9. The Unvegetated Tidal Flats in Catanduanes Island, Philippines: Current and Future Trends

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1. Introduction

Tidal flats are some of the most important providers of ecosystem services. However, many of these habitats have already been lost due to anthropogenic activities[1, 2, 3] yet information on their status and assessments is largely unknown[4]. Several factors have been related to their loss and degradation, including land reclamation, coastal erosion, rise in sea level, sediment compaction, and other pressures from coastal development[1, 2, 3, 5, 6].

Unvegetated tidal flats are coastal areas periodically inundated by tides and predominantly characterized by sandy and muddy sediments[7, 8, 9]. Healy et al. (2002) further defined them as sand, rock, or mudflats that undergo regular tidal inundation[10]. These areas have generally exposed substrates in contrast to those of vegetated tidal habitats such as mangrove forests, seagrass beds, and salt marshes[9, 11].

Compared to vegetated tidal habitats, these zones are relatively poorly studied, probably due to their "barren" landscape. However, these areas have been known to support high benthic biodiversity[12, 13], many of which are difficult to observe due to their enigmatic nature. Under certain conditions, scavengers and predators are also known to frequent the area, as shown by fish assemblages[14] and active foraging activities of shorebirds and waterfowl[15, 16, 17.]

They have also been suggested to be an important carbon sink[11] and have an active role in marine bioturbation and nutrient cycling due to activities of marine species that live in their burrows[18, 19, 20, 21, 22]. Due to the sedentary nature of burrowing benthic communities, it is suggested that bioturbation processes within unvegetated tidal flats are highly active and relatively continuous, hence the importance in the dynamics of intertidal ecology.

In Catanduanes, the importance of unvegetated tidal flats is paramount, as most people are coastal dwellers. However, its status is less known, although there is generally a wide promotion in the conservation of mangroves and other ecosystems by the media, non-governmental organizations (NGOs), and government agencies. Included here are preliminary sampling/surveys and local interviews, as well as secondary data to provide information on the characterizations and status of unvegetated tidal flats on Catanduanes Island.

2. Catanduanes Island

The island is located on the eastern seaboard of the Philippines. It is fringed with several minute bays or coves on the east coast (typhoon frontline zone). This protective coastline may have contributed to the formation of unvegetated tidal flats in this area. Meanwhile, several tidal flats are also found on the southwest coast. Although few coves are present in this area, there may be weaker waves and currents due to its non-frontline location, which may have supported the natural establishments of these intertidal habitats. However, the effects of typhoons on sediment wash and tidal biodiversity on the island are unknown.

Classification of unvegetated tidal flats is poorly available, but on Catanduanes island, they can be qualitatively characterized by the following features:

1. **Compressed sediments with firm tidal marks** (Figure 1a). These areas are dominated by compact silt and mud sediments, which are characteristics of tidal flats that are periodically submerged in compressing waves and currents. In this area, tidal marks (wrinkled lines) are highly noticeable. Crustacean burrows are low, although sand and ghost crabs are present, as well as many types of burrowing gastropod[23, 24].

2. **Loose sediments with high burrow density** (Figure 1b). These areas have loose sediments approximately composed of silt, mud, and sand and are relatively far from a strong tidal influx.

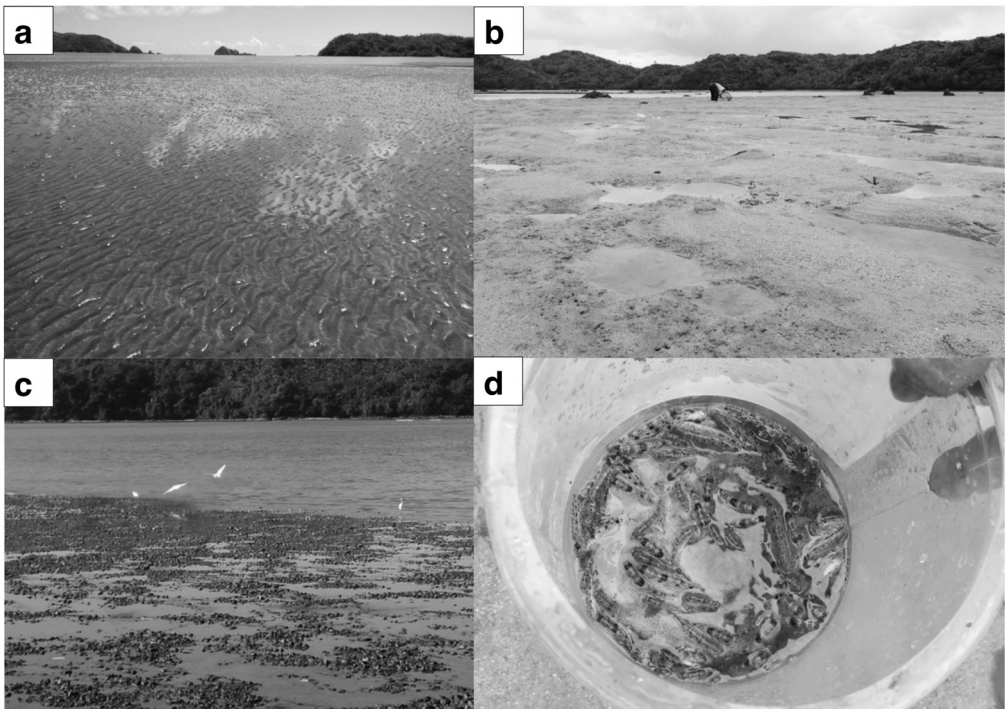

Figure 1 Unvegetated tidal flats in Catanduanes island. a) a tidal flat with prominent wrinkled marks, b) a tidal flat with high density of crustacean burrows, c) a partly pebbled tidal flat, and d) gobies collected by local people at the tidal flat in Figure. 1b.

Crustacean burrows are highly abundant. Dark sediments may be present in patches near the burrows. Tidal marks are low or moderate. The surface topography is uneven as a result of burrows and mounds.

3. **Sediments mixed with pebbles** (Figure 1c). Sediments are approximately composed of silt, sand, and mud, as well as pebbles. Although pebbles are observed on the surface, these tidal flats are also composed of sediments hidden below. Crustacean burrows can be moderate to high. Tidal marks are low or absent. Gastropods are abundant compared with the other tidal types.

3. Tidal Species and Livelihood Services

In general, preliminary sampling/surveys conducted have noted various upogebiid and axiid host shrimp species and some burrows of unknown hosts. These are keystone species that support other symbionts that live with them. This suggests an active benthic activity in the area. Notable burrow-associated species are different kinds of gobies (Figure 1d), alpheid shrimps, and copepods. Various gastropod species were also present in the area[23, 24]. Fish and seabirds (many might be migratory) are also observed as temporary residents.

Aside from crustaceans and mollusks, there is no further information on other invertebrate benthos evaluated in these areas. There are also no data on the plankton or algal population, but in certain seasons a thin film of algae can be seen. These algae easily disappear, suggesting their non-permanent habit in the tidal flats.

Gleaning is popular on the island. In this activity, people collect any kind of edible organism during or about 2 hours before and after low tide. In many cases, collections are mostly macroinvertebrates; hence, the term macroinvertebrate gleaning. This is usually done in seagrass, partly in unvegetated tidal flats, and sometimes in mangroves or coral reefs[23]. Most of the time, collected species are only for family consumption, although gleaners may sometimes sell them for additional income.

Gleaners may also find fish that are concentrated in seagrass beds. In Catanduanes, virtually all tidal flats are adjacent to seagrass. They acknowledge that they can find fish in the tidal flats when the areas are not fully drained (before or after the low tide peak). This suggests the importance of tidal flats as foraging grounds for fishes.

4. Infrastructures/Reclamation

Reclamation of unvegetated tidal flats is not common in Catanduanes, probably because their locations are not adjacent to major urban centers. In Virac town, however, recent constructions were carried out at the port site as part of the improvement of the access roads project[25]. This had reclaimed some areas of a nearby sandy beach. With the possible expansion of settlements in the future, developments like this may extend to unvegetated tidal flats of the island.

5. Habitat Conversion

5.1 Unvegetated Tidal Flats and Aquaculture

The conversion to aquaculture is another serious concern in the decline of the world's coastal ecosystems. FAO (2012) addressed that the conversion of tidal flats to aquaculture ponds is widespread in the Yellow Sea and that Asia currently supplies 89% of global aquaculture production[26].

In Catanduanes, most conversion of wetland ecosystems to fishponds occurs primarily at mangrove sites[23, 27]. In many parts of the island, unvegetated tidal flats are located relatively far from big rivers and mangroves-the usual zones where locals may establish their fishponds. Tidal flats in Catanduanes are generally seafront (although many of them are in small bays or coves), thus generally spared from fishpond conversion.

5.2 Unvegetated Tidal Flats Issues with Mangrove Conservation

The conversion of habitat to another valuable habitat is perhaps the most important current issue in the tidal flats of Catanduanes. This has raised concerns about their conservation. In the Philippines, much effort has been made to conserve mangrove forests in line with mangrove destructions in the last decades[28, 29]. Mangrove activities are carried out to serve as a shield against typhoons, floods, destructive waves, and soil erosion[30, 31] and as a source of food and livelihood services[32]. In Catanduanes island, locals strongly believe that they also enhance natural beauty and estuarine diversity regardless of the sites of their introduction[23, 27].

The current mangrove trend in the world has produced various mangrove reforestation projects in mangrove-denuded areas, as well as afforestation initiatives that extend into unvegetated tidal flats. In mangrove planting, many factors should be considered (e.g. site stability, soil characteristics, signs of natural regeneration, etc.)[33] but many planting activities fail to connect the absence or poor natural colonization and recovery of mangroves in the sites that led to continued planting efforts in the tidal flats[28]. These works are often unsuccessful with high mangrove mortalities[28]. The popular practice of planting in mudflats (also in seagrass beds) is ecologically misguided[34, 35].

At present, there are no official data on intrusions into the tidal flats by mangrove activities in Catanduanes, but mangrove seedlings are observed in the tidal flats in some mangrove planting projects. In a mangrove planting activity in tidal flats, an interview with people generated a consistent response of mangrove mortality rate as high as 99%-100%. This may not be surprising, as the tidal flats could have long supported mangroves to thrive in the area if only natural conditions are met.

6. Marine Protected Area

Probably the most successful coastal biodiversity initiative on the island is the establishment of the Agojo Marine Protected Area (AMPA) in the municipality of San Andres. In recent decades, the participation of legislative, civic, and other stakeholders played an important role by actively participating in its conservation practices[23]. Other government units recently had sanctuary establishment projects that may require sustainable community involvement[23]. However, most established sites are primarily mangrove-seagrass beds, although one is a coral reef (Takot Reef)[23].

In general, the following are identified: 1.) There is no established MPA dedicated to unvegetated tidal flats

and 2.) Unvegetated tidal flats are usually not part of conservation initiatives on the island. This is reflected in trainings and research conducted extensively in relation to mangroves (and seagrass to some extent) that are conducted by civic society, academia, and NGOs.

7. Conclusions and Recommendations

Unlike mangrove forests and marshes, these ecosystems are not always seen (due to tidal submergence and the "barren surface"), thus hardly recognized by communities and stakeholders. This might have been contributing to their limited conservation efforts. However, with the ecological services provided by the unvegetated tidal flats in Catanduanes, their value in biodiversity and local livelihood cannot be undermined.

Coastal development is generally not a problem in the island's tidal flats at least at present. However, the intrusions into other coastal habitats indicate possibilities of intrusion by coastal infrastructures in the future. Furthermore, while the conversion of tidal flats into aquaculture is not common, this trend may also emerge. In this case, this would be in conjunction with the expanding population, as well as the coastal development programs linked with the economic framework initiated by the national government. The fate of unvegetated tidal flats on this aspect is difficult to predict.

Mangrove afforestation in unvegetated tidal flats is like creating a productive ecosystem (if successful at all) from existing productive ones. This means additional costs and works with the tendency that afforestation may not even be 100% successful. Furthermore, since mudflats are noted to support rich intertidal biodiversity, conversion into mangrove forests would lead to local endangerment of tidal flat species and all migratory animals that depend on them during seasonal migration. Therefore, the value of tidal flats in this part is crucial for both local and transnational intertidal biodiversity.

Conversion to another valuable habitat (e.g. mangrove forests) may have value on aesthetics, but there is no scientific evidence that conversion of a productive ecosystem would fully supply ecosystem services of a replaced productive habitat. Typhoon buffering is probably one of the main reasons government units are converting tidal flats into mangroves. It must be noted, however, that even in high sediment-accreted areas, high mangrove mortalities are also recorded. Although mangroves are important buffers against storms, investment in these may not work if ecologically misguided. With these concerns, it is generally not recommended to convert unvegetated tidal flats to mangrove forests.

Furthermore, the absence of MPA based on tidal flats may have been due to the strong public preference for mangroves and seagrass; therefore, the notion of its establishment may be difficult to raise but is nevertheless recommendable. It is also necessary to include conservation activities and research for existing unvegetated tidal flats (if any) adjacent to or within the enclosure of already established MPAs.

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