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EDITORIAL

Comment on Gazi et al. (2020): Detecting Coral Reef Degradation on St. Martin's Island, Bangladesh?

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Abstract
St. Martin's Island is a small sedimentary island situated at the southernmost part of Bangladesh (20°37.6′ N and 92°19.3′ E). The island is surrounded by rocky reefs composed of Neogene bedrock consisting of moderately hard and soft sandstones and conglomerates belonging to the Tipam Sandstone (Islam in Bangladesh J Univ Sheffield Geol Soc 7:269–275, 1980). The rocky reefs are covered by fields of conglomerate boulders and calcareous concretions that provide a suitable substrate for coral settlement and the establishment of coral communities. Before 1997 it was reported that St. Martin's Island was a coral island surrounded by coral reefs (Ahmed in Bangladesh J Environ Sci 1:67–73, 1995; Anwar in National workshop on coastal area resource development and management, Part II. CARDMA, BRAC Printers Bangladesh, Dhaka, pp 36–66, 1988; UNEP/IUCN in Indian Ocean, Red Sea and Gulf. UNEP regional seas and bibliographies. IUCN, Gland, 1988). However, the first underwater survey conducted in 1997 did not find any evidence of coral reefs (Tomascik in Management plan for coral resources of Narikel Jinjira (St. Martin's Island). National Conservation Strategy Implementation Project-1, Ministry of Environment and Forest, Government of the People's Republic of Bangladesh, p 125, 1997). The island has become an important tourism destination and concerns have been raised about the impact of local development on its coral resources (Tomascik 1997). Recently a paper was published on the degradation of coral reefs on St. Martin's Island (Gazi et al. in Ocean Sci J 55(3):419–431, 2020) that makes many factually incorrect assertions. The rocky reefs that surround the island have been misclassified by Gazi et al. (2020) as "coral reefs". Here, we discuss Gazi et al. (2020) and examine if the results and conclusions provide factual evidence of spatiotemporal coral reef degradation.

Keywords Bangladesh · Coral reefs · Remote sensing · Rocky reefs · St. Martin's Island

1 Misclassification of Coral Reefs and Coral Islands

Gazi et al. (2020) begin with a title implying that coral reefs are present on St. Martin's Island. Coral reefs are massive, wave-resistant, biogenic carbonate structures with positive topographic features that were built over millennia, mainly through the action of scleractinian (Scleractinia) corals and crustose coralline algae, and fall into three developmental stages: (1) veneering coral communities, (2) incipient reefs, and (3) mature reefs (Kleypas et al. 2001; Tomascik et al. 1997). Based on the above definition of coral reefs we can state with certainty that while the island is surrounded by sandstone rocky reefs it is devoid of coral reefs. The rocky reefs, dotted with numerous round calcareous concretions and conglomerate boulders, provide suitable substrates on which scleractinian corals settle, grow and form veneering communities. These coral communities represent a relatively diverse assemblage of scleractinian corals, coralline algae, sponges, and other reef-associated organisms. While these coral communities may be precursors of coral reefs they are also persistent features along many coastlines in relatively marginal environments characterized by frequent disturbances.

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Past reports on the presence of coral reefs on St. Martin's Island have also led to its geological misclassification as a coral island (Khan 1985; Anwar 1988). Coral islands are formed through the accumulation of sand and gravel derived from coral skeletons and other coral reef-associated flora and fauna, and therefore they consist of materials derived from the coral reef itself (Stoddart and Steers 1977). To our knowledge, there is no evidence of a coral reef foundation for the island. Based on the geological setting, St. Martin's Island is characterized as a continental sedimentary island (Hoque et al. 1979).

2 Water Column Correction

Gazi et al. (2020) used satellite imagery to estimate the spatial dynamics of coral cover but did not provide information on water column correction procedures. They applied an algorithm developed for clear oceanic waters without giving proper consideration to the algorithms' assumptions and limitations outlined in Bierwirth et al. (1993). Water masses around the island are not comparable to clear tropical oceanic waters, and therefore using a water correction algorithm for clear oceanic waters is problematic. Tomascik (1997) reported that the average water transparency, measured by Secchi disk, during the dry season was 2.5 m ($\pm$1.2 m, $N=31$), which can be converted into an attenuation coefficient of $k=0.68$ m^{-1}. Bierwirth et al. (1993) derived their water correction algorithm using much lower water attenuation coefficients ranging from $k=0.10$ m^{-1} to $k=0.19$ m^{-1}.

The water correction algorithm used by Gazi et al. (2020) was designed for clear waters of oceanic derivation and developed and tested in Hamelin Pool, Western Australia. In areas with high turbidity and suspended sediments the water column correction algorithm developed by Bierwirth et al. (1993) would underestimate water depth and skew towards higher substrate reflectance in the green and red visible wavelength bands (Bierwirth personal communication; Bell et al. 2020). Bierwirth et al. (1993) suggested that alternate approximation methods for water attenuation derivation, such as those of Lyzenga (1981), be used for water masses that do not meet the Hamlin Pool criteria.

3 Lack of Sufficient Ground Truthing and Sensor Resolution

Based on the information provided it is our opinion that the Gazi et al. (2020) study has minimal ground-truthing and lacks the necessary analysis of classification accuracy. There is a need to examine the accuracy of the ground-truthing (underwater photos) in this study, but no assessment was provided. Furthermore, the names of coral species given in Fig. 3b–g (p. 423) are not correct. We suggest the following species names in Fig. 3b–g (p. 423): 3b—coral is not *Diploastrea heliopora*, but because of poor picture quality it is not possible to give it a species level designation; 3c—*Dipsastraea speciosa*; 3d—*Favites complanata*; 3e—*Astraeosmilia maxima*; 3f—*Plesiastrea versipora*; and 3 g—*Platygyra acuta*.

We would also like to point out that in Fig. 4 (p. 424) coral colonies identified as dead are alive. Two of the dead corals belong to the genus *Porites* and the third coral colony (middle of the bottom 3 pictures) could be *Paragoniastrea russelli*. The *Porites* colony in the bottom left corner of Fig. 4 is encased in a mucous sheet. In response to high sedimentation rates, this species uses mucous sheets to trap the sediments that are settling on the colony surface and then sloughs them off the colony to clean itself.

The estimation of coral cover using the 30 m resolution multispectral Landsat imagery cannot provide the level of detail and accuracy that could detect coral community changes around St. Martin's Island. While the Landsat sensors have been used to examine coral reefs as far back as 1984, their spectral resolution was able to only discriminate between different components of a reef ecosystem such as broad habitat classifications and physical structure (Hedley et al. 2016). The rocky reefs that surround the island are dotted with thousands of conglomerate boulders and calcareous concretions that are covered with benthic algae, presenting a reflectance signature that is easily misclassified as coral. Several studies have demonstrated that Landsat sensors cannot differentiate between live coral and benthic algae due to their similarity in spectral reflectance (Andréfouët et al. 2001; Hochberg and Atkinson 2003). Andréfouët et al. (2001) concluded that: "*…the assessment of the rates of change in three ubiquitous classes 'sand,' 'background' (including rubble, pavement, and heavily grazed dead coral structure), and 'foreground' (including living corals and macroalgae) emerges as the most reproducible and feasible application for the ETM + sensor*." Recent studies have shown that hyperspectral sensors possessing many more spectral bands than Landsat are necessary to accurately discriminate between coral and algae (Hedley et al. 2012). Since the Landsat ETM + sensor (and spectrally analogous Landsat TM and OLI) cannot separate corals from algae, we suggest that the Gazi et al. (2020) study documents changes in the coral/algal benthic cover complex of the various conglomerate boulders and calcareous concretions scattered over the intertidal and rocky subtidal.

Gazi et al. (2020) misclassified many bare sandy areas as "Coral Colony". For example, in Fig. 5e (p. 426) the area at the northeast tip of the island defined as "Coral Colony" is dominated by sand, some rocks but only a few corals. Moreover, the "Coral Colony" classification appears in the flooded field and ponds on the island interior, well above sea level as shown in Fig. 5a–d (p. 426). These misclassifications raise questions regarding the acceptability of model outputs that seem to lack reality. According to Fig. 5a–d corals form a narrow band in the upper intertidal, extending about 100 m from shore around the entire island, yet the intertidal that surrounds the entire island is 200 to 500 m wide and, in reality, coral communities are found further offshore from the seaward edge of the lower intertidal. Despite public availability of Landsat imagery at no cost, Gazi et al. (2020) only examined one Landsat image per decade, abandoning the opportunity to use additional imagery to confirm the classifications within a season or year. In Table 1 the authors also misrepresent the sensor used to acquire the imagery for February 13, 1980. Since the Landsat TM instrument was first launched in 1982, it is probable that the image for February 13, 1980 was collected by the Landsat 3 Multispectral Scanner Instrument (60 m resolution) and not Landsat 4.

4 Has Degradation of Coral Communities been Measured?

We agree with Gazi et al. (2020) that degradation of coral resources has likely occurred since the 1980s, however, there have not been any quantitative coral studies to quantify the degree of their spatiotemporal degradation. Gazi et al. base some of their conclusions on coral degradation on the results of Ahammed et al. (2016). Both Gazi et al. (2020) and Ahammed et al. (2016) cite English et al. (1997) as a key reference for historical quantitative assessment of coral abundance on St. Martin's Island. However, English et al. (1997) is a "Survey Manual for Tropical Marine Resources" and does not contain any historical quantitative information on the corals of St. Martin's Island. We found no studies that support their assertion that there were 141 and 127 coral species in 1980 and 1990, respectively. The intertidal and subtidal rocky reefs that surround the island can be mistaken for a coral reef both in-field assessments and in multispectral imagery by inexperienced observers. We suggest that the red zones as depicted by Gazi et al. (2020) in Fig. 5 (p. 426) represent the intertidal zone and not the subtidal areas where coral communities exist. Based on Tomascik (1997) we can state with confidence that coral abundance around the island varies greatly from place to place. The highest abundance and coral cover documented by Tomascik (1997) was at the southern part of the island, well to the south of the southernmost ground truth station of the Gazi et al. study. Due to the lack of rigorous field assessments along with erroneous remote sensing observations, there is no evidence that the spatial patterns of coral degradation suggested by Gazi et al. are accurate.

Gazi et al. assert that during the last four decades 'coral colonies' have been reduced from 1.33 km^2 in 1980 to 0.39 km^2 in 2018. Because corals on St. Martin's Island occur in very low numbers, and coral cover represents only a small percentage of the bottom substrate, we do not believe that Landsat sensors have the resolution needed to detect subpixel changes in the abundance of coral colonies and/or coral cover. Thus, we submit that while the study may document changes in the composition of the algal-dominated rocky intertidal, it does not detect the degradation of coral reefs which do not exist on St. Martin's Island.

References

Ahammed SS, Hossain MA, Abedin MZ, Khaleque MA (2016) A study of environmental impacts on the coral resources in the vicinity of the Saint Martin Island, Bangladesh. IJSTR 5(1):37–39

Ahmed M (1995) An overview on the coral reef ecosystem of Bangladesh. Bangladesh J Environ Sci 1:67–73

Andréfouët S, Muller-Karger FE, Hochberg EJ, Hu Ch, Carder KL (2001) Change detection in shallow coral reef environments using Landsat 7 ETM+ data. Remote Sens Environ 78(1–2):150–162. https://doi.org/10.1016/S0034-4257(01)00256-5

Anwar J (1988) Geology of coastal area of Bangladesh and recommendation for resource development and management. In: Moudud HJ, Rashid HE, Rahman AA (eds) National workshop on coastal area resource development and management, Part II. CARDMA, BRAC Printers Bangladesh, Dhaka, pp 36–66

Bell TW, Okin G, Cavanaugh KC, Hochberg EJ (2020) Impact of water characteristics on the discrimination of benthic cover in and around coral reefs from imaging spectrometer data. Remote Sens Environ 239:111631. https://doi.org/10.1016/j.rse.2019.111631

Bierwirth PN, Lee TJ, Burne RV (1993) Shallow sea-floor reflectance and water depth derived by unmixing multispectral imagery. Photogramm Eng Remote Sens 59(3):331–338

English S, Wilkinson CR, Baker VJ (eds) (1997) Survey manual for tropical marine resources, 2nd edn. Australian Institute of Marine Science, p 390

Gazi MY, Mowsumi TJ, Ahmed MK (2020) Detection of coral reefs degradation using geospatial techniques around Saint Martin's Island, Bay of Bengal. Ocean Sci J 55(3):419–431. https://doi.org/10.1007/s12601-020-0029-3

Hedley JD, Roelfsema CM, Chollett I, Harborne AR, Heron SF, Weeks SJ, Skirving WJ, Strong AE, Eakin CM, Christensen TRL, Ticzon V, Bejarano S, Mumby PJ (2016) Remote sensing of coral reefs for monitoring and management: a review. Remote Sens 8(2):118. https://doi.org/10.3390/rs8020118

Hochberg EJ, Atkinson MJ (2003) Capabilities of remote sensors to classify coral, algae, and sand as pure and mixed spectra. Remote Sens Environ 85:174–189. https://doi.org/10.1016/S0034-4257(02)00202-X

Hoque M, Islam MA, Ahmed ST, Hoque SM (1979) Geology of the Saint Martin's Island. Bangladesh J Sci Res 2(B):17–27

Islam MA (1980) Neogene stratigraphy and sedimentation of the St. Martin's Island. Bangladesh J Univ Sheffield Geol Soc 7:269–275

Khan MAR (1985) St. Martin's—a vanishing coral island of Bangladesh. Tigerpaper 12(4):6–12

Kleypas JA, Buddemeier RW, Gattuso JP (2001) The future of coral reefs in an age of global change. Int J Earth Sci 90:426–437. https://doi.org/10.1007/s005310000125

Lyzenga DR (1981) Remote sensing of bottom reflectance and water attenuation parameters in shallow water using aircraft and Landast

data. Int J Remote Sens 2(1):71–82. https://doi.org/10.1080/01431168108948342
Stoddart DR, Steers JA (1977) The nature and origin of coral reef islands. In: Jones OA, Endean R (eds) Biology and geology of coral reefs, IV. Geology II. Academic Press, pp 59–105
Tomascik T (1997) Management plan for coral resources of Narikel Jinjira (St. Martin's Island). National Conservation Strategy Implementation Project-1, Ministry of Environment and Forest, Government of the People's Republic of Bangladesh, p 125
Tomascik T, Mah AJ, Nontji A, Moosa MdK (1997) The ecology of Indonesian Seas. Volume VIII, Part II. Periplus Editions, Singapore, p 756
UNEP/IUCN (1988) Coral reefs of the world. Volume 2: Indian Ocean, Red Sea and Gulf. UNEP regional seas and bibliographies. IUCN, Gland, Cambridge/UNEP, Nairobi, p 387