



# Shrimp farms as a threat to mangrove forests in Kannur district of Kerala, India

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**Abstract** Mangroves are one of the most productive, diverse ecosystems on the planet and serve as a protective barrier for coastal areas. Shrimps have a productive correlation with mangroves habitat, thereby large-scale shrimp farming pose a serious threat to mangroves ecosystems. The present study was carried out to estimate the total area under shrimp farming in the intertidal regions of Kannur district. From the study, we have documented 140 shrimp ponds, which contributes to a total area of 524.4 ha. We found that active shrimp farming area in the district is 524.4 ha in 2020. The traditional shrimp farming method accounts for 60.6% of the total farmed area while non-traditional shrimp farming accounts for 36.9% of the total farmed area; both types are expanding fast in the district. Of the

five major Rivers in the district, Kuppam River has the majority of the shrimp farms followed by Dharmadam River. *Penaeus monodon*, *Litopenaeus vannamei* and *Penaeus indicus* are the shrimp species cultivated in the district. Since shrimp farms are created by replacing the mangrove habitats in the intertidal region, mangroves of Kannur district are under threat and needs serious intervention for long term survival.

**Keywords** Mangrove · Ecosystems · Intertidal regions · Shrimp farming · *Litopenaeus vannamei*

## Introduction

Mangrove ecosystems are the most productive ecosystem, that contribute several socio-economic and ecological services (Kathiresan 2010). They stabilise coastlines and mitigate the devastation caused by natural calamities such as tsunamis and hurricanes. Also serve as breeding and nursing grounds for a variety of commercially important fish, molluscs, and crustaceans. Despite occupying just 0.1% of the earth's geographical surface, mangroves account for 11% of total terrestrial carbon intake into the ocean and 10% of terrestrial dissolved organic carbon released to the ocean (Jithendra et al. 2014).

Kerala, the southern Indian state, once had 700 km<sup>2</sup> of mangroves along its 41 west-flowing Rivers and associated estuaries and backwaters (Edwin

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2002; George et al. 2018). A recent study records only 17.82 km<sup>2</sup> of mangroves in Kerala which depicts a loss of more than 90% of the historical extent. Almost 90% of these forests are privately owned and therefore highly threatened. The mangroves of Kerala are scattered in 10 coastal districts (Sreelekshmi et al. 2021). Across the districts of the state, Kannur has the largest extent of mangroves (Preethy 2019).

Mangrove areas are ideal for shrimp farming (Bartier and Cox 2004). For the preparation of shrimp farms, mangroves and wetlands are levelled and destroyed (Pérez-Osuna 2001) which is the main reason for loss of mangroves globally (Jayanthi et al. 2007; Berlanga-robles et al. 2011). The conversion to shrimp farms has detrimental effects on the dependent communities, also by impacting their livelihood (Treviño and Murillo-Sandoval 2021). Effluents from the shrimp farms adversely affect the biotic and abiotic components of the mangrove ecosystem (Primavera 1997, 2006; Ashton 2008; Mishra et al. 2008; Biao et al. 2009; Hamilton 2011; Pattanaik and Prasad 2011).

Shrimp farms in India were established in the late 1980s in response to increased demand from the worldwide market (Jayanthi et al. 2018). India ranks second in terms of shrimp production (FAO 2016). Over the past 25 years, there has been an 879% increase in aquaculture land in India (Jayanthi et al. 2018).

There are two types of shrimp cultivation systems in Kerala: traditional and non-traditional. The traditional shrimp aquaculture systems are usually sustainable, low-intensive and small scale. They mainly depend on diurnal tidal inundation to supply the larval shrimp and their food nutrients to the ponds. The non-traditional shrimp farms were introduced for increasing the production (Bhattacharya 2010). They are focussed on modern farming techniques such as intensification of culture operation by innovative changes on pond size, increasing stocking rate, employment of aeration, application of formula feed etc. In Kerala indigenous shrimp species like *Penaeus monodon* and *P. indicus* and other wild varieties are usually cultivated in traditional systems whereas in non-traditional farming, *Litopenaeus vannamei* and *P. monodon* are the common species (Bhattacharya 2010).

Farmers in Kerala are well versed in traditional shrimp farming and have a long history of traditional

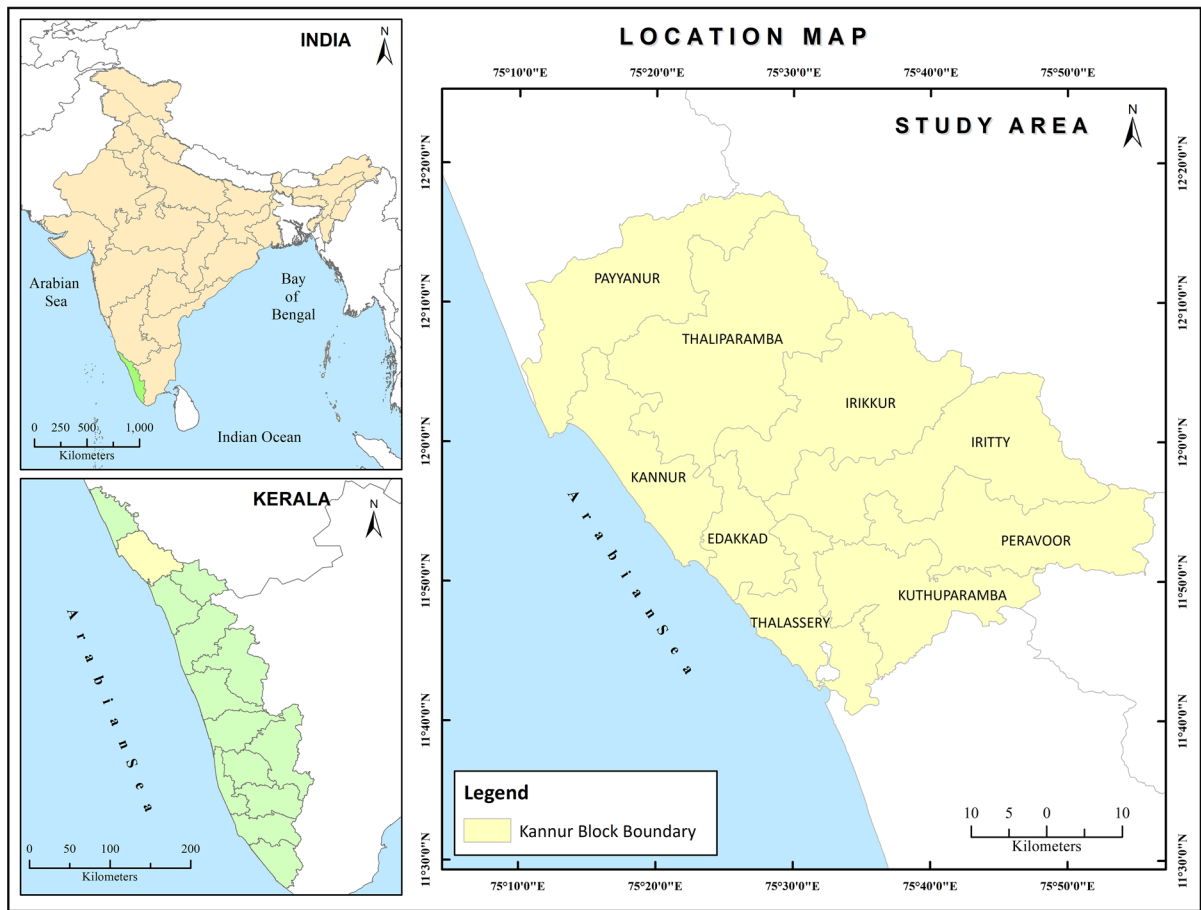
breeding of native species. The total area devoted to shrimp farming in Kerala in 2017–2018 was estimated at 10,599.26 ha, of which 8430.98 ha is under traditional farming and 2168.28 ha is under non-traditional farming. The annual production of farmed shrimp in Kerala was estimated at 2952.56 metric tons. Of this, the contribution of the traditional sector was 2174.80 metric tons (73.66%) and that of the non-traditional sector was 777.76 metric tons (26.34%). The productivity of shrimp farms in Kerala was calculated at 932.08 kg ha<sup>-1</sup> year<sup>-1</sup> (Sahadevan and Sureshkumar 2020).

The shrimp farms of Kerala are spread across 10,599 ha, while the total extent of mangroves of the state has dwindled to around 1782 ha (Sahadevan and Sureshkumar 2020; Sreelekshmi et al. 2021). The area and diversity of mangroves of Kerala is falling at an alarming rate (Pillai and Harilala 2015). Kannur district which holds largest share of mangroves of the state, has around 1500 ha of mangroves as shown by the online map published by Wildlife Trust of India. Of this extent, only 236 ha of mangroves are legally protected as Reserve Forests (Bala Kiran 2017). Since the remaining mangrove areas are threatened and unprotected, the objective of the present study is gaining understanding the status of mangroves and shrimp farms in Kannur district.

## Materials and methods

The study area is the Kannur district of Kerala, with a geographical area of 2966 km<sup>2</sup>, located between 11° 40' to 12° 08' N latitudes and 75° 11' and 76° 08' E of longitudes (Fig. 1). The district is bounded by Kasaragod district in the north, Western Ghats in the east (Coorg district of Karnataka state), Kozhikode and Wayanad districts in the south and Lakshadweep Sea in the west. Kannur district has the maximum area of mangrove forest cover in the Kerala state relative to other districts. The most suitable place for shrimp aquaculture is the mangrove habitat, which is why the number of such ponds is increasing day by day in Kannur.

An interactive map of mangroves depicting the geographic distribution and various details of the mangroves in the Kannur district was available on the website of the non-governmental organization, Wildlife Trust of India through its Kannur Kandal



**Fig. 1** Study area

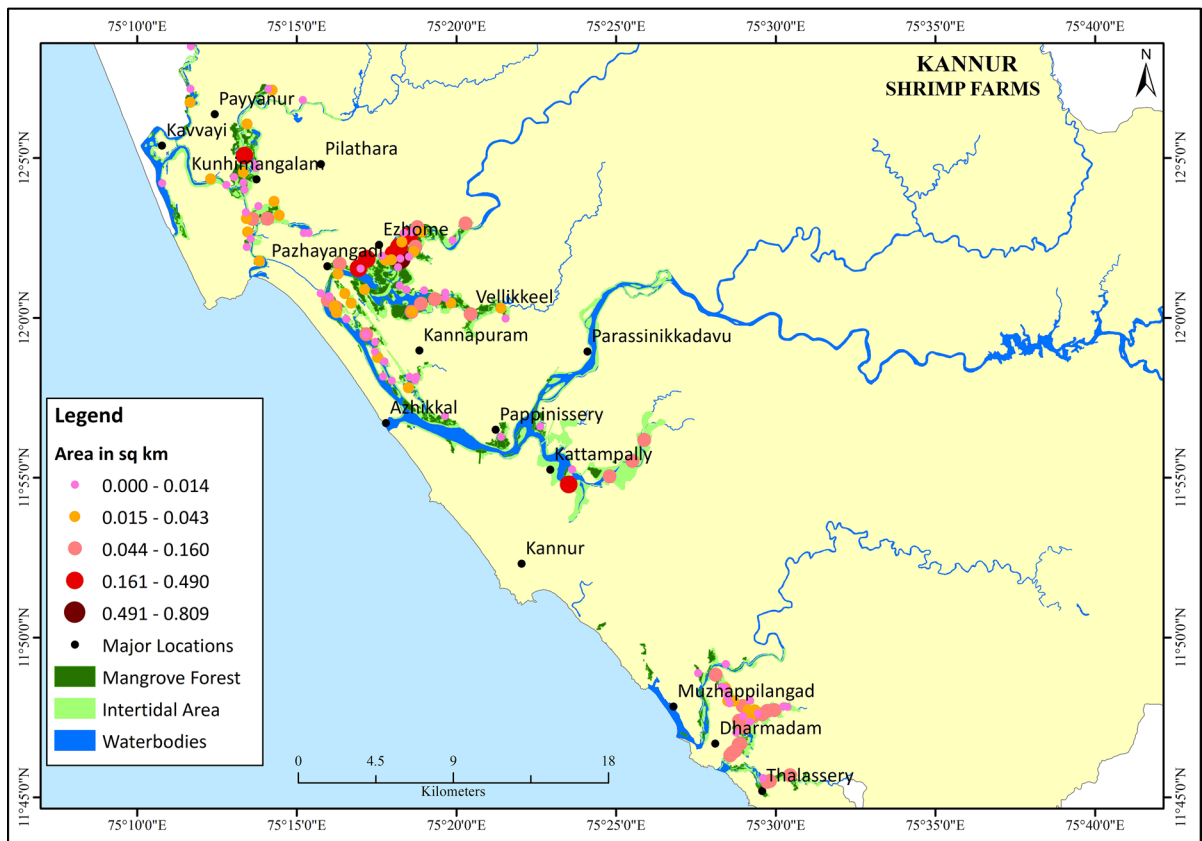
Project. Overlaying this interactive map on Google earth, all the shrimp ponds were searched in the intertidal zone of Kannur and the polygons were drawn. Then these intertidal zones were surveyed physically to collect data on all the shrimp farms across the district. The field surveys were conducted during March 2021–December 2021, collecting details including the type of farming (traditional or non-traditional), species cultivated, year of creation of the farm, area, panchayath name. Characteristics including >1 m pond depth, use of modern equipment, chemical fertilizers and feeds differentiate the non-traditional shrimp farm method from the traditional method. *L. vannamei* is cultivated only in the non-traditional shrimp farms. This data was also cross checked with the available information from the Fisheries department.

## Results

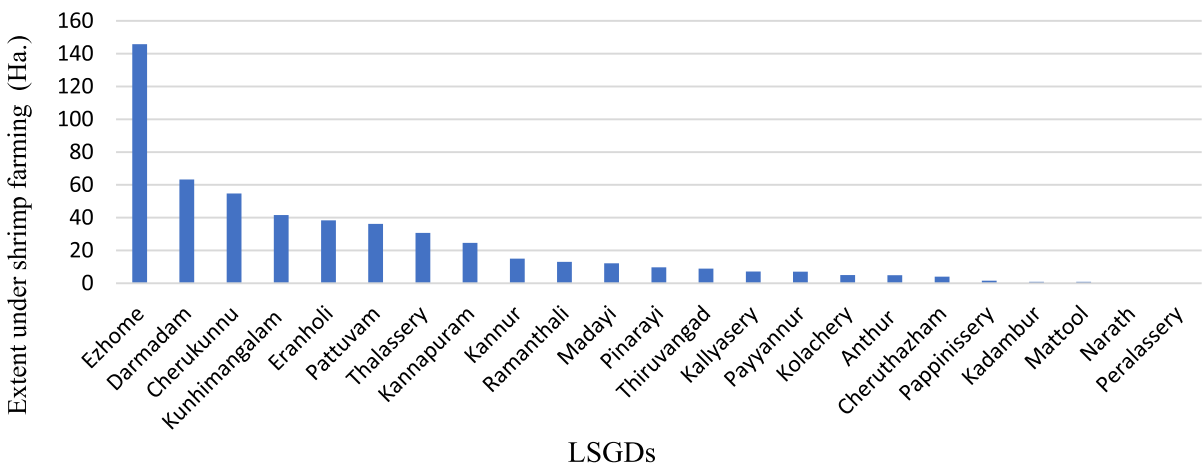
### Area under shrimp farming across different Local Self Government Departments in Kannur district

The study recorded 140 active shrimp farms in Kannur district, with a total area of 524.4 ha (Fig. 2). The study also reveals that 23 Local Self Government Departments (LSGDs) have shrimp farms, and Ezhome (27.8%), Dharmadam (12%), and Cherukunnu (10.4%) have the most abundant areas (Fig. 3).

From the analysis, mean value and standard deviation of total area of shrimp farms across the studies LSGDs in Kannur district is 0.04 and 0.06 respectively. This shows a significant impact ( $p=0.00$ ) on mangrove forests due to the shrimp farms (Fig. 4).



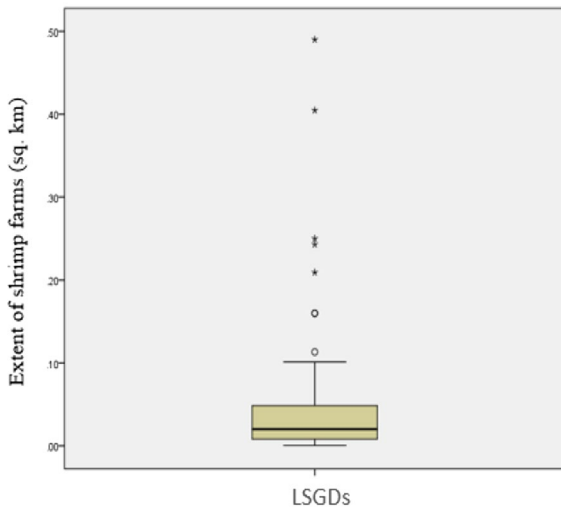
**Fig. 2** Map showing all the shrimp farms across the intertidal region of Kannur district



**Fig. 3** Area under shrimp farming in Kannur district across different LSGDs

Expansion of shrimp farming area in Kannur district since 2000

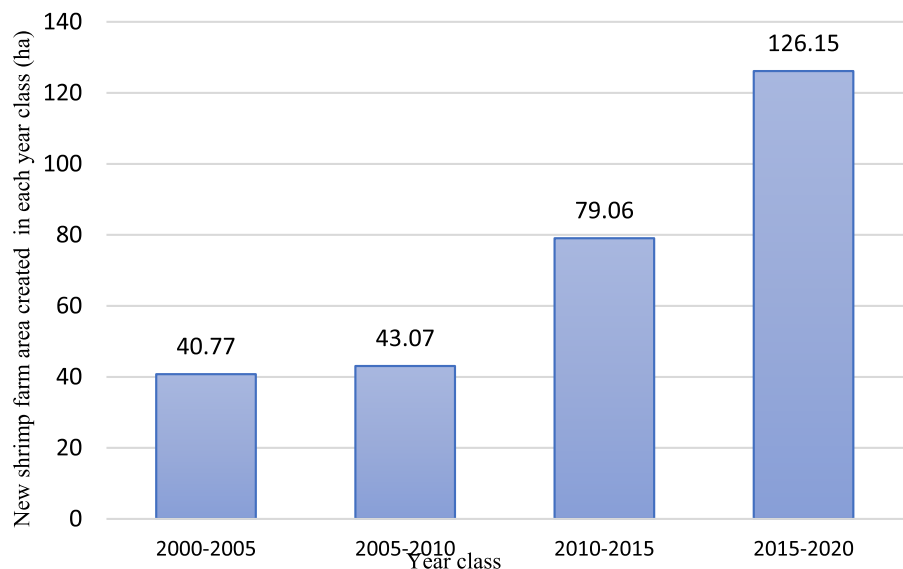
The area of active shrimp farms in the district in 2020 shown by the present study is 524.4 ha. Among these



**Fig. 4** Box plot showing area wise distribution of shrimp farms across different LSGD

active shrimp farms, only 235.4 ha (44.9%) were started before 2000. The remaining 289 ha (55.1%) were started after 2000. Of these, 126 ha were created during 2015–2020, while 79.1 ha were created during 2010–2015 (Fig. 5).

**Fig. 5** Extent of new shrimp farm area created in each year class for the presently active shrimp farms in Kannur district

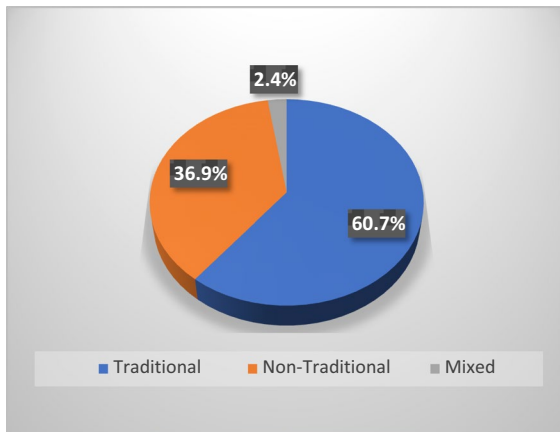


Percentage distribution of shrimp farm types in Kannur district

The percentage distribution of shrimp farm types in Kannur district are shown in Fig. 6, with traditional cultivation contributing 60.7% (318.1 ha) of total area and 36.9% (193.5 ha) under non-traditional method. Only 2.4% (12.8 ha) is under mixed farming in which both traditional and non-traditional methods are used (Fig. 6).

Shrimp species used in Kannur district

The study reveals that the shrimp species used for cultivation in Kannur district are *Penaeus monodon*, *Litopenaeus vannamei* and *Penaeus indicus*. Some shrimp farms also cultivate fishes like *Etroplus suratensis* and *Lates calcarifer*. *L. vannamei* is an exotic species from Pacific coast of Mexico and Central and South America as far south as Peru (Liao and Chien 2011). It is being utilised in many countries because of its high tolerance to wide range of salinities, low temperature, high growth rate and higher survival rate in hatchery. The omnivorous scavenger *L. vannamei* is less aggressive than *P. monodon*. It can tolerate a large range of salinities (0.5–45 ppt) but it grows well at 10–15 ppt (Sadek and Nabawi 2021). *L. vannamei* can tolerate the temperature variations, ranging from 7.5–42 °C, usually farming is recommended above 12 °C (Kumlu et al. 2010).

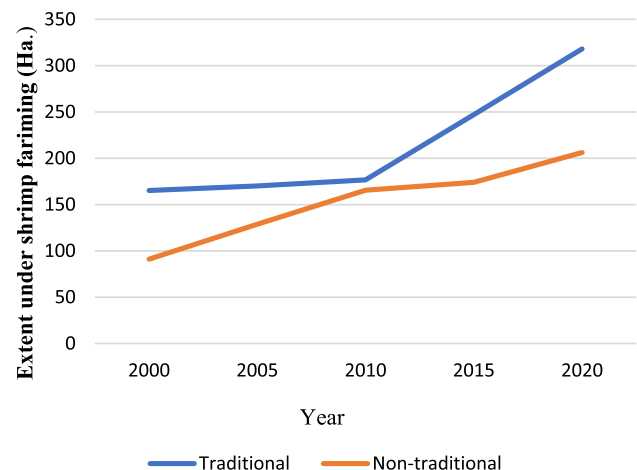


**Fig. 6** Percentage composition of shrimp farm types in Kannur district in 2020

#### Extent under traditional and non-traditional shrimp farms during 2000–2020

Among the active shrimp farms, the extent of traditional shrimp farming has increased from 165.2 to 318.1 ha during the time period 2000–2020. At the same time, the area under non-traditional shrimp farming has increased from 91.1 in 2000 to 206.3 ha in 2020 (Fig. 7). The increase in the extent of non-traditional shrimp farms during 2015–2020 is mainly due to the introduction of *L. vannamei*. Due to its resistance to a wide range of salinities, fast weight gain over a short period of time and high meat production, majority of the farmers are

**Fig. 7** Extent under traditional and non-traditional shrimp farming in Kannur district



choosing *L. vannamei* over other indigenous species for farming (Kumaran 2016).

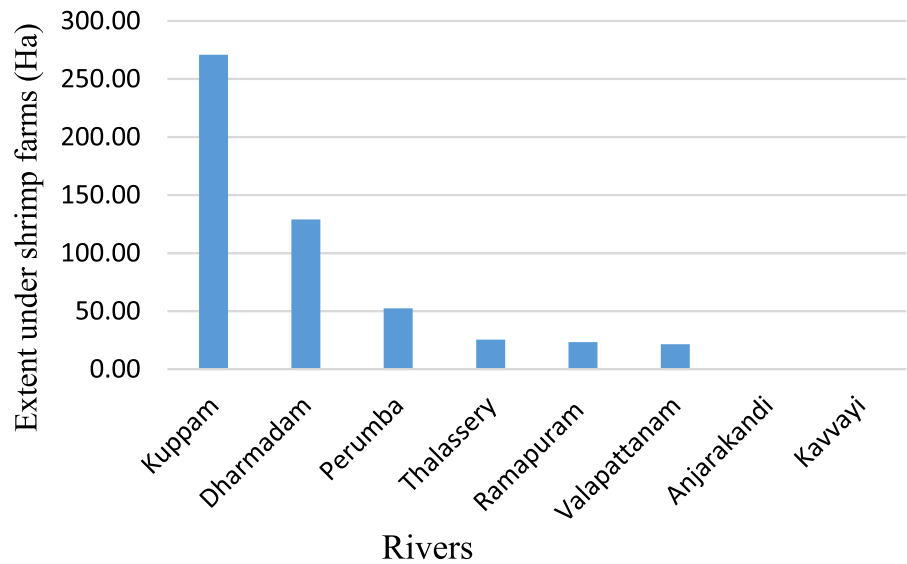
#### Extent of shrimp farm distribution across various rivers in Kannur district

There are many minor and major rivers flowing through Kannur district. Shrimp farming in the district is mainly distributed along the rivers: Kuppam (51.7%), Dharmadam (24.6%) and Perumba (10%). The extent of shrimp farms along Kuppam river is 270.9 ha. The Kuppam river flows between Ezhome and Cherukunnu panchayaths, where the majority of shrimp farms are found. Dharmadam river and Perumba river has shrimp farms of area 129 ha and 52.4 ha respectively. Kavvayi river and Anjarakandy river possesses comparatively small areas of ponds of less than 1 ha (Fig. 8).

#### Discussion

The present study recorded 524.4 ha area of shrimp farms in the intertidal regions of the Kannur district. A study in 2007 recorded only 251.5 ha of shrimp farms in Kannur district (Harikumar and Rajendran 2007). This shows that over the last 13 years, there was an increase of 272.9 ha in the shrimp farm area. The results also prove that the area of shrimp farms is increasing since 2000 especially after 2015. Kerala Fisheries Department is providing financial and technical support to shrimp farmers; financial subsidies from the department to shrimp farmers raise

**Fig. 8** Extent of shrimp farms along the Rivers of Kannur district during the present study



up to 80% of the cost for setting up new shrimp farms. At the same time, private land owners protecting mangroves in their land are not getting any support or incentives from the Government. This scenario will aggravate the rate of destruction of mangroves in Kannur district. Since Kannur district holds major portion of mangroves in Kerala, urgent measures are required to secure the mangroves in the district.

Because of its advantages, farmers choose *L. vannamei* over other species. *L. vannamei* requires scientific farming techniques for successful cultivation. This promotes the non-traditional shrimp farming which causes larger long-term impacts on the mangrove ecosystems. Non-traditional shrimp ponds are usually 1–1.5 m depth in the district, which prevents natural regeneration of mangroves even after the ponds are abandoned. Topographical changes are required to initiate mangrove restoration in the abandoned ponds. Such measures must be initiated to bring back the lost mangrove cover. Mangrove afforestation along the borders of the functioning ponds also has to be facilitated to minimize the impacts of shrimp farming.

Application of several chemicals, fertilizers and feeds in the shrimp farms will adversely affect several micro-organisms (Rahman et al. 2013; Iqbal and Milon 2018). Lime, urea and other inorganic fertilizers used in shrimp ponds can have a negative impact on the natural soil structure, reducing the prospects

for further mangrove restoration (Balakrishnan et al. 2011).

## Conclusion

In the intertidal regions of Kannur district, mangrove ecosystems have been deforested and converted to shrimp farms. The conclusion we have reached through the study is that the excessive encroachment onto mangrove forest for shrimp farming increased across the last decades. This is severely affecting the structure and function of mangrove ecosystems. The mangrove forests of the LSGDs like Ezhome, Dharmadam, Cherukunnu are under very immediate threat. Continuing such trends in long-term might degrade the mangrove forest cover. In the light of global climate change and sea level rise, the coastal areas near these cultivations are under serious threat from flooding. It is therefore imperative that all stakeholders become aware of the impending danger, and the Government take necessary actions towards regulating shrimp farms.

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**Author contributions** Conceptualization, RM; methodology, RM.; BP.; software, SKP; validation, BP, RM, MT; formal analysis, BP, RM; investigation, BP, PMN; data curation, BP; writing-original draft preparation, BP, MT, PMN; writing-review and editing, RM, BP, SKP; project administration, RM; All authors have read and agreed to the published version of the manuscript.

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**Data availability** Not applicable.

**Declarations**

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical approval** Not applicable.

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