

EFFECTS OF GROWTH AND SPREAD OF INVASIVE SPECIES IN KOLE WETLANDS: A GEOSPATIAL ANALYSIS OF THE ALIEN AQUATIC INVASIVE SPECIES *CABOMBA FURCATA* IN KOLE WETLANDS OF THRISSUR DISTRICT, KERALA

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Introduction

As a Ramsar site in Kerala, the Kole Wetlands are essential for biodiversity, climate resilience, and agriculture. These wetlands are essential to paddy farming, provide vital habitat for migratory birds, and act as natural flood buffers. But over the past ten years, the unchecked invasion of *Cabomba furcata* has upset the ecological balance, endangering local communities' livelihoods and native biodiversity (Vidya et al., 2023).

The wetlands have been negatively affected by the spread of *Cabomba furcata* and other invasive species, including *Salvinia molesta*, *Ipomoea aquatica*, and *Eichhornia crassipes*. These species reduce the wetlands' capacity to provide ecosystem services like groundwater recharge, carbon sequestration, and flood control, degrade water quality, and outcompete native plants (Nameer, 2021). According to geospatial studies, these invasives thrive near agricultural and populated areas, exacerbating the ecological and socioeconomic effects.

Studies conducted on aquatic ecosystems in India and around the world demonstrate how ecological changes and human activity interact to cause habitat degradation and invasive species spread (Dudgeon et al., 2006). Invasive species and habitat modification have disturbed biodiversity and hydrological processes in the Kole Wetlands. Effective conservation measures are hampered by issues like hydrological connectivity and a lack of data, even with the development of geospatial technologies (Raj et al., 2021).

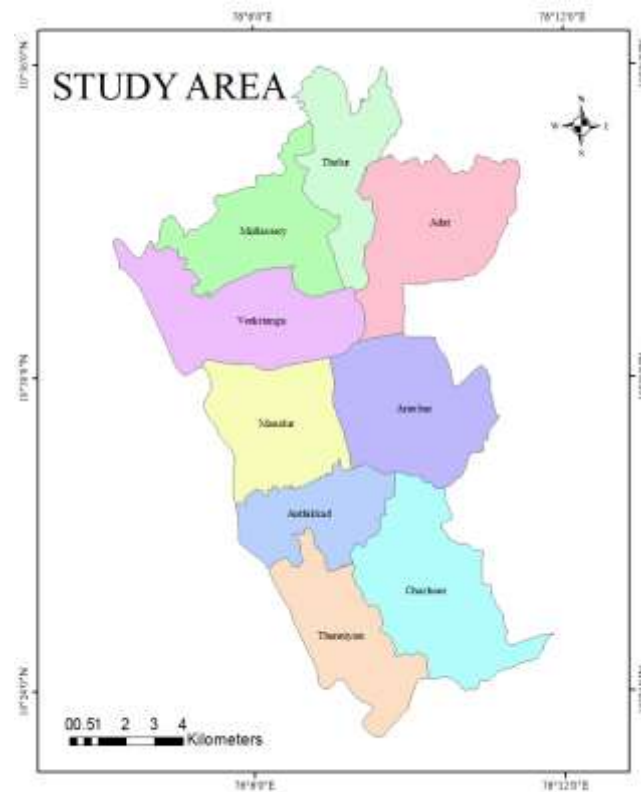
This study emphasizes how urgently targeted conservation measures are needed to control *Cabomba furcata* invasions, save native biodiversity, and maintain wetlands-dependent livelihoods (Sarkar et al., 2021). The ecological and economic benefits of the Kole Wetlands must be preserved for future generations through integrated strategies that include GIS-based mapping, community involvement, and stronger regulations (Sajeev T V et al., 2012).

Study area

The nine panchayats, Adat, Arimboor, Anthikkad, Thaniyam, Chazhoor, Venkitangu, Manalur, Tholur, and Mullassery, that are situated on the western side of Thrissur, Kerala, are the subject of the study. The Kole Wetlands, a distinctive ecological feature essential to Thrissur's environmental and hydrological balance, define these 176.24 square kilometre areas. The wetlands sustain a variety of plants and animals by serving as natural flood barriers, groundwater storage areas, and water purifiers. Their ecological functions are improved by the interconnected system of canals and rivers, which includes the Puzhakkal and Karuvannur Rivers. Nevertheless, despite their importance, these wetlands are threatened by invasive species like *Cabomba furcata* and habitat degradation, putting local agricultural practices and native biodiversity at risk.

The ecological integrity of the Kole Wetlands is seriously threatened by the invasion of *Cabomba furcata*, agricultural pressures, and human activity. This species spreads quickly, upsetting ecosystem processes and competing with native vegetation. Furthermore, census data indicates that the wetlands are impacted by population growth, with the population density

increasing from 586.72 per square kilometre in 2001 to 631.83 per square kilometre in 2011. (Census of India n.d.). These panchayats are connected to the district's urban centres by the region's extensive road and waterway networks, which include important state highways and canals. In order to control invasive species and encourage sustainable land-use practices, the study highlights the necessity of integrated conservation measures that combine ecological research, community engagement, and policy interventions. This will guarantee that the wetlands' ecological and economic benefits are maintained for future generations.



Materials and Methods

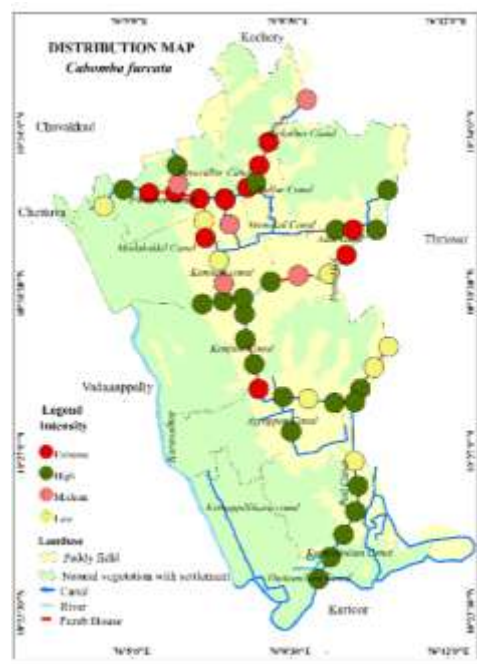
Within Kerala's Kule Wetlands, a Ramsar site renowned for its ecological and economic significance, the study was carried out in nine panchayats. The study sought to map the density and distribution of invasive aquatic plants, including *Cabomba furcata*, *Salvinia molesta*, *Eichhornia crassipes*, and *Ipomea aquatica*, with a focus on irrigation canals and rivers. 86 data points for distribution analysis and seven for water sampling were obtained from field surveys conducted from January 19 to 30, 2024, using a Garmin eTrex® 10 GPS to record geocoordinates at 1-kilometer intervals. In order to create a visual record of the density of invasive species, geotagged photos and site-specific information were collected using the Map Marker mobile app. Observations at each GPS point included ecological assessments using a visual scale of 1 (very low) to 4 (very high) aggressiveness. Socio-economic data were collected via structured questionnaires targeting stakeholders such as farmers and fishers, capturing the impacts of invasions and existing management practices.

Canal systems were digitized by georeferencing secondary data, such as official toposheets and boundary descriptions, using ArcGIS and Google Earth Pro. The identification of invasive species was guided by a checklist based on important publications by (Suresh T et al., 2012) and (Hrideek T K et al., 2020), with additional input from researchers at the Kerala Forest

Results and Discussion

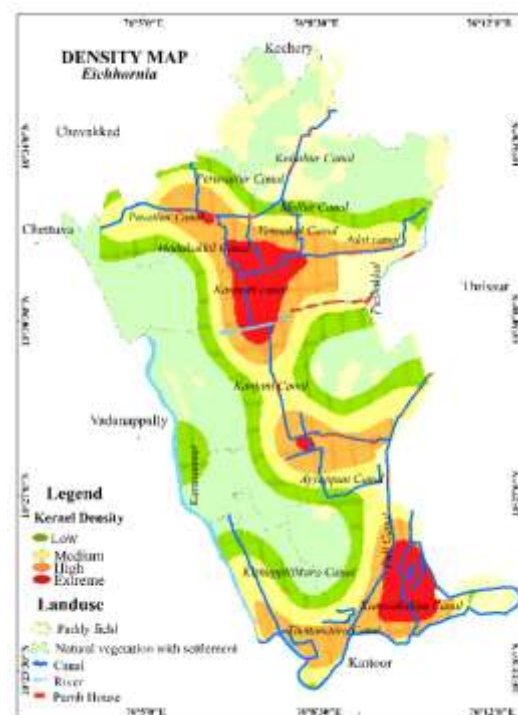
Canal systems were digitized by georeferencing secondary data, such as official toposheets and boundary descriptions, using ArcGIS and Google Earth Pro. The identification of invasive species was guided by a checklist based on important publications by Suresh et al. (2012) and Hrideek et al. (2020), with additional input from researchers at the Kerala Forest Research Institute. The sampling locations were methodically selected based on their accessibility and closeness to regions where *Cabomba furcata* is known to proliferate. This thorough method evaluated the ecological and socioeconomic effects of invasive species on the Kole Wetlands by combining stakeholder inputs, geospatial tools, and field observations.

Originating in Central and South America, *Cabomba furcata*, also known as Red Cabomba, is an invasive species that is both aesthetically pleasing and aggressive. Its preference for canal systems over riverine environments was demonstrated by kernel density analysis, especially in regions close to paddy fields. The Puvathur-Kulathoor and Adat-Kanjani canal segments showed the highest concentrations, whereas the southern canal systems showed lower densities. Significant *Cabomba furcata* clustering was found between 1700- and 2600-meters using Ripley's K function analysis, most likely as a result of advantageous environmental conditions. The species showed a more scattered pattern above 3500 meters. These results highlight the need for focused interventions in densely populated areas.



Impact of *Eichhornia crassipes* in the Wetlands

Originating in South America, water hyacinth (*Eichhornia crassipes*) is a well-known invasive plant that creates thick mats that obstruct oxygen flow and sunlight penetration in aquatic environments. It predominates in river segments and canal systems in the Kole Wetlands, with different densities determined by environmental factors. The central Pull Canal, the Ayappan Canal, and the Adat-Puzhakkal rivers are among the notable infestations. Significant clustering was found between 1100 and 3000 meters by Ripley's K function analysis, with dispersion starting at 3500 meters. To limit its detrimental ecological effects and stop its spread, effective management techniques are essential.



Distribution Patterns of *Salvinia molesta* and *Ipomoea aquatica*

Thick mats of the floating fern *Salvinia molesta* (Giant Salvinia), which is renowned for its quick vegetative reproduction, deteriorate the quality of water. Although it is widely distributed across the Kole Wetlands, its intensity of distribution is not as great as that of *Eichhornia crassipes*. Significant clustering was found between 1300 and 3600 meters, with dispersion beyond 3800 meters, according to Ripley's K function analysis. On the other hand, the distribution of *Ipomoea aquatica*, or water spinach, is more restricted, with significant concentrations found in the Ayappan Canal and Karuvannur River. Even though its presence is less severe, it still needs to be addressed to stop ecological disruption and further spread.

Socio-Economic Impacts and Survey Insights

The survey's gender distribution showed that 80% of respondents were men, which is consistent with the study area's farming and fishing occupational demographics. Farmers took an average of 5.74 days to remove *Cabomba furcata* before planting, according to an analysis of efforts that showed variation across occupations. Six and eight days were the most frequent durations, accounting for 20% and 22% of cases, respectively. These observations highlight the socioeconomic costs associated with invasive species and the significance of incorporating local stakeholder initiatives into management plans.

Conclusion

In the Kole Wetlands, Thrissur District, four major invasive aquatic plant species, *Cabomba furcata*, *Eichhornia crassipes*, *Salvinia molesta*, and *Ipomoea aquatica*, present serious ecological and socioeconomic challenges, according to the study. With *Cabomba furcata* exhibiting the highest density in the central and northern canals, spatial analyses showed that each species exhibited unique clustering patterns that were influenced by environmental factors and proximity to paddy fields or canal systems. *Salvinia molesta* and *Eichhornia crassipes* were more common in the wetlands, where they formed thick mats that degraded the water quality and aquatic biodiversity. Although the distribution of *Ipomoea aquatica* was more localized, early interventions are necessary to stop further spread. According to socioeconomic evaluations, farmers, who are most affected by invasive species, invest a lot of time and energy in getting rid of them before planting. Additionally, gender-disaggregated data showed that most wetland-related activities were undertaken by men. In order to lessen the effects of these invasive species and restore the ecological balance of the Kole Wetlands, these findings highlight the urgent need for integrated, region-specific management strategies that combine ecological, technological, and socioeconomic approaches.

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