Connected Component Segmentation For The Extraction of Aquaculture Ponds Along India's Coast Using Time Series Sentinel-1 SAR Data

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Aquaculture in India – An Overview

Aquaculture is one of the fastest growing primary food production sectors in India, ranking second after China. Coastal aquaculture in India is mainly concentrated in dedicated ponds along deltas and coastal wetlands. Uncontrolled aquaculture development in India has led to large scale conversion of coastal wetlands such as mangroves, swamps, lagoons etc. to shrimp cultivation ponds. Nutrient rich effluents, chemicals, antibiotics, and feeds from aquaculture ponds leads to ecological degradation and eutrophication of coastal and estuarine systems (Murthy et al. 2013)

Study Area and Data

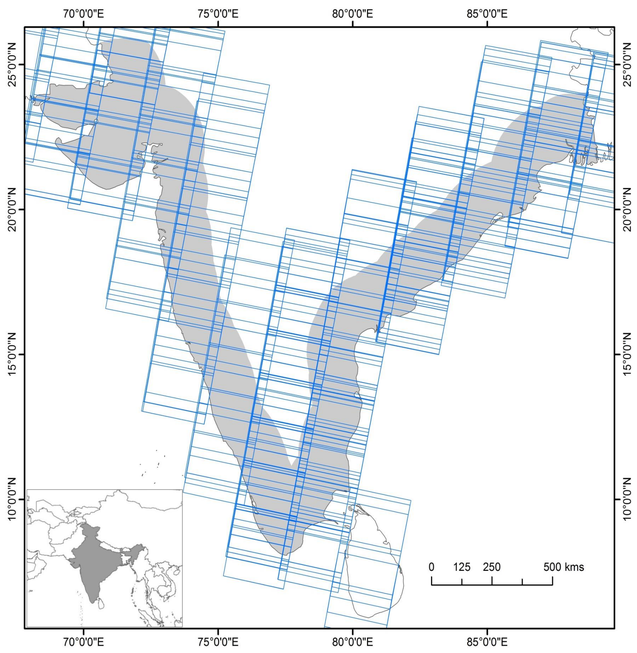

Fig 1: Study Area – 200 km coastal zone along India Coast is represented by grey colour. Overlying blue tiles represent Sentinel-1 descending mode IW GRDH data coverage over the study area.

- Study area: entire coastal zone of India with approx. 1.1 Mio. km². (200 km inland from the coastline with length of 5,400 km).
- Satellite Data: Sentinel-1 IW GRDH SAR data, descending mode.
- Period of Study (September 2014 to June 2017)
- 2983 Sentinel-1 scenes were processed
- 3100 pond samples were collected along the coast for validation and shape metrics calculation

Methods

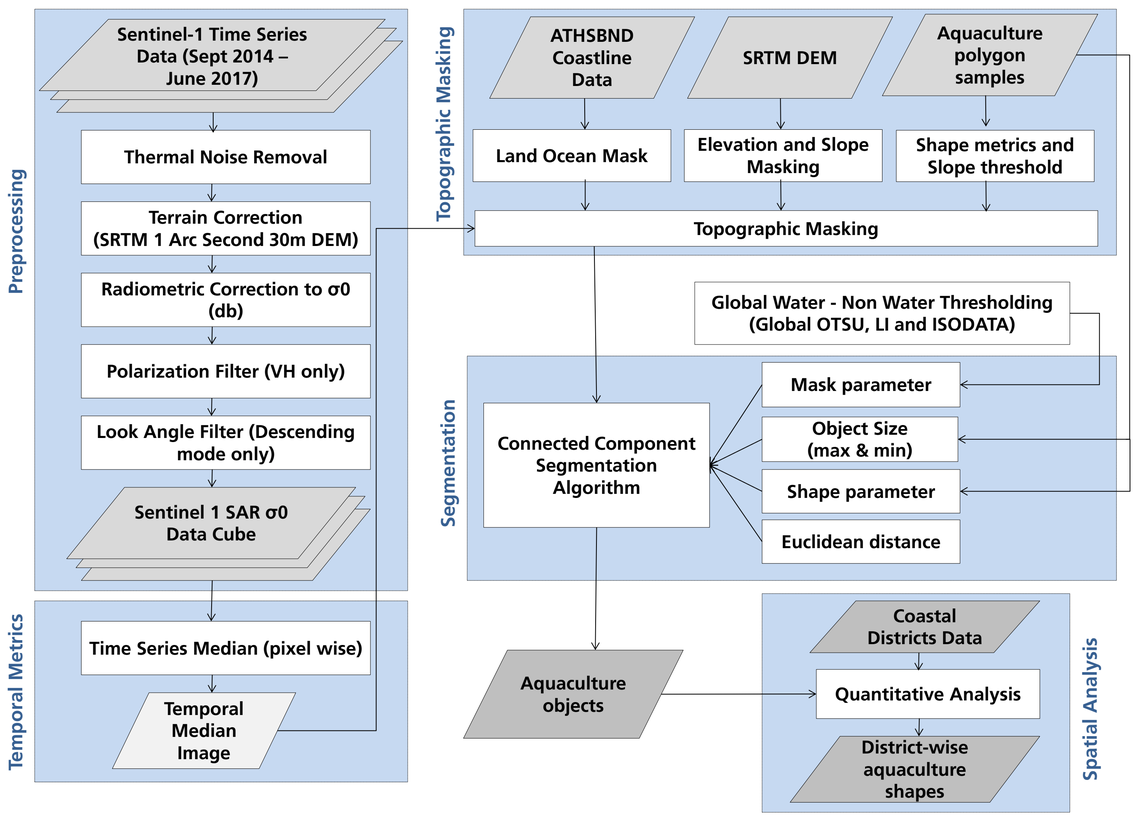

Fig 2: Flow chart of the adopted methodology

The methodology generally follows the approach of Ottinger et al. 2017. Preprocessing of Sentinel-1 data begins with removal of thermal noise and radiometric calibration to convert intensity values to backscatter coefficient. Terrain correction is done using SRTM elevation data. SRTM DEM data was used for masking inappropriate terrain. Shape metrics (Perimeter, Area, Compactness, P2A) and slope were calculated from 3100 aquaculture pond samples collected using visual interpretation. Pixel-wise temporal median was calculated from all Sentinel-1 data. Open-source connected component segmentation algorithm was used in the identification of ponds based on the difference in backscatter intensity of inundated surface and shape metrics calculated as input. Validation of the approach was done based on 1000 sample points distributed via stratified sampling.

Results

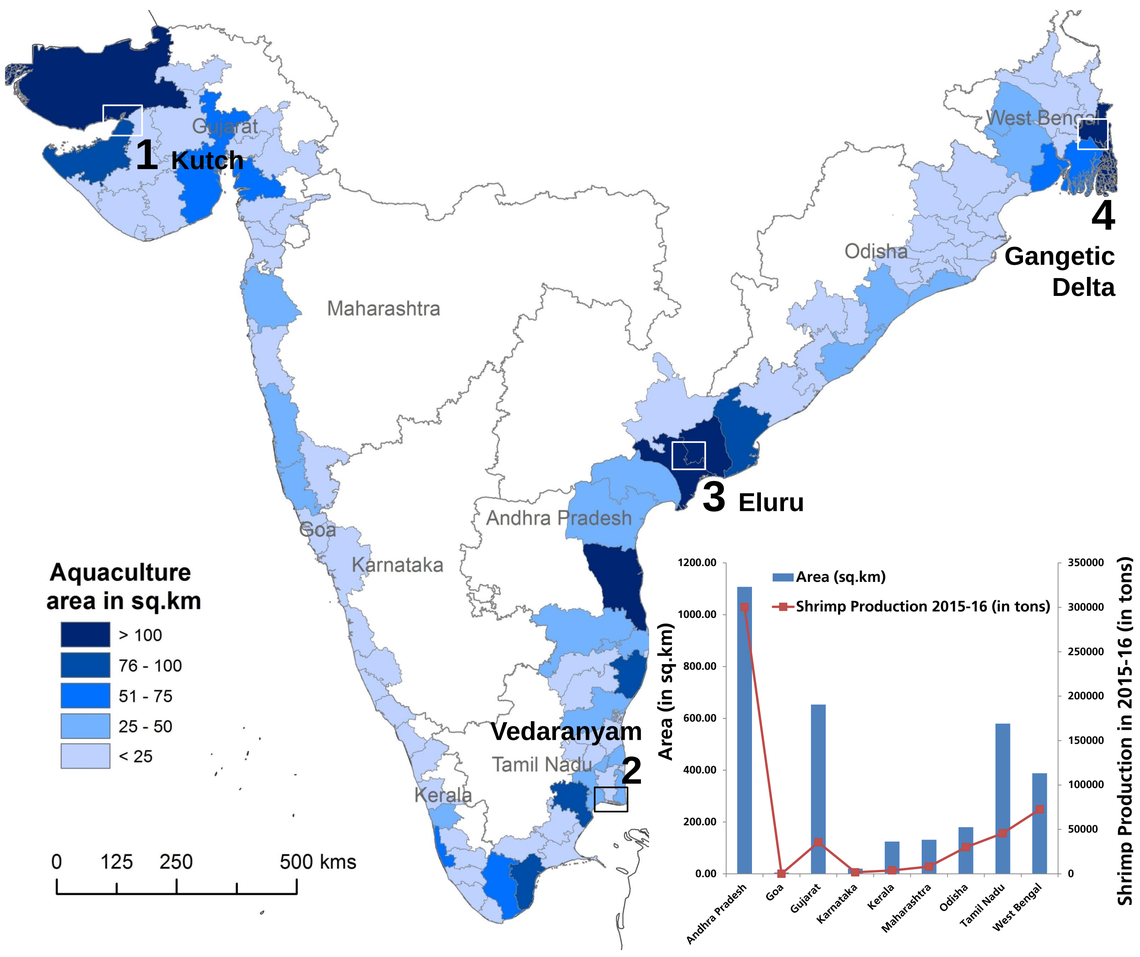

Fig 3: District-wise spatial distribution of aquaculture ponds along the districts in Indian Coast. The inserted graph represents the area (in sq.km) and shrimp production (in tons) in the year 2015-16.

From the results, the total area under coastal aquaculture in India is 3189 sq.km. Of this, 34.73% of area is in Andhra Pradesh followed by Gujarat with 20.48% of area. Krishna (347.5 sq.km) and West Godavari (282.65 sq.km) districts of Andhra Pradesh province are dominant in shrimp aquaculture in India. The approach resulted in an overall accuracy of 89%. Our results are highly correlated with the shrimp production data (2015-2016) from Marine Products Exports Development Authority (MPEDA), Govt. of India. (Figure 3).

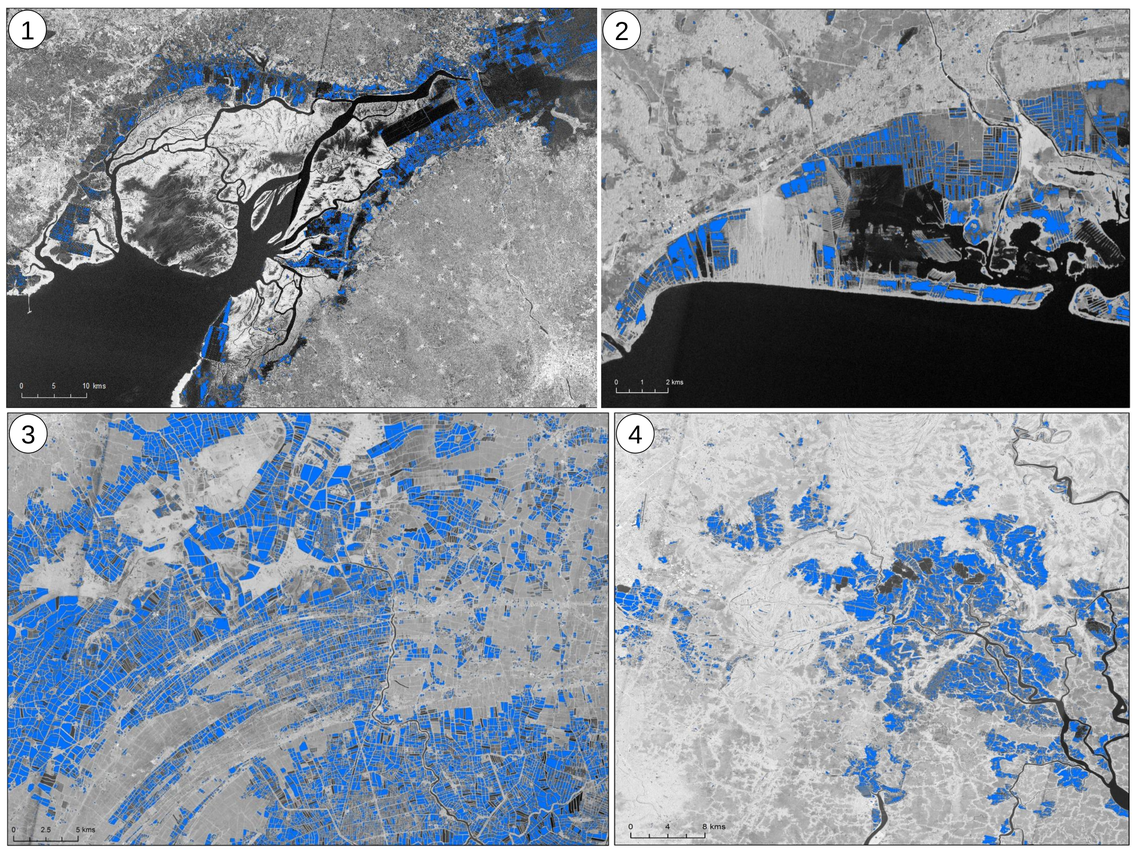

Fig 4: Aquaculture ponds extracted from Sentinel-1 median image using Connected Component Segmentation method. Few examples, (1) Kutch, Gujarat; (2) Vedaranyam, Tamil Nadu; (3) Eluru, Andhra Pradesh; (4) Gangetic Delta, West Bengal.

Conclusion

The current research highlights the large-scale mapping of aquaculture ponds using open-source time series Sentinel-1 data. This approach has given satisfying results with an overall accuracy of 89% with few quality issues related to missing out of small scale aquaculture ponds. This framework can be updated with data from current and future Sentinel-1 satellites for continuous mapping and monitoring of coastal aquaculture in India. This approach is spatio-temporally transferable to different parts of the world and cost effective.

Ottinger, M., K. Clauss, and C. Kuenzer. 2017. "Large-Scale Assessment of Coastal Aquaculture Ponds with Sentinel-1 Time Series Data." Remote Sensing 9(5):1–24.
Murthy, T. V. R., J. G. Patel, S. Panigrahy, and J. S. Parihar. 2013. National Wetland Atlas : Wetlands of International Importance Under Ramsar Convention. Space Application Centre (ISRO), Ahmedabad, India.

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