Gulf of Mottama Project

Economic Valuation of Coastal Ecosystems in Mon State of the Gulf of Mottama

Wint Hte, Luke Brandar
Moe Kyaw Kyaw Hein

December, 2023

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Economic Valuation of Coastal Ecosystems in Mon State of the Gulf of Mottama

Reported by

Wint Hte
Coastal Resources Programme Officer | International Union for Conservation of Nature (IUCN)

Luke Brander
Institute for Environmental Studies, Vrije Universiteit Amsterdam, The Netherlands

Moe Kyaw Kyaw Hein
Research Assistant | Myanmar Coastal Conservation Lab (MCCL)

Research Team

Thae Eaindra Hsu
Thazin Htet
Pann Yahmone Oo
Zun Pyae Oo
Myanmar Coastal Conservation Lab (MCCL)

Reported Date: 19 December 2022

EXECUTIVE SUMMARY

- Coastal ecosystems in the Gulf of Mottama deliver services with substantial economic value to local communities. The average household in the six villages assessed in this study receives provisioning and regulating services worth approximately 19.98 million MMK (9,514 USD) per year.
- Provisioning services contribute the largest share of the total economic value of coastal ecosystems. In villages with large areas of neighbouring mangrove cover, the value of protection from floods, storms and erosion is also of economic importance.
- The results are highly village specific. The economic value of both provisioning and regulating services varies greatly across villages depending on the extent of coastal ecosystems in the vicinity of each village and the level of dependence on resource extraction. This variation in values across villages means that it is not straightforward to generalise the importance of ecosystem services or extrapolate results to other areas of the GoM.
- Similarly, the relative importance of different ecosystem types varies greatly across villages. In all cases, however, rivers and the sea are the most important source of harvestable resources.
- Harvested resources are primarily sold but a substantial proportion is also used for subsistence consumption. The value of subsistence income can be high; the average household directly consumes resources harvested from rivers and the sea with a value of 10.8 million MMK (1,200 USD) per year.
- A high proportion of households that coastal ecosystems have changed negatively (in extent, condition, and access) during the past 10 years and view the conversion of ecosystems to agriculture as detrimental to their livelihood.
- Making a comparison between the annual value of coastal ecosystems and agricultural land, we find that the value of ecosystem services from mangroves and mudflats generally exceeds the returns on land converted to agriculture.

ACKNOWLEDGEMENT

The research project was supported by Gulf of Mottama Project (GoMP) which is mainly supported by Swiss Development Corporation (SDC). Therefore, we would like to provide our sincere acknowledgement to SDC for supporting the research through the GoMP. Most importantly, we would like to appreciate the participants in the communities who involved in the interviews and discussions for their meaningful and valuable contributions. Then, we would like to thank Dr. Tara Sayuri Whitty for initiating fundamental background of the research as well as continuous guidance throughout the project. In addition, we want to thank the townships and clusters coordinators (TCCs) and the community facilitators and monitors (CFMs) of the project for their supports in development of the project as well as coordination for field activities. Finally, we would like to appreciate field researchers and research assistants from Myanmar Coastal Conservation Lab (MCCL) @ Point B Design + Training, who actively participated throughout the research process.

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1 INTRODUCTION

1.1 Social Ecological System in the Gulf of Mottama

The Gulf of Mottama (GoM), the funnel-shaped area sitting on the southwestern coast of Myanmar comprising administrative boundaries of Yangon Region in the west, Bago Region in the north, Mon State in the east, and the Andaman Sea in the south, is one of the most dynamic intertidal systems in the world (MIMU, 2019). The dynamic turbid area is due to annual transportation of about 350 million tonnes of sediments from Sittaung River, Thanlwin River, Irrawaddy River and Yangon River (Robinson *et al.,* 2007). The magnitude of water flowing from the rivers create a "tidal bore", a tide at a speedy flow of roughly 3 metres per second which can temporarily reverse the flow of the river. As a result, the waves flowing upstream with a tidal range of 7 metres erode the coastline and create a highly productive yet largest known area of perennial turbidity with up to 4,500,000 Ha (GoMP, 2018).

Figure 1.1. The satellite image of the Gulf of Mottama acquired on November 07, 2022 (Source: NASA Worldview)

This dynamic hydrological regime creates one of the largest intertidal mudflats in the world which expands over 130,000 Hectares (Kyaw Htet Aung, 2022). The mudflats are rich in nutrients supporting food for bottom dwelling benthic communities including commercially important mud crab (*Scylla serrata*), calms, molluscs and a variety of estuarine fish species (GoMP, 2018). Therefore, it attracts 150,000 residents and migratory shorebirds especially from East Asian Australian Flyway (EAAF) to winter in the GoM including critically endangered Spoon-billed sandpiper (*Calidris pygmaea*) and other IUCN red list migratory bird species (Zöckler, C., *et al.,* 2014). On the boundaries of the stabilised mudflats are coastal grassland which is dominated by *Oryza minuta* (locally known as Nat Sa Pa). Although there is about 35,000 Ha of coastal grassland (Kyaw Htet Aung, 2022), the species, distributions, ecological roles and functions of coastal grassland in the GoM are poorly understood but there is local ecological evidence of habitat use from shorebirds and mud crabs. The mangroves in the GoM are in the phase of active accretion and therefore, only sparse distribution of patches of mangroves occur in the mouth of the gulf. So, there are no mangroves in Bilin and Kyaik Hto townships of Mon State and Waw and Thanatpin townships of Bago Region. In total, there are about 12,810 Ha of mangroves in the GoM with about 13 true mangrove species distributed on the eastern bank of the gulf and mostly dominated by *Avicennia* species (WIF, 2021, Khin Aye Maw *et al.,* 2021) (See Figure 1.2).

Surrounded by these coastal wetland ecosystems, the waters of the gulf are important habitats as well. The waters of the upper GoM are largely brackish, with substantial freshwater discharge and turbidity, while the lower GoM is more marine (GoMP, 2018). They are important habitats for aquatic and marine species including commercially important fish stocks. There are about 39 fish species (Thazin Htet, 2017) and 3 marine mammal species (Yin Yin Htay *et al.,* 2019). One of the marine mammals in the GoM is Irrawaddy Dolphin (*Orcaella brevirostris*) which is critically endangered and the other two species are vulnerable in the IUCN red list.

Due to the unique ecosystems and enriching biodiversity of the gulf, about 70,000 people in about 86 villages are inhabiting within 2km - 5km from the coast and creating social ecological systems of the gulf (GoMP, 2018). Many of these coastal villages are relatively remote. Major livelihoods are fishing, farming, livestock rearing, as well as casual wage labour depending on work opportunities.

The gulf support major source of income by supporting capture fisheries of economically important fish species such as Croaker (*Johnius belangerii*), Toli shad (*Tenualosa toli*), Hilsa shad (*Tenualosa ilisha*), Seabass (*Lates calcarifer*), Threadfin (*Polynemus indicus*), Sea catfish (*Arius thalassinus*), Mullet (*Liza parsia*), Whiting (*Sillago* sp), Bombay Duck (*Harpadon nehereus*), and mixed species of prawns. Fishing grounds include river channels, seasonal riverine lakes, estuaries, inundated paddy fields and low-lying areas, perennial lakes and tanks, irrigation canals and tributaries, and the sea. In Bago Region, fisheries are primarily freshwater, while coastal fisheries are much more important in Mon State (Salagrama, 2015). In addition, the mudflats and coastal grassland support mud crab harvesting as a valuable source of income for small-scale fishers, women, and landless households. Although the mangroves in the GoM are in the early successional stage and occur in low diversity, mangrove patches are still locally important as recognized by local community members. The local people recognize that mangroves are important habitat for fisheries species including mud crab, provide firewood for household use, protect from coastal erosion, and support some medicinal plants and edible plants (EDF, 2019). Therefore, the GoM is not only supporting important ecosystems for its biodiversity but also providing resources required for well-being of coastal communities and these social ecological systems are closely linked and interdependent to each other. The importance is recognized as the fourth Ramsar site of Myanmar expanding an area of 161,030 Ha of the GoM in 2017.

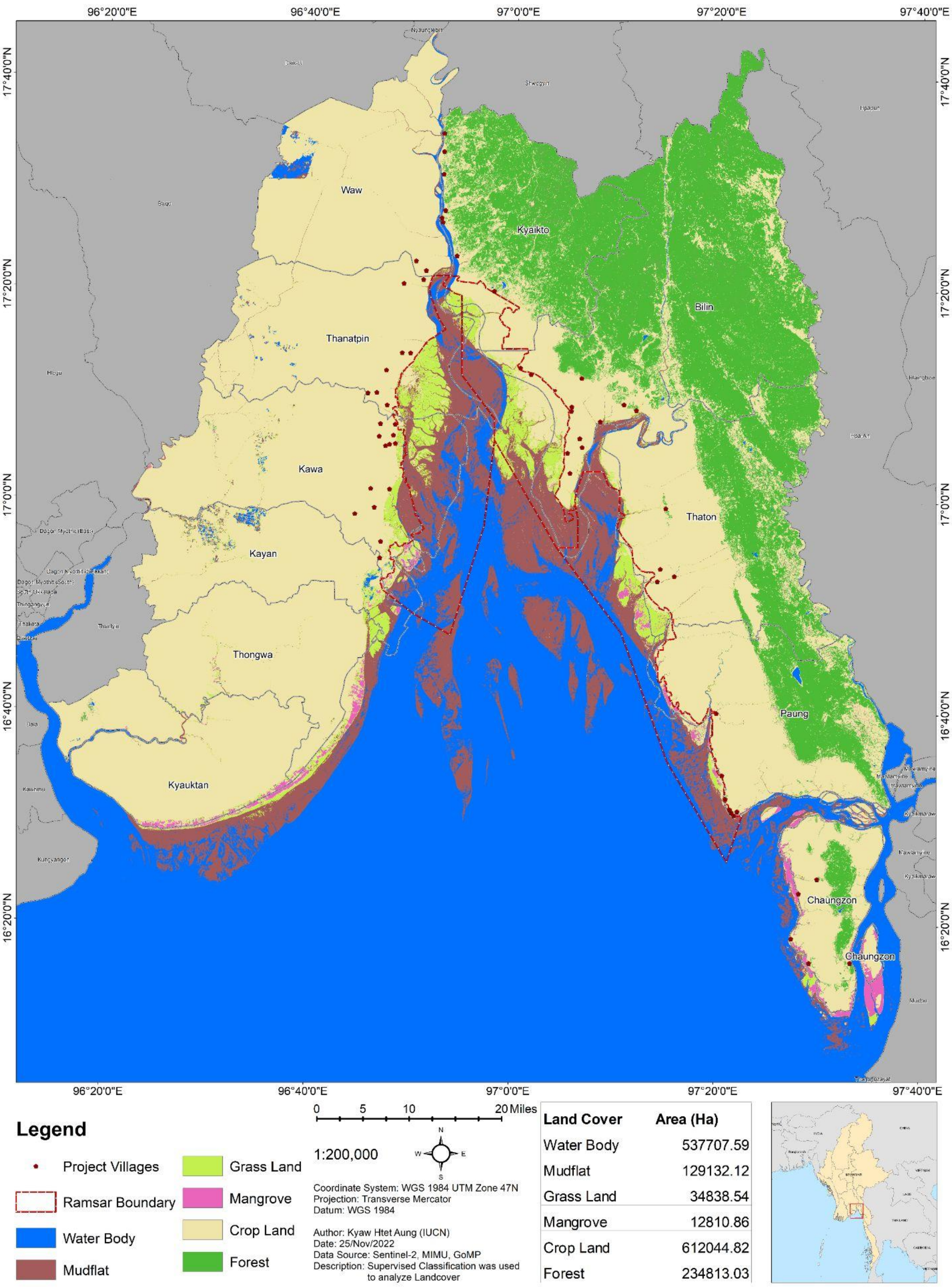


Figure 1.2. Land cover map of the Gulf of Mottama showing the extent of four major coastal ecosystems (Kyaw Htet Aung, 2022).

1.2 Threats to Ecosystems

The coastal wetland such as GoM plays a significant role to improve socio-economic conditions by growing household income, provide food security, and support overall well-being of the community dependent on its ecosystems. However, the excessively dependence of social systems on the ecological system imposes greater conservation threats for the sustainability of these ecosystems. In the GoM, the major threats are identified as change in the geophysical system of the gulf, overexploitation of coastal natural resources, and alteration and degradation of coastal ecosystems (GoMP, 2018).

Naturally dynamic geophysical and hydrological system of the gulf is a major factor for substantial erosion cycles causing one side of the bank to erode and accrete sediments and form new land on the other side of the bank. This natural threat caused over 10 villages and thousands of hectares of agriculture to wipe out and resulted in displacement of local communities.

Unsustainable extraction of openly accessible resources in the gulf is regarded as one of the immediate threats to the biodiversity of the gulf. In the past decade, the increasing demand on fishery products led to overfishing and appliance of different types of illegal fishing gears which resulted in declining fish stocks. The widespread use of different gears also causes bycatch of marine megafauna such as sea turtles and marine mammals.

In addition, the conversion of coastal ecosystems into farmland for rice cultivation is a major cause for ecosystem change and degradation. From 2016 to 2022, about 17,645.19 Ha of coastal ecosystems are converted into cultivated land (Kyaw Htet Aung, 2022). However, these lands are mostly acquired by wealthy and influential people in or outside of the community and exposed to conflicts in land tenure among groups in the communities. The adverse impacts of alteration of ecosystems not only eliminate biodiversity but also endanger the livelihood opportunities of communities especially marginalised people whose income mainly depends on extraction of resources. Moreover, the other factors affecting the degradation of the ecosystem include construction of bridges, sand mining, pollutants from upstream sources, and deforestation within catchments of the waterways especially Sittaung River.

1.3 Critical Knowledge Gaps

In order to conserve the unique biodiversity of the GoM from anthropogenic threats and sustainably develop the well-being of communities, Gulf of Mottama Project (GoMP) is advocating the wise use of natural resources by supporting sustainable natural resource management activities, alternative livelihood opportunities to strengthen the resilience of local communities and community-based conservation initiatives. Since 2018, the project is implementing several approaches such as establishment of community forests for mangroves (200 Acres of mangroves in Kar Te, Paung Township), plantation of mangroves (about 10,000 plants in Paung and Thaton Township), development of fishery co-management area, setting up conservation areas for mud crabs (50 Acres of mudflat off Aung Kan Thar, Thaton Township), and raising awareness to the communities in the area in order to sustain the wise use of coastal resources and ecosystems. With the advocacy from local communities, the state government declared a protected public forest which covers 1,000 Ha of mudflat, coastal grassland, and mangroves in Thaton Township.

Starting in 2021, the project initiated the Ecosystem Approach to Fishery Management (EAFM) for more integrated management of coastal resources from ecosystem approach. As EAFM is an integrated approach for coastal management through the lenses of ecosystems, more in-depth knowledge regarding the ecosystem services in the GoM need to be well documented and shared effectively through different stakeholders.

In addition, the dynamic nature of the tidal channels in the gulf resulted in severe coastline regression, at immense rates and over large distances. It creates erosion in one side of the bank while creating accretion on the other side due to sedimentation. These changes are as frequent as the cycles repeats each 10 to 15 years according to anecdotal reports. These issues raise on how to allocate villages in eroded regions and how the new land should be managed in accreted regions. Therefore, more intensive knowledge to support decision making for thousands of hectares of newly formed land for effective coastal land use planning.

The above information suggests a need to understand the economic values of coastal ecosystems in the GoM to support decision making for the coastal land use planning in the area.

1.4 Ecosystem Services

The concept of ecosystem services provides a useful framework to identify the importance of the natural environment to humans. The term "ecosystem services" has been defined in several different ways (see summary of definitions in Box 1) but put most simply, they are the variety of benefits that humans obtain from the environment.

Ecosystems contribute to human well-being in a wide variety of ways and the processes by which ecosystems provide benefits to people has been described as an "ecosystem services cascade" in which bio-physical structures and processes ("ecosystem functions") can deliver inputs (ecosystem services) to the production of goods and services that are consumed by people (see Figure 1.3).

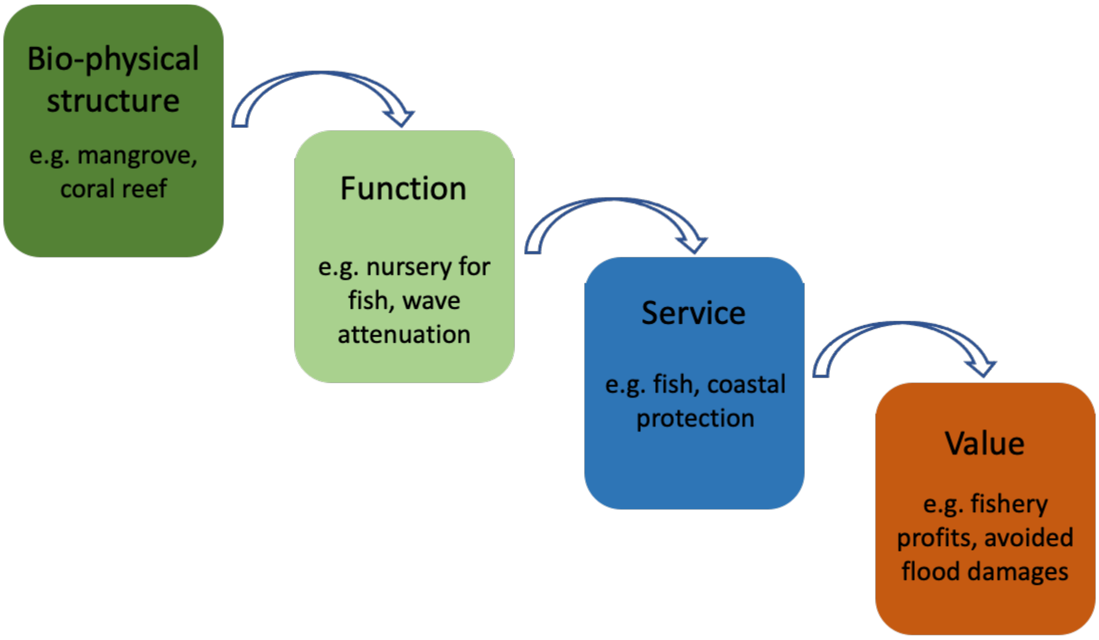


Figure 1.3. Ecosystem services "cascade". Adapted from Haines-Young and Potschin (2010).

Ecosystem services can also be viewed as the flow of benefits received from "ecosystem capital" – see Figure 1.3. Ecosystem capital is a component of natural capital, which can be defined as the stock of natural assets that provide society with renewable and non-renewable resources and a flow of ecosystem services. Natural capital includes abiotic assets (e.g., fossil fuels, minerals, metals) and biotic assets (ecosystems that provide a flow of ecosystem services). The biotic component of natural capital is termed ecosystem capital. Natural capital is analogous to build capital (e.g., transport infrastructure), human capital (e.g., a skilled and educated workforce) or social capital (e.g., rules, norms, and trust) as an input to the production of goods and services that humans consume. Natural capital may be both a complement to other forms of capital (i.e., used in combination with them to produce goods and services) or a substitute (used instead of other forms of capital).

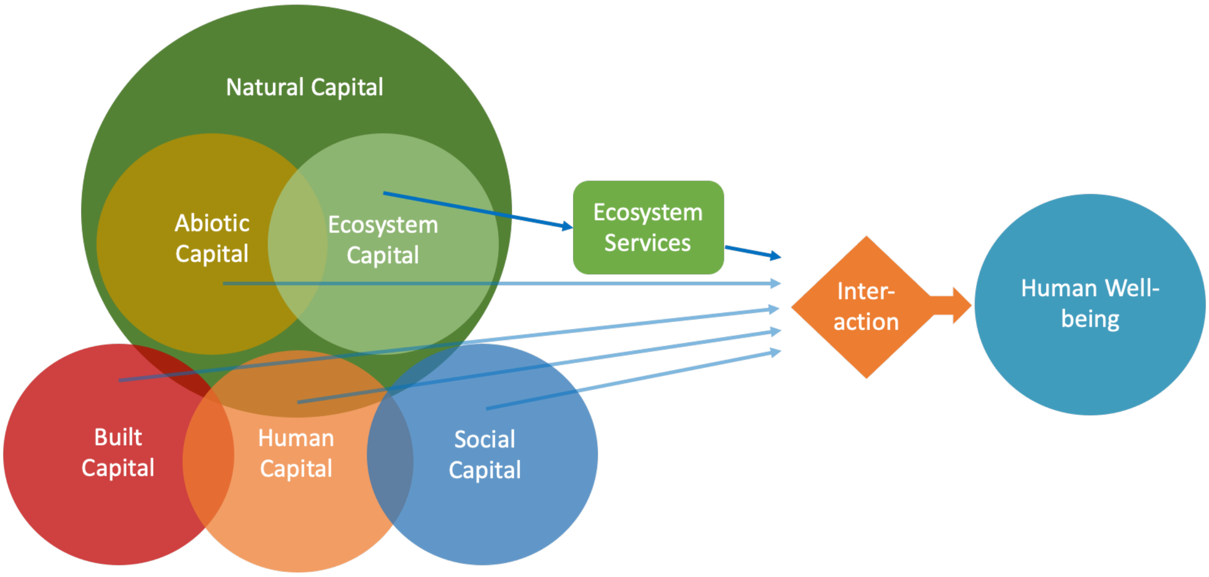


Figure 1.4. Interactions between natural, abiotic, ecosystem, built, human and social capital to contribute to human well-being. Adapted from Costanza et al. (2014).

Box 1. Defining ecosystem services

The conceptualization and understanding of ecosystem services has gradually been refined over the past 20+ years and a number of different definitions have been provided by different initiatives. These include:

- Ecosystem services are the benefits that ecosystems provide for people (Millennium Ecosystem Assessment – MA 2005).
- Ecosystem services are the direct and indirect contributions of ecosystems to human well-being (The Economics of Ecosystems and Biodiversity – TEEB; Kumar 2012)
- Ecosystem services refer to those contributions of the natural world that are used to produce goods which people value (UK National Ecosystem Assessment – UKNEA, 2011).
- Ecosystem services are the contributions that ecosystems make to human well-being (Common International Classification of Ecosystem Services – CICES; Haines-Young and Potschin 2012).
- The US Environmental Protection Agency (US EPA) uses the term "final ecosystem goods and services" (FEGS) to mean "components of nature, directly enjoyed, consumed or used to yield human well- being" (Landers and Nahlik, 2013).
- The EU Mapping and Assessment of Ecosystems and their Services (MAES) working group defines ecosystem services as "the contributions of ecosystem structure and function (in combination with other inputs) to human well-being" (Burkhard and Maes, 2017)
- The International Panel of Biodiversity and Ecosystem Services (IPBES) introduced an additional term for ecosystem services – "nature's contributions to people" (NCP) – to describe the contributions, both positive and negative, of living nature (diversity of organisms, ecosystems, and their associated ecological and evolutionary processes) to people's quality of life (Diaz et al., 2018).

The Millennium Ecosystem Assessment (MA, 2005) classified ecosystem services into four categories, as follows:

- Provisioning services are the "products obtained from ecosystems" (e.g., food and raw materials);
- Regulating services are the "benefits obtained from the regulation of ecosystem processes" (e.g., protection from flooding and storms, nutrient recycling);
- Cultural services are the "non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences" (e.g., recreation, inspiration for art and design, and appreciation of the existence of diverse species); and
- Supporting services "are necessary for the production of all other ecosystem services" (e.g., soil formation and oxygen production).

The inclusion of supporting services in ecosystem service assessments can potentially lead to double counting of values (Fisher and Turner, 2008) this category has therefore been omitted from more recent classification systems (e.g., The Economics of Ecosystems and Biodiversity – TEEB; Common International Classification of Ecosystem Services – CICES; and the System of Environmental Economic Accounts SEEA EA reference list).

1.5 Total Economic Value

The concept of Total Economic Value (TEV) is used to describe the comprehensive set of utilitarian values derived from a natural resource. It is useful for identifying the different types of value that may be derived from an ecosystem. TEV comprises use values and non-use values. Use values are the benefits derived from physical use of the resource. Direct use values may derive from on-site extraction of resources (e.g., fish, crabs, molluscs, fuel wood) or non-consumptive activities (e.g., recreation). Indirect use values are derived from off-site services or other processes that are impacted by the resource (e.g., protection from coastal flooding). Option value is the value that people place on maintaining the option to use a resource in the future (e.g., the option to develop ecotourism).

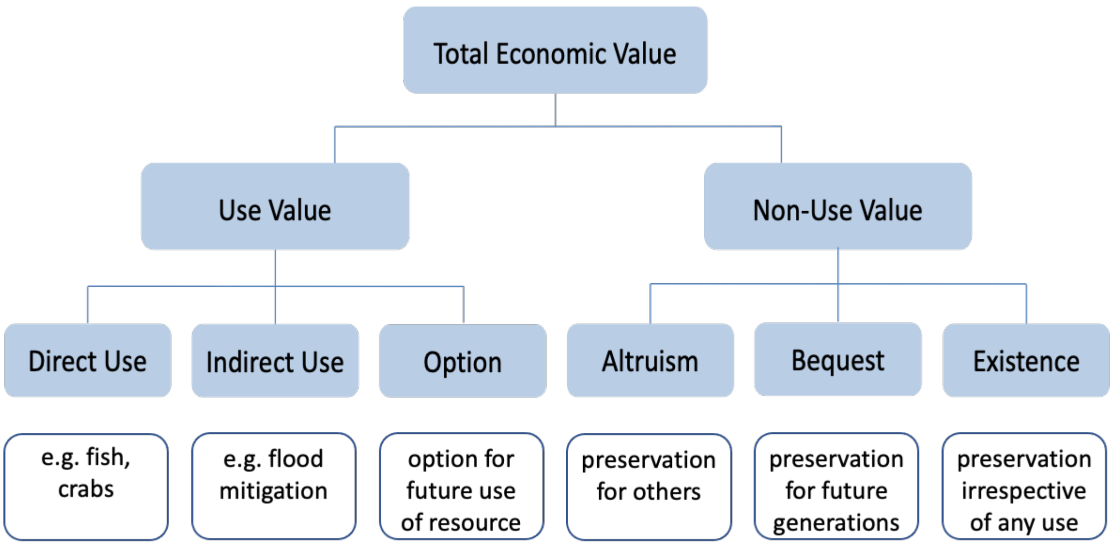


Figure 1.5. Components of Total Economic Value. Adapted from Pearce and Turner (1990).

Non-use values are derived from the knowledge that an ecosystem is maintained without regard for any current or future personal use. Non-use values may be related to altruism (maintaining an ecosystem for use by others), bequest (for future generations) and existence (preservation unrelated to any use) motivations. The constituent values of TEV are represented in Figure 1.5. It should be noted that the "total" in Total Economic Value refers to the inclusion of all components of utilitarian value rather than the sum of all values derived from a resource i.e., the TEV framework can be used to assess marginal changes in value as well as total values.

1.6 Ecosystem Valuation

Economic value is simply a means to describe how important the things we use are to us, including our use of the natural world or "natural capital". In the case of ecosystem services from the coastal and marine environment, there are often no prices that reflect their value, since the services that are provided are not traded in markets (e.g., subsistence use of harvestable resources, climate regulation, coastal protection, biodiversity). As a result, we tend not to take the value of ecosystem services into consideration when we make decisions that affect the marine and coastal environment. When we investigate the consequences of environmental change (e.g., climate change, development, marine accidents) we need to fully understand the effects on ecosystem services and human well-being. Economic valuation tries to measure the importance of environmental change, usually in monetary terms, in order to communicate the scale of impacts to human well-being. Such information can be used to raise awareness of the economic importance of marine ecosystems, set fees for the use of marine ecosystem services, or determine compensation payments for environmental damage.

Economic valuation of ecosystem services involves identifying and quantifying the contribution of environmental resources to human well-being; and incorporating this information into decision-making and the design of financing mechanisms and policy instruments.

Economic valuation methods do not stand alone but are often used in combination with other methods for assessing environmental change and the provision of ecosystem services. The added value of using economic valuation methods is that the importance of ecosystem services is expressed in terms of human welfare and measured in common units (i.e., money), allowing values to be aggregated across ecosystem services and directly compared with the values of other goods and services in the economy.

Economic valuation of ecosystems involves quantifying the contribution of ecosystems to human wellbeing. It builds on the conceptualisation of nature as a productive asset - natural capital - which provides humanity with a flow of inputs into production and consumption - ecosystem services (Dasgupta, 2021). Economic values are generally measured and communicated in monetary units in order to enable comparison with the value of other resources, costs and investments in the economy.

Estimating the economic values of ecosystems can help to support better decision-making and resource management. Ecosystem services contribute substantially to human welfare and, in some cases, are fundamental to sustaining life (e.g., climate regulation and nutrient recycling). The underlying natural capital is, however, finite and cannot necessarily be regenerated or replaced. With growing human populations, and consumption per capita increasing over time, it is often the case that the human use of renewable resources outstrips their natural rate of regeneration (i.e., human use is ecologically unsustainable).

Such resource limitations mean that we must constantly choose between alternative uses of available resources. Every time a decision is made to do one thing, this is also a decision to avoid another – value is implicitly placed on each option. If the valuation of alternative resource uses is unavoidable in making decisions, it is arguably better to make these values explicit and ensure that decisions are transparent and well informed.

1.7 Goals and Objectives

The Gulf of Mottama Project (GoMP) is working to facilitate integrated, ecosystem approach management of natural resources in the area. In order to develop more compelling, evidence-based decision-making in land use and other natural resource management decisions, a stronger base of information and analysis about the value of various ecosystems in the GoM. Therefore, the study is conducted with the aim to identify the economic values of four major types of ecosystems in the GoM: mangroves, mudflats, coastal grasslands, and rivers and/or sea and compare how these values may be provided by rice fields. The key objectives of the study are as follow:

- To identify the total economic values of coastal ecosystems in the Gulf of Mottama with emphasis on direct use of the ecosystems (primarily includes "provisioning" services) and other services provided by the ecosystem (less directly tangible ES such as protection, regulation and supporting services),
- To assess the status and condition of the coastal ecosystem including local extent, trends over the past 10 years and the drivers of the trend, and
- To compare these economic values with the revenues provided by rice fields converted from the coastal ecosystems.

2 METHODOLOGY

2.1 Study Area

In this action research, the study sites were identified based on where four major ecosystems: mangroves, mudflats, coastal grassland, and river/sea are located. In coordination with township clusters coordinators (TCCs) and community facilitators and monitors (CFMs) of the Gulf of Mottama Project (GoMP), the study conducted data collection from 8 villages of five townships as shown in Figure 2.1. The three villages in Chaung Zone: Ta Ka Mar, Taw Pon and Chaung Pauk shared the same ecosystems, and they were under the same village administration. Therefore, these three villages are combined as "Taw Ka Mar" in the study.

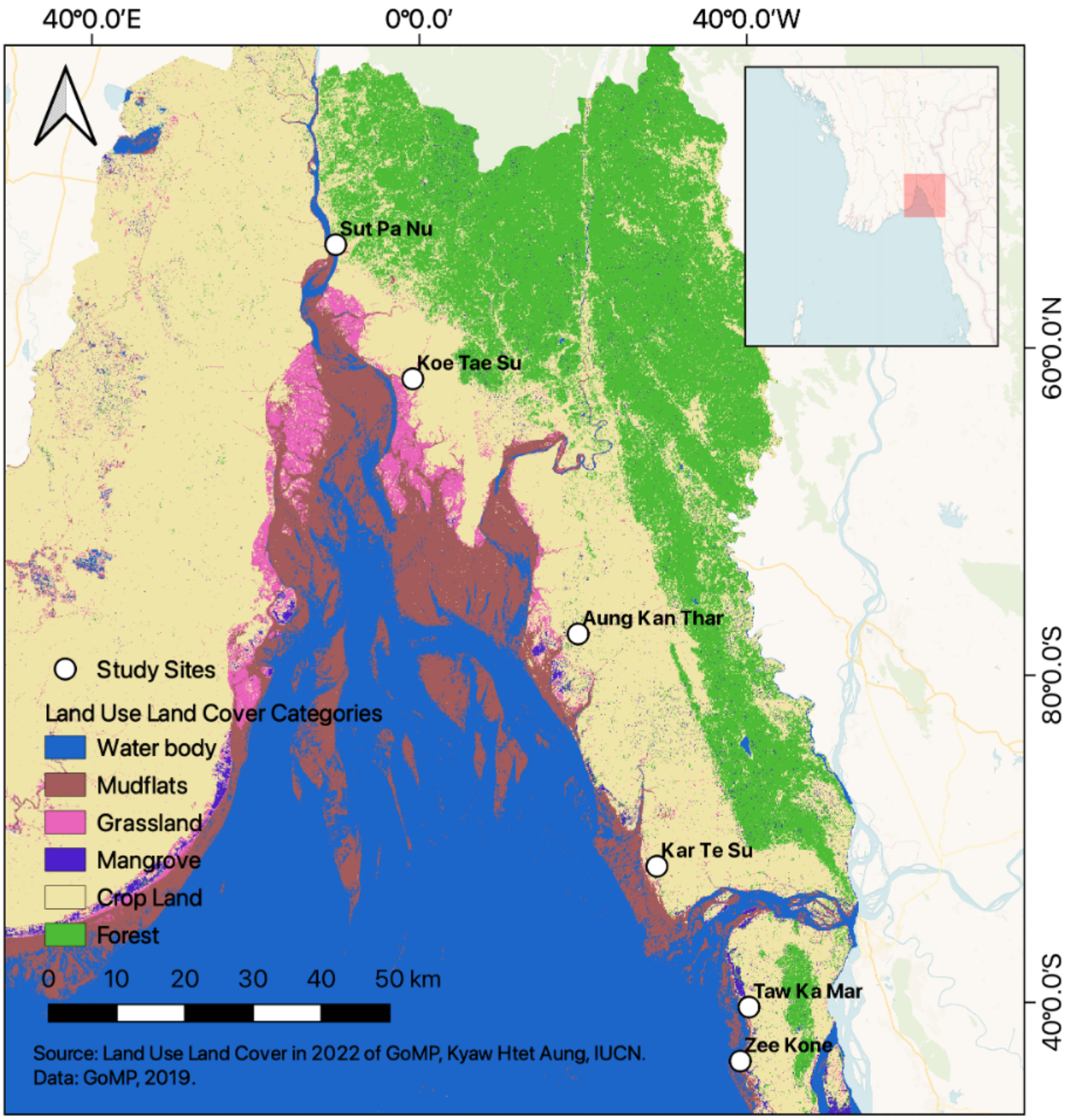


Figure 2.1. Map showing the villages where the study was conducted. The base map shows different types of ecosystems in the study area.

2.2 Methods

The study applied quantitative methods to identify the economic values of ecosystem services from four major types of ecosystems and comparable values if these ecosystems are converted into farmland. It also equipped a qualitative approach to understand community values, experiences, and perceptions on these ecosystems as well as to explore community feelings on converting these ecosystems as farmland. The field survey applied two methods: key informant interview (KII) and household in-depth interviews (HH). The field visits were conducted from April 2021 to May 2022. In conducting field research, the field researchers from MCCL @ Point B Design + Training were trained in the economic valuation process of ecosystems, interviewing, and data enumerations. The field activities, data enumerations, data management and quality control were supervised and managed by the research officer of the GoMP.

2.2.1 Key Informant Interviews

In order to gain general context of the community and ecosystems, 1-2 key informant interviews were conducted with village leaders and/or community leaders in each village. The interview is to gain an overview description on resource use patterns, problems and conflict resolution in resource use and extraction, economic importance of the habitats, service and benefits provided by the ecosystems. In addition, to get market prices of trading goods extracted from resources, market interviews were conducted to local traders, fish, and crab collectors in each village.

2.2.2 Focus Group Discussion

In each village, one FGD was facilitated with participants pre-selected by the GoMP or VDC due to coordination issues with the community. In each group, a total of 5-6 participants (2-3 males and 2-3 females) participated. Each discussion took 45-60 minutes by applying the visual tools to discuss: the resources communities are extracting, types of activities and tools involved in extraction of resources, primary and secondary users for these activities, and the key problems facing in extraction of these resources.

2.2.3 Household Surveys

The research team designed semi-structured questionnaires to collect personal information of respondents, household income, sources of income, and wealth, dependence on ecosystem services (mainly focused on provisioning services and regulating services), changes in ecosystems and feelings on converting of these ecosystems as farmland (See **Appendix 1** for Household Survey instrument). In order to get information on revenues from farmland, separate interviewers for farmers who are currently working in converted farmland are also surveyed.

In each village 20-30 households were selected through convenient sampling. Representatives from different livelihoods, social status, gender, religion, and social groups were selected to gain diverse perspectives from the community. The sample size for each village is shown in Table 2.1. Each interview was conducted by 2-3 trained interviewers and took from 30 – 45 minutes to complete the questionnaire.

2.3 Data Analysis

The field data were entered into Excel immediately following data collection. The quantitative data were analysed in SPSS and Excel using simple descriptive statistics. To analyse qualitative data, the team mainly applied thematic analysis by coding the data using Excel. For each piece of qualitative information, different codes were assigned from a standardised list of codes to identify the main theme covered by that piece of information. Then, they were quantified and evaluated the insights provided by the data.

Table 2.1. Sampling frame showing total number of households, sample size and percentage of total household for questionnaires conducted in the study.

Villages	Townships	Total households*	Sample size	Percentage of total household
Kar Te	Paung	130	30	23%
Sut Pa Nu**	Kyaik Hto	314	12	4%
Koe Tae Su	Bilin	108	30	28%
Aung Kan Thar	Thaton	230	35	15%
Taw Ka Mar***	Chaung Zone	82	23	29%
Taw Pon***	Chaung Zone	20	7	35%
Kwin Pauk***	Chaung Zone	20	6	30%
Zee Gone	Chaung Zone	162	29	18%

*Data updated by GoMP in 2020.

**The village is a relatively large village with diverse livelihood activities. There are only about 76 households who directly use coastal ecosystems, which is fishing in Sittaung River.

***The three villages have very similar ecosystem services and are closely situated. They are under the same village administration and the three villages are combined as "Taw Ka Mar" in the report.

2.3.1 Household Income from Resource Harvesting

The household survey data were used to quantify total household income from resource harvesting. Total household income comprises of components that are received in money (e.g., from paid employment, remittances, sale of harvested natural resources and other sources) and those that are received directly in the form of natural resources that are consumed by the household (i.e., subsistence use of harvested natural resources) – see Figure 2.1.

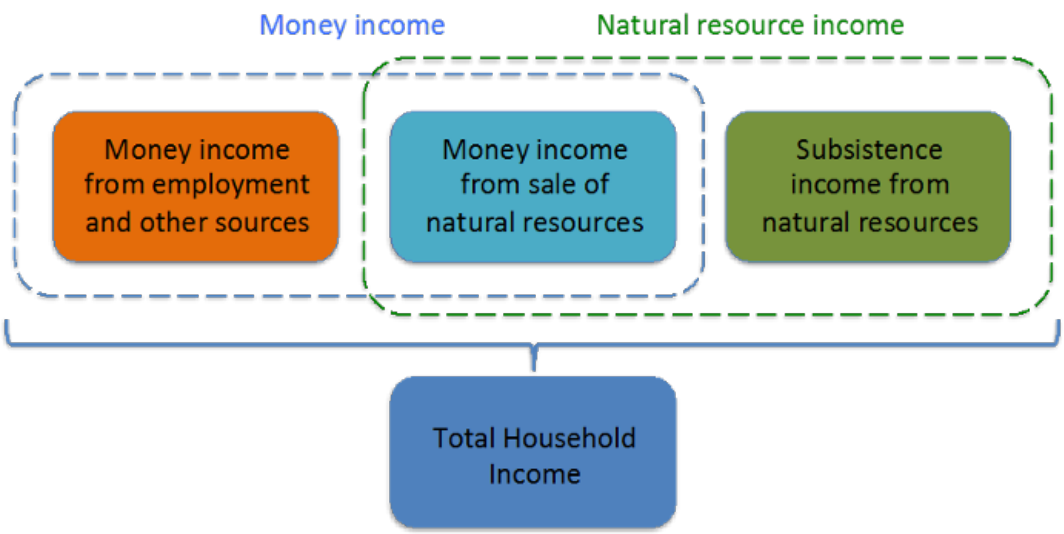


Figure 2.2. Components of total household income.

The analysis in this study focuses on income from natural resources (coastal ecosystems), including both money income and subsistence income. Money income is computed using data on the quantities of each resource harvested, the proportion that is sold, and the market price of the resource. Prices were obtained from a market survey and key informant interviews (See Table 6.1 in Appendix). Subsistence income is computed in a similar way using data on the quantities of each resource harvested, the proportion that is consumed or given away, and the market price of the resource. This approach to estimating subsistence value is based on the assumption that, in the absence of the harvestable resource, households would replace the harvested resources that they consume with a marketed equivalent.

2.3.2 Avoided Damage Costs

Mangroves and other coastal ecosystems mitigate tidal inundation and storm surges. The level of provision of this service is dependent on a number of biophysical factors (e.g., bathymetry, tidal range, slope, storm profile etc.) and socio-economic factors (e.g., population exposed, assets at risk, adaptive capacity etc.). Koch et al. (2009) describe how variation in this ecosystem service is influenced by ecosystem type, extent, condition, and configuration to the assets that are protected.

The value of coastal protection provided by ecosystems is the savings from avoided damages attributable to the role of the ecosystem in mitigating flooding and other hazards. The avoided damage cost method looks at different types of avoided costs including property damage, loss of crops and livestock, missed days of work, and health impacts. The approach involves an assessment of the difference in the extent and value of damages under the current level of protection (with existing ecosystems) versus a baseline or counterfactual level of protection (without ecosystems). The avoided damage cost method requires information on (i) the population, property, and human infrastructure at risk from flood damage, and (ii) the reduction in probability or extent of damages given the presence of ecosystems.

In this study we obtain information on the value of damage costs from natural hazards incurred by households in the sampled villages from the household survey. This provides an estimate of damage costs under the current level of protection provided by coastal ecosystems. To quantify the reduction in the extent of damage attributable to coastal ecosystems, we use a non-linear function derived from Koch et al. (2009) that relates the extent of mangrove cover to the value of avoided damages. We generalise this function to relate the percentage of mangrove cover to the % reduction in damages. This non-linear function reflects a declining marginal effect of additional mangrove extent on avoided damage costs. Although all coastal ecosystems can have a functional (and complementary) role in the mitigation of flood damage, this analysis focuses on mangroves because the literature on the role of mangroves is more developed and provides the necessary quantitative information to measure the relationship between ecosystem extent and reduced damage costs. This approach is therefore conservative and avoids potential double counting of values of protection provided by combinations of coastal ecosystems.

3 RESULTS

3.1 Ecosystem Services from Coastal Ecosystems in GoM

The ES from the coastal ecosystems of GoM identified in the FGDs of the study are summarised in Table 3.1. The mentioned ecosystem services are provisioning, regulating and some of cultural services. The provisioning services from mangroves, mudflats and coastal grassland are very similar but mangroves reportedly provide more regulating services.

Table 3.1. Identified ecosystem services from four major types of ecosystems in GoM from FGD with communities

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

There is no mangrove in Bilin and Kyaik Hto townships and dispersed and successional patches of mangroves were found in Paung township. In Chaung Zone, the mangroves patches are denser and so more prominent ES are gained in communities in Chaung Zone. Mud crabs and molluscs are common products directly extracted from mangrove and some communities also produce small fish (such as mullets and striped dwarf catfish). Taw Ka Mar and Zee Gone extract firewood for both household use and selling especially to use as fuel in boiling shrimps and household use. In the mangrove forest of Taw Ka Mar, *Catenella sp.* of seaweeds were extracted. Communities believe that the presence of mangrove protects from storm surges, erosion, and attenuate waves. Taw Ka Mar has some visitors who are interested in mangroves and communities in FGD stated the potential for tourism development.

The ES from mudflats and coastal grasslands are very similar as people produce mud crabs and fish for the whole year round and molluscs in some months. In some villages, people fish along the creeks in the mudflats or grassland or during high tide. The target fish includes mullets, Pama croaker and paradise threadfin. Except Sut Pa Nu, all the villages have access to ES from mudflats and grassland. However, the areas on the mouth of Sittaung River (upper part of the gulf) have extensive mudflats associated with coastal grassland in the landward boundaries of mudflats. Therefore, the resources extraction from mudflats and grassland are more prominent in such regions than the lower part of the gulf. The assumed regulating service is attenuation of storm waves. In addition to direct use, the community expresses that these ecosystems are important for shorebirds including critically endangered spoon-billed sandpipers (*Calidris pygmaea*).

The study villages are all in close proximity to the river or sea and therefore, they all access to ES from river and sea. Fish and shrimps are the main resources harvested by the communities. The main target fish species include hilsa shad, Pama croaker, paradise threadfin, and Bombay duck. In addition, these water channels are very important for navigation purposes of the community as well.

3.2 Household Survey Demographic Overview

The study conducted a total of 170 household interviews, 6 focus groups discussions, 12 key informant interviews and 17 farmer interviews in 6 villages of 5 townships in Mon State of the Gulf of Mottama. A total of 94 men (55.29%) and 76 women (44.71%) participated in household interviews as shown in Figure 3.1. The age group of most respondents were 41 – 50 years (n = 51) and the second was 31-40 years (n = 46). Different age groups of respondents in each village are illustrated in Figure 3.2. More than half of the respondents (51.2%) are original residents and spent their whole lives in their respective communities.

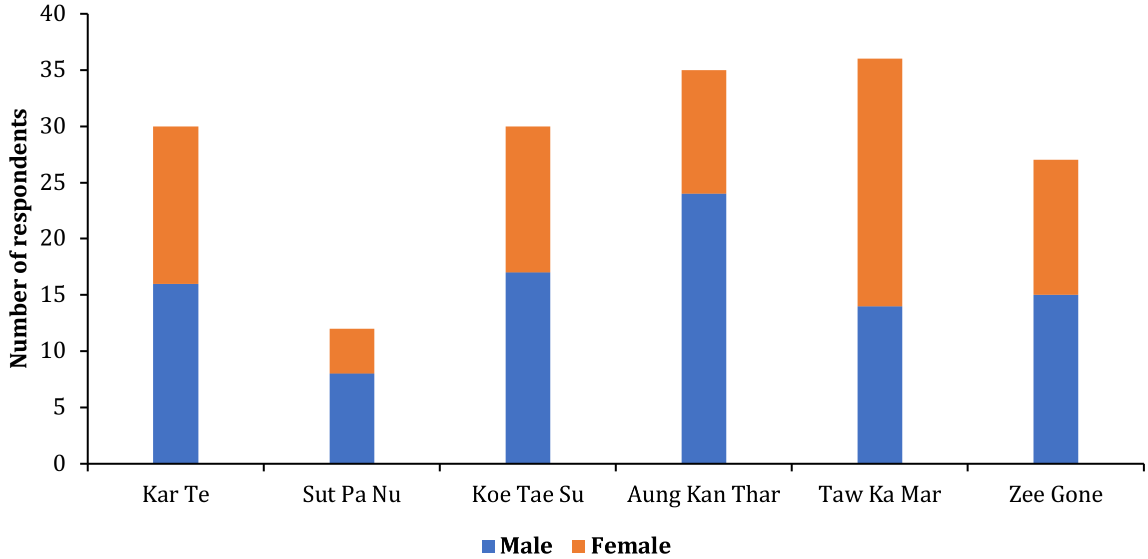


Figure 3.1. Number of males and females participated in each village in the household survey

The farmers included in the survey are owners of farmland and currently working on farming or leasing their land. All the farmers were from Koe Tae Su (n = 8) and Kar Te (n = 9) as only these villages have farmlands extracted from mudflats and coastal grassland.

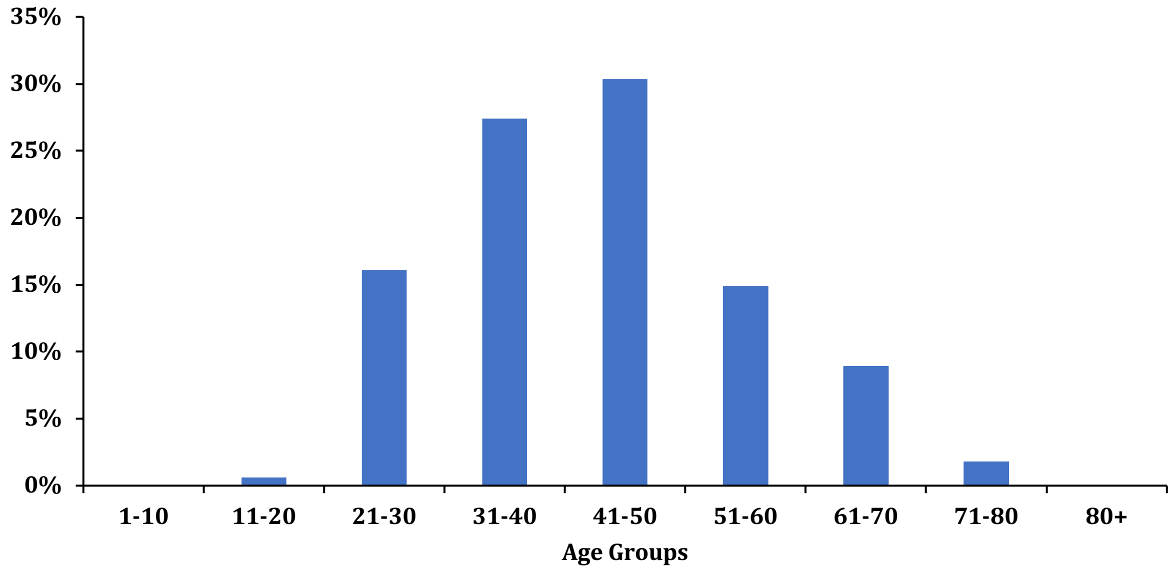


Figure 3.2. Percent of respondents from different age groups participated in the household survey

The mean annual household money income from all livelihood activities for the whole sample is 2,377,825 MMK (~1,700 USD). The mean annual household money income from each village is shown in Figure 3.4. Sut Pa Nu has higher annual income (2,908,333 MMK/ ~2,154 USD) and Taw Ka Mar has the lowest with 1,350,000 MMK (~643 USD) annually.

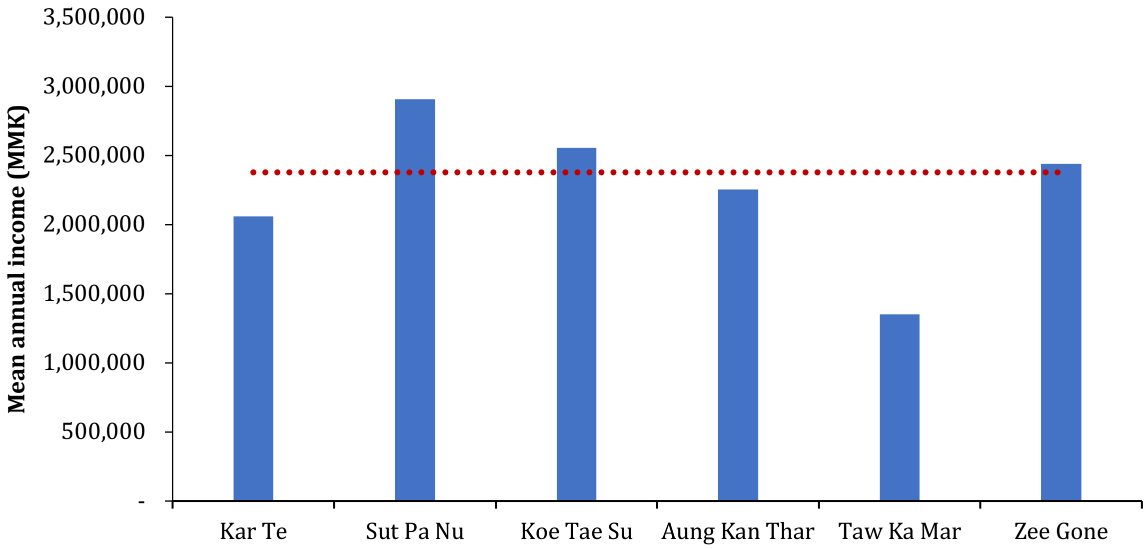


Figure 3.3. Mean annual income per village. The red dotted line represents the mean annual income (2,377,825 MMK/ ~1,700 USD) for the whole sample.

3.3 Economic Values of Provisioning Services

3.3.1 Resource harvesting

The proportion of households that harvest resources (fish, crabs, mollusc, and shrimps) from each ecosystem type are presented in Figure 3.4. This shows that a high proportion of household harvest resources from coastal ecosystems and that some ecosystems are more widely used than others. In all villages, a high proportion of households (47-85%) harvest resources from rivers and the sea. Mudflats are also widely used, except in the case of Sut Pa Nu. A high proportion of households (83%) at Taw Ka Mar harvest resources from mangroves.

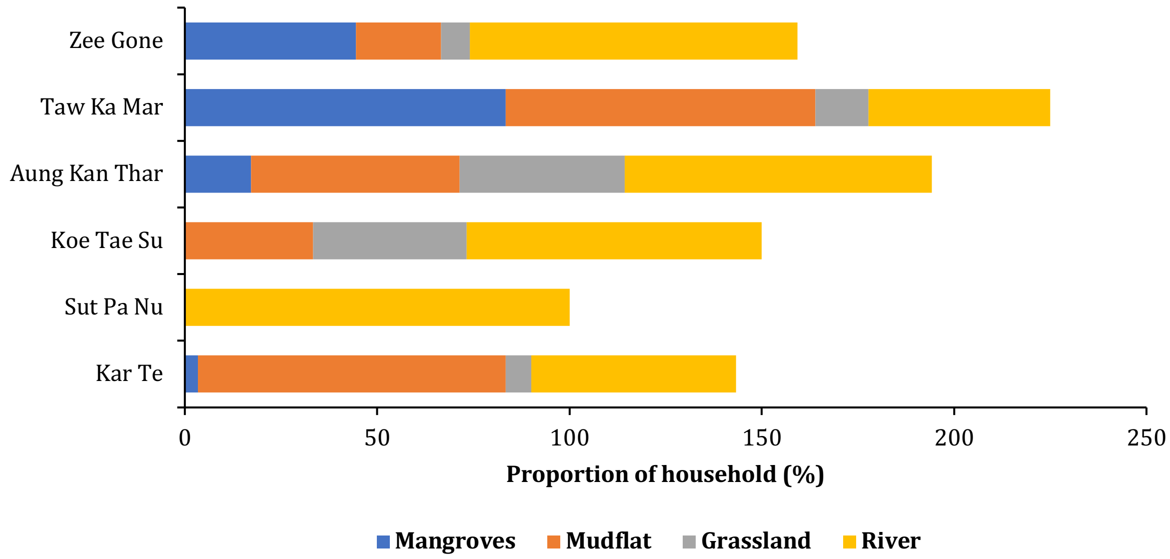


Figure 3.4. Proportion of households extracting resources from each ecosystem

The mean annual income from harvesting of resources is shown in Figure 3.5. Annually, the mean income per household from fishing is 1,067,364 MMK (~508 USD), 456,325 MMK (~217 USD) from mud crab, 142,841 MMK (~68 USD) from shrimps and 56,457 MMK (~27 USD) from mollusc.

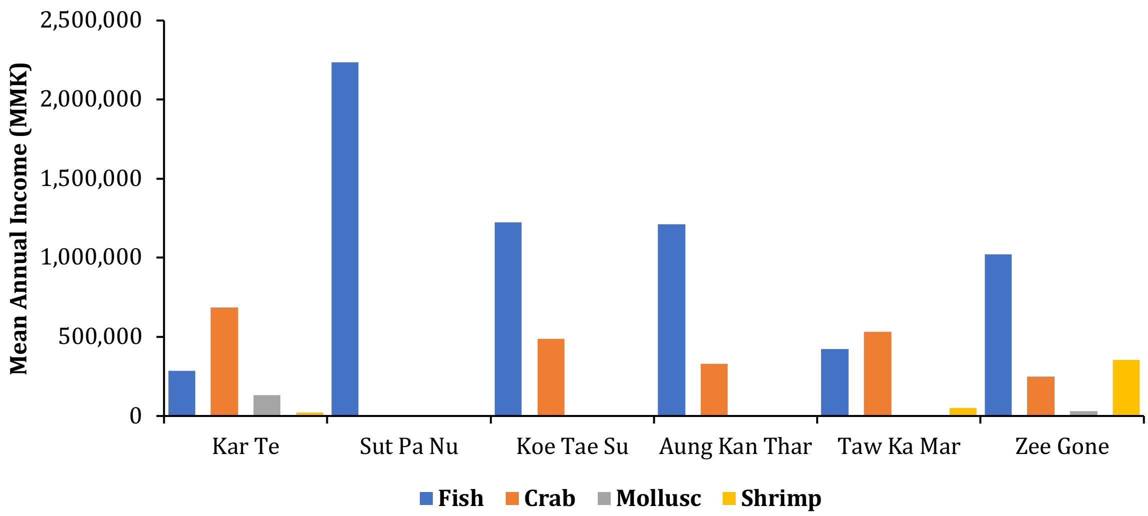


Figure 3.5. Mean annual income from harvesting of resources.

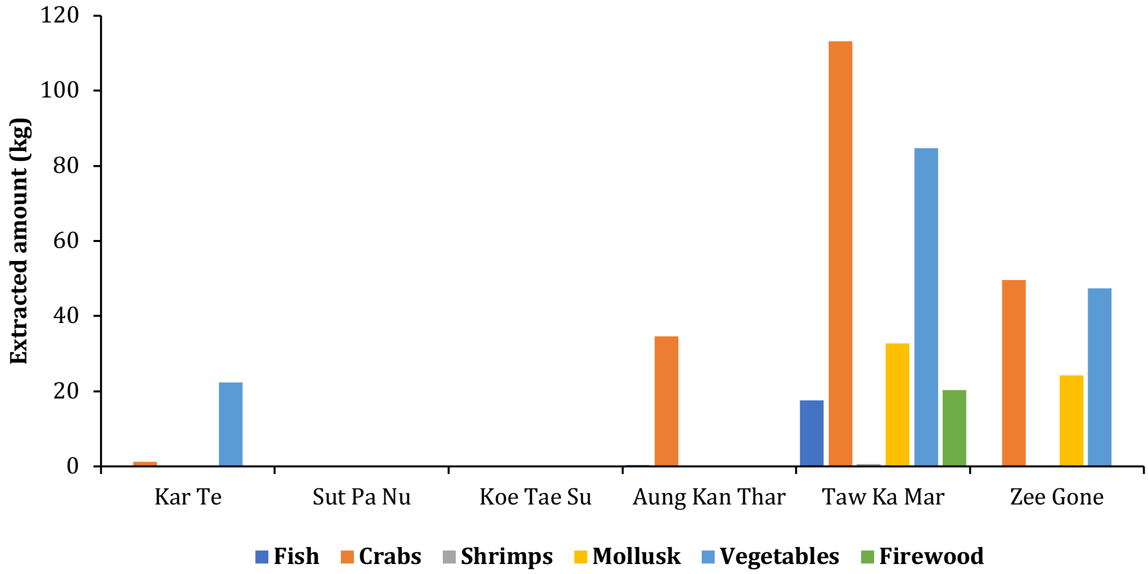
3.3.2 Mangroves

There is considerable variation across the sampled villages in terms of the quantity of resources harvested from mangroves. Due to proximity with denser patches of mangrove forests, communities in Chaung Zone (Taw Ka Mar and Zee Gone) harvest a variety of mangrove resources including fish, crabs, molluscs, vegetables (seaweeds), and fuelwood. Kar Te harvest vegetables and Aung Kan Thar extract mud crabs in the mangroves (see Figure 3.6 (a)). Mud crabs were the most harvested resource with an annual average household harvest of 113.255 kg in Taw Ka Mar, 49.597 kg in Zee Gone, 34.608 kg in Aung Kan Thar and 1.149 kg in Kar Te. In Taw Ka Mar, Zee Gone and Kar Te, the annual average household harvest of seaweed is 84.78 kg, 47.413 kg, and 22.4 kg respectively. Taw Ka Mar and Zee Gone also glean molluscs with an annual average household harvest of 32.808 kg and 24.183 kg per year. A small quantity of fish (average harvest per household 17.597 kg) was produced in Taw Ka Mar annually.

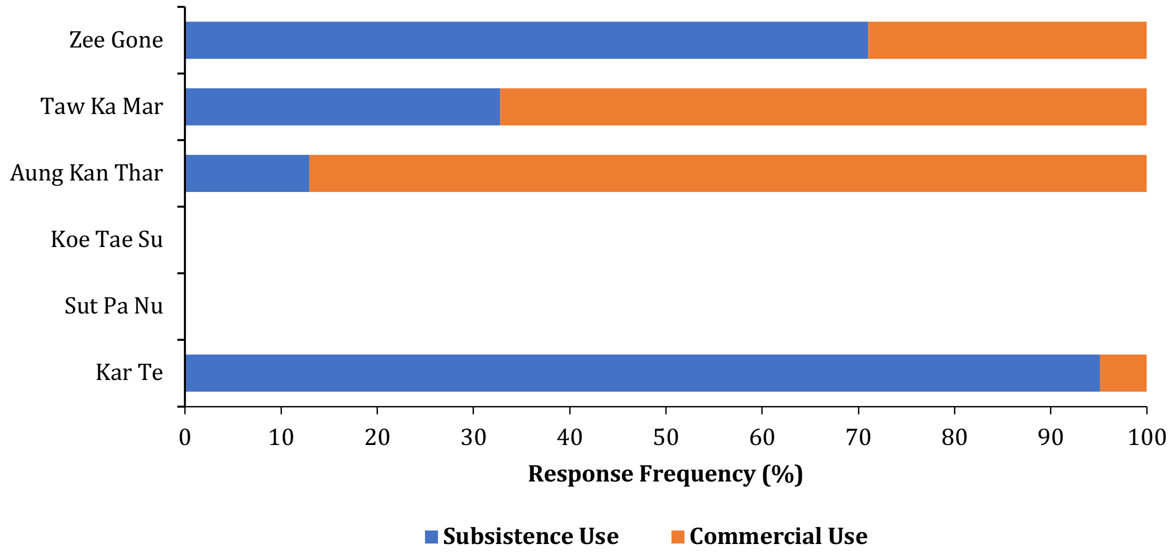
In addition, there is variation across the sampled villages in terms of the use of resources, i.e., whether used for subsistence or commercial purposes. On average a higher proportion of the harvested resources were used for commercial purposes in Taw Ka Mar (87%) and Aung Kan Thar (67%). Whereas in Kar Te and Zee Gone, the majority of harvested resources is used for household consumption or sharing the resources to neighbours or relatives (see Figure 3.6 (b)).

The mean annual household revenues from commercial use for the sample is 139,355 MMK (~66 USD). The resource with the highest commercial value in all villages is mud crabs (5,374 MMK - 575,211 MMK (~3 USD - 274 USD)). The mean annual subsistence use is 67,415 MMK (~32 USD).

In total, the mean annual household revenue from resources extracted from mangroves is calculated as 206,770 MMK (~98 USD). Extrapolating across all households, the annual revenue from mangrove is 8,524,994 MMK (~4,060 USD). The mean mangrove cover area where the people are extracting resources is 108.06 Ha. Therefore, the economic value from provisioning services provided by mangrove in the study area is estimated as 78,890 MMK (~38 USD)/Ha.



(a) Total extracted resources from mangrove.



(b) Percentage of subsistence uses and commercial use of extracted resources from mangrove.

Figure 3.6. Annual extraction of resources per household from mangroves.

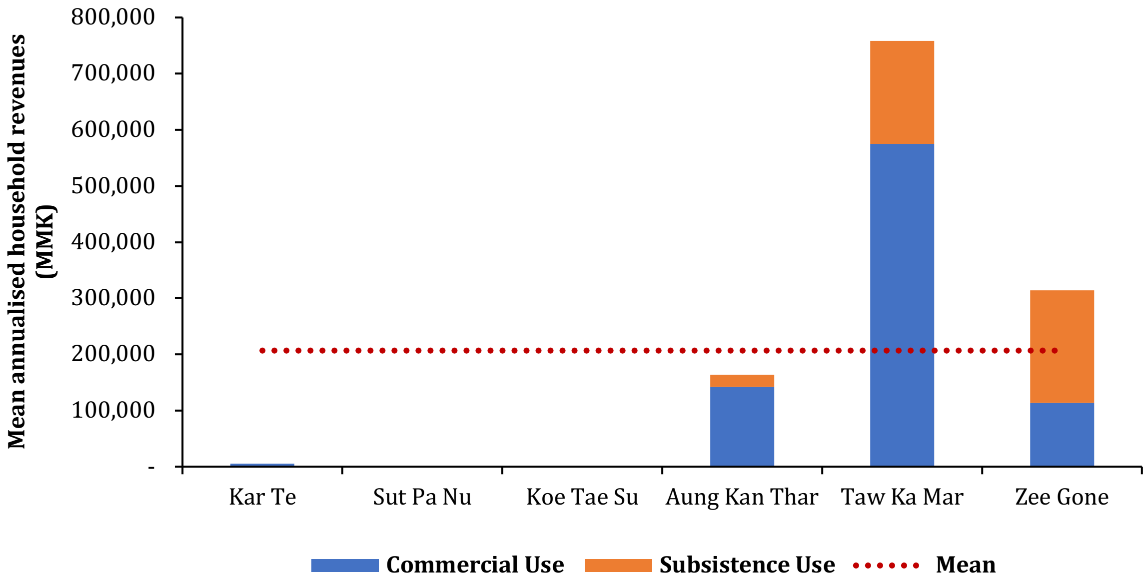
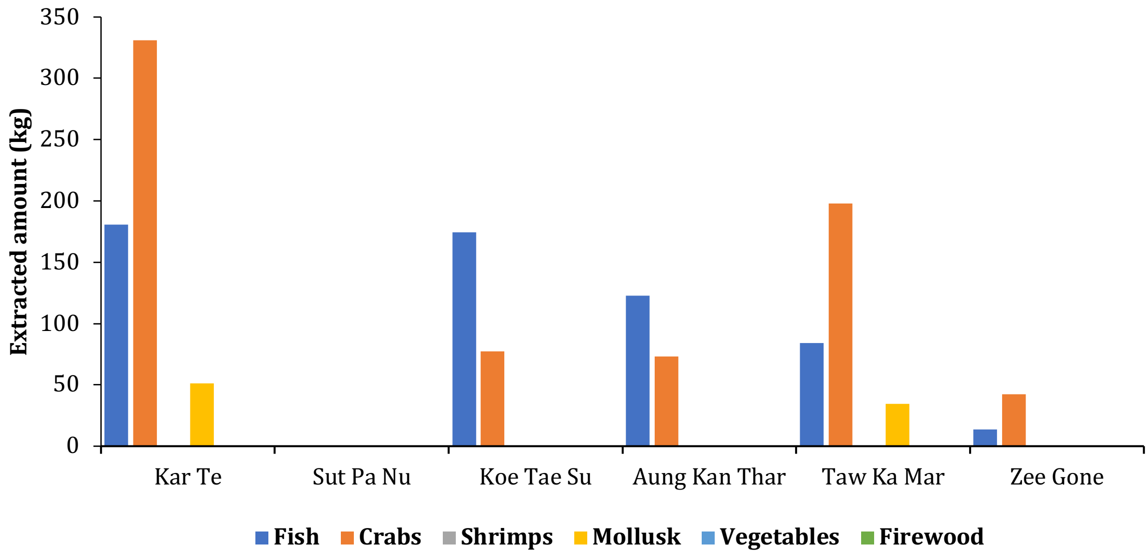


Figure 3.7. Mean annualised household revenues from total use of provisioning services from mangrove ecosystems in each village. The red dotted line represents the mean revenue for the whole sample (206,770 MMK (~98 USD)).

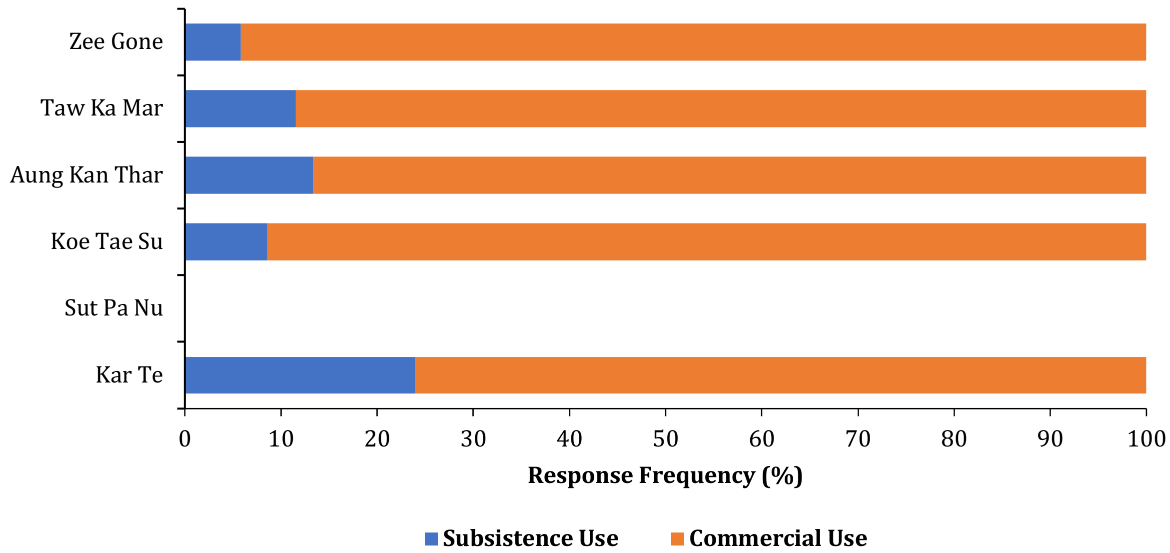
3.3.3 Mudflats

All the villages extracted resources from mudflats except Sut Pa Nu. The resources are fish, mud crabs and molluscs. The mean annual extraction per household for each resource from mudflats is shown in Figure 3.7 (a). Kar Te produced highest extraction of mud crabs (331.262 kg) followed by Taw Ka Mar (198.084 kg), Koe Tae Su (77.339 kg), Aung Kan Thar (73.16 kg) and Zee Gone (48.549 kg). On average, 96.011 kg of fish were produced from mudflats from each household annually with highest extraction in Kar Te with 180.736 kg and Zee Gone with 13.616 kg. Taw Ka Mar and Kar Te collected molluscs from mudflats about 34.621 kg and 51.244 kg respectively.

The villages extracted resources from mudflats are mainly applying for commercial use. On average, about 73% are extracted to sell them as shown in Figure 3.7 (b). Kar Te has highest subsistence use of resources from mudflats among the sample with subsistence use for 23.933% and commercial use for 76.067%. The other villages used 5-10% of the resources for household consumption and sharing with neighbours or relatives.



(a) Total extracted resources from mudflats.



(b) Percentage of subsistence uses and commercial use of extracted resources from mudflats.

Figure 3.8. Annual extraction of resources per household from mudflats.

So, the mean annualised household revenues from commercial use of resources from mudflat is 863,264 MMK (~411 USD). Kar Te and Taw Ka Mar contributed higher commercial values of mudflat from selling mud crabs with 1,386,357 MMK (~660 USD) and 809,055 MMK (~385 USD) respectively. The mean subsistence value per household is only 170,955 MMK (~81 USD). Therefore, total value for provisioning services from mudflat for the whole sample is 1,034,219

MMK (~492 USD) per household as shown in Figure 3.9. Then, the mean annual value from mudflat is extrapolated as 73,492,564 MMK (~34,996 USD) per village. The mean mudflat area for each village where people extracted resources is estimated to be 345.32 Ha. Therefore, it is estimated that annual revenue from each hectare of mudflat is 212,823 MMK (~101 USD).

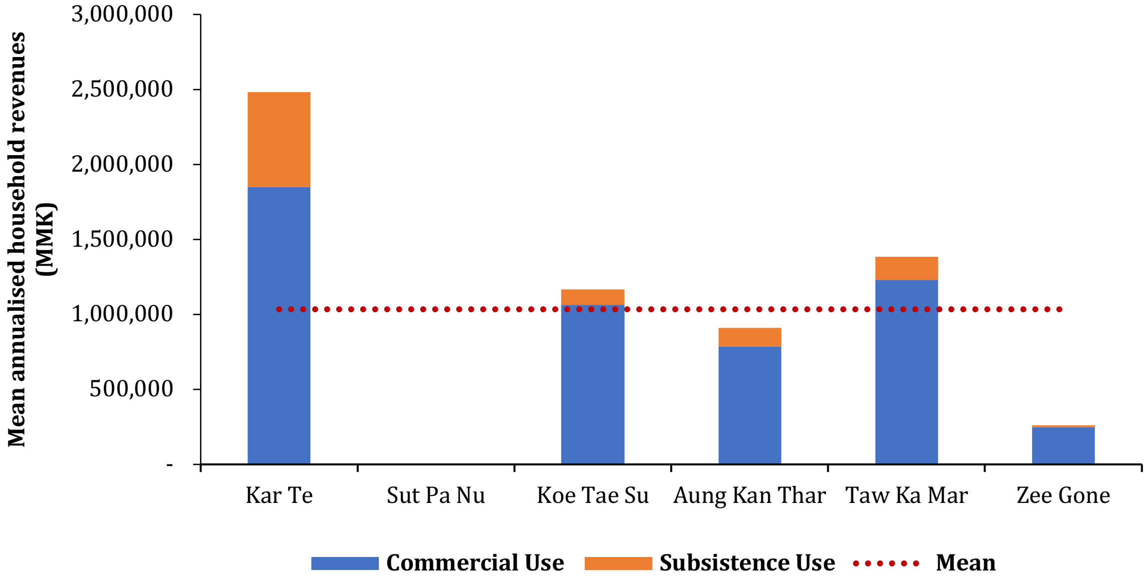
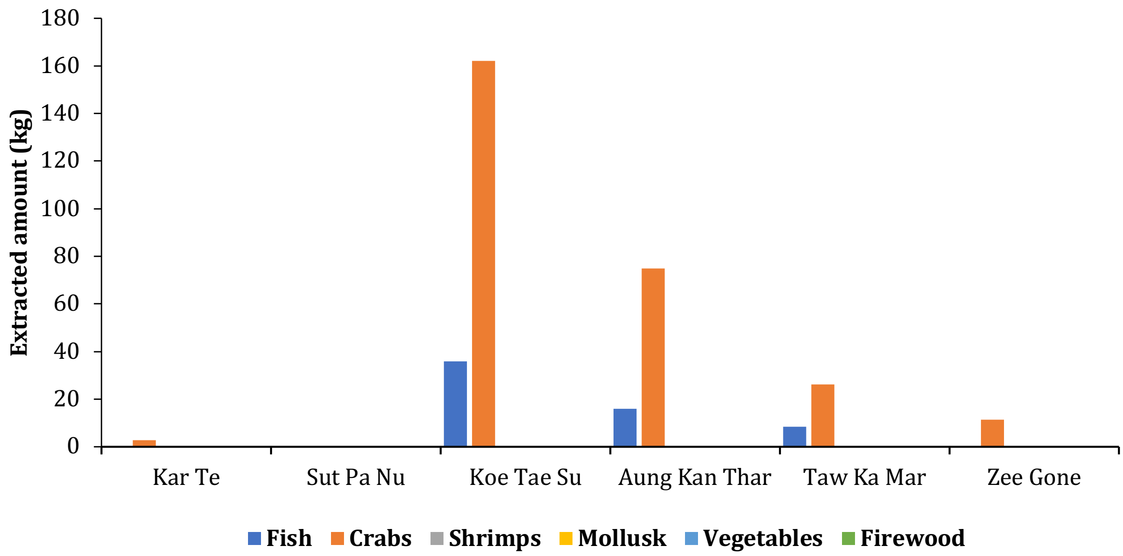


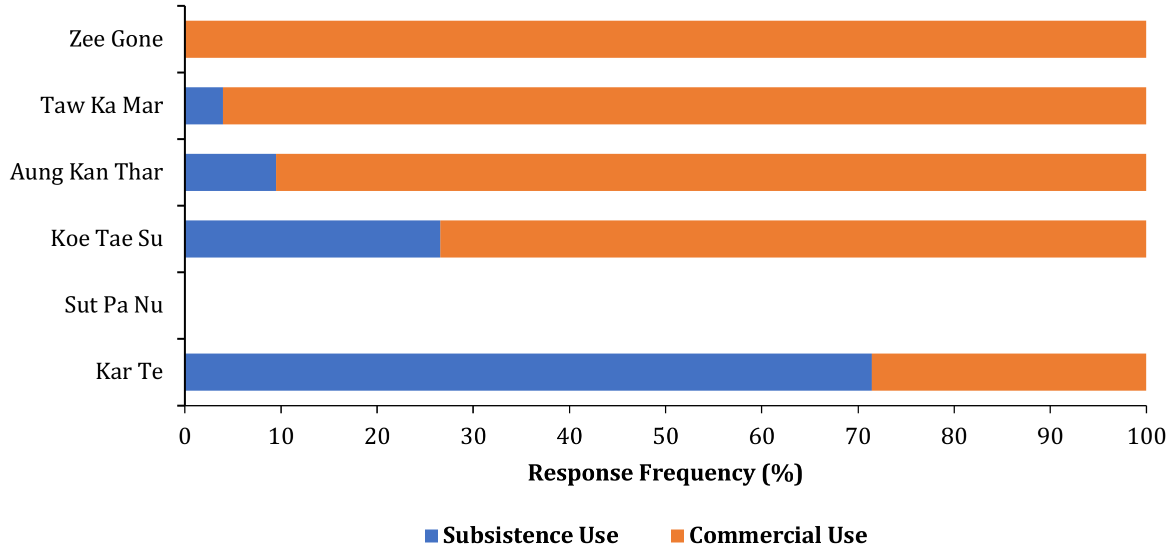
Figure 3.9. Mean annualised household revenues from total use of provisioning services from mudflat ecosystems in each village. The orange line represents the mean revenue for the whole sample (1,034,219 MMK (~492 USD)).

3.3.4 Coastal grassland

Only mud crabs and fish are extracted from grassland in 5 villages without Sut Pa Nu. The highest number of extractions were in Koe Tae Su with 35.926 kg of fish and 162.056 kg of mud crabs. Kar Te only produced mud crabs (2.861 kg annually) and most of them are used in the household (72.239 %). Except for Kar Te, all other villages applied their resources for commercial purposes. Significantly, Zee Gone sold all the extracted products from grassland (See Table 3.10 (a) and (b)).



(a) Total extracted resources from coastal grassland.



(b) Percentage of subsistence uses and commercial use of extracted resources from coastal grassland.

Figure 3.10. Annual extraction of resources per household from coastal grassland.

Annually, the mean revenue from commercial uses of resources from coastal grassland is 212,252.45 MMK (101.07 USD) per household. The mean subsistence value is 50,319 (~24 USD). The total economic value for provisioning services of grassland is (262,572 MMK (~125 USD)) as shown in Figure 3.11 which ranged from 923.854 MMK (~4403 USD) in Kar Te and 13,375 MMK (~6 USD) in Kar Te. By extrapolating these figures, the average value per village is estimated as 12,381,967 MMK (~5,896 USD). The mean cover of coastal grassland where people go fishing is about 191.42 Ha. Therefore, the value for direct use of resources from coastal grassland is 64,685 MMK (~31 USD) per hectare.

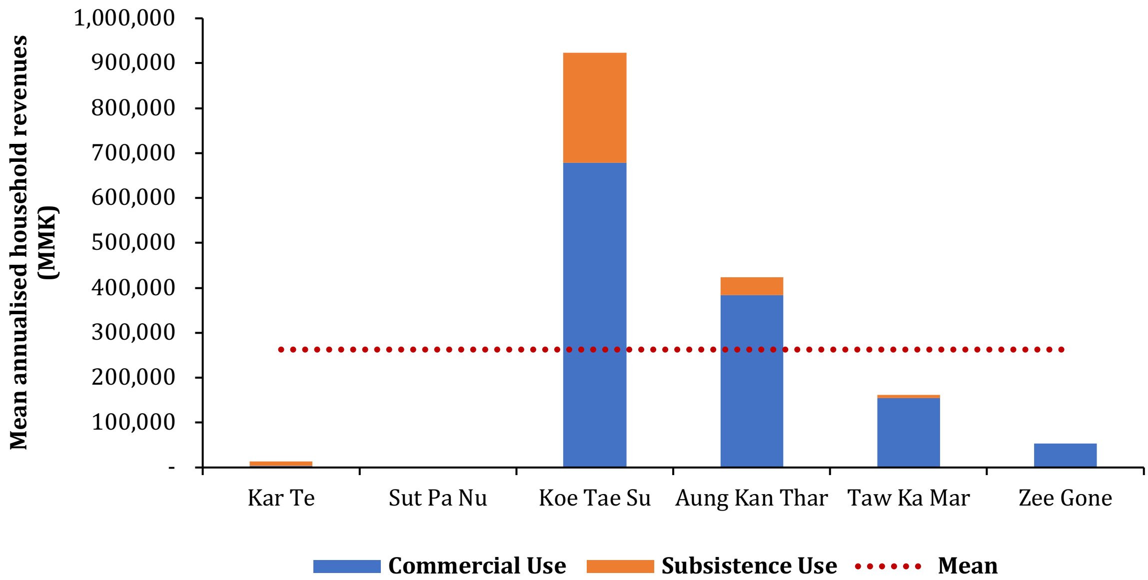
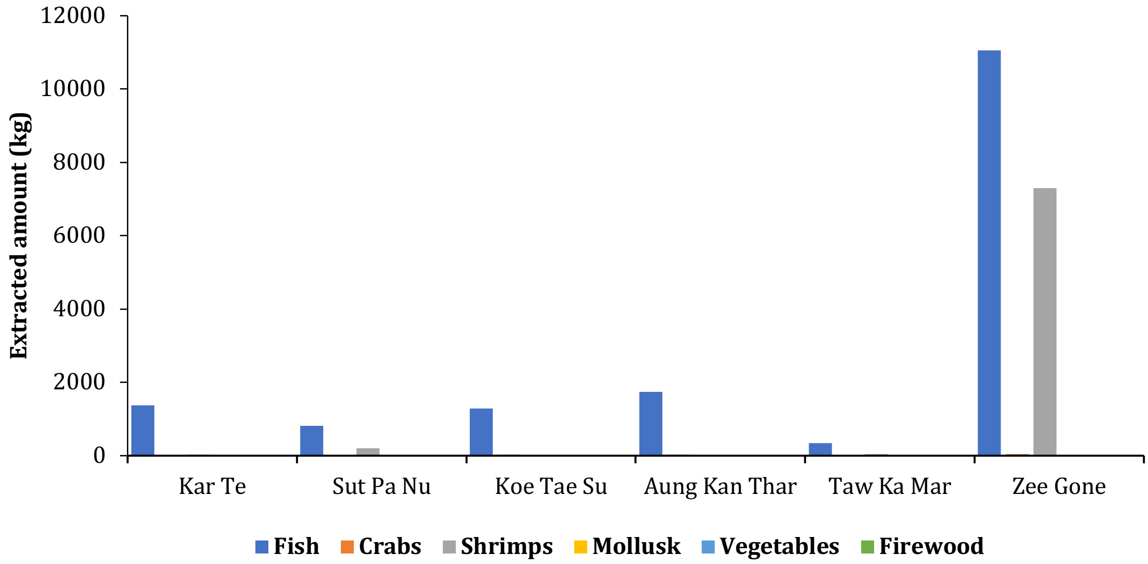


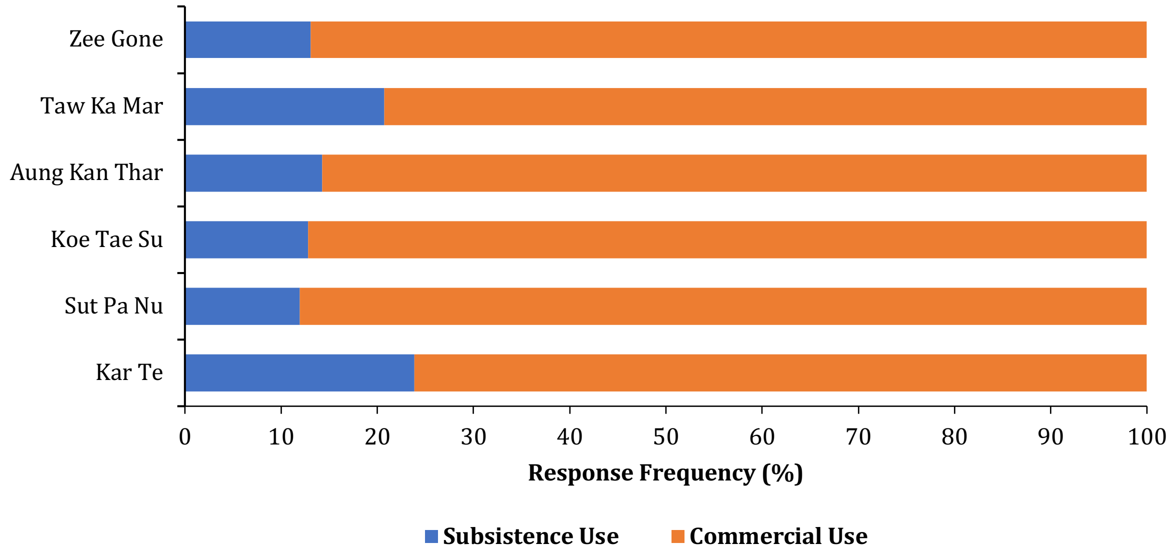
Figure 3.11. Mean annualised household revenues from total use of provisioning services from coastal grassland ecosystems in each village. The orange line represents the mean revenue for the whole sample (262,572 MMK (~125 USD)).

3.3.5 River/sea

All the study villages are extracting resources from rivers and/or sea based on the location. Only Sut Pa Nu depends only on Sittaung River for fishing while other 5 villages fish in nearby creeks, rivers (Bilin, Sittaung and Thanlwin), and sea (GoM). The most discriminating village is Zee Gone which catch highest number of fish (11,033.559 kg) and shrimps (7,293.135 kg) per year from each household. However, the target fish for Zee Gone is Bombay duck which has the lowest market price in the gulf. The rest villages mainly focus on estuarine fish with high economic values. The annual fish catch per household are 1,745.082 kg in Aung Kan Thar, 1,378.912 kg in Kar Te, 1,281.948 kg in Koe Tae Su, 810.51 kg in Sut Pa Nu and 341.51 kg in Taw Ka Mar. The extracted amount is shown in Figure 3.9 (a). Most of the catch are used for commercial uses by selling as in Figure 3.9 (b).



(a) Total extracted resources from river/sea.



(b) Percentage of subsistence uses and commercial use of extracted resources from river/ sea

Figure 3.12. Annual extraction of resources per household from river/sea.

For direct selling of resources, the mean annualised household income from river/ sea is 18,228,545 MMK (~8,680 USD), which is the highest revenue out of four ecosystems in the study area. Among them, Zee Gone has the highest revenue with 82,240,635 MMK (~39,162 USD) and the lowest in Taw Ka Mar with 1,800,692 MMK (~857 USD). The mean subsistence value for the whole sample is 252,687 MMK (~120 USD). The total value for provisioning services from the river/sea is 1,582,567,102 MMK (~753.603 USD).

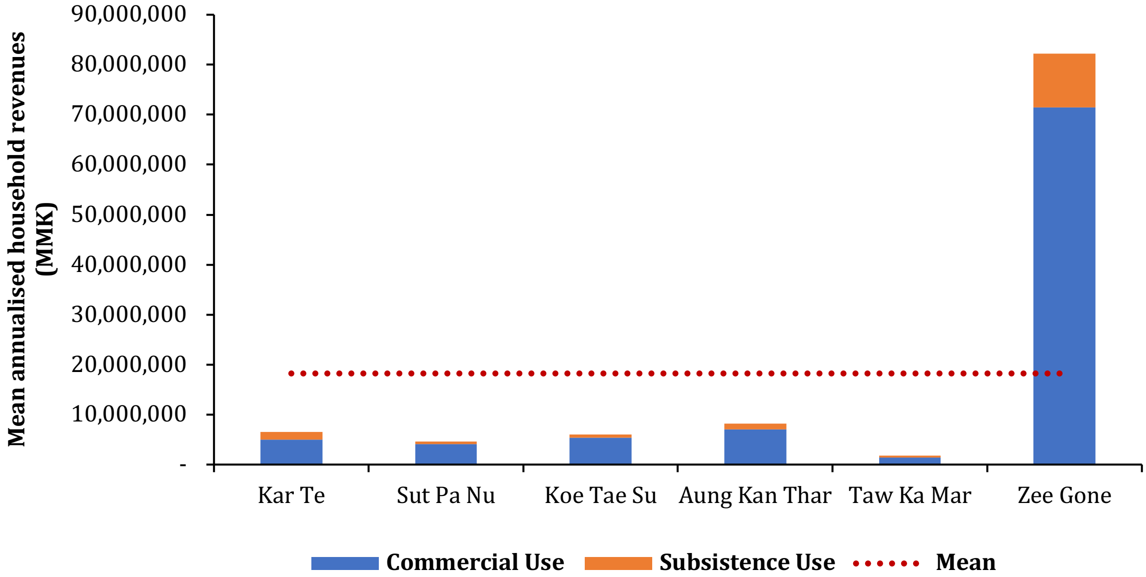


Figure 3.13. Mean annualised household revenues from total use of provisioning services from river/sea in each village. The dashed orange line represents the mean revenue for the whole sample (18,228,545 MMK (~8,680 USD)).

3.3.6 Summary of provisioning service values

The values of provisioning services obtained from coastal ecosystems are summarised in Table 3.2 and Figure 3.14. For all villages, rivers/sea is the most important resource for provisioning services. The harvest of resources from mudflats is second in terms of value but only of comparable magnitude in the cases of Taw Ka Mar and Kar Te.

Table 3.2. Summary of provisioning service values from each village (MMK/year)

Village	Mangrove	Mudflats	Coastal Grassland	Rivers/Sea
Kar Te	23,289	169,672,789	57,959	278,206,432
Sut Pa Nu	-	-	-	194,211,715
Koe Tae Su	-	28,390,708	34,984,949	492,140,841
Aung Kan Thar	4,915,214	46,765,289	23,411,470	907,999,231
Taw Ka Mar	38,968,578	118,052,326	2,995,983	120,371,586
Zee Gone	7,242,881	4,581,705	459,471	7,502,472,804

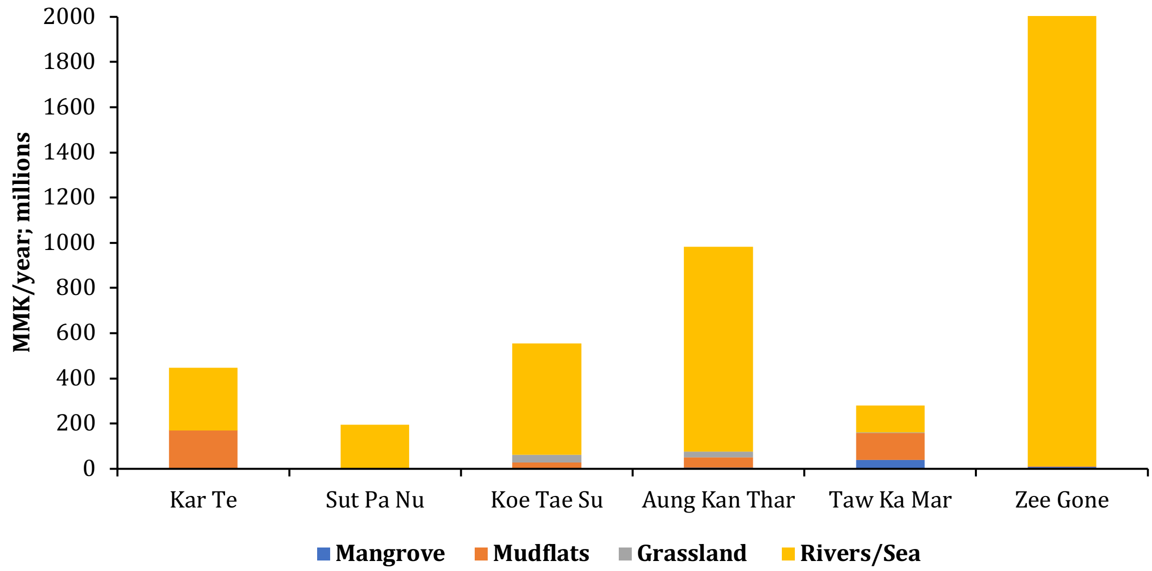


Figure 3.14. Annual value of provisioning services per village (MMK/year; millions)

3.4 Economic Values for Regulating Services

The value of flood damage mitigation by mangroves is estimated as the avoided damage costs attributable to the presence of mangroves surrounding each study site. For each village, Table 3.3 reports the area of mangrove within a 5 km radius (source) and the current total annual damage from natural hazards (extrapolated from the household survey). The counterfactual level of damage that would occur in the absence of mangroves is computed using an empirical function derived from Koch et al. (2009). The difference between the current and counterfactual levels of damage gives an estimate of the annual avoided damage costs attributable to mangroves (see Figure X). The results show that villages with zero or very small mangrove extent naturally receive no benefits from this service, whereas the benefits can be substantial for villages with extensive mangroves. This is particularly the case for Taw Ka Mar, which has 554.6 ha of mangrove and is estimated to avoid MMK 135 million in damages per year.

Table 3.3. Avoided damage costs attributable to flood mitigation by mangroves

Village	Mangrove (Ha)	Damage (MMK/year; millions)	Damage cost avoided (MMK/year; millions)	Damage cost avoided (MMK/ha/year; millions)
Kar Te	106.99	31.78	24.74	0.23
Sut Pa Nu	0.00	10.40	0.00	0.00
Koe Tae Su	1.15	39.50	0.00	0.00
Aung Kan Thar	78.25	14.57	8.75	0.11
Taw Ka Mar	554.6	7.02	135.00	0.24
Zee Kone	251.45	8.09	24.34	0.10

The value of this service can also be expressed per hectare of mangrove extent to enable more direct comparison across sites and with estimates in the literature (see Figure 3.15). We find considerable variation in the per hectare value across villages with neighbouring mangrove areas ranging from 0.1 MMK millions/ha/year (~46 USD/ha/year) in the case of Zee Kone to 0.24 MMK millions/ha/year (~116 USD/ha/year) for Taw Ka Mar. To make a comparison with values in the literature, these estimates are towards the lower end of the range recorded in the Ecosystem Service Valuation Database (ESVD.net).

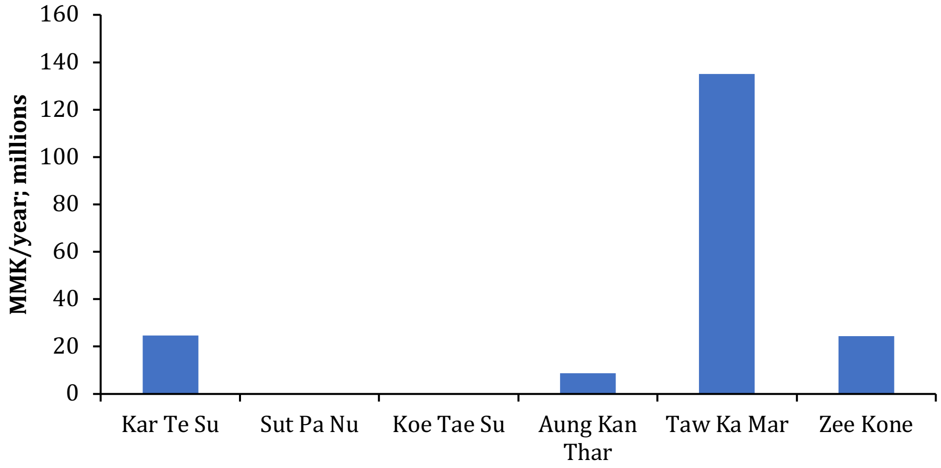


Figure 3.15. Annual avoided damage costs attributable to the presence of mangroves (MMK/year; millions)

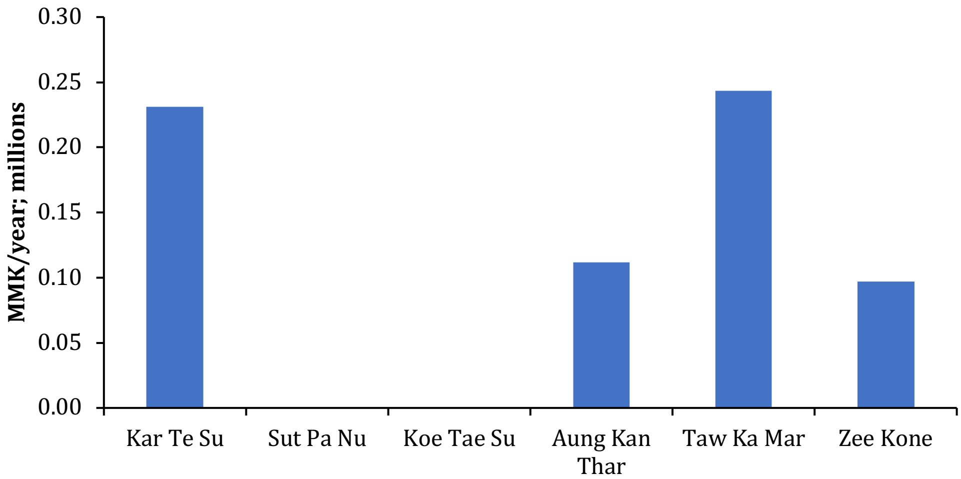


Figure 3.16. Annual avoided damage costs attributable to the presence of mangroves (MMK/hectare/year; millions)

3.5 Total Economic Value of Coastal Ecosystems in the Gulf of Mottama

In this section we provide an overview of the value of ecosystem services provided coastal ecosystems in the Gulf of Mottama by aggregating the values estimated in this report. It is important to recognise that this is a partial estimate of the total economic value of ecosystem services since it includes only the values of provisioning services from coastal ecosystems and coastal protection by mangroves. Other potentially important ecosystem services, such as cultural services (e.g., recreation and tourism) and other regulating services (e.g., climate regulation), are not included.

The aggregated values of the assessed provisioning and regulating services are represented in Figure 3.17. There is substantial variation across the sampled villages in terms of the economic importance of ecosystem services. In some cases (i.e., Sut Pa Nu) the value of provisioning services is low, and no regulating service is provided. Whereas at other locations (i.e., Zee Kone), the value of ecosystem services is very high. The total value is primarily due to provisioning services, with regulating service contributing a relatively small proportion (at most 32% at Taw Ka Mar). These results highlight the high spatial variability in the values of ecosystem services, driven by variation in the presence of different ecosystems and level of use/dependence by local populations of beneficiaries.

In per household terms, the total value of ecosystem services for the targeted villages is on average worth 19.98 MMK million per year (9,514 USD/household/year). It is again important to highlight the variation across villages with households in Sut Pa Nu receiving services worth 0.62 MMK million/household/year (295 USD/household/year) and households in Zee Gone receiving 46.54 MMK million/household/year (22,161 USD/household/year).

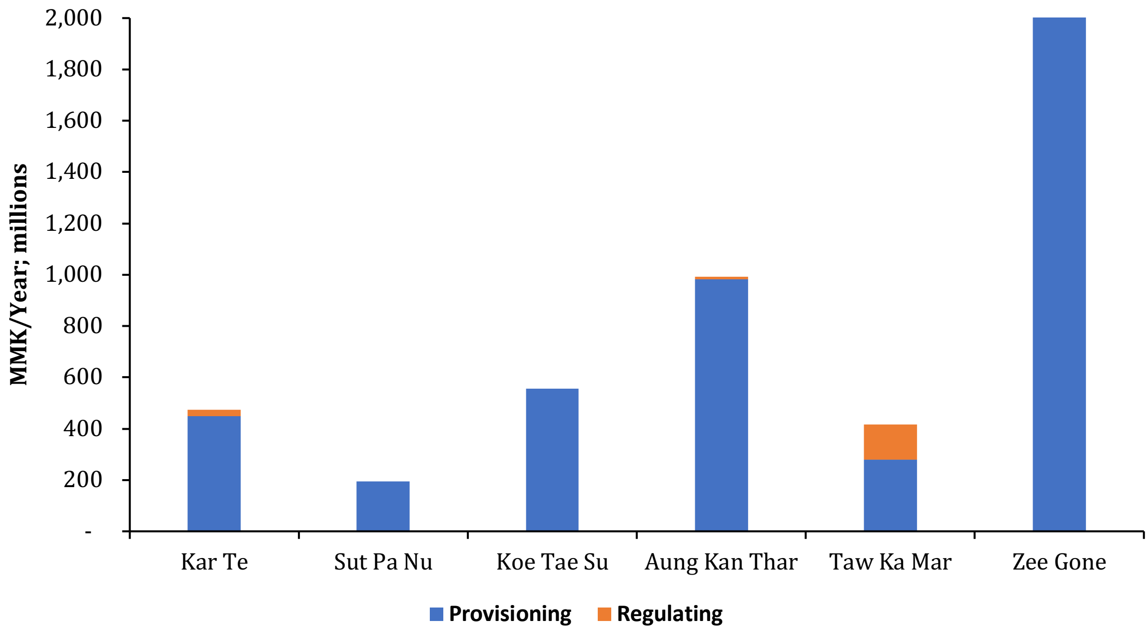


Figure 3.17. Annual values for provisioning and regulating services

3.6 Comparison of Economic Values of Ecosystems and Converted Farmland

In order to inform decisions regarding ecosystem conservation and land use planning, we attempt to make an explorative comparison between the economic values derived from farmland, mangroves, mudflats, and grasslands. Note that rivers and sea are not included in this part of the analysis since it is concerned with coastal ecosystems that can potentially be converted to farmland.

Data on the price of farmland in three of the sampled villages (Kar Te, Koe Tae Su, and Aung Kan Thar) were obtained from a survey of recent land sales through interviews with farmers. In principle, land prices represent the expected flow of future returns on the land (i.e., revenue from agricultural use). These land price data were then converted to annualised values using a time horizon of 20 years and a discount rate of 10%. In the absence of data on land prices for the remaining three villages, we assume that the annual value of agricultural land is equal to the average for the three villages for which data is available.

The annual economic values for coastal ecosystems are obtained from the study. For mangroves this is the sum of provisioning services and coastal protection, whereas for mudflats and grasslands this is only the value of provisioning services.

The annual value per hectare of each land use across the six villages is presented in Figure 3.18. It shows that, in general, coastal ecosystems have a higher value per hectare than converted farmland. This is particularly the case for mangroves, which deliver a higher value return than converted farmland at every village where mangroves are present. In other words, there is a strong economic case for protection, restoration and possibly expansion of mangroves, even at the expense of agricultural land. In some cases, the per hectare value of mudflats is also found to be higher than converted farmland (i.e., Aung Kan Thar and Koe Tae Su). Grassland is generally found to have similar per hectare values to farmland and only substantially lower in Zee Gone.

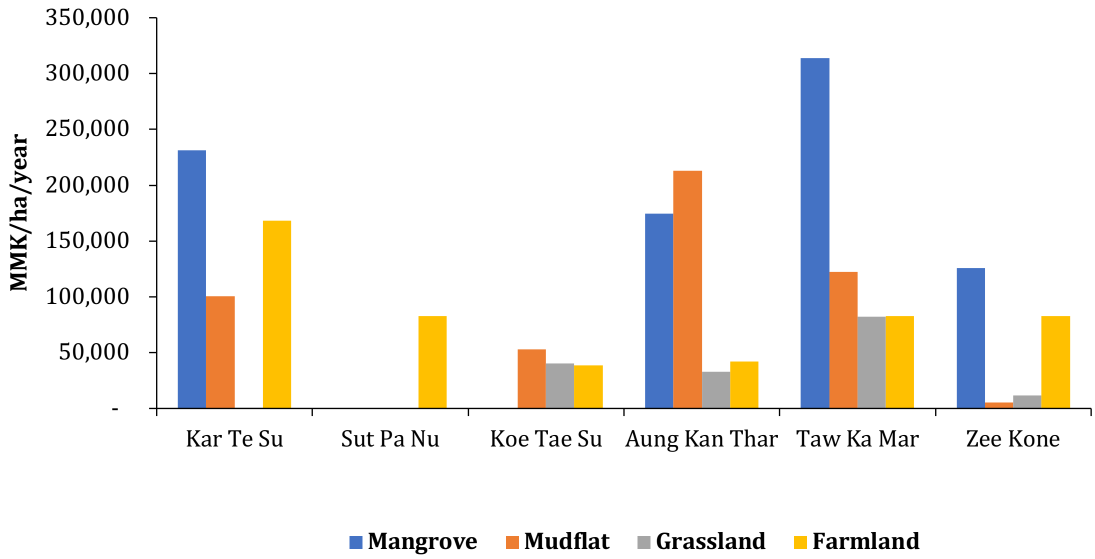


Figure 3.18. Annual economic values by land use (MMK/hectare/year)

Figure 3.18 again highlights the variability in the value of land uses across locations, including large variation in the value of farmland across the six villages. It is necessary to extend the survey of land sales in order to make a more robust analysis of this variation.

This preliminary comparative analysis of values across land uses also flags the need to assess the full set of relevant ecosystem services in order to make valid comparisons. The values of mangroves include both provisioning services and coastal protection, which provides a more complete picture of the value of this ecosystem relative to that of farmland. The inclusion of other ecosystem services (also for the other coastal ecosystem types) may change the picture further.

We caution that the results of this explorative analysis should not be used to inform land use decisions but can be improved on in further research to enable a robust comparison of values derived from coastal ecosystems and agricultural land.

3.7 Feelings and Perceptions of Communities on the Conversion of Coastal Ecosystems

In order to understand the community perceptions on the trends in changes of natural resources, the impacts to the communities if negative changes occurred and their willingness for conversion of coastal ecosystems to other development activities especially farmland are discussed in the following sessions.

3.7.1 Changes in Ecosystems

Majority of the respondents (69% - 75%) reported that the ecosystem has changed in the past 10 years. The arguments on the responses and the frequencies are shown in the Appendix (Table 7.2).

A total of 75 people reported that the area of mangrove expanded. The driving force the respondents expressed are mostly natural but in some areas such as Kar Te, the expansion is as result of plantation activities (14 responses) and establishment of community forest (4 responses) which protected from all the extractions of resources. In contrast, people reported that mangroves were depleted from firewood production and grazing of cattle. Similarly, there were 59 reports on more expansion of mudflats and 43 responses on coastal grassland. The reason is mostly natural processes such as increasing alluvial formation and sedimentation (36 responses). Regardless of the expanding area of mangroves, mudflats and grassland, there were reports on conversion of these ecosystems into farmland (8 responded for mangroves, 9 for mudflats, and 17 for grassland). In addition, 16 people reported that coastal grasslands are shrinking due to expansion of the sea from rising sea level, plantation of mangrove (habitat alteration) and less tidal influence. However, 46 people expressed that the river systems degraded as it gets shallower due to sedimentation, alluvial formation, and less tidal influence from the sea. It is due to erosion and formation of new land along the tidal channel.

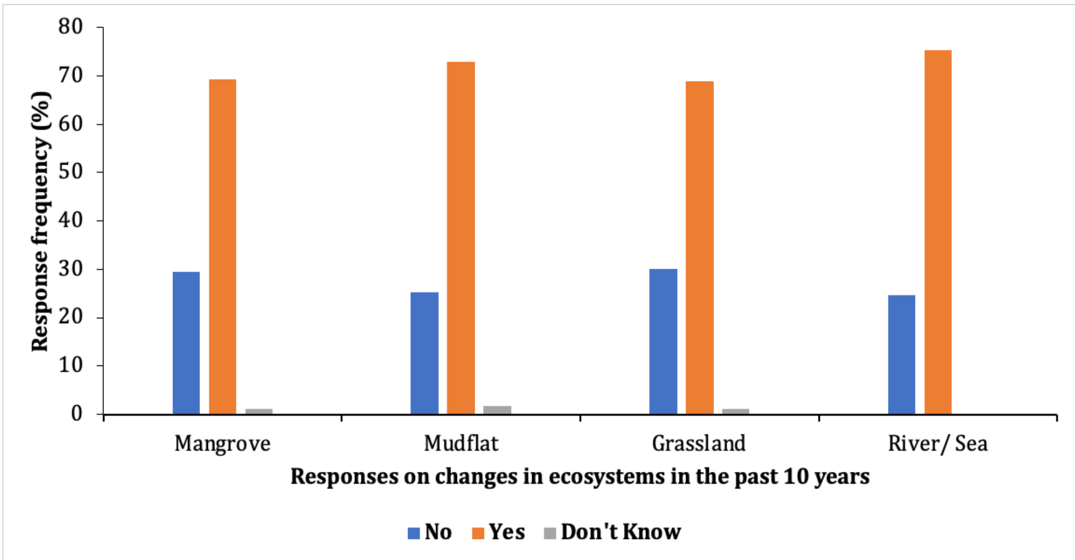


Figure 3.19. Frequency of responses per ecosystem to the question "How has ecosystems changed in the past 10 years in GoM?"

Linking with these changes, people also expressed changes in interactions with these ecosystems within the past 10 years. Due to the expansion of mangroves, people feel safer as they believe they are protected from flood, wind, and storm surges. It also supports a variety of provision services such as to extract more resources, and to do crab aquaculture in the mangroves. However, the growing mangrove forest exposed challenges for people (walking through dense forest, increasing dangers from snakes and insects) to access their designated habitats to extract resources. Some people also expressed that the services from mangroves are negligible as they are still very young and small. For mudflats, the larger the area, the better for the community for resource extraction as it supports more resources such as mud crabs and bivalves. However, people have to travel further and longer to pass through the larger area of mudflats. The presence of dense coastal grassland makes people safe from natural hazards as well. In areas where these ecosystems are converted, there is more competition to extract resources as the areas are shrinking. The major change regarding the degraded river system is difficulties in navigation and fishing activities.

3.7.2 Perceptions on the Degradation of Ecosystems

The higher percentage (about 58%) of respondents (16.44% strongly agreed and 41.64% agreed) expressed that degradation in each ecosystem will impact negatively on the livelihoods, incomes, and well-being of the household. People reported the highest impacts will be from river/sea (36.97%) followed by mudflats (31.33%) as these are major ecosystems where the communities are depending for their livelihoods. The community believe that mangroves are nursery habitats for resources they are extracting (fish, crab, and prawn), so 29 people worry that they will no longer access provisioning services for their incomes if mangroves are degraded and no longer support aquatic animals. In addition, the degradation of the mudflat and grassland ecosystem will result in limited access to extract resources and challenge the survival and well-being of the household (79 responses for mudflats and 48 responses for grassland). It will force them to seek refuge in other places for the collection of resources which may take more time and effort to travel and cost more. The degradation of rivers and canals might decrease in fish catch and result in lower income for people who depend mainly on fishing activities (100 responses). Eventually, the respondents argued that fishing grounds will disappear from fish extinction due to degraded river systems. It will lead fishers to travel further to extract resources. In general, degradation in coastal ecosystems will lose opportunities for households who depend on them to extract resources and degrade their well-being.

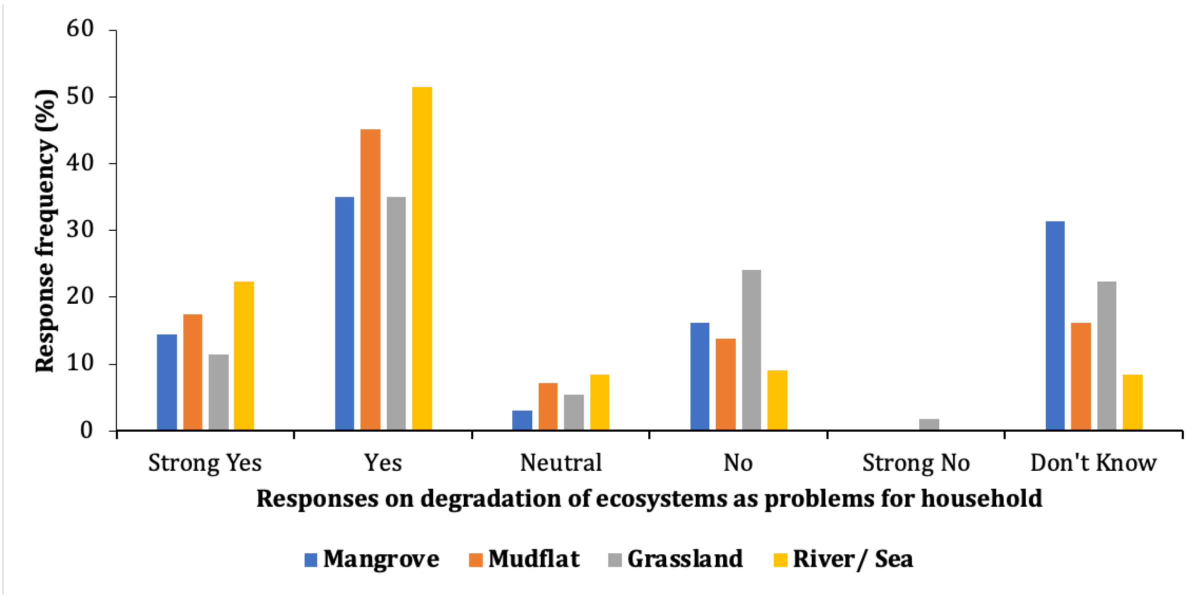


Figure 3.20. Frequency of responses per ecosystem to the question "For your household, do you think a degradation in the following ecosystems in the area is a problem?"

Furthermore, people described that the presence of coastal ecosystems is vital to protect communities from natural disasters. Therefore, 80 people reported a loss of these ecosystems would lead to more floods, stronger wind, waves, tides, saltwater intrusion, and erosion. Consequently, farmers will lose farmland or reduce yield due to saltwater intrusion and erosion from lack of protection mudflats, grassland, and river and sea. As a result of being directly prone to disasters, communities may displace and/or change livelihoods to adapt to the degradation of ecosystems. Some expressed loss in cultural services is declination of important species such as shorebirds and wildlife from destruction of natural ecosystems.

There are also some indications from 16.28% of respondents with households that will not be impacted by the degradation of ecosystems. Most of these households do not depend on the ecosystems for their livelihoods. Even for households who depend on these, they have alternatives to mitigate if the ecosystems are degraded such as migrating to other places, changing fishing grounds, etc., The other belief is that these ecosystems are natural and are not impossible to degrade. For example, some of the community believes that mangrove can regenerate naturally, the mudflats are extensively existing and even if one area is degraded, there will be a lot more places.

3.7.3 Feelings on the Conversion of Ecosystems

The research collected the community perceptions on the conversion of the ecosystems into farmland and the results show that nearly 48% of the respondents do not prefer to convert them as they continuously want to gain ecosystem services for the well-being of individuals and community. However, there are some respondents (13.44%) in particular areas who are willing to convert with the hope to strengthen alternative livelihood opportunities. The ones who have no opinion on the conversion and stay neutral are due to recognition of both pros and cons of the conversion to the community.

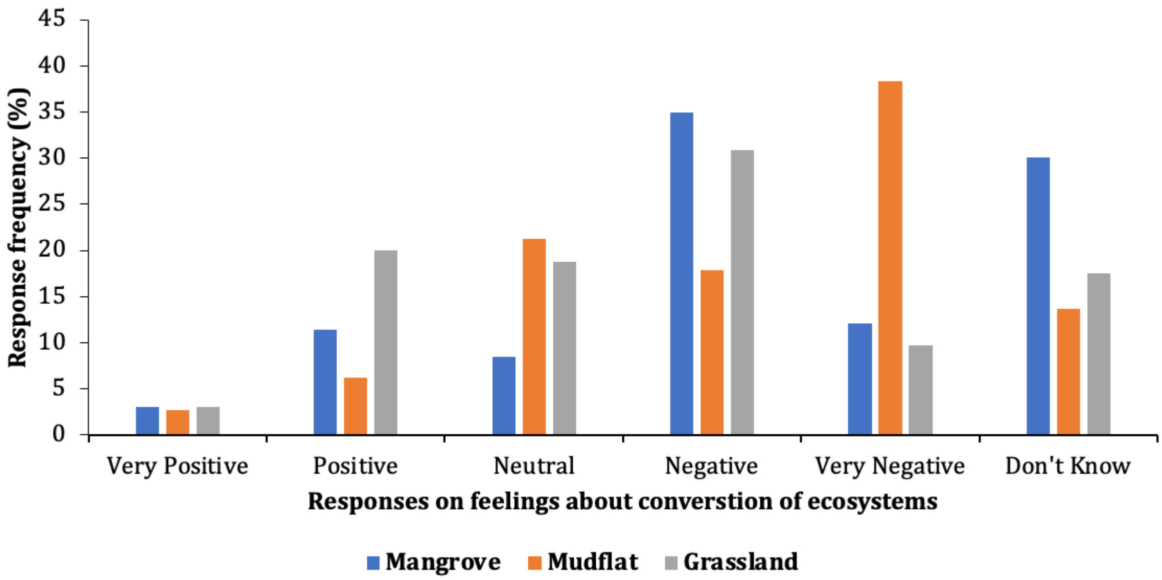


Figure 3.21. Frequency of answers on feelings about converting to farmland or development per ecosystem

Among six study villages, the ecosystems in every village except Sut Pa Nu are threatened to be converted into farmland. The higher percent of people from Kar Te and Koe Tae Su favour to convert. The respondents who prefer the conversion because they are willing to diversify livelihood options such as farming different crops as landowners or as wage labours. People motivate to become farmers because they believe it is more profitable, have more secure livelihood than extracting resources. Even some people acknowledge that farming in converted land take time to be profitable they are willing to own land as a figure of social status in the community. However, most people suggested that they will accept to convert if these lands are owned by villagers or preferrable original residents of the village, not businessmen or owners outside the village.

In contrast, most of the people against the conversion because they will be more prone to natural disasters and negatively impacted on their respective livelihood of extracting resources from these ecosystems. Without the protection from ecosystems, the people are in fear of severe wind and storm, drought and riskier to climate change. If the ecosystems are converted, they will be privatized, and it shrink the areas to extract resource. In addition, farmers do not allow the people to pass their farms to get access to destinated ecosystems. So, people have to go further and take more time to get resources. As the ecosystem was completely altered, the fish and other aquatic resources will loss habitats and resulted in decline of fishery related resources. Such impacts restrained the communities to convert coastal ecosystems into agricultural land or other land use.

4 DISCUSSION AND CONCLUSION

The research presented in this report provides information on the economic values of ecosystem services provided by coastal ecosystems in the Gulf of Mottama. In this section we summarise the key insights, identify the main limitations of the study, and make recommendations for policy and further research.

4.1 Key Insights

- Coastal ecosystems in the Gulf of Mottama deliver services with substantial economic value to local communities. The average household in the six villages assessed in this study receives provisioning and regulating services worth approximately 19.98 million MMK (9,514 USD) per year.
- Provisioning services contribute the largest share of the total economic value of coastal ecosystems. In villages with large areas of neighbouring mangrove cover, the value of protection from floods, storms and erosion is also of economic importance.
- The results are highly village specific. The economic value of both provisioning and regulating services varies greatly across villages depending on the extent of coastal ecosystems in the vicinity of each village and the level of dependence on resource extraction. This variation in values across villages means that it is not straightforward to generalise the importance of ecosystem services or extrapolate results to other areas of the GoM.
- Similarly, the relative importance of different ecosystem types varies greatly across villages. In all cases, however, rivers and the sea are the most important source of harvestable resources.
- Harvested resources are primarily sold but a substantial proportion is also used for subsistence consumption. The value of subsistence income can be high; the average household directly consumes resources from rivers and the sea with a value of 10.8 million MMK (1,200 USD) per year.
- A high proportion of households that coastal ecosystems have changed negatively (in extent, condition and access) during the past 10 years and view the conversion of ecosystems to agriculture as detrimental to their livelihood.
- Making a comparison between the annual value of coastal ecosystems and agricultural land, we find that the value of ecosystem services from mangroves and mudflats generally exceeds the returns on land converted to agriculture.

4.2 Limitations

The analysis and results described in this report are constrained by several limitations and uncertainties that are identified here to transparently frame the robustness of the results and identify avenues for future research.

- The valuation of provisioning services in this report provides a snapshot of the current harvest level but does not assess whether this level is sustainable (i.e., exceeds the capacity of the ecosystems to provide this service in the long term). An assessment of the sustainability of resource harvesting would require understanding and projection of harvests and ecosystem dynamics over time.
- Related to the previous point, the coastal ecosystems in the Gulf of Mottama are changing over time due to a combination of natural and human processes, which has consequences for the provision of ecosystem services. The perceptions of these changes by the local communities are captured through in the household survey. The valuation results presented in this report, however, provide a snapshot of the current level of provision. Further research could develop scenarios for the future extent, condition, and

accessibility of coastal ecosystems, and how the economic value of ecosystem services changes accordingly.
- The study only estimates the value of a limited set of ecosystem services. Other regulating services and recreation could also be relevant to land use decisions.
- Only a small number of villages are included in the assessment. These show considerable variation in terms of the extent of coastal ecosystems and dependence on ecosystem services. This provides too narrow a basis to extrapolate the results to other villages in the Gulf of Mottama.

4.3 Key Recommendations

- Mangroves provide high value coastal protection service, and it is advisable to protect, restore and possibly extend the area of this ecosystem.
- Given the observed variation in the value of coastal ecosystem services across locations, there is a need to target conservation efforts to areas that would deliver high ecosystem service values relative to the costs (i.e., deliver high net returns). Such a cost-benefit analysis (CBA) approach to ecosystem conservation would require, in addition to the valuation of benefits, measurement of the effectiveness of various conservation actions and their respective costs, including both implementation costs and the opportunity costs of restricted activities.
- Additional questions for future research projects include: What are the social impacts of conservation interventions, especially for communities that use coastal ecosystems for subsistence and/or cultural activities? How can local communities be engaged and involved to support ecosystem conservation?

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6 APPENDIX

6.1 Household Survey Instrument

Ecosystem Valuation of the Gulf of Mottama

Pilot Questionnaire: Household Interview **Page __/__**

Date: ___/___/2021.
Location: ________________

Interviewer: ____________________________
Interview # : __________

Introduction: My name is ______ and we are researchers from Gulf of Mottama Project. We are conducting research on how communities in GoM use the environment and what are its economic values. We will share this information with Gulf of Mottama Project, universities, organizations and researchers who want to learn more about economic valuation of natural resource uses in GoM. We will also prepare a report to share back to the stakeholders. Your responses are confidential; we will not share your name. This should take ___ minutes. Are you willing to participate in this interview?

Consent to the interview? ☐ **Yes** ☐ **No**

I. General Information

1. Name : ___________________ 2. Age : ________ 3. Sex : ☐ Male ☐ Female

4. Are you originally from ________? (Were you born here?) ☐ 1) Yes ☐ 2) No

5. **If No**, where are you from? ________________

6. Ethnicity: __________ 7. Religion: __________

8. How many years have you lived in the village?

☐ 1) 0-5 years ☐ 2) >5-10 years ☐ 3) >10-25 years
☐ 4) 25 years or more ☐ 5) Whole life

9. How many people are there in your household ___________
(# people living together under one roof)

II. Household Income and Wealth

10. What is your total weekly/ monthly income seasonally? (in MMK).

A. Rainy Season	B. Transition Season	C. Dry Season
☐ 1) 0 – 500,000	☐ 1) 0 – 500,000	☐ 1) 0 – 500,000
☐ 2) >500,000 – 100,000	☐ 2) >500,000 – 100,000	☐ 2) >500,000 – 100,000
☐ 3) >100,000 – 150,000	☐ 3) >100,000 – 150,000	☐ 3) >100,000 – 150,000
☐ 4) >150,000 – 200,000	☐ 4) >150,000 – 200,000	☐ 4) >150,000 – 200,000
☐ 5) >200,000	☐ 5) >200,000	☐ 5) >200,000

Ecosystem Valuation of the Gulf of Mottama

Pilot Questionnaire: Household Interview **Page __/__**

11. Where does the household income come from?
If useful, can use: 1 = Everything (100%), 2 = More than half (>50%), 3 = approximately half (~50%), 4 = less than half (<50%), 5 = hardly anything (~10%), 6 = nothing (0%)

1) Fishing (fish)	_______	2) Crab collecting	_______
3) Farming	_______	4) Gardening	_______
5) Remittances	_______	6) Livestock	_______
7) Aquaculture	_______	8) Other paid employment: Specify: ______________	_______
9) Other paid employment: Specify: ______________	_______	10) Other paid employment: Specify: ______________	_______

12. Do you (or your household) own a fishing boat? ☐ 1) Yes ☐ 2) No

If Yes, how many fishing boat do you have? ______________

What are the sizes? ______________ ft/m

13. Do you (or your household) own land? ☐ 1) Yes ☐ 2) No

If Yes, what do you use land for?

☐ 1) House ☐ 2) Gardening ☐ 3) Livestock
☐ 4) Renting it out ☐ 5) Nothing ☐ 6) Other: ____________

If Yes, estimate total land area: ___________________ Acre/ Hectares/ km^2

14. Do you (or your household) own livestock? ☐ 1) Yes ☐ 2) No

If Yes, what type of livestock and how many are there?

☐ 1) Pigs _____ ☐ 2) Goats _____ ☐ 3) Chicken _____
☐ 4) Ducks _____ ☐ 5) Cows _____ ☐ 6) Other: ____________

III. Dependence on Ecosystem Services
A. Provisioning Services

15. Do you harvest resources from the following ecosystems?

☐ 1) Mangroves and/ or tidal forests (If Y for 1, do **#A1**, if N, skip)
☐ 2) Mud flat (If Y for 2, do **#A2**, if N, skip)
☐ 3) Coastal grassland (Nat Sapar) (If Y for 3, do **#A3**, if N, skip)
☐ 4) Rivers and/ or canals (If Y for 3, do **#A4**, if N, skip)

Ecosystem Valuation of the Gulf of Mottama

Pilot Questionnaire: Household Interview **Page __ /__**

A1. Mangroves and/ or Tidal Forests

16. Do you harvest the following resources from **Mangroves area**? If **Yes**, how much is consumed and how much income is received per category per week (on average)? (1= everything, 2= more than half, 3= approximately half, 4= less than half, 5= hardly anything, 6= nothing)

17. Are there more or less of these resources since the last 5-10 years? (1 = much less, 2 = less, 3 = no change, 4 = more, 5 = much more, 6 = don't know)

18. Do you spend more or less time on the following activities since the last 5-10 year? (1 = much less, 2 = less, 3 = no change, 4 = more, 5 = much more, 6 = don't know)

	# 16							**#17**	**#18**
Resources	**Do you extract? (Y/N)**	**How many months a year?/ Which month?**	**How much per week?**		**Own consumption (1-6)**	**Share to other (1-6)**	**Sold at trader (1-6)**	**Resource abundance (1-6)**	**Time spent (1-6)**
			Quan	**Unit**					
1) Fish									
2) Mud crab									
3) Other invertebrates									
4) Wood (fuel)									
5) Wood (timber)									
6) Vegetables									
7) Medicinal plants									
8) Raw materials									
9) Food for livestock									
10) Grazing									
11) Other: ______________									

Ecosystem Valuation of the Gulf of Mottama

Pilot Questionnaire: Household Interview **Page __ /__**

A1. Mangroves and/ or Tidal Forests

19. Do you earn money from processing, reselling, etc. (any work along the value chain) the resources from **Mangroves area**.

Resource	**Do you process? (Y/N)**	**What did you do?**	**How much per week?**
1) Fish			
2) Mud crab			
3) Other invertebrates			
4) Wood (fuel)			
5) Wood (timber)			
6) Vegetables			
7) Medicinal plants			
8) Raw materials			
9) Food for livestock			
10) Grazing			
11) Other: ______________			

Ecosystem Valuation of the Gulf of Mottama

Pilot Questionnaire: Household Interview **Page __ /__**

A2. Mud Flats

20. Do you harvest the following resources from **Mud flat area**? If **Yes**, how much is consumed and how much income is received per category per week (on average)? (1= everything, 2= more than half, 3= approximately half, 4= less than half, 5= hardly anything, 6= nothing)

21. Are there more or less of these resources since the last 5-10 years? (1 = much less, 2 = less, 3 = no change, 4 = more, 5 = much more, 6 = don't know)

22. Do you spent more or less time on the following activities since the last 5-10 year? (1 = much less, 2 = less, 3 = no change, 4 = more, 5 = much more, 6 = don't know)

	# 20							#21	#22
Resources	**Do you extract? (Y/N)**	**How many months a year?/ Which month?**	**How much per week?**		**Own consumption (1-6)**	**Share to other (1-6)**	**Sold at trader (1-6)**	**Resource abundance (1-6)**	**Time spent (1-6)**
			Quan	**Unit**					
1) Fish									
2) Mud crab									
3) Other invertebrates									
4) Other: ______									

23. Do you earn money from processing, reselling, etc. (any work along the value chain) the resources from **Coastal Grassland area**. (1= everything, 2= more than half, 3= approximately half, 4= less than half, 5= hardly anything, 6= nothing)

Resource	**Do you process? (Y/N)**	**What did you do?**	**How much per week?**	
1) Fish				
2) Mud crab				
3) Other invertebrates				
4) Other: ______				

Ecosystem Valuation of the Gulf of Mottama

Pilot Questionnaire: House Hold Interview **Page __ /__**

A3. Coastal Grassland (Nat Sapar)

24. Do you harvest the following resources from **Coastal Grassland rea**? If **Yes**, how much is consumed and how much income is received per category per week (on average)? (1= everything, 2= more than half, 3= approximately half, 4= less than half, 5= hardly anything, 6= nothing)

25. Are there more or less of these resources since the last 5-10 years? (1 = much less, 2 = less, 3 = no change, 4 = more, 5 = much more, 6 = don't know)

26. Do you spent more or less time on the following activities since the last 5-10 year? (1 = much less, 2 = less, 3 = no change, 4 = more, 5 = much more, 6 = don't know)

	# 24							#25	#26
Resources	**Do you extract? (Y/N)**	**How many months a year?/ Which month?**	**How much per week?**		**Own consumption (1-6)**	**Share to other (1-6)**	**Sold at trader (1-6)**	**Resource abundance (1-6)**	**Time spent (1-6)**
			Quan	**Unit**					
1) Fish									
2) Mud crab									
3) Other invertebrates									
4) Vegetables									
5) Medicinal plants									
6) Raw materials									
7) Food for livestock									
8) Grazing									
9) Other: ______									

Ecosystem Valuation of the Gulf of Mottama

Pilot Questionnaire: Household Interview **Page __ /__**

A3. Coastal Grassland (Nat Sapar)

27. Do you earn money from processing, reselling, etc. (any work along the value chain) the resources from **Coastal Grassland area**.

Resource	Do you process? (Y/N)	What did you do?	How much per week?
1) Fish			
2) Mud crab			
3) Other invertebrates			
4) Vegetables			
5) Medicinal plants			
6) Raw materials			
7) Food for livestock			
8) Grazing			
9) Other: ____________			

Ecosystem Valuation of the Gulf of Mottama

Pilot Questionnaire: Household Interview **Page __ /__**

A4. Rivers and Canals

28. Do you harvest the following resources from **Rivers and Canals**? If **Yes**, how much is consumed and how much income is received per category per week (on average)? (1= everything, 2= more than half, 3= approximately half, 4= less than half, 5= hardly anything, 6= nothing)

29. Are there more or less of these resources since the last 5-10 years? (1 = much less, 2 = less, 3 = no change, 4 = more, 5 = much more, 6 = don't know)

30. Do you spent more or less time on the following activities since the last 5-10 year? (1 = much less, 2 = less, 3 = no change, 4 = more, 5 = much more, 6 = don't know)

	# 28							#29	#30
Resources	Do you extract? (Y/N)	How many months a year?/ Which month?	How much per week?		Own consumption (1-6)	Share to other (1-6)	Sold at trader (1-6)	Resource abundance (1-6)	Time spent (1-6)
			Quan	Unit					
1) Fish									
2) Mud crab									
3) Other invertebrates									
4) Wood (fuel)									
5) Wood (timber)									
6) Raw materials									
7) Other: ____________									

Ecosystem Valuation of the Gulf of Mottama

Pilot Questionnaire: Household Interview **Page __ /__**

A4. River and Canals

19. Do you earn money from processing, reselling, etc. (any work along the value chain) the resources from **Rivers and canals**.

Resource	**Do you process? (Y/N)**	**What did you do?**	**How much per week?**
1) Fish			
2) Mud crab			
3) Other invertebrates			
4) Wood (fuel)			
5) Wood (timber)			
6) Raw materials			
7) Other: ______________			

Ecosystem Valuation of the Gulf of Mottama

Pilot Questionnaire: Household Interview **Page ___/___**

B. Changes in Ecosystems

32. In the past X year, how has the following ecosystems in the area changed?

Ecosystems	**Y/N**	**How has the ecosystem changed?**
1) Mangroves		
2) Mud Flats		
3) Coastal Grassland		
4) Rivers/ Canals		

33. For your household, do you think a degradation in the following ecosystems in the area is the problem? (1 = strong yes, 2 = yes, 3 = neutral, 4 = no, 5 = strong no, 6 = don't know)

Ecosystems	**Degradation as a problem (1-6)**	**Why?**
1) Mangroves		
2) Mud Flats		
3) Coastal Grassland		
4) Rivers/ Canals		

34. How do you feel about converting the following into rice fields/ other development and why?

Habitat	***How do you feel?**	**Why?**
1) Mangroves		
2) Mud flats		
3) Coastal Grassland		

* 1) Very positive, 2) Positive, 3) Neutral, 4) Negative, 5) Very negative, 6) Don't Know

Ecosystem Valuation of the Gulf of Mottama

Pilot Questionnaire: House Hold Interview **Page __/__**

III. Dependence on Ecosystem Services
C. Regulating Services
C1. Coastal Protection

35. Have you experience damages to **your house or property** from the following events within the past 20 years?
☐ 1) Flood ☐ 2) Storm ☐ 3) Erosion

36. Can you chose a prominent event during this time period.

Event	Year of Event	*What were damaged due to the event?	What is the total cost of the damage. Estimate in MMK.
1) Flood			
2) Storm			
3) Erosion			

***Damage:** 1) House (2) Wall (3) Floor (4) Roof (5) Household furniture (6) Household appliances (7) Wells (8) Road (9) Water storage (10) Boat (11) Land (12) Livestock (13) Other

C2. Water and Soil Regulation

37. Have you experienced negative effects of droughts in the past 20 years? ☐ Yes ☐ No

38. a. **If Yes**, How many times in the past 20 years? ______________

39. b. What did you do to adapt to the drought?

☐ 1) Dig new well
☐ 2) Reduce water use at home
☐ 3) Choose not to water crops
☐ 4) Get water form neighbours
☐ 5) Collect water from other places
☐ 6) Buy water from other places
☐ 7) Other people donate water

40. What were the total cost of managing the drought. Please give estimate from the most recent event/ the most severe event? (TBD on estimate)

C3. Farming and Gardening

41. Do you take any measures to protect saltwater intrusion or erosion?
☐ Saltwater intrusion ☐ Erosion ☐ No

42. **If Yes**	**Saltwater intrusion**	**Erosion**
a) What method did you use?		
b) How much this cost you initially?		
c) How much this cost to maintain per month?		
d) How many hours per month of extra work did/ does this require?		

6.2 Supplementary Data

Table 6.1. Mean price per kilogram (in MMK) of each resource extracted from ecosystems in each village. The prices are direct selling prices to the local collectors and/or wholesalers.

Resources	Kar Te	Sut Pa Nu	Koe Tae Su	Aung Kan Thar	Taw Ka Mar	Zee Gone
Fish	4,608	10,400	7,488	9,188	4,608	3,098
Crab	4,675	-	5,506	11,400	6,000	4,675
Shrimps	-	8,167	4,259	4,259	4,259	3,525
Molluscs	2,000	-	-	-	2,000	2,000
Vegetables	-	-	-	-	700	-
Firewood*	-	-	-	-	1,000	1,000

*Unit = stack

Table 6.2. Economic values (MMK) provided from farmland

Location	Annualized land price/ Acre	Net revenue/ Acre
Kar Te	555,293	258,333
Kar Te	107,096	51,429
Kar Te	116,702	58,065
Kar Te	68,518	352,400
Kar Te	107,182	209,714
Kar Te	15,563	266,667
Kar Te	30,875	110,000
Kar Te	30,204	139,200
Koe Tae Su	30,204	201,367
Koe Tae Su	2,349	-82,950
Koe Tae Su	7,635	-75,625
Koe Tae Su	21,534	1,250
Koe Tae Su	6,505	50,842
Koe Tae Su	7,708	86,123
Koe Tae Su	35,238	108,750
Koe Tae Su	13,214	94,167
Aung Kan Thar	17,005	1,185,500
Mean	**72,239**	**114,358**

Table 6.3. The extent of coastal ecosystems (Ha) within 5 km radius of the villages

Village	Mangrove	Mudflat	Grassland
Kar Te	106.99	1690.42	377.04
Sut Pa Nu	-	615.03	80.47
Koe Tae Su	1.15	534.44	872.12
Aung Kan Thar	78.25	219.66	716.91
Taw Ka Mar	554.6	965.44	36.47
Zee Kone	251.45	873.68	39.59
Mean Extent	165.41	816.45	353.77

Table 6.4. The extent of coastal ecosystems (Ha) in each village where people are extracting resources

Village	Mangrove	Mudflat	Grassland
Kar Te	72.72333333	663.0266667	161.83
Sut Pa Nu	-	270.37	-
Koe Tae Su	0.743333333	197.7066667	5.8
Aung Kan Thar	29.91666667	89.98	191.83
Taw Ka Mar	315.7966667	435.3233333	487.5
Zee Kone	121.1266667	415.5266667	301.56
Mean Extent	**108.0613333**	**345.3222222**	**191.42**