STATE OF

THE GULF OF MOTTAMA REPORT

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GoMP – August 2023

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OVERVIEW

The Gulf of Mottama is a globally significant wetland area of riverine, estuarine, and coastal ecosystems that support local communities and species of conservation concern. With inputs from four major rivers, the Gulf is highly turbid, productive, and hosts the most extensive mudflats in Southeast Asia. Its ecosystem services include fisheries, rich agricultural land, and important habitat for migratory shorebirds and waterbirds, coastal cetaceans, and other marine megafauna. It was Myanmar's fourth Ramsar site designated in 2017[1].

With high community dependence on fisheries and agriculture, as well as the presence of multiple endangered and threatened species, proper management of the Gulf's resources is vital for resilient communities and for biodiversity conservation. This is particularly important considering the high rates of poverty among the Gulf's communities. Threats to the Gulf's resources include illegal fishing and overfishing, bycatch and illegal capture of threatened species, plastic pollution and possibly other chemical pollution, sand mining and other upstream effects (e.g., potential future damming projects). Local communities also face the risks inherent in migration for work when they cannot rely on local economy driven by natural resources and other enabling conditions for their livelihoods.

Furthermore, the highly dynamic nature of the Gulf's hydrology includes an apparently natural cycle of substantial erosion along the banks of the Sittaung River, which resulted in the loss of farmlands and villages in Bago Region in the mid-2010s. Communities also are impacted by flooding during the rainy season and drought during the dry seasons. Increased temperatures and prolonged drought, more intense storms and flooding, and saltwater intrusion into agricultural fields and drinking water wells, have been reported by communities – all likely to be further exacerbated as climate change continues.

The management of the Gulf's natural resources reflects recent changes to natural resource governance in Myanmar more broadly, which shifted toward decentralization in the mid-2010s (particularly for fisheries management) and which included the establishment of national and state/regional Coastal Resource Management Committees (CRMCs) starting in 2016. Since 2015, the Gulf of Mottama Project (GoMP) has worked with local stakeholders to establish the structures and capacity for co-management with state and regional CRMCs down to the village level until the political change in February 2021; since then, efforts have focused on community-based management by local institutions at village and township levels.

The COVID19 pandemic has had serious impacts on local communities, including through disruptions to markets and interruptions to management efforts due to limitations on public activities and gatherings. The political change in February 2021 has further impacted communities and management efforts, weakening markets, interrupting ongoing engagement with government institutions (including patrolling efforts for illegal fishing), and prompting increased migration (domestic and international, particularly to Thailand). There has been a noted increase in illegal fishing as well as hunting of shorebirds and waterbirds and a substantial decrease in local livelihoods. Efforts continue to build capacity and institutions for community management at the village up through the township level.

GULF OF MOTTAMA CONTEXT & STATUS

The Gulf of Mottama, spanning from Mon State westward to Bago and Yangon Regions in Myanmar, is home to productive wetland ecosystems, productive fisheries, species of conservation concern, and rural communities who depend on its natural resources. It connects the major cities of Mawlamyine in Mon State and Bago in Bago Region. The Gulf is globally unique, with a highly dynamic hydrological profile and extensive mudflats (among the largest in the world). It was Myanmar's fourth Ramsar area, with ~40,000 hectares (ha) initially designated in 2017, increased to 161,030 hectares in 2020[1] (Figure 1). Part of the Gulf has also been designated as an East Asian-Australasian Flyway Partnership (EAAFP) Flyway Network Site due to its importance for migratory waterbirds. *(See Box 1)*

Wise management of its natural resources will be critically important to ensure the resilience and well-being of its local communities, as well as to protect its biodiversity - particularly in the face of climate change. The Biodiversity and Nature Conservation Association's work in the Gulf since the early 2010s laid the foundation for the Gulf of Mottama's Ramsar designation. The establishment of the national Coastal Resource Management Committee consisting of diverse government institutions in 2016, and the Mon State and Bago Region Coastal Resource Management Committees (CRMCs) in 2018, were encouraging steps toward integrated, multi-stakeholder management of coastal resources. Starting in 2015, the Gulf of Mottama Project (GoMP) has worked with stakeholders from the village level up to the state and regional CRMCs to support institutions and capacity for wise management of the Gulf in Mon State and Bago Region.

Though the COVID19 pandemic and the 2021 political change have severely impacted the Gulf's communities as well as its management, particularly as related to government institutions, dedicated efforts by local stakeholders with the support of the GoMP continue to work toward sustained community-based management of this globally unique and significant wetland.

Key non-governmental organizations that have been involved in research, community engagement, and resource management in the Gulf include:

- Gulf of Mottama Project (GoMP), a consortium project funded by the Swiss Agency for Development and Cooperation (SDC) and implemented by Helvetas Myanmar, Network Activities Group (NAG), and International Union for Conservation of Nature (IUCN).
- Biodiversity and Nature Conservation Association (BANCA), a local conservation organization whose work in the Gulf has focused on waterbirds as well as community education and engagement in conservation.
- Point B Design + Training (Point B), a local education and research organization with a focus on human-centered research and community engagement, and their Myanmar Coastal Conservation Lab (MCCL), a youth-led conservation research and action group.

- Worldview International Foundation (WIF), an international non-government organization with expertise on mangrove restoration and blue carbon; WIF Myanmar has worked to advise mangrove plantation and conservation efforts in the Gulf.

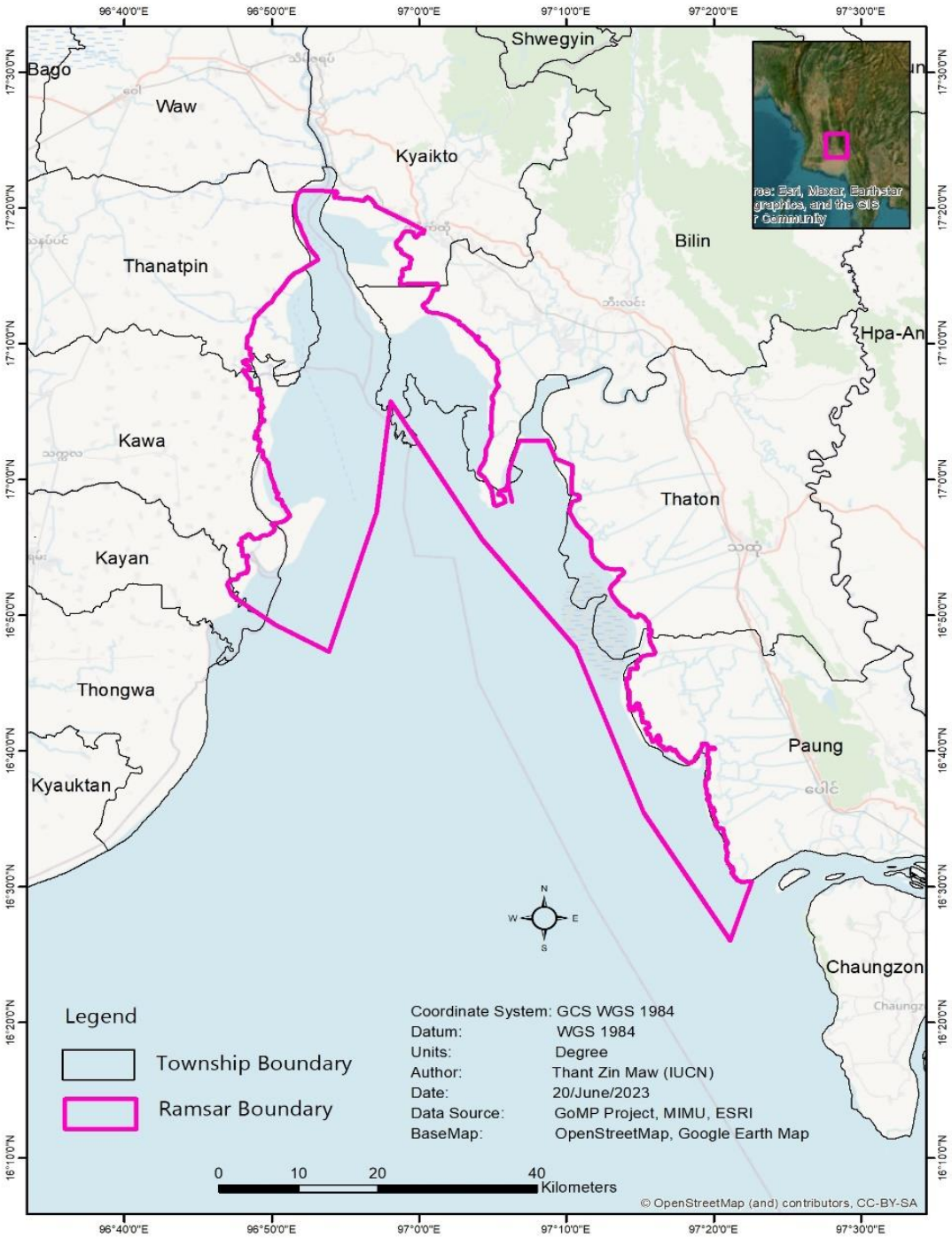

Figure 1. Map of the Gulf of Mottama Ramsar site boundaries and surrounding coastal townships

Box 1. Regional and Global Designations

The Gulf of Mottama is one of the most important sites for migratory waterbirds in mainland southeast Asia. It was designated as an East Asian-Australasian Flyway Network Site in 2014, highlighting its importance for migratory waterbirds in the East Asian-Australasian Flyway, one of the nine major migratory waterbird flyways globally. The site is one of six Flyway Network sites in Myanmar[a].

Following this, the site was designated as Myanmar's fourth Ramsar site on 5 May 2017. The Gulf of Mottama Ramsar site originally covered 42,500 hectares of the eastern side of the Gulf. Following two years of research and consultations with local stakeholders, the site was extended by the government in early 2020, quadrupling the total area to 161,030 ha, and extending it into the Bago and Yangon regions, making it the largest Ramsar site in Myanmar, and one of the largest coastal Ramsar sites in the Bay of Bengal[b]. The GoM meets six of the nine criteria for designation as a Ramsar site, namely:

- Criterion 1: Hosts representative, rare or unique natural or near-natural wetland types;
- Criterion 2: Supports rare species and ecological communities;
- Criterion 4: Supports plants or animal species during critical stages in their life cycles, or provides refuge during adverse conditions;
- Criterion 5: Regularly supports >20,000 waterbirds;
- Criterion 6: Regularly supports >1% of the individuals in a population of one species of waterbird;
- Criterion 8: Supports food, spawning grounds, nurseries or migration path for fish.

The dynamic mudflats and tidal cycle of the site is highly unusual in the region (Criterion 1), making it one of the most dynamic estuaries in the world. This feature also supports the site's high biological productivity, acting as habitat for fish, invertebrates, and tens of thousands of migratory shorebirds (Criterion 5). It supports rare species such as the critically endangered Spoon-billed Sandpiper (*Eurynorhynchus pygmeus*), and the endangered Great Knot (*Calidris tenuirostris*) and Indian Skimmer (*Rynchops albicollis*), among others (Criterion 2). The site also supports a number of migratory bird species during their life cycle, including the Spoon-billed Sandpiper, the Great Knot, the Indian Skimmer, and the endangered Nordmann's Greenshank (*Tringa guttifer*) (Criterion 4). The site regularly supports more than 1% of the individuals in a population for a variety of shorebird species (Criterion 6), including the Broad-billed Sandpiper (*Limicola falcinellus*), Black Tailed Godwit (*Limosa limosa*), Painted Stork (*Mycteria leucocephala*), and the Pacific Golden Plover (*Pluvialis fulva*), among others. The marine biodiversity of the site is also rich, with over 39 fish species documented in a 2014 survey, including Hilsa Shad (*Tenualosa ilisha*), Burmese mullet (*Sicamugil hamiltonii*) and Toli Shad (*Tenualosa toli*), among others (Criterion 8) [b].

[a]Gulf of Mottama Information Sheet. https://www.eaaflyway.net/wp-content/uploads/2019/08/SIS-EAAF117-Gulf-of-Mottama_v2017.pdf

[b]Ramsar Information Sheet: Myanmar: Gulf of Mottama. https://rsis.ramsar.org/RISapp/files/RISrep/MM2299RIS_2002_en.pdf

Hydrological and Climate Characteristics

The Gulf of Mottama is a uniquely dynamic body of water[2], fed by the Ayeyarwady, Yangon, Sittaung, and Salween Rivers. It is one of the largest perennially turbid zones in the world and encompasses the largest mudflat area in Southeast Asia (and one of the largest in the world). With its shallow topography (<30 m), as well as its funnel-like shape, the Gulf is characterized by extreme tides which remobilize sediments[3]. The Salween carries massive amounts of sediment to the Gulf at relatively high speeds due to the narrow and steep topography of its floodplain, which is bounded by a range of hills until the rivermouth[4]. For comparison, the Salween catchment's median slope is 16.4°, while the Ayeyarwady's is 7.1°[4]. This rapid speed of flow plus the remobilization of sediment by the tides explain why the Salween, usually for a river of its size and sediment load, has no delta. The tides drive a tidal bore in the Sittaung, and the strong tidal currents create a dynamic context of shifting patterns of erosion and land accretion, particularly near the mouth of the Sittaung.

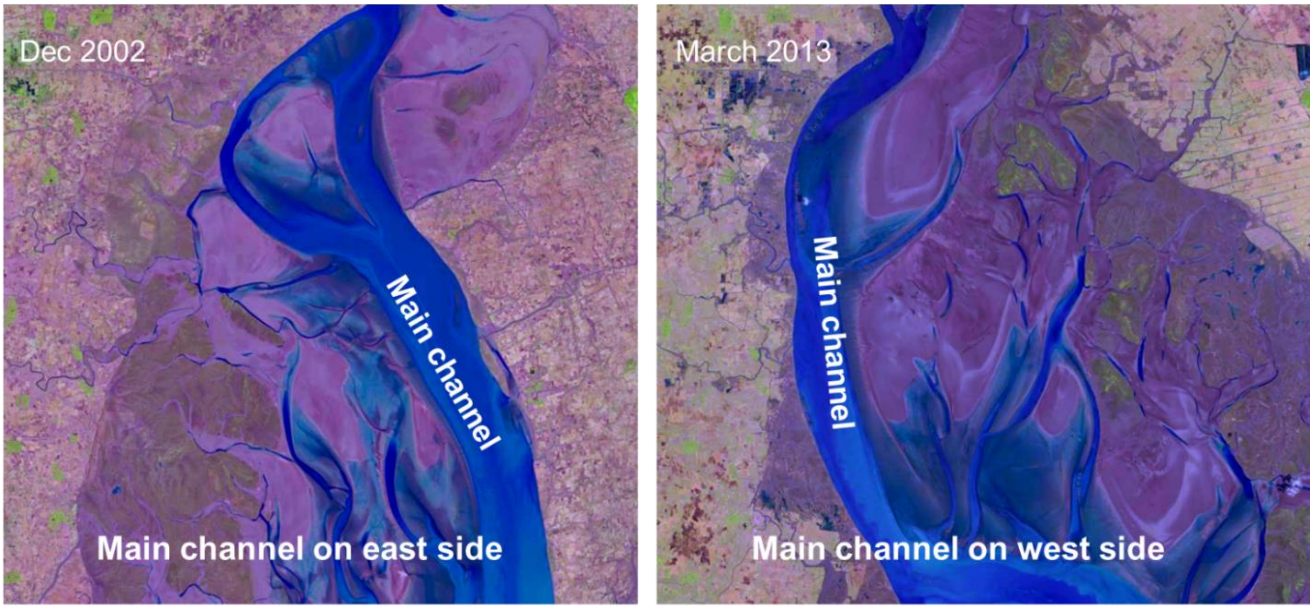

Figure 2. Satellite images of the Sittaung estuary from December 2002 (left), with the main channel on the Mon State side, and March 2013 (right), with the main channel on the Bago Region side. From Arcadis Report on erosion in the Gulf of Mottama, 2018.

This erosion appears to occur on a natural cycle, shifting between the Bago and Mon sides of the Sittaung every 10 to 15 years, with land accretion occurring on the opposite side[2] (Figure 2). The most recent, and current, leg of the cycle has eroded away shoreline on the Bago side, resulting in the loss of agricultural lands and even whole villages that needed to be rapidly relocated. Protective measures against this erosion are unlikely to be effective or even feasible, with adaptation via "managed retreat" being the recommended response[2]. Since 2016, about 20,000 hectares of land was lost due to erosion on the Bago side of the Sittaung river channel while 62,000 hectares of new land was formed on the Mon side[5]. Since 2022, the channel has since moved toward the Mon side[5].

The Ayeyarwady and Salween Rivers are likely globally significant sources of sediment and particulate organic carbon (POC) to the ocean (at an estimated 1.0-3.3 Mt C/year of POC), delivering influxes of sediment comparable to the Ganges-Brahmaputra[4]. The strong tides heavily influence the amounts of Suspended Sediment Concentrate (SSC), resuspending sediments and resulting in major fluctuations in SSC with the monthly spring tides[3,6]. A portion of the sediments from the Gulf are transported to the deep Andaman Sea, as well as to the Bay of Bengal during the north-east monsoon period[7]. It is probable that the Salween influences coastal processes in the Ayeyarwady Delta[4].

This important driver of productivity in the Gulf, and beyond, would be reduced by future damming or other impacts to the Ayeyarwady and Salween[4]. Theses rivers are largely free flowing[4,8], though impacts from infrastructure development (including bridges) and sand mining in the Ayeyarwady and Sittaung appear to have reduced sediment flow from those rivers[8]. Substantial reduction in sediment influx in the future, particularly along the Salween, would compound with climate change to reduce the resilience of the Gulf's coastal areas. Further impacts would include degradation or loss of habitat, including spawning grounds, for fisheries-important species.

The climate of the Gulf of Mottama is heavily influenced by monsoons, with the rainy season (May to September) bringing the risk of flooding while the dry season brings drought risk in terms of drinking water shortage. Community leaders and members have reported increasing severity of storms, flooding, drought, and saltwater intrusion (impacting agriculture and drinking water wells), as well as higher peak temperatures that impact livestock, agriculture, and human health[9–11]. Climate change is expected to exacerbate these impacts. Modeling of flood risk suggests that most of the villages in the Gulf face high to very high levels of flood risk, particularly in Paung, Chaungzon, and Kyaikto Townships, as well as part of Kawa Township[12]. *See Climate Change: Disaster Risk Management and Adaptation section.*

Ecosystems

The high inputs of riverine POC fuel the Gulf's coastal ecosystems, which are vital to local livelihoods as well as important for biodiversity. Though direct studies of net primary productivity (NPP) have not been conducted on the Gulf, it is reasonable to assume that elevated nutrient influx and remobilization of nutrients due to greater tidal amplitudes can drive increased primary productivity[13,14] (and, in general, primary production of wetlands is high relative to other ecosystem types)[14]. Such productivity forms an important foundation for resilient and thriving ecosystems, provided that external impacts that reduce or divert the productivity available to the ecosystem are reduced or removed[15,16].

The Gulf's ecosystems include rivers, coastal grasslands, tidal forests, mudflats, nearshore waters, and offshore waters, providing diverse ecosystem services for local communities (see Value of Ecosystem Services section). Inland in Mon State, there are also mountainous areas. The rivers of the Gulf are important

habitats for fisheries species, including spawning grounds for hilsa shad (*Tenualosa ilisha*) and Pama croaker (*Otolithoides pama*). In addition to the impacts of construction and sand mining mentioned above, pollution from mining, factories, and agriculture has also been reported as a problem for riverine and downstream habitats[10,17].

Not much is known about the Gulf's grasslands. They are also important habitats for shorebirds and waterbirds, as well as mud crabs which are important for lower income fishers. Local communities also use grasslands for livestock grazing, and see the presence of grassland species like *Oryza sativa* as an initial indicator that the land is suitable for agricultural use[5].

MacKay 2017 identified four ecological zones: (1) Bilin Mudflats, in northern Mon State and southern Bago Region; (2) Bago Shore High Erosion Zone; (3) Upper Gulf (Sut Pa Nu village) to the Bago Region, with freshwater for most of the year, and including critical habitat for spawning and juvenile nurseries for fisheries species; (4) Southern Zone (southern Thaton and Paung Townships), an estuarine system with mangroves in the creeks and some coastal areas and predominance of marine and estuarine fish[17].

Most of the research on nearshore waters has centered on fisheries as well as marine mammals (see sections below), with little direct research on offshore waters. Mudflats and tidal forests have been the most studied habitats.

Mudflats

The mudflats and the benthic communities within them are important for fisheries (including mud crabs), shorebirds and waterbirds, and coastal small cetaceans who consume benthic invertebrates. The Gulf's mudflats can be categorized based on inundation period: higher level, midlevel, and lower level[18]. A study in Bilin Township in 2011 identified 67 species of benthic macrofauna, with various small crabs being the most abundant[18]. Research in 2017-2018 also in Bilin reported only 12 species, as well as eight species in Thaton, 12 in Paung, and 19 in Chaungzon[19]. This difference could be due to sampling differences or to changes in the Bilin mudflat habitat over those years[19]. Over time, stable mudflats can undergo a process of succession into grasslands or tidal forest[5].

Tidal Forests

Tidal forest coverage is relatively sparse in the Gulf[6] (Figure 3) probably due to the strong currents and dynamic patterns of land erosion and accretion, i.e. relative lack of suitably stable habitat for mangrove forests to become established[20]. The historical extent of mangroves on the Bago and Yangon Regions coastlines is

also uncertain, with researchers and Department of Fisheries suggesting that coverage was always sparse, though anecdotal reports from long-time residents suggests the opposite[6]. Mangrove areas have been identified in Kawa Township, along the Bilin River, and Thaton, Paung, and Chaungzon Townships.

The mangrove forests provide locally important ecosystem services for neighboring villages, while also providing important nurseries for the fishers of the Gulf[10,21–23]. They are also important habitats for some waterbirds as well as the Red-breasted Parakeet (*Psittacula alexandri*) and Rose-ringed Parakeet (*Psittacula krameri*)[24].

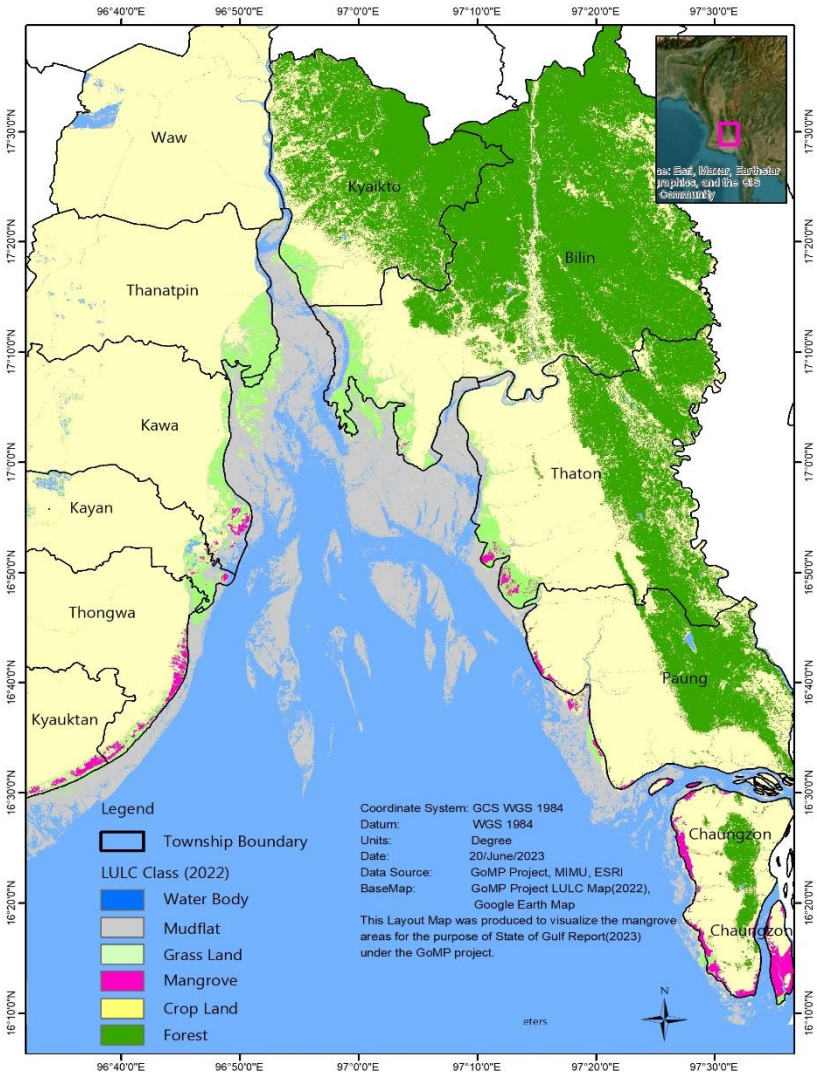

Figure 3. Mangrove coverage in the Gulf of Mottama, in dark pink.

The Gulf's tidal forests have low diversity, with *Avicennia officinalis* as the dominant species and *Sonneratia apetala* as another local mangrove species[25]. Other tidal forest species documented in Paung Township include: *Acanthus ilicifolius*, *Dalbergia candenatensis*, *Dalbergia spinosa*, *Derris trifoliata*, *Ipomaea pes-caprae*, and *Sesuvium portulacastrum*[26]. In Kawa Township, 15 species of plants were identified in tidal forest habitat, including *A. officinalis*[23] as the only mangrove species.

Local communities benefit from ecosystem services provided by these forests, including nursery grounds for fisheries, habitat for mud crabs, temperature and wind modulation, and harvestable goods (wood, honey, medicinal plants, fruits as fishing bait) (see Value of Ecosystem Services). The primary threat to these mangrove areas is conversion to rice fields[5,27]. Efforts to maintain and expand tidal forests focus on mangrove plantations and Community Forest designation, including near Kar Tae village as of 2020 (*see Priority Management Issues*).

Land Cover Change: Mudflats, Mangroves, and Grasslands

The dynamic nature of the Gulf leads to the formation of new land. There is a natural succession process in some parts of the Gulf, e.g. Crab Island in Thaton[28], where mudflats become vegetated and transformed into grasslands or tidal forests[5]; from 2016 to 2022, a considerable extent (8,414 hectares) of mudflats was converted into grasslands[5] (Figure 4). In Kyaikto Township, mudflats and grasslands are set aside until the salinity of the sediment is low enough to allow for agriculture[29]. This includes 2,916 hectares of mudflats that have been converted into agricultural land from 2016-2022[5]. Ar the same time, 37% (13,243 hectares) of grasslands were converted to agricultural land[5]. The main cause of mangrove loss is conversion to agricultural land; from 2016 to 2022, this affected 18% (1,486 hectares) of the 2016 mangrove area. However, 1,633 hectares of grasslands were converted into mangroves in the same time[5]. The conversion of mangroves to agricultural land will likely continue or even intensify in the future[5,27].

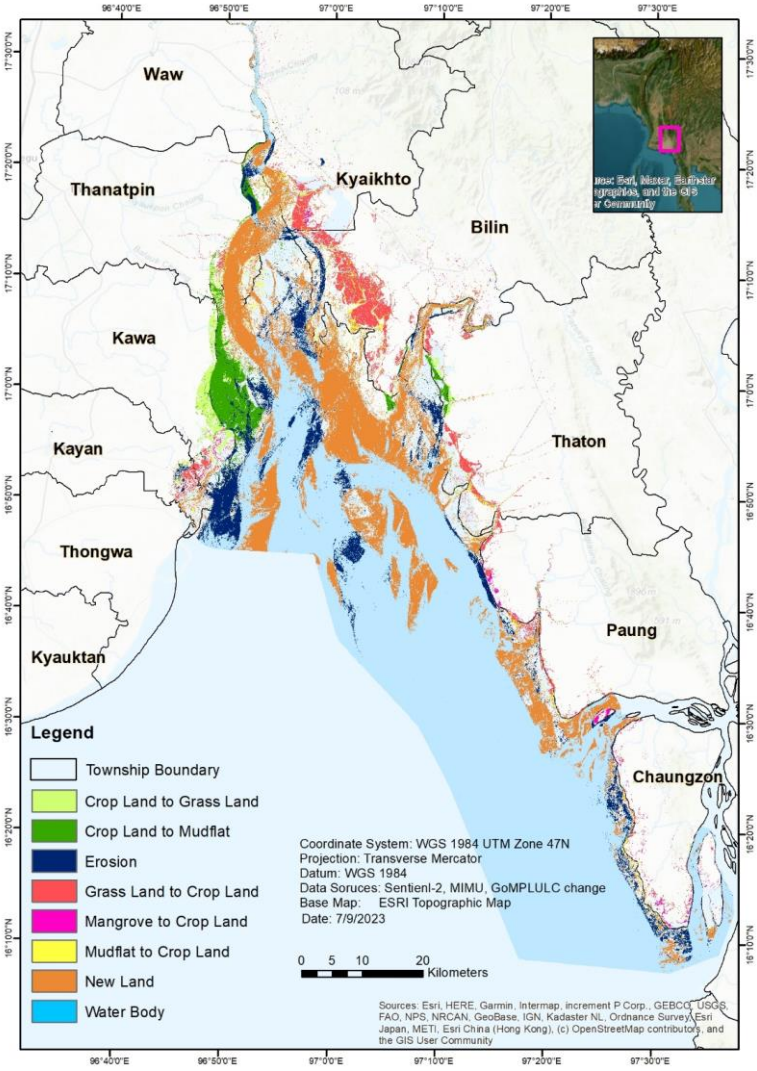

Figure 4. Land cover change from 2016 to 2022.

Fauna

Fisheries Species

See also Livelihoods and Fisheries Management for more information on the fisheries sector

The Gulf offers productive spawning and nursery grounds for fisheries species – finfish, crabs, and shrimps – including estuarine areas, river habitat, and patchy mangrove forests[17]. Target fisheries species vary across the Gulf, and over 30 fish species were identified in an initial survey of local fisheries[17,30]. Overall, though, the most commercially important species include Hilsa shad (*Tenualosa ilisha*), Pama croaker (*Otolithoides*

pama), Mango fish/Paradise threadfin (*Polynemus paradiseus*) – all anadromous – as well as Flathead silago (*Sillaginopsis panijus*) and Mud crab (*Scylla olivacea*)[17,30].

Other major fisheries species include Flathead grey mullet (*Mugil cephalus*), Freshwater mullet (*Rhinomugil corsula*), Dwarf catfish (*Mystus vittatus*), Sea bass (*Lates uwisara*), Wallago (*Wallago attu*), Toli shad (*Tenualosa toli),* Croaker (*Johnius belangerii),* and Bombay Duck (*Harpadon nehereus)* [30–37]. Local wild aquaculture ponds, in rice fields, host at least 15 species, primarily blackfish (*Channa* snakeheads, *Clarius* catfish, *Anabas* climbing perch) [38]. An invasive species, the Suckermouth catfish, has been observed and reported by rice-fish and wild fish farmers in Bago[39]. It has a fast growth rate and is not consumed, and there is a risk of injury to the farmer from the fish's spines. It was previously an aquarium fish released into rivers as part of Buddhist religious customs.

Fishers have reported a general decline in catch since the early 2000s to the late 2010s, at which point a remarkable increase in catch in Pama croaker, Hilsa shad, and Mango fish was observed at various sites in the Gulf[30]. This has been largely attributed to enforcement against illegal fishing with *than-za-gar pike* fine-mesh (6mm) stake nets, which stretch up to 4-km long and use the extreme tidal range to catch small and juvenile fish impacting the recruitment of river hilsa, Indian threadfin, catfishes, Toli hilsa, Pama croaker, mullet, and seabass. These nets also block access to fishing areas by small-scale fishers[17,40] (Figure 5). Illegal fishing is considered the major threat to local fisheries[17,30]; other reported forms of illegal fishing include poison fishing and electrofishing[37,41].

Figure 5. Than-za-gar pike: Illegal, fine-mesh stake nets. Photo credit: BANCA. From MacKay & Soe Min Oo, 2017.

Additional threats include increased fishing effort, pollution from factories, and possibly runoff of agricultural chemicals, and possible impacts from sand mining and potential upstream infrastructure projects, which alter

the hydrology of the rivers and thus potentially affect important spawning and nursery grounds[30,41]. With mud crabs, concerns include: the common practice of harvesting crabs below the legal size of 100 g[32,42]; increase in fishing effort[42]; and ,given the dynamic nature of erosion and accretion that affects mud crab habitat, the catch is dynamic as well[42].

Significant declines in catch had been reported from 15-20 years ago until the late 2010s, where it seems that regular patrolling against *than-za-gar pike* stake nets resulted in large increases in the catch of Pama croaker, among increases observed in catch of Hilsa shad and Mango fish[30]. This recovery reflects that the Gulf's ecosystems are healthy and that if the most destructive fishing practices are eliminated or substantially reduced, fish stocks will recover rapidly. Though impacts of the COVID19 pandemic and political change have affected fisheries, data collected through 2022 from Mawlamyine Holdings Ltd (MHL). in Mon State indicate steady landings since 2019, while findings are more variable from the three villages where catch data has been regularly collected between 2020-2022[43,44]. *See Fisheries Management section for more on fisheries trends.*

Migratory Shorebirds & Waterbirds

The Gulf's extensive mudflats are an important habitat for local and migratory waterbirds and shorebirds, including the Critically Endangered Spoon-billed Sandpiper (*Calidris pygmae*) for whom the Gulf is the most significant wintering grounds (Figure 6), as well as the Great Knot (*Calidris tenuirostris*; Endangered) and

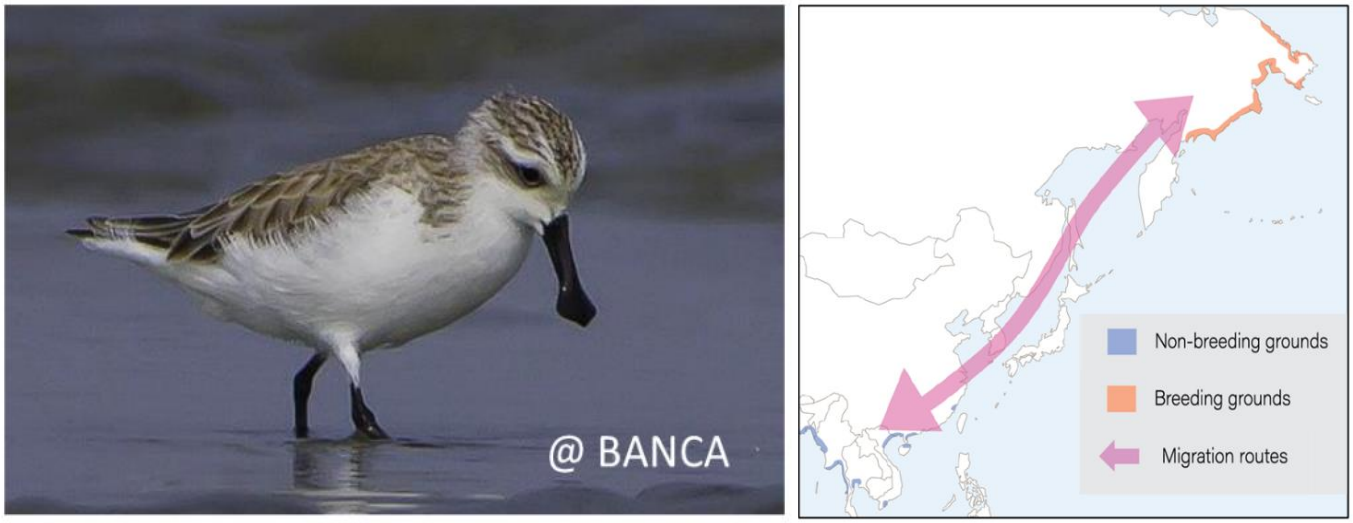

Figure 6. Critically Endangered Spoon-Billed Sandpiper (photo by BANCA) and migratory range from breeding grounds northeastern Russia down to wintering grounds in South & Southeast Asia, with the Yellow Sea as an important stopover site. Map from EAAFP Spoon-billed Sandpiper Task Force & EAAFP Secretariat.

Nordmann's Greenshank (*Tringa guttifer*; Endangered)[45,46]. It is part of the East Asian-Australasian Flyway Network, one of 9 major migratory waterbird flyways in the world; 195,000 ha of the Gulf has been designated

as an East Asian-Australasian Flyway Partnership (EAAFP) Flyway Network Site[47] (*See Box 1, Box 2)*. In the most recent (January 2023) surveys, 53 waterbird species were recorded, with the estimated number of small wader sindividuals being 55,000-85,000[45]. Across all surveys, over 70 waterbird species have been recorded in the Gulf[47], with 2008-2012 surveys estimating a total of 120,000-150,000 waterbirds[46].

Variations in survey effort by year make it challenging to entirely attribute trends in counts to abundance of animals; however, researchers say their results over the years indicate a decline in the Spoon-billed Sandpiper population[45]. Other species also appear to have declined, e.g. Lesser Sand Plovers (*Charadrius mongolus*), while others have increased, e.g. Kentish Plover (*Charadrius alexandrinus*), Pallas' Gull (*Ichthyaetus ichthyaetus*), Broad-billed Sandpiper (*Calidris falcinellus*), Common Redshank (*Tringa totanus*), Bar-tailed Godwit (*Limosa lapponica*), Asiatic Dowitcher (*Limnodromus semipalmatus*), and Eurasian Curlew (*Numenius arquata*)[45]. The primary threat to shorebirds and waterbirds in the Gulf is illegal hunting[24,48], which had been observed as occurring in nets as well as by poison (e.g., poisoning ducks in rice fields)[49]. *See Priority Management Issues for more on the recent resurgence of this hunting*

Marine & Aquatic Megafauna

The coastal waters of the Gulf are home to three species of small cetaceans: the Irrawaddy dolphin (*Orcaella brevirostris*; Endangered), Indo-Pacific finless porpoise (*Neophocaena phocaenoides*; Vulnerable), and Indo-Pacific humpback dolphin (*Sousa chinensis*; Vulnerable), though the latter is relatively rarely observed[50]. These have been observed in the waters off of Chaungzon and Paung Townships in Mon State (Figure 7); interviews with community members indicate likely presence in Thaton Township as well as at the mouth of the Sittaung River[50,51]. The Gulf appears to be a potential hotspot for finless porpoises, a relatively little-studied species. The primary threat identified is bycatch in small-scale fisheries, including in set bag nets, drift gillnets, gillnets, and trammel nets; there is local consumption of bycaught animals [50,51]. (*See Marine Mammal Bycatch & Consumption section).*

No population abundance estimates have been calculated for the Irrawaddy dolphins, Indo-Pacific finless porpoises, or Indo-Pacific humpback dolphins in the Gulf, but data for this have been collected from boat-based transect surveys and photo-identification by Myanmar Coastal Conservation Lab (MCCL). MCCL will

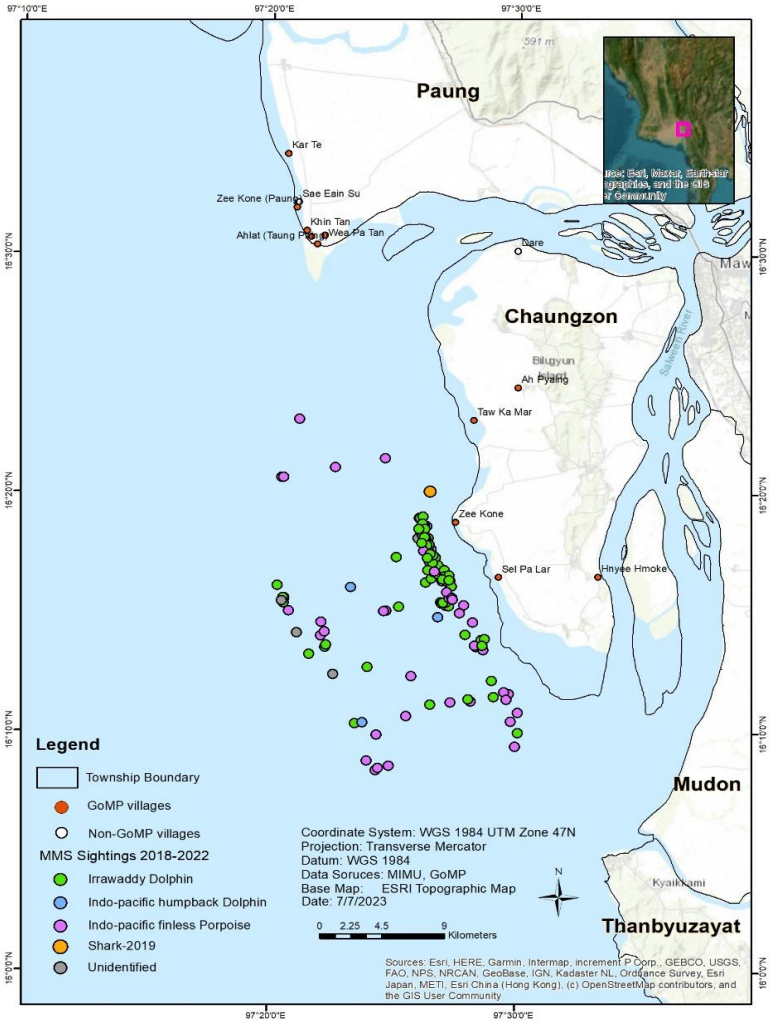

Figure 7. Sightings of 3 marine mammal species (plus one shark sighting) from boat-based surveys conducted by Myanmar Coastal Conservation Lab, 2018-2022. Survey efforts have been limited to waters off Chaungzon Township.

also start piloting acoustic surveys for finless porpoises in 2023[50,51]. Local Ecological Knowledge (LEK) surveys indicate that the number of marine mammals has decreased in the Gulf and that there have been shifts in their range (possibly due to dynamic changes in mudflat accretion and erosion along the coast)[50,51]. These data are also being analyzed to identify locations of marine mammal strandings observed by coastal communities.

LEK surveys on the marine mammals also yielded information on other marine megafauna in the area, including marine turtles and elasmobranchs (sharks and rays). Marine turtle strandings have been reported anecdotally to research teams, including a turtle found stranded and then tagged by the Bago Department of Fisheries (Figure 8) – this appears to be an Olive Ridley (*Lepidochelys olivacea*) sea turtle, though it was locally identified as *pyin that lake* which is the local name for Green Turtle (*Chelonia mydas*)[52] (both species have been documented in Mon State[53]). There are reports of leatherback turtles (*Dermochelys coriacea*) from decades ago, but no recent evidence of their presence in the Gulf[6].

Spadenose sharks have been documented in local fisheries[31,40,54,55]. A robust-bodied *Carcharhinus* was observed landed in Chaungzon in 2018 (Figure 9)[52]; the photo looks similar to a pigeye (Java) shark *(Carcharhinus amboinensis*) or bull shark (*Carcharhinus leucas*). Villagers reported catching 4 of that same species within the previous fishing season, and that the fins are sold (though apparently for a disappointing price)[52].

Box 2. From the Yellow Sea to the Gulf of Mottama: the need for Flyway-level coordinated conservation for migratory birds

Conservation of migratory waterbirds, whose migrations span multiple nations, requires coordinated efforts across their ranges; efforts at individual sites, such as the Gulf of Mottama, are critically important but not sufficient on their own. In addition to the Gulf, the Yellow Sea is a vitally important site for waterbird conservation in the East Asian-Australasian Flyway (EAAF). Bordered by the People's Republic of China (PRC), the Democratic People's Republic of Korea (DPRK) and the Republic of Korea (ROK), the Yellow Sea's intertidal wetlands are the most important staging area for migratory water birds in the EAAF, acting as a "bottleneck" i.e. a migration stopover on which millions of waterbirds depend. This includes Spoon-Billed Sandpipers, a portion of which fly to the Gulf for winter.

Governments in the Yellow Sea have taken measures to protect tidal flats and coastlines, including the ordering of halts to new coastal land claims (PRC, ROL) and increases in protected wetland area (DPRK, ROK). Two properties along the Yellow Sea have been inscribed by the World Heritage Committee on the World Heritage List: Migratory Bird Sanctuaries along the Coast of Yellow Sea-Bohai Gulf of China (Phase I) in PRC, and the Getbol, Korean Tidal Flats in ROK. Community support for wise use of wetlands appears to have increased over the last decade, with a substantial rise in the number of volunteer groups and NGOs helping to monitor waterbird migrations, and increased media coverage and related special events.

Though satellite analyses suggest that the rate of loss of tidal wetlands in the Yellow Sea has slowed since 2013[a], it still continues. The estimated area of land claims developed along the Yellow Sea coastline in the last 40 years is ~10,000km^2, exceeding the most recent estimate of the area of remaining tidal flats in the region (6,668 km^2). International population monitoring of threatened or near-threatened migratory waterbirds that depend on the Yellow Sea wetlands indicates that population declines continue in 81% of monitored species. Declines of migratory shorebirds have been quantitatively linked to reliance on Yellow Sea habitats, suggesting that global-scale declines in migratory birds are being driven by widespread degradation and loss of habitats in the Yellow Sea migratory bottleneck.

This has implications for biodiversity beyond Yellow Sea's wetlands, and demonstrates the need for coordinated conservation efforts across the countries of the EAAF. The East Asian-Australasian Flyway Partnership (EAAFP) was launched in 2006 to organize such regional-level coordination to protect migratory waterbirds, their habitats, and the livelihoods of people dependent upon those habitats. There are currently 39 Partners including 18 national governments (including Myanmar), 6 intergovernmental agencies, 13 international non-governmental organizations (NGOs), 1 international organization and 1 international private enterprise. EAAFP Partners work together to develop the Flyway Site Network (which includes the Gulf as a site) to ensure that internationally important wetlands are sustainably managed through site-level and regional efforts.

[a]IUCN (2023). The 2023 IUCN Situation analysis on ecosystems of the Yellow Sea with particular reference to intertidal and associated coastal habitats. Bangkok, Thailand: IUCN.

Some community leaders reported that it was more common to sharks (unspecified species) 15 years ago, especially in the Sittaung (previous anecdotal evidence suggested they came up to where the Sittaung Bridge is now[17]), with a minimum of 70-80 sharks landed per year, but they are not seen now[10]. Rays documented in fisheries include Dwarf whipray (*Himantura walga*) and Leopard whipray (*H. undulata*)[31] as well as Freshwater whipray (*H. marginata*)[56] and Bengal whipray (*Brevitrygon imbricata*, formerly *Dasyatis ibricatus*)[57].

Large whale strandings have also been observed periodically; in fact, the type specimen for Bryde's whale (*Balaenoptera edeni brydei*) was collected from a the Sittaung River in 1878[58]. However, apart from the three small cetaceans mentioned above, no surveys have been conducted in the field on any other marine megafauna species.

Figure 9. Olive Ridley sea turtle found stranded and tagged & released in Bago. Photo from GoMP.

Figure 8. Carcharhinus sp. landed in Chaungzone Township. Photo by Wint Hte.

Social Context

Based on census data from 2019, the eight townships of Kawa, Thanatpin, Waw, Kyaikto, Bilin, Thaton, Paung, and Chaungzon have a total population of approximately 1.6 million inhabitants[59]. This includes the 86 coastal villages (defined as being within 5 km of the coast) in these townships[47]. In Mon State, Bamar and Mon are the predominant ethnic groups, with Bago being primarily Bamar; other ethnic groups in the area include Rakhine, Karen, and Tamil people[11,47].

Many of the Gulf's rural communities are relatively remote, with limited access to electricity, road transport, education, and health services[60]. In a study of Thanatpin Township, the most commonly reported needs included better access to loans, health services, drinking water, sanitation, as well as improved livelihood security and means of mitigating negative impacts from extreme weather[61].

Electricity access is particularly limited in Bago Region. The main sources of power for lighting, for example, are batteries and kerosene in Kawa and Thanatpin, and private generators, candles, and kerosene for Waw; in contrast, electricity is one of the main sources of power for lighting in Kyaikto, Bilin, Thaton, and Paung (though not Chaungzon)[59]. Firewood is the main source of cooking fuel for these eight townships, though electricity is also used in 12 to 25% of households in the Mon townships except for Chaungzon[59]. In these townships, between 13 and 26% of households had no latrine. The main source of drinking water for the Bago townships are drinking water ponds (for at least 94% of households), while protected wells or springs are the main water source for the Mon townships (38 to 66% of households) (Figure 10)[59]. Drinking water supplies are threatened by saltwater intrusion and seasonal flooding, necessitating serious investment in solutions for adequate and sustained drinking water supplies.

Figure 10. Drinking water pond, Koe Te Su village. Photo by T.S. Whitty.

Efforts to build water, sanitation, and hygiene (WASH) infrastructure and practices in the Gulf area include work by the GoMP to support villages in building drinking water ponds and developing water usage master plans, along with trainings for maintenance of water quality and hygiene. Habitat for Humanity also undertook WASH support work in two villages in Thanatpin in 2022, providing supplies, awareness-raising materials, trainings, and toilet installations.

The villages in the Gulf of Mottama have a high degree of dependence on local ecosystem services, as well as a high rate of poverty[55]. Unemployment in the Mon State townships is between 10 to 15% of the total labor

force, and just under 5% for the Bago Region townships[62]. The main livelihoods are fishing, farming, livestock rearing, and casual wage labor, with remittances from migrant workers being important for local incomes[55,61,62].

Throughout Myanmar, migration (seasonal, temporary, or permanent) is a common response to seek livelihoods, both within Myanmar as well as internationally (primarily to Thailand)[63]. Mon State is a major destination for internal migrants, with most of its internal migrants moving around *within* the state, as well as a major source of international migration, with over 25% of the labor force migrating abroad for work[63,64]. This migration has implications both for the migrant as well as the family and community left behind[63] – e.g., this has led to the increase in women-headed households and decrease in youths in some communities, and Mon State missing a large portion of it labor force between ages 20-55 years[64]. Remittances from workers abroad constitute the second largest source of income in Mon State, behind agriculture[64].

The Village Administrators are the village heads and link to the General Administration Department (GAD). Within villages, there are leaders representing groups of 10 and 100 households, as well as informal social groups (e.g., traditional culture groups, elder groups, community service groups). Coordination of village development activities is often led by these social groups. The GoMP supported villages in establishing Village Development Committees (VDCs) as the coordinating bodies for livelihood and co-management-related activities[47]. These VDCs include a Fishery Group, Farmer Group, and Income Generating Activities (IGA) Group to represent the respective priorities and needs of different livelihood profiles; 13 villages also have their own Local Conservation Groups (LCGs), guided by the Biodiversity and Nature Conservation Association (BANCA). *See Governance Institutions section.*

The Gulf's communities have been hard-hit by the COVID19 pandemic and the political change, including impacts to market chains and costs of inputs for livelihoods, as well as food security[65]. Marginalized groups, small-scale fishers, mud crab fishers, post-harvest workers, labor on boats, rice-fish farmers, and women small-scale sellers in local markets were particularly affected[65]. Climate change impacts will likely continue to increase, including extreme weather events, flooding, drought, saltwater intrusion, and higher temperatures, with significant negative repercussions for infrastructure, livelihoods, livestock, agriculture, and human health[9–11]. For example, flooding was reported as damaging agricultural fields, home gardens, wild fish ponds, road and other infrastructure (including some damage from strong winds), and drinking water ponds in Thanatpin in a recent study[61]. *See Climate Change: Disaster Risk Management and Adaptation section.*

Livelihoods

The primary livelihoods in the communities in the Gulf are farming and fishing (Figure 11), both affected strongly by seasonality, while other livelihood activities include labor, small shops, and seasonal work elsewhere, including remittances from migrant workers abroad (a major source of livelihood in Mon State in

particular). A lack of skilled or properly trained employees is often cited as a major limitation by various sectors in Myanmar[62]. The main livelihood diversification opportunities beyond agriculture and fisheries appear to be: industrial sewing for Bago Region (where industrial operations are more prevalent than in Mon State, where they are scarce); rural mechanics for repairing agricultural and fishing machinery; repair mechanics for motorbikes, electrical appliances, and mobile phones; construction, including welding and electrical wiring; and rural barbers[62].

There have been various vocational training programs, including those by the government (e.g. through the Department of Labor, Department of Social Welfare, Department of Rural Development, and the Electrical Inspection Department), as well as INGOs (e.g., FXB and Swiss Contact, though Swiss Contact did not operate in coastal areas), as well as private operations[62]. Efforts by the GoMP to promote strengthened and more resilient livelihoods have included: technical trainings for specific farming, fishing, and aquaculture practices; subsidizing inputs for these practices; trainings to build skills in other livelihoods (sewing, motorbike repair, small-and-medium-scale enterprises).

Another effort to diversity livelihoods is the revolving funds, established with the support of GoMP and managed by the IGA groups in the VDCs. These funds are particularly helpful as they offer lower interest rates than other available forms of credit, and as debt is a widespread issue in these communities. With GoMP support, the VDCs have also implemented a cash for work (C4W) program through which villagers in the lowest-income villages can be compensated financially for their participation in project activities[66].

There have been more difficulties encountered in paying back loans to the revolving fund; what used to take six months to pay off now takes 8-10 months[66]. Debt has increased, and the presence of multiple microfinance companies in communities means that people are able to take out multiple loans from different companies – but

Figure 11. The two major livelihood activities in the Gulf are farming and fishing. Top: Fisher with boat while women sort the catch (photo by T.S.Whitty). Bottom: Rice farmers at work (photo from GoMP)

then get trapped in a cycle of loans and debts[66]. Costs for inputs have skyrocketed for fishing, agriculture, and pretty much any livelihood venture, driving switches to other livelihoods and out-migration[66].

Gender Roles

The rural communities of the Gulf follow traditional gender roles where men are seen as the default leaders and women are responsible for maintaining the household[29,60,67]. Generally, men are the primary income earners, responsible for fishing and farming; other livelihood activities for men in lower socioeconomic positions include crab harvesting and daily labor[11,60,68]. Women tend to manage the household incomes and are the primary household members tending to children and household chores, but also are responsible for seafood product processing and selling, feeding and care in animal husbandry and aquaculture ponds, and various agricultural tasks (manual transplanting, weeding, harvesting, and storing grains), as well as working as shopkeepers and labor on farms[11,60,68,69]. Increased migration, both internal and international, has been fueled by the political situation; while international migration was previously dominated by men, recent research indicates that 44.6% of migrants working abroad are women[63,70].

Women appear to lead or collaborate with their husbands in decision-making on procurement of household goods, and men do also appear to share responsibilities for health and education in the household[60]. Though women have traditionally been discouraged from opportunities to build their skills and participation in activities outside of the household, their involvement in community activities and decision-making has increased during GoMP's engagement with communities[71,72].

Fisheries & Aquaculture

Fisheries in the Gulf include small-scale fisheries, where fishers fish relatively close to their village, and medium-scale fisheries, in which boats may traverse the Gulf (including from the Sittaung area to waters off of Mawlamyine)[30]. There are also fisheries for which boats are not used, including the mud crab fishery, which is particularly important for landless and women harvesters[30,42]. There are coastal and offshore fisheries, as well as inland fishing, with inland fishing area types including main channels of rivers, seasonally formed riverine lakes, estuaries, flooded paddy fields and low-lying areas, lakes and tanks, and irrigation canals[17,69]. Gear types are diverse, including bag nets and stow nets, gillnets (drift and set), trammel nets, traps, throw nets, beach seines, crab hooks and crab traps, and a unique small hook-and-line system for Dwarf catfish[30,37].

While the fishing itself is primarily carried out by men, women play important roles in the processing of fish products. These include dried and salted fish, as well as fish paste. Products are sold in local markets, transported to markets in urban areas (Mawlamyine, Bago City, Yangon, Mandalay), exported from larger cities, used as animal feed, or consumed locally. Value chain support from GoMP to improve the value of products has included providing or loaning ice boxes for storing fresh catch and value-added processing for

fisheries products[73]. Further loss reduction strategies are still needed to address value loss from spoiling and transport-related damage[73].

Fish buyers (often women, and often local to the community) play an important role in the sector, not only as a link in the market chain, but also as a source of credit as well as social support[17,29,73]. Debt is highly prevalent among fishing households, with loans taken out for gear, fuel, and boat costs; often, these loans are provided by fish buyers, to whom the fisher then guarantees the (generally lower than market price) sale of their catch[17,29,69]. There is an opportunity for local small- and medium-scale enterprise (SME) development for the provision of fishery inputs, e.g. gear, ice, and other needed materials; at the moment, fishers must go to urban center to purchase these supplies[74].

After a long period of decline, 2019 saw the start of an increase in fish catch that was particularly pronounced in 2020[30]. This correlates with regular patrolling activity against illegal *than-za-gar pike* fishing, with huge increases in Pama croaker catch as well as hilsa and Mango fish[30] (see Fisheries Management Issues for more). Correspondingly, the average income per fisher in Sut Pa Nu village (one of the focal villages for fisheries research) increased from 800 USD in 2017 to 2,200 USD in 2020[30].

However, the COVID19 pandemic had significant impacts on the fisheries and aquaculture sectors, disrupting access to export markets, inputs, and transportation, affecting not only fishers and rice-fish farmers but those involved in post-harvest steps in the market chain[65]. Major impacts include reduced food security due to food shortages and loss of income, as well as increased illegal fishing due to reduced patrolling[65].

Due to the decrease in law enforcement capacity as a result of the political change and COVID19 pandemic, illegal fishing is increasing[75]. At the same time, due to significant increases in the price of fuel and other inputs, as well as disruptions to the market, there is a reduction in the number of active fishing vessels[43,66,75]. For example, in Aung Kan Thar, there were about 100 active boats prior to the pandemic, and now there are only 30-40; similarly, Baing Laung went from 70 to 30-40[75]. Boat owners instead work as labor on other vessels or as wage/daily labor in Mon and Bago, with middle-aged individuals who have some financial means migrating out of country[75].

There is both wild and stocked rice-fish aquaculture as well as constructed pond aquaculture in the Gulf area[58–60]. Most people practicing aquaculture are land-owning farmers[75]. The wild fish aquaculture system relies on the natural monsoon cycle's flooding season, during which indigenous fish species move into small farm ponds, and is a relatively profitable system that contributes to local food security[38]. As practiced in the Gulf, it is unique in that brood stock – about 10-25% of each year's catch – is saved and retained in the ponds to supply the following year's stock[38]. This type of aquaculture appears to be widespread in the area, practiced by hundreds of farmers in the Gulf's villages[38].

Mud crab aquaculture is relatively new, having been piloted in Aung Kan Thar and Kar Te with just a small number of people[75]. In Kar Te, this is taking place in their Community Forest mangrove area as a mangrove-friendly approach, whereas in Aung Kan Thar, it is not integrated into the mangrove area[75].

At the township level, Fisher Development Associations (FDAs) are a platform developed with support from GoMP where representatives from village Fishery Groups can collaborate with each other and represent local fisher interests to government departments[47]. *See Governance Institutions for more on FDAs.*

Agriculture

Local agriculture is primarily wet-season rice farming, while dry-season pulses (and rice with irrigation) are the next most important crop[76]. Village agriculture in Mon State is generally low input, low output, producing primarily local rice varieties (*paw san*) for self-consumption and the domestic market, with organic practices as the default. In Bago, medium- and long-grain rice is produced for domestic and export markets, and green gram is primarily produced as a cash crop. There had been an increase in the use of chemicals for agriculture, but this was reduced after 2020 due to the increased cost of inputs.

Flooding and saltwater intrusion are major causes of crop losses[77]. Other challenges include limited information, cooperation, technical training, and access to infrastructure, markets, and quality inputs[6]. With the Farmers Groups and Department of Agriculture, GoMP's areas of work include the support of coordination in the sector, training on improved planting practices, improved quality of inputs, and testing of more climate change-resilient crops (climate smart rice). This includes the creation of Coastal Farmer Development Associations (CFDAs), township-level platforms where representatives from village Famer's groups can collaborate. *See Governance Institutions for more on CFDAs.*

Through these efforts, farmers can implement practices that are more adaptive to climate change as well as pests; e.g., there are climate-smart rice plantations now using more resilient rice varieties and resource-efficient practices, with reference to the Sustainable Rice Platform (SRP) Standard which also helps to conserve biodiversity.[78]. Access to certified seeds (rice and green gram) to improve yield has improved due to GoMP and CFDA work to create a seed bank of quality seeds that they produce and then sell (or loan) to farmers, thus raising funds for the CFDA[78]. Yields have improved since the inception of GoMP, and the CFDA has established one of the first publicly-owned seed cleaning machines in Mon State to improve access to quality seeds[78].

The COVID19 pandemic impacted the rice planting cycle for the 2020 season, resulting in a reduction of food availability of rice and pulses[65]. Though the COVID19 pandemic did not have a substantial impact on agricultural input prices, these more than doubled following the political change[78]. The pandemic, similarly, did not seem to significantly impact the selling prices for agricultural outputs, and they are now a bit higher (e.g., a variety of rice that would have been 15 lakh MMK for 100 baskets is now 20-22 lakh for the same amount)[78]. However, this does not cover the drastic increase in input costs, and profitability in the agricultural

sector is now very low[78]. The government has tried to subsidize the purchase of urea and other fertilizers, but this has not been adequate, so farmers are now relying more on locally-produced organic fertilizers (produced by CFDAs)[78]. This might be a positive step for the environment, but it does lead to decreased yields[78].

Because most farmers are landowners, and farming is a traditional livelihood passed down through generations for them, there has not been a notable shift to other livelihoods (though the younger generation might be more likely to seek work abroad)[78]. Rather, they are adapting their inputs to try to reduce costs.

Value of Ecosystem Services

The high dependence of communities on local fisheries and farmland indicates the importance of the Gulf's ecosystem services. An ecosystem valuation study in 8 villages in Mon State estimated that the average household receives provisioning and regulating services worth 9.52 million MMK (4,542 USD) per year, though this is in reality variable across villages[21] (*see Box 3)*. These services include fisheries species, plants (consumable herbs, seaweeds), wood for fuel, storm surge protection, wave attenuation, protection from erosion, and potential for tourism and access to transportation[21] (Table 1). Other studies have also collected reports of mangrove-related ecosystem services in the form of medicinal plants, honey, and bait (mangrove fruits) for fishing[10,79].

Ecosystems	Provisioning services	Regulating services	Cultural services
Mangroves	• Vegetables (herbs) • Seaweeds (Catenella sp. on the tree trucks of mangrove) • Mud crabs • Molluscs (clams, snails) • Fish (small fish such as mullets) • Firewood (dry branches of mangrove)	• Storm surge • Wave attenuation • Protect from erosion	• Tourism
Mudflats	• Mud crabs • Molluscs (clams, snails) • Fish (fishing of mullets, Pama croaker, striped dwarf catfish, etc. during high tide) • Shrimps and prawns	• Wave attenuation	• Bird watching
Coastal grassland	• Mud crabs • Molluscs (clams, snails) • Fish (fishing of mullets, Pama croaker, striped dwarf catfish, etc. during high tide) • Shrimps and prawns	• Wave attenuation	
Rivers/ Sea	• Fish (variety of economically important species including hilsa shad, Pama croaker, paradise threadfin, Bombay duck etc.) • Shrimps and prawns • Firewood (drifted from elsewhere)		• Transportation, Navigation

Table 1. Ecosystem services of the Gulf of Mottama's coastal ecosystems, reported in Focus Group Discussions in 8 Mon State villages for ecosystem valuation study. Table 3.1 from Wint Hte et al. 2021.

The value of ecosystem services was found to generally exceed the returns on land converted to agriculture[21]. Subsistence provision from the Gulf's rivers and sea (e.g. for household consumption) was calculated at an average of 10.8 million MMK (1,200 USD) per year per household[21]. Another study found that interviewed households in Mon State saw wetland habitat as an important resource, e.g. "The wetlands are like a food bank" and "The wetland is like our second mother," providing food for fishers who don't have boats (via crab harvesting and other gleaning activities), supplementing the food and income for those who do own boats, and providing fertile silt for agriculture[11].

TOWARD AN ECOSYSTEM APPROACH TO MANAGEMENT

From 2015 until 2021, efforts to manage and conserve the Gulf's natural resources had primarily focused on developing resilient co-management structures and mechanisms[47]. Myanmar's steps toward decentralization of fisheries management starting in 2008 marked an opportunity for developing co-management of fisheries, where stakeholders from villages up through the state and regional level could collaborate[80]. Similarly, the Community Forestry Instructions issued by the Forest Department in 1995 and revised in 2016 paved the way for co-management of forest systems and their resources[47].

Box 3. Ecosystem Valuation of the Gulf of Mottama

The many ecosystem services of the Gulf of Mottama (i.e., the benefits that it provides) extend beyond what can easily be described in monetary terms. However, ecosystem valuation is an important approach for estimating the economic value or "natural capital" of the ecosystem services that can be feasibly measured. Such studies can demonstrate the significant benefits of maintaining and restoring ecosystem function through proper management efforts.

A 2021-2022 ecosystem valuation study[a] of the Gulf of Mottama's coastal resources investigated ecosystem services in eight villages across five townships (from Kyaikto to Chaungzon) in Mon State, focusing on mangroves, mudflats, coastal grasslands, and aquatic and marine habitats (see Table 1). Key findings for these eight villages include estimates of the total annual economic value of different categories ecosystem services in the study area:

- Provisioning services (food and materials harvested from the ecosystem) totalling at least 51 million MMK from mangroves, 367 million MMK from mudflats, 61 million MMK for coastal grasslands, and 9495 million MMK from the rivers and sea.
- Regulating services as flood protection provided by mangroves totalling between 8.75 million MMK and 135 million MMK of flood damage cost avoided for villages with a mangrove extent of 78 ha or more.

A comparison with the annual value per hectare of mangrove, mudflat, grassland, and farmland areas shows that the natural coastal ecosystems generally have a higher value than converted farmland, particularly for mangroves. Since conversion to agriculture is a major threat to mangroves, this valuation finding is of particular importance to future decision-making about land use; it indicates that economic returns to the local area from mangrove ecosystem services outweighs the economic value of agricultural land.

These findings are from a small portion of the Gulf of Mottama, meaning that the total economic value of the Gulf's ecosystem services to Mon State and Bago Region far exceed the estimates from the study. And, of course, this does not include those ecosystem services that are not readily expressed in monetary terms!

[a] Wint Hte, Brander L, Moe Kyaw Kyaw Hein. Economic Valuation of the Ecosystems in the Gulf of Mottama. Gulf of Mottama Project, 2022.

The GoMP worked to support the formation of a co-management structure in which villages, township and state/regional (and up to national) government bodies, private sector, and other stakeholders could collaborate[47]. This has involved concurrent "bottom-up" and "top-down" approaches, strengthening village-level organization while engaging with a national and state/regional context of decentralization and movement toward integrated coastal management.

GoMP, particularly NAG, engagement with Mon State and Bago Region parliaments facilitated the revision of their respective fisheries laws to incorporate co-management and recognize involvement of FDAs[56]. In Mon State Fisheries Law specifically, this includes rights of the FDAs to develop their own co-management plans, monitor their co-management areas, and receive assistance from DoF and other relevant agencies. These efforts built on similar efforts to promote co-management of freshwater fisheries elsewhere in Myanmar, including efforts by NAG; historically, fisheries management in Myanmar has focused on freshwater fisheries in its laws and technical practices. The expansion of work on co-management to inshore fisheries in the Gulf marks a pioneering step in fisheries management for the country.

Goals for co-management of the Gulf's coastal resources included: promoting sustainable fisheries; developing strong and connected fisher groups; improving accountability and responsibility in the sector; increasing opportunities for earning for small-scale fishers; and supporting the government in collecting sector taxes[56].

With the political change in 2021, coastal management efforts in the Gulf of Mottama have shifted to a focus on community-based management at the village and township levels, as collaboration with government agencies in co-management was no longer feasible. Central to these efforts is the formation and strengthening of Ecosystem Management Units (EMUs).

Governance Institutions for Co-Management

Government interest in integrated coastal management drove the formation, beginning in late 2016, of national as well as state and regional Coastal Resources Management Committees (CRMCs) – multi-stakeholder entities largely comprising relevant government departments (e.g., Department of Fisheries, Forest Department, Department of Agriculture) as well as private sector and research institution representatives. These CRMCs were mandated to oversee the management of coastal natural resources. The Mon State and Bago Region CRMCs were engaged, until 2021, in the management of the Gulf of Mottama.

The VDCs have been the focal entity at the village level for coordinating management, via their Fisheries Groups, Farmers Groups, and Income Generating Activities Groups, and in some cases Local Conservation Groups (LCGs). The revolving funds run by the VDCs generate interest, of which 50% is maintained as the capital fund for livelihood development loans, 25% is used for committee operations costs, and 25% is to be

allocated to village development work (including natural resource management) according to the village's Action Plan[81].

The Biodiversity And Nature Conservation Association (BANCA) has worked with 13 villages to form LCGs as a way to engage bird hunters in conservation activities[82]. In Paung, a township-level LCG coordinates across eight villages on activities such as mangrove planting, engagement with the township Forest Department in applying for Community Forest and establishment of Public Protected Forest area status, patrolling, and awareness-raising, advised by GoMP and BANCA[27]. Further LCG development is currently planned in other townships, with focal persons from included villages[27].

The township-level Fisher Development Associations (FDAs) and Coastal Farmer Development Associations (CFDAs) were developed as extensions of the village-level fisher and farmer groups. They serve as communication platforms for representatives from VDCs and representatives from different government departments and other stakeholder groups. These include research institutions, e.g. Mawlamyine and Bago Universities, as well as the Myanmar Fisheries Federation (MFF) and the Rice Production and Selling Association representing the private sector in the FDAs and CFDAs respectively[47]. MHL, a key member of MFF, is particularly active in management platforms, as well as contributing to fisheries data collection.

The Mon State and Bago Region Fisheries Partnerships collaborate as the joint Bago/Mon Inter-Regional Fisheries Partnership, including government authorities along with local stakeholders; they coordinated regular patrolling for illegal fisheries prior to the COVID19 pandemic[83]. The patrol teams consisted of township FDAs, DoF, GAD, MFF, police, and armed village paramilitary or militia[30].

While the patrolling efforts represent a major success pre-2021, coordination of co-management more broadly had proved challenging. The diverse member ministries and departments of the CRMCs were overextended and unused to collaboration with other departments; it became clear that other entities would need to be responsible for active implementation of co-management. The 2021 political change and the resulting turnover of personnel in government departments, as well as widespread resignations from the universities (as government institutions) as part of the Civil Disobedience Movement, have led to a reduction among the government institutions in familiarity and skills related to supporting co-management, including patrolling efforts[84].

Focus on Community-Based Management

Under the current political situation, focus has shifted from co-management to supporting community-based management. Previously, co-management efforts were focused toward developing township-level co-management areas or zones[47]. This has been reframed in an Ecosystem Approach to Management lens, for which Ecosystem Management Units (EMUs) will be the institution driving community-based management

efforts. Through EMUs, ecologically important areas will be managed by local communities through coordination with CSOs, NGOs, and the private sector[85]. Each EMU will be managed by an EMU Committee, which will coordinate activities under (a) ecosystem and biodiversity conservation, (b) climate change mitigation and adaptation, (c) fishery development, and (d) agricultural improvement[27,52,85].

Each EMU Committee will develop and implement their own management plans[86]. These EMUs will comprise representatives from each village (not limited to VDC members in order to address concerns over representation and inclusion), FDAs, CFDAs, private sector (if present and relevant), and CSOs (as relevant); an EMU Executive Board is also planned for each EMU[85,86]. There are four EMUs covering five townships at present, aligned with the previously outlined co-management areas but with a broader focus beyond fisheries-relevant work (Figure 12). An additional three EMUs are planned in Kyaikhto, Chaungzon, and Kawa Township areas[86].

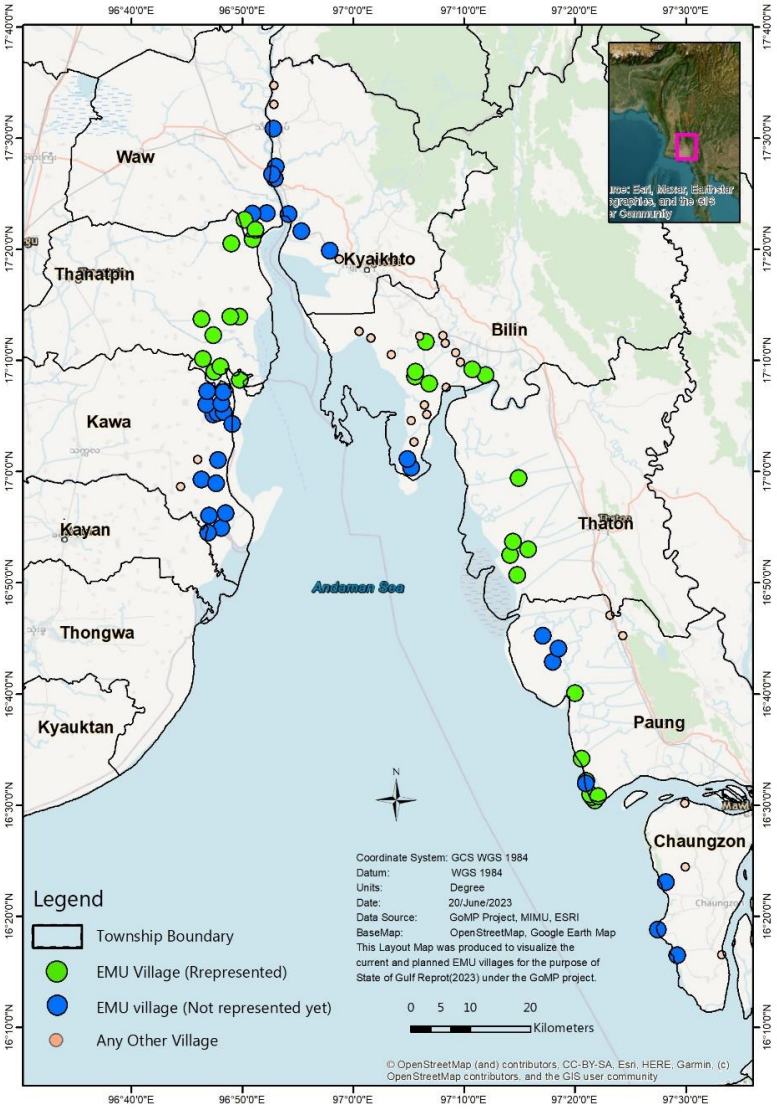

Figure 12. Villages currently represented by Ecosystem Management Units (EMUs) in green, with villages linked to planned EMUs in blue.

Priority Management Areas

Previous and ongoing engagement and research in the Gulf has indicated the following issues as priorities for targeted management efforts:

Community Awareness

BANCA began conducting awareness activities in Gulf of Mottama communities in 2012, as part of the Ramsar Convention's Programme on Communication, Capacity-building, Education, Participation, and Awareness

(CEPA)[87]. This work, primarily focused on migratory shorebirds, targeted approximately 100 villages as well as State and Regional Government authorities, including a mobile education awareness program visiting coastal villages in the Gulf, World Wetlands Day events, presentations to government authorities, and events and displays at BANCA's Environmental Education and Sustainability Center in Bilin Township[55,87]. These activities were important in the designation of the Gulf of Mottama Ramsar as a Ramsar site. Currently, CEPA activities are undertaken by the GoMP in partnership with Point B, with content broadened to include information on biodiversity beyond shorebirds, fisheries, agriculture, and disaster risk reduction[48]. This work by GoMP included training two local civil society organizations in implementing CEPA activities, while the more recent focus is on training community members, including youths, as CEPA facilitators [27,48,88].

Fisheries Management

Co-management, Community-Based Management, & Enforcement with Open Access

Management of fisheries had previously been limited to the DoF-mandated "closed season" from May to July; however, while this was intended to protect fish spawning, it is not aligned with the spawning phenology of many marine and estuarine species, and thus would not be effective at protecting these species during their respective spawning seasons [30]. Data suggest that May to July is an important fishing time during which 16 to 40% of the annual catch occurs, indicating that there is low compliance with this closed season regulation anyway[30]. There is interest in community-managed Fish Conservation Zones[27], which will be integrated into EMU planning. GoMP is conducting community consultations for establishment of community-managed Fish Conservation Zones along the Sittaung River. A no-take-zone approach in a relatively small area is highly feasible and recommended by the fishing communities, as they would likely suffer greater hardship with seasonal closures in a relatively large area (*see Box 4 on Hilsa Fisheries Management in Bangladesh)*.

Co-management and community-based management of marine fisheries in the Gulf is challenging given the open access nature of these fishing grounds, which requires cooperation in management zones across townships[17,30]. There is a great deal of movement by fishing boats across township boundaries, varying by season[30]. The challenge will be how these and any other zones are enforced, as presently any enforcement requires government authority. DoF`s management capacity has always been limited, and now it is even more constrained, with complete turnover of staff following the political change and an increase in internal corruption[84]. There will also need to be coordination of management efforts across township boundaries.

The joint Bago/Mon Inter-Regional Fisheries Partnership had previously patrolled regularly for illegal fishing using *than-za-gar pike* nets starting in 2018, leading to an observed decrease in this illegal practice (estimated as an 85% decrease) [89,90]. Subsequently, large increases in catch were noted in 2019 and 2020 of croaker,

mullet, Indian threadfin, and hilsa[90]. However, since COVID19 and the political change, there have only had two patrolling activities since the pandemic, in which the DoF, MFF Mon, FDA, and Police Force joined[75] .

Box 4. Hilsa Fisheries Management in Bangladesh

Hilsa shad (*Tenualosa ilisha*) is the most valuable fisheries species in Bangladesh, making up 12% of the total national fisheries production and providing vital livelihoods for fishers and other actors along the value chain[a]. A drastic decline in hilsa stocks prompted management efforts by the government in 2005 to increase reproduction and recruitment, focusing on seasonal protections of critical habitat (spawning grounds and migration routes) and life history stages[a]. This includes five sanctuaries in the main rivers and four breeding grounds, comprising 7000 km^2 in the lower Meghna River, where fishing is banned during March and April[a]. There is also a ban on catching juvenile hilsa from November to June, and mature hilsa during September and October full moon days[a]. Gear bans include monofilament gillnets and set bagnets[a]. To support hilsa fishers during the bans, the government provides a compensation package including rice and support for diversified income generating activities[a].

These efforts saw an increase in catch at an average annual rate of 5% [b]. In 2014, a new five-year initiative ECOFISH, funded by USAID and implemented by WorldFish and the Department of Fisheries, was launched [c]. Activities included the establishment of Hilsa Conservation Groups, Hilsa Landing Center Groups, fisher women's Community Savings Groups, and Community Fish Guards near sanctuaries and breeding grounds, migration routes [a]. These groups were the means for implementing adaptive co-management, with activities including awareness-raising programs and livelihood support. High hilsa catches have continued through these efforts, with 2016 yielding a 28% increase in catch from previous years [a].

The increased hilsa catches have led to increased income for value chain actors, including fishers, wholesalers, buyers, retailers, and consumers, and has resulted in improved repayment of loans and investment in household needs [a]. However, other studies have found that hilsa fisher households still face difficult conditions, particularly during the seasonal bans, when many experience food and income insecurity and serious impacts to their well-being [d,e]. Compensation provided by the government was reported as inadequate and improperly dispensed, with many hilsa fishers not included on the beneficiary list while nonfishers received benefits due to corruption [d,e]. Efforts to support alternative livelihoods were also seen as inadequate. Such difficulties in some cases have incentivized fishers to turn to illegal fishing, since gaps in enforcement allow for illegal fishing to continue [d,e]. These challenges, plus continued threats to the fishery such as pollution, siltation, and climate change, might obstruct long-term, sustained success of management efforts.

This case study exemplifies the importance of incorporating species-specific life history research (e.g., data on breeding grounds and seasons) into management, but also ensuring that negative impacts to communities are meaningfully mitigated. Recommendations include greater promotion of community involvement and empowerment in fisheries management (particularly enforcement), along with improved strengthening of fisher community resilience [e].

[a]Khan MdA, Wahab MdA, Haque ABMM, Nahiduzzaman M, Phillips MJ. Value chain impact of the increased hilsa shad (Tenualosa ilisha) harvest in Bangladesh. International Food and Agribusiness Management Review 2020; 23: 355–368.

[b]Milton DA. Status of the hilsa (Tenualosa ilisha) fishery management in the Bay of Bengal: an assessment of population risk and data gaps for more effective regional management. Bay of Bengal Large Marine Ecosystem Project, 2010.

[c]Dutton IM, Hossain MS, Kabir H. Enhanced coastal fisheries in Bangladesh mid-term performance evaluation report. ,. United States Agency for International Development (USAID), 2018.

[d]Ahmed M, Mitu SJ, Schneider P, Alam M, Mozumder MMH, Shamsuzzaman MdM. Socio-Economic Conditions of Small-Scale Hilsa Fishers in the Meghna River Estuary of Chandpur, Bangladesh. Sustainability 2021; 13: 12470.

[e]Mozumder, Pyhälä, Wahab, Sarkki, Schneider, Islam. Understanding Social-Ecological Challenges of a Small-Scale Hilsa (Tenualosa ilisha) Fishery in Bangladesh. IJERPH 2019; 16: 4814.

Catch Monitoring

Small-scale fisheries are generally challenging to monitor due to their dispersed nature and relative remoteness of landing sites in many cases, along with limited oversight and inadequate institutional capacity for regular monitoring that often characterize developing countries. However, sustained monitoring over time is essential to inform management practices.

The GoMP worked to establish regular catch data collection practices, including from fish buyers (Sut Pa Nu village) since 2016, fishers themselves (Zwe Ka Lar, Bilin Township; Aung Kan Tar, Thaton Township; Baing Laung, Paung Township) since 2020, and MHL, a commercial landing station since 2016. Data from Sut Pa Nu and MHL show catch landings, while data from the fishers in Zwe Ka Lar, Aung Kan Thar, and Baing Laung have been used to calculate CPUE. However, CPUE data collection began only in 2020, too recently to demonstrate trends over time (particularly considering the impacts to fishing effort of the dynamic economic and political conditions since 2020)[43]. Continued data collection is necessary to identify possible trends[43]. Data from MHL, which began disaggregating landing data into eight size classes in 2018, has allowed for collection of greater detail on the croaker catch that would have otherwise required extensive biological sampling[56].

The collation, collection, and analysis of these data are primarily undertaken by GoMP staff and collaborators; capacity for this, or access to funds to hire consultants, will need to be established for long-term monitoring to continue via EMUs.

Other fisheries data have been collected through discrete research projects conducted from 2017 to 2020 by Mawlamyine University and Bago University research teams[30–36,54,91], including fisheries in Chaungzon Township (Sepelar and Kalwei villages[31]), Kawa Township (Kyunton and Kokko villages[32]), and Thaton (Aung Kan Thar), Bilin (Zoke Ka Li), and Paung (Baing Laung) Townships[33–36]. A collaboration with Greenovator to develop the Green Way mobile application for collecting and sharing data on fishing effort, catch, and value was piloted in 2020, but logistics constraints limited usefulness and the app is no longer being used[30].

Trends in Catch

Overall, declines had been reported in fisheries yields in the 2010s, with some fishers reporting as much as an 80% decrease in catch, attributed to illegal fishing with small mesh nets (particularly *than- za-gar pike*) as well as overfishing and pollution[30]. This includes a 90% reduction in Hilsa shad over the past 15 years, possibly due to overfishing in the marine environment, capture during spawning migration damage to spawning habitat from sand mining, and hydrological changes due to barrage and dam construction, in addition to capture of juveniles in *than-za-gar pike* and other small-mesh nets[30].

However, from 2017 to 2020, a dramatic increase in landings was reported, driven by increases in Pama croaker but also observed for Mango fish and Hilsa[30] (Table 2). This has been attributed by fisheries stakeholders as an outcome of patrolling and enforcement against illegal *than-za-gar pike* stake nets. Of further note for Pama croaker is that 2019 and 2020 saw particularly large catches in June and July, which were previously low-catch months; fishers reported that they hadn't seen this sort of pattern since over 10 years prior[44]. Other observations (size classes, timing of the presence of larvae and juveniles, fishers observing ~75% of females carrying eggs) further suggest that this indicates a spawning migration[44].

Long-term data on catch from Sut Pa Nu village as well as MHL provide two different vantage points on catch, with the former being a small- to medium-scale, multi-species fishery and the latter being a single-species medium-scale fishery[30]. From 2017 to 2020, Sut Pa Nu landings increased every year (a 240% increase in 2020 over the average catch of the three previous years), with Pama croaker increasing 633%, Hilsa 218%, and Mango fish almost 450% (though more variable than the other two species)[30]. MHL's data also show large increases in annual landings of Pama croaker (200% from 2017 to 2018, and then another 300% in 2019); even during the COVID19 pandemic, the 2020 catch was even higher, with the station manager reporting that this was the highest catch in 12 years[30]. Anecdotal reports indicate that catch increased in other locations as well[30].

Again, these increases have been attributed by fishers to the decrease in illegal fishing due to patrolling efforts. However, illegal fishing has resumed after 2021 political change due to reduced patrolling efforts, and continued fisheries monitoring will be needed to track what impacts this might have on catch.

Data from from three villages in Mon State (Aung Kan Thar, Baing Laung, and Zwe Ka Lar) demonstrate an increase in fisheries landings and value since 2018, except for 2021 which saw a decrease in value due to the COVID19 pandemic[43]. However, data on CPUE collected since 2020 show a decline in CPUE from 2021 to 2022[43]. This time period has seen a general reduction in fishing effort overall in response to political and economic challenges (though specific responses vary across villages and among fishers) and it is a short period of time for tracking long-term trends; as such, it is difficult to interpret these CPUE findings for now[43]. It will be important to continue and expand collection of CPUE data as an indicator of the long-term sustainability of the Gulf's fisheries[43].

Table 2. Landings , value*, and % difference of Pama Croaker landings from 120-150 boats at Mawlamyine Holdings Ltd. buying substation, Kyaikhto Town, Mon State. Provided by Dr. Kenneth MacKay. *US$/MK Exchange: 1US$= 1300 (2020), 1800 (2021), 2300 (2022).

Date	Landings (kg)	% Difference	Value MMK (US$)	% Difference MMK
2016	25,931			
2017	24,902	-4.1%		
2018	44,925	44.6%	280,575,632 ($215,827)	
2019	136,038	67.0%	922,095,942 ($709,305)	228.6%
2020	141,859	4.1%	801,702,975 ($616,695)	-13.1%
2021	141,975	0.1%	896,391,950 ($497,996)	11.8%
2022	148,711	4.5%	952,336,125 ($414,059)	6.2%

Table 3. Fisheries Data from three GoM Villages in 2020-22 based on data collection from five fishers in each village Provided by Dr. Kenneth MacKay. *US$/MK Exchange: 1US$= 1300 (2020), 1800 (2021), 2300 (2022).

Year	Catch (kg)	Catch /Day (kg)	Catch/ Fisher (kg)	Value in MMK	Value/Fisher in MMK (US$)	Major Species caught
ZWE KA LAR, BILIN TOWNSHIP						
2020 Sep-Dec	2,432.1	12.2	486	7,357,400	1,548,926 ($1,191)	Flathead Grey Mullet; Pama Croaker; Flathead Silago; Mango fish: Freshwater Mullet; Seabass
2021 Jan-Dec	6,512.3	9.1	1,303	15,415,725	3,083,145 ($1,713)	
2022 Jan-Dec	9,940.6	13.8	1,988	35,423,300	7,084,660 ($3,080)	
AUNG KAN THAR, THATON TOWNSHIP						
2020 April-Dec	12,575.4	27.8	2,515	30,260,640	6,052,128 ($4,655)	Flathead Silago; Pama Croaker; Bombay Duck; Tidal Puffer Fish; Toli Shad
2021 Jan-Dec	23,047.7	48.1	4,609	42,836,440	8,567,288 ($4,760)	
2022 Jan-Dec	10,286.6	43.4	2,057	24,793,660	4,958,732 ($2,156)	
BAING LAUNG, PAUNG TOWNSHIP						
2020 Jan-Dec	24,571	46.4	4,914	63,644,155	12,728,832 ($9,791)	Flathead Silago; Pama Croaker; Tidal Puffer Fish; Bombay Duck;
2021 Jan-Dec	24,665	55.9	4,933	37,492,780	7,498,556 ($4,166)	
2022 Jan-Dec	17,904.2	42.4	3,581	41,630,255	8,326,051 ($3,620)	

Table 4. Fish landings and values at one fish buyer in Sut Pa Nu Village, Kyaikto Township, Mon State. Estimated values for 2017-2020, and actual values for 2021-22 . Value/Fisher was calculated assuming 40 fishers. Provided by Dr. Kenneth MacKay.

Year	Landings (kg)	Gross value		Value/Fisher (USD)	% increase over previous year	Major species
		MMK	USD			
2017	8,278	42,528	32,714	818		Hilsa Shad; Pama Croaker; Mango fish;
2018	12,295	67,557	51,967	1,299	58.90%	

2019	15,367	89,460	68,815	1,720	32.40%	Wallago; Mullet (2 spp Anchovy (2 spp); Giant River Prawn
2020	21,856	114,692	88,225	2,206	28.20%	
2021	8,202	13,839	7,688	192	-91.3%	
2022	11,091	58,569	25,465	637	231.2%	

Spawning Grounds and Seasons

Understanding life history and population dynamics, including spawning seasons and grounds, of fisheries species is critical to management. The management of hilsa fisheries in Bangladesh is a strong example for the benefits of integrating such research into management efforts *(see Box 4)*. Research has investigated the spawning grounds in the Sittaung River and Bilin River of *T. ilisha* in particular, with some research on spawning grounds for *P. paradiseus*, and *O. pama* in the Sittaung[41,92,93]. Catch data has provided further insight into possible timing of spawning for these species.

An initial LEK survey of local fisheries in 2017 yielded the following information on spawning seasons and location: River hilsa, April-May, in freshwater above the bridge on the Sittaung River; Pama croaker, July-August, where fresh and saltwater meet above the bridge on the Sittaung River; Mango fish, April-June, above the bridge on the Sittaung; and mullet, March-June, above the bridge on the Sittaung as well as in Bilin River and associated creeks[17].

Hilsa shad migrate at least 200km upriver in the Sittaung, among other rivers, to spawn[18,30]. Larvae have been recorded in the Sittaung in January and March 2018[92], as well as November through March 2018-2019[93]. A more recent study, in 2020, suggests spawning from December through February[94], and another in 2020-2021 suggests that the main spawning season is in January and February[41]. Four priority areas have been identified for potential Fish Conservation Zones for hilsa, including two spawning grounds (Sittaung River) and two nursery grounds (one in the Sittaung, one in Bilin River)[41].

LEK suggests that there was a 90% reduction in Hilsa abundance since the early 2000s, attributed to overfishing, illegal fishing, and damage to spawning and nursery areas due to sand mining and infrastructure development on the river[30,41]. Similar concerns exist for Pama croaker and Mango fish spawning and nursery areas; because the two species have similar migration and spawning patterns, their management plans could be closely aligned, though more information is needed on both[30].

Pama croaker catch data from 2019-2022 suggest that spawning fish were present between May and July at the mouth of the Sittaung River[44], aligning with previous findings documenting larvae in the Sittaung in May and July in 2018 and 2019[93]. Larvae were also detected in January and March in 2018[92]. Mango fish larvae were recorded in March-July in 2018 and 2019[93], as well as January in 2018[92]. Mango fish are primarily captured in May and June, with most females carrying eggs, indicating that they are migrating upriver to spawn in the Sittaung in May and June[30].

Further research on, and subsequent conservation of, the spawning and nursery grounds of Pama croaker and Mango fish is a management priority[30]. Community-based protection of critical spawning and nursery habitat will be important for management of these species, in addition to decreasing use of fine-mesh nets such as *than-za-gar pike* as well as *da min*, legal stow nets with fine-mesh cod-ends[30,41]. It is also important to note that critical spawning areas, particularly for Hilsa, in the upper Sittaung overlap with areas of conflict.

Resilient Agriculture

Priorities for the agricultural sector in the Gulf include (1) dealing with the substantial increase in the cost of inputs (See Livelihoods section), (2) ensuring continued transfer of technical skills, resources, and inputs, such as quality seeds, and (3) building adaptive capacity to climate change impacts, including intensified flooding and saltwater intrusion.

The CFDAs will align with the EMUs for integrative management, since climate adaptation and reducing the environmental impacts of agriculture are priorities for both. A priority for the CFDA is to generate enough income to cover its costs (this is projected to be achieved for the Mon CFDA by the end of 2023) for sustained self-management. Currently, the CFDA hires technicians to support activities. Though it is registered as a CSO currently, it plans to try to change to a social enterprise to support its fundraising needs[78]. The CFDAs had a closer relationship with Department of Agriculture (DoA) prior to the 2021 political change, with technical and coordination support from the department; ongoing communication with the current DoA will need to continue effectively[78]

Mangrove Forests: Gains and Losses

There have been both loss and gains in mangrove areas in recent years. In the Gulf, there are Community Forest areas for mangrove management, Sepelar in Chaungzon (formed at the encouragement of the FD in 2006) and Kar Tae in Paung. Plantation activities are also underway at Ahlat South Village in Paung, which had initially been supported by the FD in these efforts[25]. GoMP currently supports the management and plantation activities in these areas as well as the establishment of further community forests (Figure 13).

Mangrove management is essentially a land use issue, and one that is complicated by the fact that mangroves on the land at the disposal of the government are relevant for the mandates of different government departments that communicate or collaborate rarely among themselves: DoF, Forest Department, Department of Agricultural Land Management and Statistics (DALMS) and GAD[22,25,27]. As such, decisions made by one department might contradict those made by others.

The biggest threat to mangroves in the Gulf is conversion to agriculture, with the GAD allocating this land to external businesses from Mawlamyine or other cities (i.e., not to local farmers). This has played out multiple times in the mangrove areas of the GoM. For example, Crab Island Conservation Zone had been recognized by the Mon State government as a mud crab conservation zone as well as a mangrove plantation area, managed by the Thaton FDA working closely with GoMP and Worldview International Foundation. However, this was apparently not known to the Department of Agriculture or GAD, and conversion of that land for agriculture was approved – and the mangrove area was only narrowly saved from destruction[27]. Similarly, in 2023, the GAD and DALMS approved the use of land for rice fields next to the Kar Tae Community Forest, including removing already-planted mangroves[84].

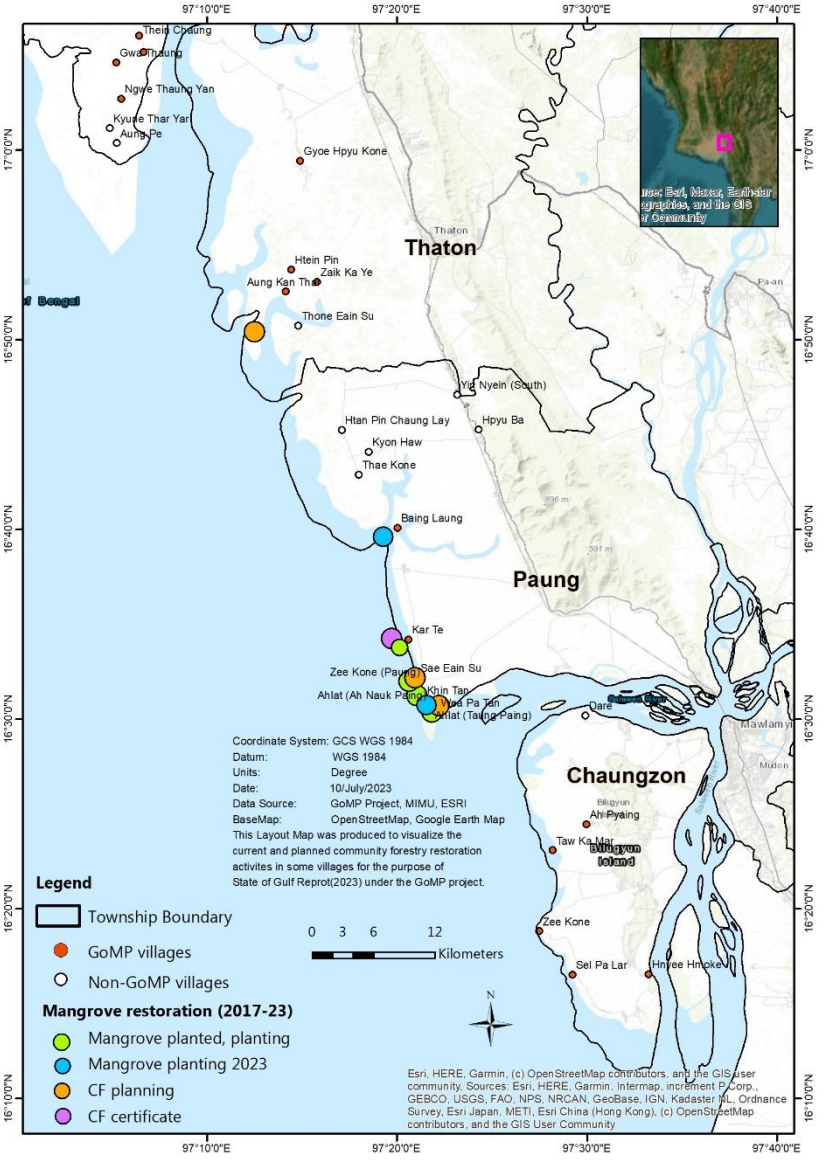

Figure 13. Mangrove management activities related to planting and establishment of Community Forests (CFs) in Mon State.

This conversion of mangroves to agriculture run by external businesses risks the further marginalization of those who rely on mud crab harvesting in mangrove habitats (mud crabs being an important livelihood source for landless people[17]). For example, in two villages near the Kawa mangrove area, crab harvesters were struggling to meet their livelihood needs because wealthier stakeholders had been clearing the mangroves with machinery to use as agriculture[79]. The cleared area, now farmland, was then enclosed by dikes, which also blocked mud crab harvesters from accessing the remaining mangrove area[79].

It is also important to note that proper zonation of mangrove plantation areas is needed not only to ensure that suitable sites are used in terms of mangrove viability, but also to avoid encroachment upon valuable mudflat habitat for shorebirds[20].

Resurgence of Waterbird Hunting

Hunting is the main threat to waterbirds within the Gulf, though migratory species face major threats elsewhere along their migratory pathways (e.g., land reclamation in the Yellow Sea.) Hunters in the Gulf use mist nets, poison (e.g. potassium cyanide), and snares[55]. Previously, BANCA had identified 63 hunters in the mid-2010s and engaged with them through education, alternative livelihoods training (e.g., fisheries, livestock, agriculture) and financial support, as well as training for guiding birdwatching trips[55]. This was accompanied by BANCA supporting the formation of LCGs in 13 villages, through which former hunters could participate in conservation actions, e.g. through patrolling and monitoring for illegal activities[55,95]

At one point, hunting was believed to have largely ceased[95]. However, community members have reported an increase in the bird hunting, attributed to the impacts of COVID19 and the political change on livelihoods as well as enforcement capacity[45,48]. Targets include herons, egrets, and small waders, though when the birds are sold in the market, identifying characteristics are removed[48]. There even appear to be recipes with different styles of cooking the birds emerging[48]. Recently, in Kar Tae, Paung, one of the LCG members confiscated 30 live birds caught in one net [48].

LCG members in Paung lead monthly monitoring trips along mangroves and mudflats to collect data on shorebirds, hunting, and illegal mangrove extraction, using standardized SMART patrolling forms (but not yet using the SMART protocol for data entry)[48]. However, their capacity for enforcement against hunters is limited under the current situations.

Marine Mammal Bycatch & Consumption

The major concern is the accidental capture (bycatch) of these species in local fisheries; set bag nets are the main gear in which bycatch occurs off the coast of Chaungzon, though bycatch in driftnets, gillnets, and trammel nets has also been reported in LEK surveys[50,51]. Irrawaddy dolphins appear to be the most commonly caught, followed by finless porpoises, and then humpback dolphins, though additional analysis is needed to calculate approximate rates of bycatch[50].

Consumption of cetaceans, primarily from bycatch but also with some reports of deliberate catch, varies across villages and townships, but does appear to be increasing, with some villages reporting the development of new recipes[51]. Traditionally, the fresh meat would be cooked or dried, but now fins are being added to salads, heads are being fermented, and internal organs are being included in curries, while the oil from skin and bones are used medicinally. Some restaurants even serve these cetacean meat dishes. Though most of this consumption was reported as occurring with bycaught animals, anecdotal reports made to the team indicate some targeted hunting, as well[50].

The challenge with bycatch is that it is difficult to monitor an illegal activity, and any efforts to enforce penalties on fishers for bycatch would likely discourage communities from collaborating in research and conservation efforts, driving the problem of bycatch underground. Fortunately, there is also interest within communities to be involved in marine mammal research and conservation[50,96]. In addition to planning on collaborating with selected fishers on the deployment of acoustic receivers to study finless porpoises, MCCL and GoMP have also run a training for local communities on stranding response methods[50].

Solid Waste Management

Plastic pollution impacts both urban and rural communities in the Gulf. Interviewed residents of the Gulf reported that it impacted quality of life due to the smell and infestation by pests in areas where plastic waste accumulated, that it blocks waterways and thus leads to flooding, and can entangle marine life[97]. Plastic debris is even intermingle with fisheries catches, causing extra labor for women who process the catches as they need to sort out the plastic; for shrimp catches, this entails boiling the shrimp and plastic together and then sieving out the plastic pieces after drying[98]. Government waste management services do not extend to rural communities, who have no options for dealing with plastic debris others than gathering it up and bringing it to an open disposal area (or, sometimes, leaving it to be washed out to sea again)[97,98]. High-temperature incinerators, which would reduce toxic fumes compared to regular burning, is one possible approach, but steps to reduce plastic waste and improve pathways to recycling would be more sustainable in the long-term[97].

Erosion & Impacts on Communities

Currently, the severity of the erosion on the Bago side has eased, with no further loss of land at present[66]. Data continue to be collected on the risk of erosions and floods, and relevant information can be passed on to the Mon State Disaster Risk Management Committee, a multi-partner entity led by UNDP and composed of development, humanitarian, and emergency responder organizations and agencies[66]. Physical protective interventions are likely not logistically feasible nor economically viable[2]. Long-term strategies will need to be developed for adaptation and protection from future loss of land and livelihoods as the erosion cycle continues, e.g. avoiding development on vulnerable areas, preparing support for livelihood changes that might be necessary for future impacted communities, and adopting an approach of “managed retreat” when necessary, particularly since any specific timing of the change in erosion direction cannot be precisely predicted[2]. Local capacity for Disaster Risk Management (DRM) will need to be further strengthened through Community-Based DRM plans and strategies for implementation.

Climate Change: Disaster Risk Management and Adaptation

Climate change will likely continue to exacerbate the intensity of flooding (Figure 14), storms, drought, and saltwater intrusion. Environmental Defense Fund's Comprehensive Assessment of Risk to Ecosystems (CARE) score for Mon State, based on focus group discussions with selected village leaders, was 7 out of a maximum possible of 10, indicating "major anticipated climate impact"[99].

Ecosystem-based adaptation measures could include conserving existing mangrove habitat and expanding to suitable habitat areas (being mindful to not convert valuable shorebird habitat on the mudflats to mangrove plantations), using deep-rooted mangrove species such as *Avicennias* or *Sonneratias*; these could offer protection from wind and storm surges[9]. They could also help communities adapt to saltwater intrusion via integrated mangrove-pond aquaculture, in areas where suitable conditions exist[9]. In the villages, shade trees and fruit trees (with deep roots, to prevent risk of toppling over) could provide not only cooler micro-climates in the face of increasing temperatures but also household food security, as observed in villages that already have good shade coverage[9].

More resilient agricultural products will be important in helping farmers adapt to climate change. GoMP work to support inputs and technical skills of rice farmers related to "climate smart" rice has resulted in greater resilience to climate change impacts, through planting rice varieties that are flood- and saltwater-tolerant as well as through improving the sector in general through seed banks, access to fertilizer, and trainings in good planting practices[78]. Support for other livelihoods vulnerable to climate change, especially fisheries, will be important to ensure a more resilient fisheries sector, while diversified livelihoods would reduce fishing household dependence on fishing income.

DRM coordination and planning will need to be strengthened to further adapt to climate change impacts. *See Erosion & Impacts on Communities section*

Outlook & Recommendations for Management Approaches

Since 2015, local institutional capacity for management has been substantially strengthened through intensive efforts by stakeholders and GoMP. There is steady progress toward the implementation of a local framework for community-based management via the Ecosystem Management Units (EMUs) – a multistakeholder platform at the township level, benefiting from years of capacity building for the VDCs, FDAs, and CFDAs. The extent to which these EMUs will be formalized and to which this community-based focus might be linked to co-management with government departments and ministries remains unclear; these are critical questions that must be assessed with great care moving forward.

For sustained management of the Gulf of Mottama, it will be vitally important to have a multi-stakeholder, multi-sector management body that spans the Gulf, linking and coordinating across Mon State and Bago

Region while representing more local management bodies from township and village levels. This entity should integrate research findings into its decision-making; for example, research on the life history and population dynamics of fisheries species should be used to inform decisions around fishing seasons, fishing grounds, and any special management or conservation areas (*see Box 4 on Hilsa Fisheries Management in Bangladesh*).

Figure 14. Researchers, community members, government officials, and other stakeholders discussing research for the Gulf's management at the 2019 Research Symposium for Stakeholders. Photos by T.S.Whitty.

Local research capacity has grown, with Point B and MCCL equipped with the technical capacity to conduct research and training for research, while researchers from Nature Conservation Society continue to conduct annual surveys on waterbirds. Community members have also been involved in the research process through providing research priorities at research strategy meetings with GoMP, expressing a strong desire to be actively involved in setting research agendas and even conducting research. A Research Symposium for Stakeholders in late 2019, with a focus on interactive sharing and active discussion of research findings and proposed research projects with community members, government officials, private sector, and members of the general public, proved popular with attendees, with requests for such events to be held regularly (though this has yet to be implemented due to the COVID19 pandemic) (Figure 15).

Community members – both men and women – who participated in GoMP activities have reported significant improvements in their technical knowledge and skills related to livelihoods, natural resource management, and WASH issues[71,100]. Many of these community members linked these improvements to better livelihoods (pre-COVID19), as well as increased confidence and capacity to communicate and collaborate[71,100,101]. In general, decision-making processes in VDCs appear to be consensus-based, though this is variable across villages[11]. Of vital importance is local awareness of the importance of natural resource management and conservation and local interest in engaging in management[71,102,103].

Sustaining integrated ecosystem management without intensive support from GoMP or similar projects will require further progress in institution building and social capital, as well as identifying feasible, reliable means

for funding[102]. An evaluation of the village revolving funds indicated a moderate to high likelihood of their sustainability into the future, though there are some weaknesses to be addressed[102]. A portion (25%) of the village revolving funds can be allocated to village development priorities, including natural resource management[81]. However, there is no set allocation dedicated to natural resource management or conservation, and a recent evaluation of the EMU framework highlighted the importance of ensuring that conservation priorities are maintained despite competing economic considerations[67,81].

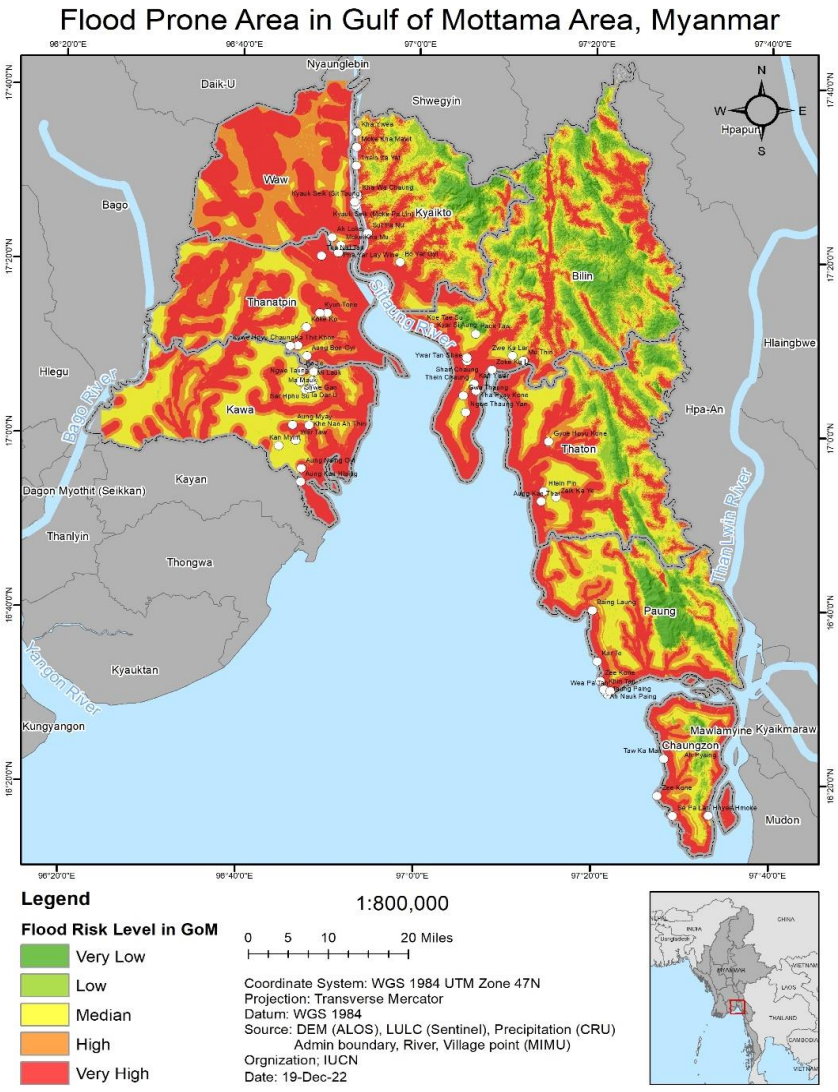

Figure 15. Flood risk levels in the Gulf of Mottama area.

Encouragingly, an evaluation published in 2021 found general enthusiasm on the part of village revolving funds, FDAs, and CFDAs in allocating at least 25% of their income to future conservation work, with many participants supporting formalized measures committing 10-50% of interest gained to conservation activities[102]. This 10-50% of interest appears to be sufficient to cover estimated costs of key conservation activities in future years (awareness sessions and patrolling)[102]. It is important to note that this evaluation was conducted prior to 2021, and should be revisited and validated to see whether current economic challenges have affected these findings.

Evaluations have identified existing questions of equality and representativeness of the VDCs, with the most poor community members being the least likely to participate on VDCs and related activities due to their limited spare time (as they are busy with their livelihoods), low confidence due to their lower educational level, and lack of belief that their opinions would be heeded in a community decision-making setting[11,67]. Women's participation has increased in VDC activities, with many women reporting greater confidence and men paying more attention to their contributions to meetings[71,100]; in fact, women seem to be in the majority of those in

attendance in many VDC meetings, with many representing their husbands who often need to leave for fishing trips[11]. However, men still dominate the decision-making process, particularly with regards to village development and resource management issues[11].

Figure 16. Community members sharing their experiences and feedback on GoMP impacts, as part of a participatory evaluation process conducted by Point B.

Perceived marginalization and inequalities in these decision-making processes and in the benefits from these processes are a risk for long-term success of these institutions. As such, greater inclusivity is a priority in management[67]. This includes broadening access to capacity building opportunities, since perceived lack of knowledge and experience are seen as a major barrier to participation in management – and this primarily applies to women and poorer community members[11]. Engaging youths was one of the priorities voiced by community members, though this is particularly challenging now due to increased out-migration of youths due to the COVID19 pandemic[100,103].

Organizational development skills, including conflict resolution, and more effective and sustainable means of peer-to-peer knowledge transfer, as well as meaningful action toward greater inclusivity, will be critically important in continued efforts to build lasting management mechanisms[11,67,104]. Regular evaluation of management efforts, including participatory evaluation with communities to understand their experiences, will allow for understanding management effectiveness, guide adaptive management, and help avoid (or mitigate) negative impacts of management efforts to community members (Figure 16). Ideally, some accountability or grievance mechanism by which community members can report misconduct or harm in management efforts would be put into place.

With sustained, adaptive, and inclusive management processes that link local efforts to Gulf-wide coordination, there is hope that this highly productive and unique wetland area will be able to thrive and sustain its locally and globally important biodiversity and natural resources, and thus support its local communities into the future.

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