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Evaluation of Site Suitability for Artificial Reefs Deployment in Southeast Coast of India Using Geographical Information System as a Management Tool

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A planned artificial reef (AR) deployment program as part of a fisheries enhancement might be a useful tool for managers to supplement traditional ways to utilize available space and augment local productivity. Several AR deployment initiatives have been carried out globally, but they are rarely subjected to a rigorous site selection process. We created a site selection procedure in this study that includes systematic stages including exclusion mapping, underwater visual transect, benthic composition, seawater quality, and comparative visual mapping. This research focused on restoring the fishing grounds for artisanal fishermen by deploying AR along the southeast coast of India. The results of each stage in the procedure enabled us to choose suitable locations at a target depth with low wave action, no slope, and a good substrate capable of supporting an AR. Analysis of variance (ANOVA-one way) showed significant ($p < 0.05$) spatial variation for depth, slope, seawater current, salinity, chlorophyll-a, benthic density, and diversity. The geographical information system (GIS) based model output showed space allocation for AR deployment. The GIS methodology for site selection was developed to be easily adaptable to the demands of diverse artificial reef programs. The integrated strategy has proven to be a successful regulatory intervention for AR deployment practices in order to facilitate coastal restoration and management.

Keywords: artificial reef, fishery, coastal, GIS, Tamil Nadu

INTRODUCTION

The artificial reef (AR) is a submerged structure deliberately placed on the seabed to mimic the functions of a natural reef, such as protecting, regenerating, concentrating, and enhancing marine organism stock, and serves as a part of the natural ecosystem (FAO, 2015). The earliest recorded AR was from the 1830s, when logs from huts were used off the coast of South Carolina, United States, to improve fishing (Weisburd, 1986). The first scientifically planned reefs were deployed in 1974 off the Adriatic coast of central Italy (Fabi and Fiorentini, 1994). However, in the Indian scenario, AR was first reported on the Coromandel Coast (Hornell, 1924), whereas the first AR construction was carried out off Puthiyathura village in 1953, and further organized efforts to deploy ARs were initiated from 1980 onward (Sreekanth et al., 2019).

Despite widespread usage of AR as a mitigating tool for restoring fisheries, they are rarely subjected to a thorough site selection protocol before deployment. Though there are site selection guidelines, they primarily focus on physical factors (shipping channels, fishing, or substrate) and methods for obtaining permits (Figley, 2005). The majority of scientific effort is focused on studying AR after deployment to obtain time-series data of community dynamics (Reed et al., 2006; Thanner et al., 2006). Although these findings are important for evaluating the effectiveness of AR, they typically do not provide the required information to develop a standard protocol for reef placement, management, and mitigation plans. Poor site selection is one of the most common causes of failure of AR deployment programs (Tseng et al., 2001; Kennish et al., 2002).

Exclusion mapping (Kaiser, 2006) is one of the most commonly utilized methods for selecting suitable locations and screening out unsuitable ones. However, it does not provide the physical and biological data needed to comprehend the ecology of a prospective AR site. Seawater currents, waves, substrate stability, seawater quality, and existing benthic fauna are key factors in site selection (Spieler et al., 2001; Duzbasilar et al., 2006; Mousavi et al., 2015). It is well known that exclusion mapping may account for the majority of these features, nevertheless very few studies have been carried out (Barber et al., 2009) that combine them with physical and biological field data to determine site suitability. Site selection is a complex process in which the role of geographical information systems (GIS) is well established (Moeinaddini et al., 2010; Mousavi et al., 2015; Jha et al., 2017).

Coral reefs on the southeast coast of India (Tamil Nadu) are located in Palk Bay (PB) and in the Gulf of Mannar (GoM) (Muley et al., 2000), which accounts for 94.3 sq km in which reef flat and reef vegetation comprise 64.9 and 13.7 sq km, respectively (Department of Ocean Development and Space Application Centre, 1997). It is reported that the GoM and PB harbor about 117 species belonging to 40 genera of coral and support the fisheries production in the region (Raghuraman et al., 2013). However, in recent times, there has been a decline in traditional fishing due to which artisanal fishermen are facing severe problems such as lower catch (Vijayanand et al., 2007). In addition, factors such as trawling (James, 1994) and damage to benthic habitats (Murugan and Durgekar, 2008) have also exacerbated the decline in annual total fish catch along the southeast coast of India (Tamil Nadu). Considering the above facts, the present research focussed on systematic site selection protocols for fishery restoration and conserving the ecosystem in the southeast coast of India (Tamil Nadu). Hence, an integrated site selection method was established before the deployment to ensure long-term success of AR in supporting the local fishery. The objectives of the present study are to (1) use exclusion mapping as the first stage for selecting target locations for AR deployment; (2) develop a comprehensive record of physical and biological parameters for each location based on quantitative *in situ* data; and (3) *in situ* and satellite data comparison for selected parameters for the site suitability to develop a simple site selection protocol that could easily be adapted in other coastal environments.

MATERIALS AND METHODS

Study Area Description

Tamil Nadu has a coastline of 1,076 km and stretches along the Bay of Bengal, the Indian Ocean, and the Arabian Sea. It constitutes about 15% of the total coastal length of India, covering PB and the GoM, which is one of the major coral-rich areas located along the southeast coast of India. Five coastal districts, namely, Thanjavur (THA), Pudukottai (PUD), Ramanathapuram (RAM), Thoothukudi (THO), and Tirunelveli (TIR), were studied for the site suitability of AR deployment (**Figure 1A**).

Exclusion Mapping

The site selection is an important step towards the AR deployment process and the restoration of fisheries in the selected coastal regions. In this study, systematic approaches were used for AR site selection: (1) Exclusion mapping (bathymetry, wave, cost-effective distances, and discharge points), (2) quantitative transect survey, and 3) constructing a GIS model (Barber et al., 2009). Sites that were too shallow or deep (<5.0 m or >15.1 m), had strong waves (>1.5 m), beyond the cost-effective distance (12 km), and within 1 km of the discharge point (i.e., shore) were eliminated from further consideration (**Table 1**).

The data for bathymetry was sourced from the General Bathymetric Chart of the Ocean (GEBCO) portal (spatial resolution of 30 Arc seconds). The average significant wave height (SWH) (spatial resolution of 0.25 degree) data was collected from the Indian National Centre for Ocean Information Services (INCOIS) over 1 year period. The depth and wave data were interpolated using the inverse distance weighted (IDW) method (Chang, 2006). We also generated buffer layers for the cost-effective distance (12 km) to incorporate that layer into the exclusion mapping model. To analyze such sites, a buffer layer of discharge locations (1 km) was also built. However, the buffer layer was not represented in the exclusion model. The criteria and sub-criteria for deploying AR are given in **Table 2**.

Quantitative Transect Survey

After completing the initial site selection process using exclusion mapping (first step), the GIS model output was validated by conducting field sampling in suitable locations from January 2020 to April 2020. During the field survey, the bathymetry data of the suitable locations were measured by a multi-beam sonar system using a fishing trawler at 42 locations. Depth was corrected for tidal elevations and values were expressed with reference to chart datum (FAO, 2015). The seawater current was measured by deploying a current meter (RCM9) by following the protocols of FAO (2015). The slope was calculated based on the difference between the depths of measured points and the distance between

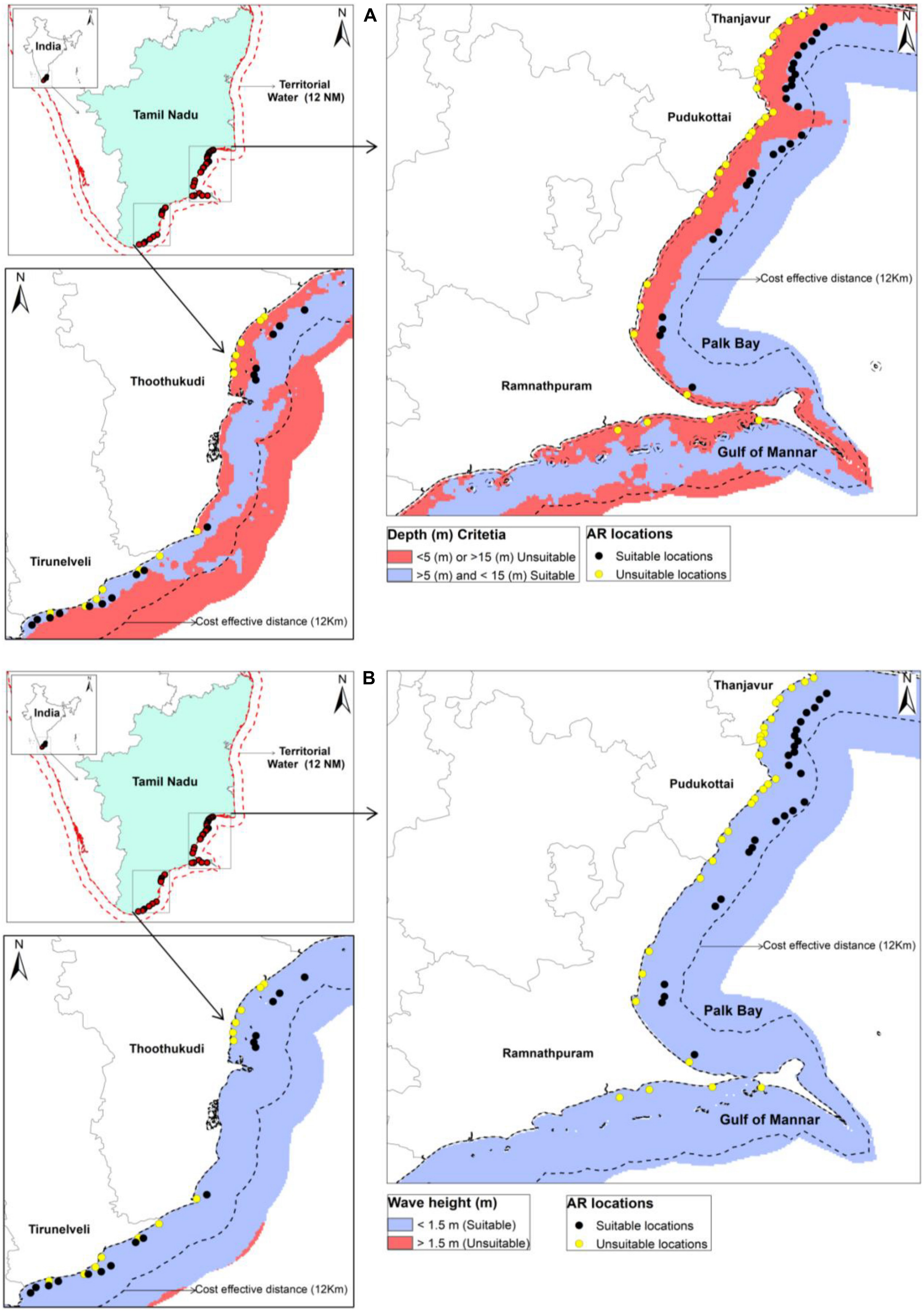

FIGURE 1 | Exclusion mapping model for AR deployment along the Tamil Nadu coast. Data layer indicates unsuitable (red) and suitable (blue) for **(A)** bathymetry and **(B)** wave height produced through the GIS reclassification tool.

those points. After initial exclusion, slope angles below 5° were considered for the AR deployment (Barber et al., 2009).

To determine the composition of the substrate at each site, underwater surveys using self-contained underwater breathing apparatus (SCUBA) were conducted along three 25-m transects at each site. The parallel transects were carried out at the 25 m × 25 m footprint for AR deployment. Each diver collected data on one side of the transect until the entire transect had been sampled (Barber et al., 2009). The viability of each site was discussed, and barren areas without seagrass or coral reef beds were selected for AR deployment among the sensitive ecosystem.

Sediment texture was determined in the field laboratory using the wet sieving and pipette method, and grain size fractions were obtained by dry sieving through a stack of 8 sieves ranging from 2 to 0.063 mm mesh sizes (Holme and McIntyre, 1984). To identify benthic fauna, sediment samples were collected using a Van-Veen grab having a surface area of 0.16 m^2, and each sample was identified up to the lowest possible taxonomic level using standard taxonomic literature, and their density was expressed as ind/m^2.

Geographical Information System Model

Considering the diversity of the data and the variety of scales on which all criteria can be measured, the values contained in the different thematic layers were transformed into comparable classes by following the reclassification tool of GIS (Malczewski, 2006). This data layer was used to identify suitable sites for the AR deployment. Out of 84 tentative locations, 42 locations that fell within these criteria were delineated as "suitable" locations and were further investigated. The average sea surface temperature (SST), sea surface salinity (SSS), total suspended matter (TSM), and chlorophyll-a (chl-a), data were collected (spatial resolution of 0.25 degree) from the INCOIS. In addition to that, the above parameters were also collected during the quantitative survey (*in-situ*) from the surface using a GOFLO sampler by a boat sampling. The sampling positions were geo-coded by using a hand-held GPS (Garmin eTrex Vista; ± 5 m). The SST and SSS were measured onboard by calibrated multi-parameter water quality instruments (Hanna HI9829). The TSS was determined by filtering 1 L of seawater through pre-dried and pre-weighed (0.45 μm Millipore GF/C) filter paper and washed with Milli-Q water to remove salt content (APHA [American Public Health Association], 2005). The chl-*a* was analyzed by a spectrophotometric method (Parsons et al., 1992). The TSS and chl-a samples were analyzed in the field laboratory and data were recorded after the analysis was completed. The samples were analyzed in triplicates, and quality control procedures were followed by careful standardization and blank measurements. One-way ANOVA was employed to test the spatial variations (station-wise) of physicochemical parameters. A geo-database of the above parameters was developed and imported to Arc GIS software (ver. 9.3.1). The parameters were interpolated using the IDW method (Chang, 2006). In this study, uniform class ranges and color codes were adopted for the maps generated through interpolation.

TABLE 1 | Reclassification values for bathymetry, wave height, cost-effective distance, and discharge points data used in the exclusion mapping model (adapted and modified from Barber et al., 2009).

Original value	Reclassified value	Reasoning for reclassification
Bathymetry		
5.0–15.0 m	Suitable	Ideal larval settlement and safe SCUBA diving depth
0.0–4.9 m >15.1 m	Unsuitable	Navigational concerns, wave action, and too deep for many larvae, and SCUBA
Wave		
<1.5 m	Suitable	Ideal wave action for fish and larval settlement
>1.5 m	Unsuitable	Affect the larval settlement and fish activity
Cost-effective distance		
<12 KM	Suitable	Safe for traditional or artisanal fishermen
>12 KM	Unsuitable	Unsafe for traditional fishermen
Discharge points		
>1 km	Suitable	Provide good water quality for the ecosystem
<1 km	Unsuitable	Not conducive for ecosystem rebuilding

TABLE 2 | Description of criteria and sub-criteria for artificial reef deployment (adapted and modified from Barber et al., 2009; Kapetsky et al., 2013; Mousavi et al., 2015; Jha et al., 2017).

Criteria	Sub criteria	Recommended limit
Exclusion mapping	Bathymetry	>5 m and <15 m
	SWH	<1.5 m
	Cost effective distance	<12 km
	Distance from sewage points	>1 km
Quantitative transect survey	Bottom slope	<5°
	Seawater current	10–75 cm/s
	Bottom type	Hard or solid bottom
	Benthos	Density and diversity
Constructing GIS model	Water temperature	26–32°C
	Salinity	29–35 PSU
	Suspended solids	<50 mg/L
	Chlorophyll-a	<5 mg/m^3

RESULTS AND DISCUSSION

Eighty-four locations were considered for the exclusion modeling for the AR deployment; only 42 sites met the site selection criteria. These locations were within a 12 km radius of cost-effective distance and in the 5–15 m water depth range, conforming to accessibility criteria (**Table 1**). Similar results were also reported in which potential sites were within 11 km radius of the nearest shore, and in the 6–15 m mean water depth range at Massachusetts Bay (Barber et al., 2009). In the present study, none of the sites were located in the shipping route marked on navigational charts. A raster classification categorized depth layers into two classes (<5 m and >15 m = unsuitable, and >5 m and <15 m = suitable). Based on the threshold value of depth, the unsuitable and suitable areas have been represented in red and blue, respectively (**Figure 1A**). The cost-effective distance is very useful since the ARs give an excellent chance for impoverished artisanal fishermen who can't afford a net can easily use a hook and line, to earn their livelihood by venturing to the AR areas for fishing (Kasim Mohamad et al., 2015). While, the optimal depth range helps in larval settlement on the AR structure (Duzbasilar et al., 2006). The spatial variation of depth was significant ($p < 0.05, F = 59.755$) in the present study. A buffer layer of 12 km was used for showing the accessible sites as per the cost-effective distance criteria, whereas a 12NM buffer was used for clipping the inaccessible territorial waters for artisanal and traditional fishermen. Further, wave height is another important technical criteria for AR deployment, because frequent high waves in the region will hamper ecosystem restoration (James and Slaski, 2006). Few areas in the offshore environment in Thoothukudi and Tirunelveli had wave heights of more than 1.5 m, as seen in **Figure 1B**, and those areas were eliminated from further investigation. The GIS model supported exclusion mapping and allowed us to eliminate 50% of prospective locations for the AR deployment.

The physical (slope, seawater current, and bottom type) and biological factors (benthos) played a vital role in the site selection process. In the present study, after initial screening through exclusion mapping, slope angles below 5° were considered suitable for the AR deployment. Similar results were reported in which slope angles below 5° were considered for the AR deployment at Massachusetts Bay (Barber et al., 2009). Similarly, optimum seawater current also plays a vital role in delivering nutrients and larvae to the newly deployed AR, as well as

TABLE 3 | Details of the Artificial Reefs deployed locations along the Tamil Nadu coast.

Latitude	Longitude	Name of the villages	Depth (m)	Slope angle (degree)	Seawater current (cm/s)	Bottom type	Benthic Taxa (nos.)	Benthos density (ind/m^2)
10.2518	79.3708	Keelathottam	5.77	0.03	12	Coarse sand	24	2,808
10.2495	79.3567	Kollukadu	5.00	0.01	14	Medium sand	23	2,340
10.2387	79.3535	Chinnamanai	5.01	0.03	20	Coarse sand	18	1,989
10.2026	79.3421	Sethubhavachathiram	5.00	0.22	15	Coarse sand	24	2,769
10.1873	79.3203	Karankuda	5.27	0.14	14	Coarse sand	28	2,457
10.1546	79.3027	Adaikathevan	5.49	0.07	11	Coarse sand	22	2,145
10.1444	79.2992	Manthiripattinam	5.83	0.10	14	Coarse sand	22	2,847
10.1339	79.3000	Somanathanpattinam	5.44	0.13	11	Medium sand	21	3,588
10.1169	79.3073	Vallavanpattinam	5.66	0.01	22	Coarse sand	26	2,145
10.1052	79.3056	Sembiyanmahadevipattinam	5.80	0.05	20	Coarse sand	19	2,574
10.0971	79.3053	Kattumavadi	5.65	0.09	12	Coarse sand	18	1,989
10.0715	79.3057	Krishnajipattinam	6.00	0.03	27	Medium sand	15	1,911
10.0586	79.3207	Kodiyakarai	6.00	0.11	27	Fine sand	15	2,145
9.9780	79.3443	Ponnagaram	5.50	0.07	28	Medium sand	18	2,964
9.9562	79.3148	Ammapattnam	6.13	0.03	18	Coarse sand	28	1,585
9.9432	79.2935	Pudukudi	5.71	0.05	20	Coarse sand	28	2,379
9.9302	79.2715	Kottaipattinam	5.88	0.03	21	Coarse sand	29	1,819
9.8826	79.2174	R. Pudupattinam	6.02	0.05	22	Coarse sand	26	1,507
9.8635	79.2103	Arasanagaripattinam	6.00	0.02	20	Coarse sand	31	1,936
9.8529	79.2022	Enathi	5.81	0.02	24	Medium sand	30	1,989
9.7342	79.1290	Pasipattinam	5.25	0.07	26	Coarse sand	34	1,936
9.7258	79.1170	Dhamodharapattinam	5.25	0.24	29	Coarse sand	36	1,936
9.5196	78.9830	Thiruppalaikudi	5.25	0.01	21	Coarse sand	38	1,351
9.4886	78.9826	Devipattinam	5.50	0.09	24	Medium sand	32	1,741
9.4735	78.9765	Mudiveranpatti	5.50	0.06	20	Coarse sand	31	1,390
9.3404	79.0573	Alaikathavalasai	6.50	0.06	18	Medium sand	45	1,897
9.0287	78.3670	Indiranagar	6.50	0.07	20	Fine sand	45	1,209
8.9788	78.2812	S.M Valasi	5.00	0.02	20	Coarse sand	43	1,429
8.9685	78.2701	Keelamundal	7.30	0.17	18	Medium sand	41	1,585
8.8366	78.2415	Vembar	5.60	0.06	20	Coarse sand	32	1,326
8.8278	78.2324	Keelavaipar	5.70	0.03	19	Very coarse sand	34	1,429
8.8136	78.2374	Sippikulam	6.20	0.05	15	Medium sand	16	1,663
8.3928	78.0950	Tharuvaikulam	8.90	0.03	34	Coarse sand	25	1,404
8.2700	77.9129	Vellaipatti	8.60	0.11	18	Very coarse sand	21	1,950
8.2580	77.8904	Siluvaipatti	7.20	0.22	47	Coarse sand	26	1,741
8.1792	77.7894	Kulasekarapattinam	5.50	0.17	24	Very fine sand	16	1,819
8.1563	77.7527	Kuduthalai	11.50	0.24	29	Very coarse silt	16	1,131
8.1360	77.6412	Uvari	12.00	0.07	26	Medium sand	19	1,209
8.1135	77.5977	Thoomaiyarpuram	9.50	0.29	16	Coarse sand	26	1,450
8.1754	77.7965	Idinthakarai	12.00	0.21	30	Fine sand	16	3,666
8.1387	77.6469	Perumanal	14.50	0.17	20	Coarse sand	21	1,560
8.1215	77.5975	Kootapulli	14.00	0.07	15	Medium sand	30	1,638

maintaining a well-oxygenated environment (Duzbasilar et al., 2006). The suggested seawater current ranges from 10 to 75 cm/s (Mousavi et al., 2015). However, in the present study, it ranged from 11 to 47 cm/s and its spatial variation was significant ($p < 0.05$, $F = 3.317$).

Hard-bottom habitat is critical to several life stages of commercially important species like lobster, crabs, marine finfish, and other species of invertebrates (Wahle and Steneck, 1992; Tupper and Boutilier, 1995; Packer et al., 1999). The bottom type in selected locations was categorized as: (1) very coarse sand, (2) coarse sand, (3) medium sand, (4) fine sand, (5) very fine sand, and (6) very coarse silt, which can support the deployment of AR. Apart from the good bottom substrate, the natural larval supply such as benthic fauna promotes the rebuilding of the newly deployed AR ecosystem (Pratt, 1994). We observed a total of 81 taxa of benthic fauna represented by a wide range of taxonomic groups namely Polychaeta, Amphipoda, Isopoda, Cumacea, Ostracoda, Nematoda, Bivalvia, Gastropoda, Echinoidea, Nemertea, and Cephalochordata (Pandey et al., 2022). The substratum heterogeneity and habitat complexity lead to higher diversity and abundance of the benthic community, which in turn supports the ecosystem formation around the ARs (Pandey et al., 2018; Pandey and Ganesh, 2019). The taxa and density of benthos varied from 15 to 45 and 1,131–3,666 ind/m^2, respectively. The spatial variation of taxa ($p < 0.05$, $F = 12.923$) and density ($p < 0.05$, $F = 6.083$) was significant. The details of the selected site with its location, depth, slope angle, seawater current, bottom type, benthic taxa, and density are given in **Table 3**.

Comparative Water Quality Model

The IDW spatial interpolation technique was used to generate spatial maps (**Figures 2A–H**) for recommended environmental variables (TSS, SST, SSS, and Chl-a). The range of *in-situ* TSS concentration was 14–40 mg/L (**Figure 2A**), whereas (**Figure 2B**) satellite-derived data ranged from 2.72 to 61.69 mg/L. Similarly, SST (26.61–29.99°C) (**Figure 2C**), SSS (28.38–34.38 PSU) (**Figure 2E**), and chl-a (0.03–0.49 mg/m^3) (**Figure 2G**) showed variation in the present study. However, the spatial variation was significant for SSS ($p < 0.05$, $F = 8.001$) and chl-a ($p < 0.05$, $F = 4.558$). Satellite derived data for SST, SSS, and chl-a, varied from 26.35 to 29.09°C (**Figure 2D**), 31.87–34.72 PSU (**Figure 2F**), and 0.24–2.07 mg/m^3 (**Figure 2H**), respectively. The average value calculated for satellite data indicates that higher concentrations were noticed in the nearshore regions, whereas it was well within the site selection criteria at the selected locations in the offshore waters. The higher TSS could be attributed to the freshwater input from many perennial rivers (i.e., Krishna, Godavari, and Mahanadi) and several seasonal rivers (i.e., Palar, Vellar, and Coleroon) in the nearshore region (Shanthi et al., 2013). A range of values are represented by color codes for mapping the area that visualizes the concentration of specific parameters and shows the comparison. Visual interpretation is an easy method to depict and explain the dispersion pattern of environmental parameters (Lillesand and Kiefer, 1979) in a broader perspective, like AR deployment. This type of comparative study will help to select the suitable parameters that are available through satellite datasets for the better coverage and management of a long coastline. *In-situ* and satellite data validation is well reported for selected physicochemical parameters, e.g., chlorophyll-a, in southeast coast of India and it revealed good correlation coefficient ($r^2 = 0.89$) (Selvavinayagam et al., 2003). Though the present study was limited to site suitability for AR deployment, earlier reports on the post-deployment study indicated a higher aggregation of juvenile fishes at the AR site along the Tamil Nadu coast.[1]

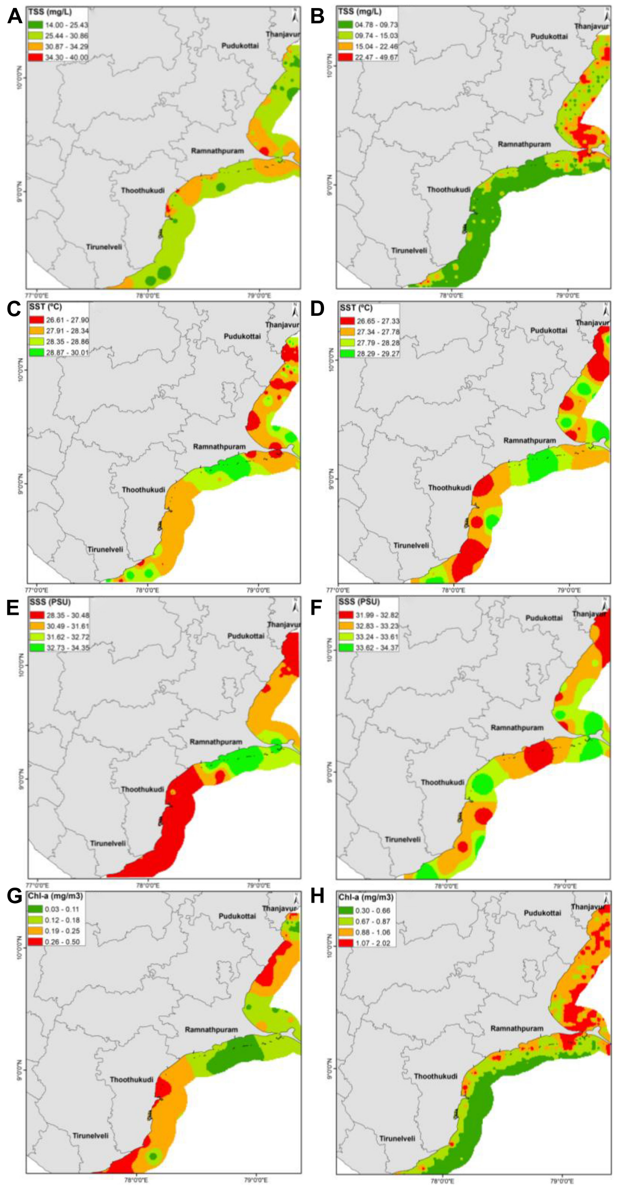

FIGURE 2 | (A–H) *In-situ* **(A,C,E,G)** and satellite **(B,D,F,H)** data comparison along the Tamil Nadu coast.

A systematically planned site selection approach contributes to the development of an ecosystem around the AR, which in

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[1] https://www.newindianexpress.com/cities/chennai/2020/nov/13/artificial-reefs-deployed-in-record-time along chennai-coast-come-to-life-2223346.html

turn promotes sustainable rural technology highly suitable for the livelihood enhancement of artisanal and traditional coastal fishermen (Kasim Mohamad et al., 2015). It is claimed that biomass output in the ARs regions ranges between 2.5 and 5 tons per year, with biodiversity products/ecosystem services valued at USD 190,000 per year (Kasim Mohamad et al., 2015). Increase productivity by reducing fishermen's reliance on natural coral reefs; it also promotes a healthy ornamental fish population, ecotourism, and natural resource conservation. Thorough monitoring of environmental factors is critical for the deployment of ARs in suitable sites. Yet, there is little data on the pre-deployment of ARs in India and globally. The current study will provide a good understanding of physical factors such as seawater quality, and benthic diversity at the pre-deployment stage of ARs in fisheries depleted coastal regions for promoting conservation and improving livelihoods through ecosystem services by enhancing 20% catch adjacent to ARs compared to sites away from the ARs in the Indian (Philipose, 1996) and global scenarios (Fabi and Fiorentini, 1994). The integrated approach will also aid in the development of a management strategy for site appropriateness prior to the deployment of ARs, resulting in improved outcomes and benefits to coastal society.

CONCLUSION

An integrated approach (exclusion mapping and quantitative transect survey) in combination with GIS proved to be a simple and systematic method to support AR site selection and deployment in the coastal environment. The deployment of ARs in the tropical coastal environment is critical for restoring the fisheries activities in depleted coastal areas. Finding a suitable site for AR deployment is an important step in the whole process. The study developed distinctive exclusion maps which supported screening out the non-potential sites for AR deployment. Results revealed that out of 84 tentative sites, only 50% met the site selection criteria. Considering the recent depletion in fish catch, especially for artisanal fishermen, a comprehensive plan needs to be evolved to initiate a systematic site selection approach before AR deployment. This will help to conserve the fish stock and support the fishermen in the coastal regions. Although Tamil Nadu was selected as the study area, the systematic site selection approach developed would be useful to other maritime nations, especially in the tropical regions.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

DJ: conceptualization, sampling design, and data validation, GIS modeling, and writing – original draft. VP: sample collection, laboratory analysis, and data processing. JS: SCUBA diving and underwater data collection. PS and SV: field investigation and analysis. JJ: co-ordination of study and reviewing the data. GD: reviewing the manuscript, suggestion, and project management. RV: reviewing the manuscript, guidance, and project management. All authors contributed to the article and approved the submitted version.

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