition prevailed in the system due to continuous exchange of water throughout the production period which reduced the methane production to minimum. Considering the environmental threats available to Pokkali farms, the Pokkali Farmers can establish a producer organization for their betterment in terms of enhancing production, protecting the Pokkali Farms from external threat and to command higher

price for their quality output.

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