Report on assessment of disaster risks in the Gulf of Mottama region, Myanmar

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EXECUTIVE SUMMARY

The Gulf of Mottama region, Myanmar is home to diverse communities whose livelihoods are mainly dependent on their coastal environment. However, the region faces various natural hazards, necessitating a participatory approach to disaster risk management. The Sendai Framework for Disaster Risk Reduction established in 2015, serves as an effective guide for CBDRM planning. This study aims at reviewing the likelihood and impacts of various disasters on coastal communities in the GoM region, identifying common disasters, assess disaster risk levels, and highlighting disaster-prone areas for risk mitigation. The methodology involves the review of CBDRM plans, focusing on disaster profiles, seasonal calendars, hazard and vulnerability mapping, and climate change impacts. Disaster risk assessment involves evaluating frequency and impacts, with risk calculated as the product of these two factors.

Among others, the study emphasizes floods, storms, coastal erosion, and drought as major challenges in the region. Specific assessments are made for each disaster type. Flood risk is widespread, with most agricultural areas in both Mon and Bago, facing median risk. Storm risk is prevalent, with 10 villages experiencing high risk. Drought risk is comparatively lower, with preventive measures implemented in many villages. Coastal erosion significantly impacts some villages, leading to the loss of agricultural land and the relocation of villages. The report is complemented with changes in the coastline from 2015 to 2022 from another study, indicating land loss due to coastal erosion in Bago and land gains due to sedimentation in Mon, however, alternating pattern is expected in the near future.

An integrated assessment considers all four disaster types, revealing medium to very high levels of risks in Thanatpin, Kawa, and Waw townships in Bago. The report discusses the regional variations in vulnerability, attributing flood risk in Bago to flat topography and human activities. Flooding with high risk mostly happened on Bago side, however, it happened in Mon side as well depending on the catchment area, and distance to the river or stream. Notably, the villages in Thanatpin, Kawa and Waw Townships face challenges associated with medium to very high levels of risks pertaining to the disasters, such as flood, storm and coastal erosion. In the case of coastal erosion, Bago and Mon sides have high risk level, besides, both sides are prone to severe erosion at the highest risk of future erosion under unpredictable circumstances for a long time. In addition, this large-scale erosion/sedimentation process is not evenly along the whole coast and in some areas the pattern can be locally different. Among studied townships, villages in Thanatpin were severely affected by the storm high risk although there was no village with a very high risk of storm in the villages on both Mon and Bago side. Coastal villages in Bago face challenges with limited infrastructure to protect from disasters, leading to village relocation. The findings serve as valuable inputs for coastal disaster risk reduction, adaptable to different coastal environments. The report emphasizes community engagement, awareness, and ownership in implementing CBDRM plans. It advocates for promoting disaster preparedness, capacity building, sustainable land management, and enhancing early warning systems.

The recommendations highlight creating communities that can be resilient in the face of disasters. This assessment highlights the importance of disaster risk reduction strategies, acknowledging regional variations in vulnerability. The study emphasises the significance of community-driven approaches, with detailed assessments providing insights for necessary interventions. The findings are expected to contribute to a deeper understanding of disaster risks, guiding initiatives for resilient and sustainable communities in the Gulf of Mottama region.

1 INTRODUCTION

The Gulf of Mottama region, Myanmar is home to diverse communities whose livelihoods are mainly dependent on their coastal environment. However, the region faces various natural hazards, including floods, storms, coastal erosion, and drought, which often threaten the well-being of its local communities. Recognizing the need for a participatory approach, community-based disaster risk management (CBDRM) is a strategy in understanding, mitigating, and responding to the disaster risks experienced in the GoM region.

Local knowledge is essential in dealing with repeated types of disasters like floods, storms, coastal erosion, and drought. Low-lands are susceptible to flooding as a result of monsoon and tidal waves. Local communities experience cyclones and severe storms frequently that leave destructive traces. Coastal erosion, which is attributed both to anthropogenic and natural processes, poses serious threats to coastal ecosystems and communities. Alongside, drought measured by water shortages poses a significant challenge for them. The Sendai Framework for Disaster Risk Reduction (SFDRR) has become as a framework that will provide proper guidelines on CBDRM. This framework set up in 2015 emphasizes on the role of communities in all aspects of disaster risk management, including disaster reduction planning and implementation processes.

In response to these challenges, the implementation of CBDRM plans plays an important role. These plans are not only community-based but also consider the unique socio-economic and environmental contexts of the local communities. In these plans, local knowledge is integrated for a sense of ownership within the communities. As part of the CBDRM framework, these disaster risk management plans are subject to regular review to adapt to evolving threats, technological advancements, and changes in community dynamics. One key element of CBDRM plan reviews is the development and utilization of risk assessment matrix. This matrix provides a structured framework to identify, prioritize, and analyse the various levels of risks associated with floods, storms, coastal erosion, and drought. By categorizing risks based on their likelihood and impact, communities can allocate resources, enhance preparedness, and identify mitigation measures. This dynamic process enables communities in the region to continually reassess and refine their disaster risk management approaches, considering new information and changing circumstances.

Essentially, the development of CBDRM programs together with risk assessment makes communities respond to floods, storms, coastal erosion, as well as drought before they occur. The community-based approach strengthens the resilience and provides for the sustainable development, thereby securing the welfare and life prospect of this population existing in an environment under constant pressure of disaster strikes.

2 OBJECTIVES

This study was carried out with the following objectives:

1) To review the likelihood of varying disasters and their environmental, social, economic impacts on coastal communities in the GoM region;
2) To identify the common disasters in the region and assess the levels of disaster risk considering likelihood and impacts on the communities and;
3) To identify disaster prone areas, particularly villages, to provide information on disaster risk management at the community level.

3 METHODOLOGY

3.1 Review on CBDRM Plans

In order to address the risks and identify relevant solutions, the Gulf of Mottama Project (GoMP) initiated CBDRM planning, implementation and review. Each and every village under the Project developed the CBDRM plan in 2019 through a participatory approach. These CBDRM plans are outlined with the following information and disaster risk reduction measures at the community level:

- Historical profile of disaster (within 10 years)
- Seasonal calendar of disaster
- Drawing hazard and vulnerability map
- Climate change impact on agricultural
- Climate change impact on fishery
- Climate change impact on ecosystem
- Frequency and impact level of disaster

In order for this study, we reviewed the existing CBDRM plans to understand what disasters are there, how frequently they occur, how severe the impacts are and local adaptation and mitigation measures of the communities.

3.2 Disasters under this Study

Based on the review of CBDRM plans, the project villages in Mon and Bago commonly and frequently suffered from disasters such as storm, flood, salt water intrusion, coastal erosion, drought among others. Hence, this study focused on the following disasters:

- **Flood** means the occurrence of the tidal wave and/or prolonged or intense rain falls over several days or over a short period of time.
- **Storm** means the occurrence of strong wind, tornado and tropical cyclone.
- **Erosion** means the loss or displacement of land, or the long-term removal of sediments along the coastline due to the action of waves, currents, tides, wind-driven water, etc.
- **Drought** means the seasonal shortage or scarcity of drinking water.

3.3 Assessment of Disaster Risk

Disaster risk is the probability that a hazard will have negative consequences (deaths, injuries, material losses, etc.), leading to a disaster. The disaster risk assessment involved extracting information on disaster frequency and impacts from the CBDRM plans. Frequency refers to the occurrence rate of a specific type of disaster over a 10-year period, and the assessment of frequency was detailed in Table 1.

Table 1. Frequency rating of a specific disaster type

Frequency (over a 10-year period)	Probability	Frequency Score
1 - 2	Rare	1
3 - 4	Unlikely	2
5 - 6	Possible	3
7 - 8	Likely	4
9 - 10	Certain	5

Impacts refer to the loss and damage of a disaster type on the affected community, environment, and economy. The impact assessment was conducted in the following four categories and rating is shown in Table 2:

- Social impact (i.e., lives of human)
- Economic impact (i.e., agriculture, livestock and fish pond)
- Infrastructure impact (i.e., buildings, road, bridge, pond and well)
- Environmental impact (i.e., mangrove, mudflat, grassland)

Table 2. Impact rating of a specific disaster type on local economy, environment, infrastructure and well-beings.

Loss or Damage	Impact	Impact Score
0 - 20%	Negligible	1
20 - 40%	Minor	2
40 - 60%	Moderate	3
60 - 80%	Significant	4
80 - 100%	Severe	5

Risk is calculated by multiplying the frequency score of a specific disaster type and average impact score of as given disaster type on local economy, environment infrastructure and well-beings.

Risk = Frequency × Impact

Based on the resulted score, disaster risk was rated following the risk matrix in Table 3. A disaster that both occurs frequently and has severe impacts represents very high risk. If a type of disaster occurs frequently but causes low impacts or if a disaster occurs infrequently but cause significant or severe impacts, it is considered median risk. A type of disaster is considered low risk if it occurs infrequently with minor or negligible impacts.

Table 3. Disaster Risk Assessment Matrix

Risk		Impact				
		Negligible 1	**Minor 2**	**Moderate 3**	**Significant 4**	**Severe 5**
Frequency	**Rare 1**	Very low	Very low	Low	Low	Median
	Unlikely 2	Very low	Low	Median	Median	High
	Possible 3	Low	Median	Median	High	High
	Likely 4	Low	Median	High	Very high	Very high
	Certain 5	Median	High	High	Very high	Very high

We reviewed CBDRM plans of 51 villages and obtained disaster-related information for 5 additional villages which are supposed to be EMU villages outside the GoMP area. The required data could not be collected for 9 villages (3 villages in Kyaikhto Township, 1 village in Bilin Township, 5 villages in Chaungzon Township) due to security constraints. Data analysis and mapping were conducted by defining

and adjusting the data to become systematic and standard code of GoMP database and linking the villages' geospatial data in Microsoft Excel and ArcMap 10.8.1 software.

3.4 Flood Prone Areas

Flood prone areas were assessed in early 2023 by the former Technical Officer (Kyaw Htet Aung) through GIS integrated multi-criteria decision approach with different 6 layers, which are digital elevation model (DEM), slope inclination, distance to water, drainage density, land cover and rainfall. These flood prone areas were determined for the probability of flood to occur. However, this study used the flood prone areas map as a base layer and overlaid flood risk assessment results on the base map to integrate both results from two different studies.

4 RESULTS

Based on the review of CBDRM plans, the disasters faced by the communities in the region include flood, heavy or irregular rainfall, coastal erosion and landslide, salt water intrusion, storm, fire outbreak, earthquake, drinking water scarcity and low impurity. This assessment revealed different risk levels of four disasters across the villages.

4.1 Assessment of Flood Risk

Table 4 showed the flood risk levels of the villages based on the risk assessment matrix in terms of frequency and impacts. We overlaid flood risk assessment results on the base map of flood prone areas (Figure 1) to visualize more comprehensive information on flood risk. Regarding flooding, there was no village in Bago Region with low flood risk. Most agricultural areas in both Mon and Bago were assessed median risk. Areas with very low and low flood risk were only found in mountainous areas and distant areas from water sources in Mon State. The flooding case would probably also depend on the conditions of watershed or catchment area at lowland. Table 4 shows that 5 villages in Thanatpin, Kawa and Waw Townships with very high flood risk, 22 villages (5 in Kawa, 7 in Thanatpin, 3 in Bilin, 2 in Kyaikhto, 2 in Paung, 3 in Thaton Townships) reached high risk level of flood, 13 villages with medium risk, 4 villages with low risks, and 12 villages with very low flood risk. Flooding with high risk mostly occurred on Bago side, however, it happened on Mon side as well depending on the catchment area, and distance to the river or stream.

Table 4. Flood risk levels of villages in Mon and Bago in the GoM region

No.	State/ Region	Township	Village	Flood Risk
1	Bago	Kawa	Khe Nan Ah Thin	Very High Risk
2	Bago	Kawa	Ta Dar U	High Risk
3	Bago	Kawa	Ma Mauk	High Risk
4	Bago	Kawa	Aung Naing Gyi	High Risk
5	Bago	Kawa	Aung Kan Hlaing	High Risk
6	Bago	Kawa	Sar Hphu Su	High Risk
7	Bago	Kawa	Kan Myint	Median Risk
8	Bago	Kawa	War Taw	Median Risk
9	Bago	Kawa	Shwe Gan	Median Risk
10	Bago	Kawa	Aung Myay	Median Risk
11	Bago	Kawa	Bo Te	Median Risk

No.	State/ Region	Township	Village	Flood Risk
12	Bago	Kawa	Ngwe Taung	Median Risk
13	Bago	Kawa	Mi Lauk	Low Risk
14	Bago	Thanatpin	Aung Bon Gyi	Very High Risk
15	Bago	Thanatpin	Pha Yar Lay Wine	Very High Risk
16	Bago	Thanatpin	Nyaung Kar Yar*	Very High Risk
17	Bago	Thanatpin	Ka Thit Khon	High Risk
18	Bago	Thanatpin	Kyun Tone	High Risk
19	Bago	Thanatpin	Kha Lat Su	High Risk
20	Bago	Thanatpin	Ka Pin*	High Risk
21	Bago	Thanatpin	Tha Nat Tan	High Risk
22	Bago	Thanatpin	Kywe Hpyu Chaung	High Risk
23	Bago	Thanatpin	Koke Ko	High Risk
24	Bago	Waw	Moke Kha Mu	Very High Risk
25	Bago	Waw	Ah Loke	Low Risk
26	Mon	Kyaikto	Kyauk Seik (Sit Taung)	High Risk
27	Mon	Kyaikto	Thein Za Yat	High Risk
28	Mon	Kyaikto	Sut Pa Nu	Very Low Risk
29	Mon	Kyaikto	Moke Kha Mawt	Very Low Risk
30	Mon	Kyaikto	Bo Yar Gyi	Very Low Risk
31	Mon	Kyaikto	Kha Wa Chaung	No Data
32	Mon	Kyaikto	Kha Ywea	No Data
33	Mon	Kyaikto	Kyauk Seik (Moke Pa Lin)	No Data
34	Mon	Bilin	Mu Thin	High Risk
35	Mon	Bilin	Shan Chaung	High Risk
36	Mon	Bilin	Ywar Tan Shae	High Risk
37	Mon	Bilin	Aung Pe*	Median Risk
38	Mon	Bilin	Pauk Taw	Median Risk
39	Mon	Bilin	Kyar Si Aung	Median Risk
40	Mon	Bilin	Tha Pyay Kone	Low Risk
41	Mon	Bilin	Ngwe Thaung Yan	Very Low Risk
42	Mon	Bilin	Koe Tae Su	Very Low Risk
43	Mon	Bilin	Kan Ywar	Very Low Risk
44	Mon	Bilin	Gwa Thaung	Very Low Risk
45	Mon	Bilin	Zwe Ka Lar	Very Low Risk
46	Mon	Bilin	Thein Chaung	Very Low Risk
47	Mon	Bilin	Zoke Ka Li	No Data
48	Mon	Thaton	Gyoe Hpyu Kone	High Risk
49	Mon	Thaton	Zaik Ka Ye	High Risk
50	Mon	Thaton	Htein Pin	High Risk
51	Mon	Thaton	Thone Eain Su*	Low Risk
52	Mon	Thaton	Aung Kan Thar	Very Low Risk
53	Mon	Paung	Ahlat (Taung Paing)	High Risk
54	Mon	Paung	Khin Tan	High Risk
55	Mon	Paung	Zee Kone (Paung)	Median Risk
56	Mon	Paung	Baing Laung	Median Risk
57	Mon	Paung	Ahlat(Ah Nauk Paing)	Median Risk

No.	State/ Region	Township	Village	Flood Risk
58	Mon	Paung	Wea Pa Tan	Median Risk
59	Mon	Paung	Sae Eain Su*	Very Low Risk
60	Mon	Paung	Kar Te	Very Low Risk

** EMU villages outside of 60 GoMP target villages*

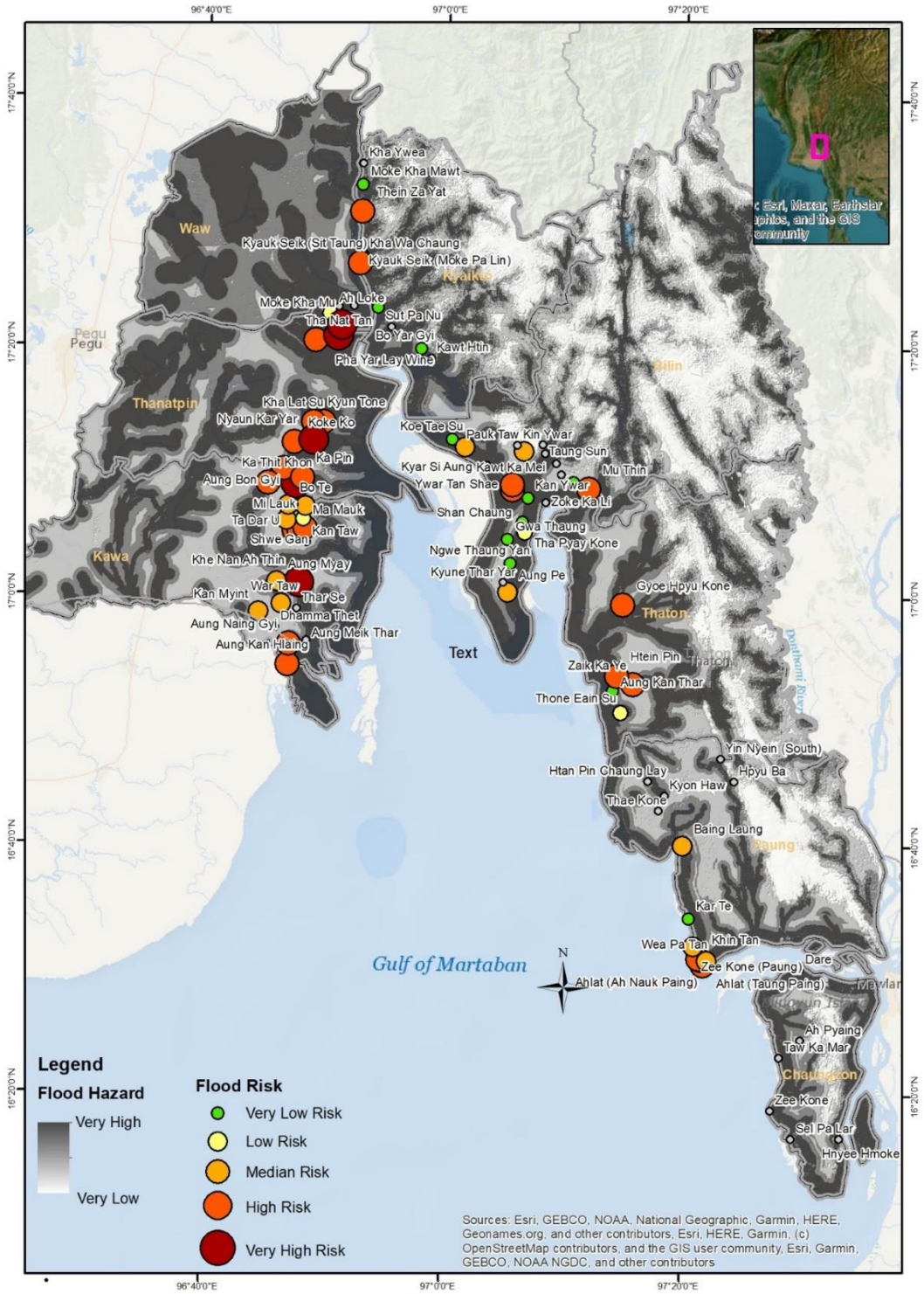

Figure 1. Map showing flood risk levels of villages in Mon and Bago in the GoM region. Base map shows flood hazard level assessed using GIS technology through a multi-criteria approach in terms of elevation, distance to water, land-use, rainfall, drainage density, and slope.

4.2 Assessment of Storm Risk

Figure 2 shows that there were no villages with very high risk of storm in the villages in both Mon and Bago. In this study area, we usually found the strong wind and tornado in few villages. Determining factors contributing to the strong wind or tornado can be challenging due to complex and dynamic nature. Tornado develops from severe thunderstorms in warm, moist, unstable air along and ahead of cold fronts. It frequently happens during the monsoon season and the transition time from summer season to rainy season. In the eight townships we studied, a total of 10 villages (1 in Kawa, 6 in Thanatpin, 1 in Kyaikhto, 1 in Bilin, 1 village in Paung) experienced high risk of storm. Villages in Thanatpin were severely affected by the storm high risk. There were 18 villages with medium risk, 7 villages with low risk, 21 villages with very low storm risk.

Table 5. Storm risk levels of villages in Bago and Mon in the GoM region

No.	State/Region	Township	Village	Storm Risk
1	Bago	Kawa	Mi Lauk	High Risk
2	Bago	Kawa	Khe Nan Ah Thin	Median Risk
3	Bago	Kawa	Ta Dar U	Median Risk
4	Bago	Kawa	Kan Myint	Median Risk
5	Bago	Kawa	Aung Naing Gyi	Median Risk
6	Bago	Kawa	Ma Mauk	Low Risk
7	Bago	Kawa	Shwe Gan	Low Risk
8	Bago	Kawa	Aung Myay	Low Risk
9	Bago	Kawa	Bo Te	Low Risk
10	Bago	Kawa	Sar Hphu Su	Very Low Risk
11	Bago	Kawa	Aung Kan Hlaing	Very Low Risk
12	Bago	Kawa	Ngwe Taung	Very Low Risk
13	Bago	Kawa	War Taw	Very Low Risk
14	Bago	Thanatpin	Kywe Hpyu Chaung	High Risk
15	Bago	Thanatpin	Nyaung Kar Yar*	High Risk
16	Bago	Thanatpin	Ka Thit Khon	High Risk
17	Bago	Thanatpin	Pha Yar Lay Wine	High Risk
18	Bago	Thanatpin	Aung Bon Gyi	High Risk
19	Bago	Thanatpin	Ka Pin*	High Risk
20	Bago	Thanatpin	Kha Lat Su	Median Risk
21	Bago	Thanatpin	Koke Ko	Very Low Risk
22	Bago	Thanatpin	Kyun Tone	Very Low Risk
23	Bago	Thanatpin	Tha Nat Tan	Very Low Risk
24	Bago	Waw	Ah Loke	Median Risk
25	Bago	Waw	Moke Kha Mu	Very Low Risk
26	Mon	Kyaikto	Bo Yar Gyi	High Risk
27	Mon	Kyaikto	Sut Pa Nu	Median Risk
28	Mon	Kyaikto	Kyauk Seik (Sit Taung)	Median Risk
29	Mon	Kyaikto	Moke Kha Mawt	Very Low Risk
30	Mon	Kyaikto	Thein Za Yat	Very Low Risk
31	Mon	Kyaikto	Kha Wa Chaung	No Data

No.	State/Region	Township	Village	Storm Risk
32	Mon	Kyaikto	Kha Ywea	No Data
33	Mon	Kyaikto	Kyauk Seik (Moke Pa Lin)	No Data
34	Mon	Bilin	Kan Ywar	High Risk
35	Mon	Bilin	Aung Pe*	Median Risk
36	Mon	Bilin	Mu Thin	Median Risk
37	Mon	Bilin	Ywar Tan Shae	Median Risk
38	Mon	Bilin	Gwa Thaung	Very Low Risk
39	Mon	Bilin	Zwe Ka Lar	Very Low Risk
40	Mon	Bilin	Koe Tae Su	Very Low Risk
41	Mon	Bilin	Kyar Si Aung	Very Low Risk
42	Mon	Bilin	Shan Chaung	Very Low Risk
43	Mon	Bilin	Tha Pyay Kone	Very Low Risk
44	Mon	Bilin	Thein Chaung	Very Low Risk
45	Mon	Bilin	Ngwe Thaung Yan	Very Low Risk
46	Mon	Bilin	Pauk Taw	Very Low Risk
47	Mon	Bilin	Zoke Ka Li	No Data
48	Mon	Thaton	Gyoe Hpyu Kone	Median Risk
49	Mon	Thaton	Zaik Ka Ye	Median Risk
50	Mon	Thaton	Aung Kan Thar	Median Risk
51	Mon	Thaton	Thone Eain Su*	Very Low Risk
52	Mon	Thaton	Htein Pin	Very Low Risk
53	Mon	Paung	Ahlat (Taung Paing)	High Risk
54	Mon	Paung	Khin Tan	Median Risk
55	Mon	Paung	Sae Eain Su*	Median Risk
56	Mon	Paung	Zee Kone (Paung)	Median Risk
57	Mon	Paung	Baing Laung	Median Risk
58	Mon	Paung	Kar Te	Low Risk
59	Mon	Paung	Wea Pa Tan	Low Risk
60	Mon	Paung	Ahlat (Ah Nauk Paing)	Low Risk

** EMU villages outside of 60 GoMP target villages*

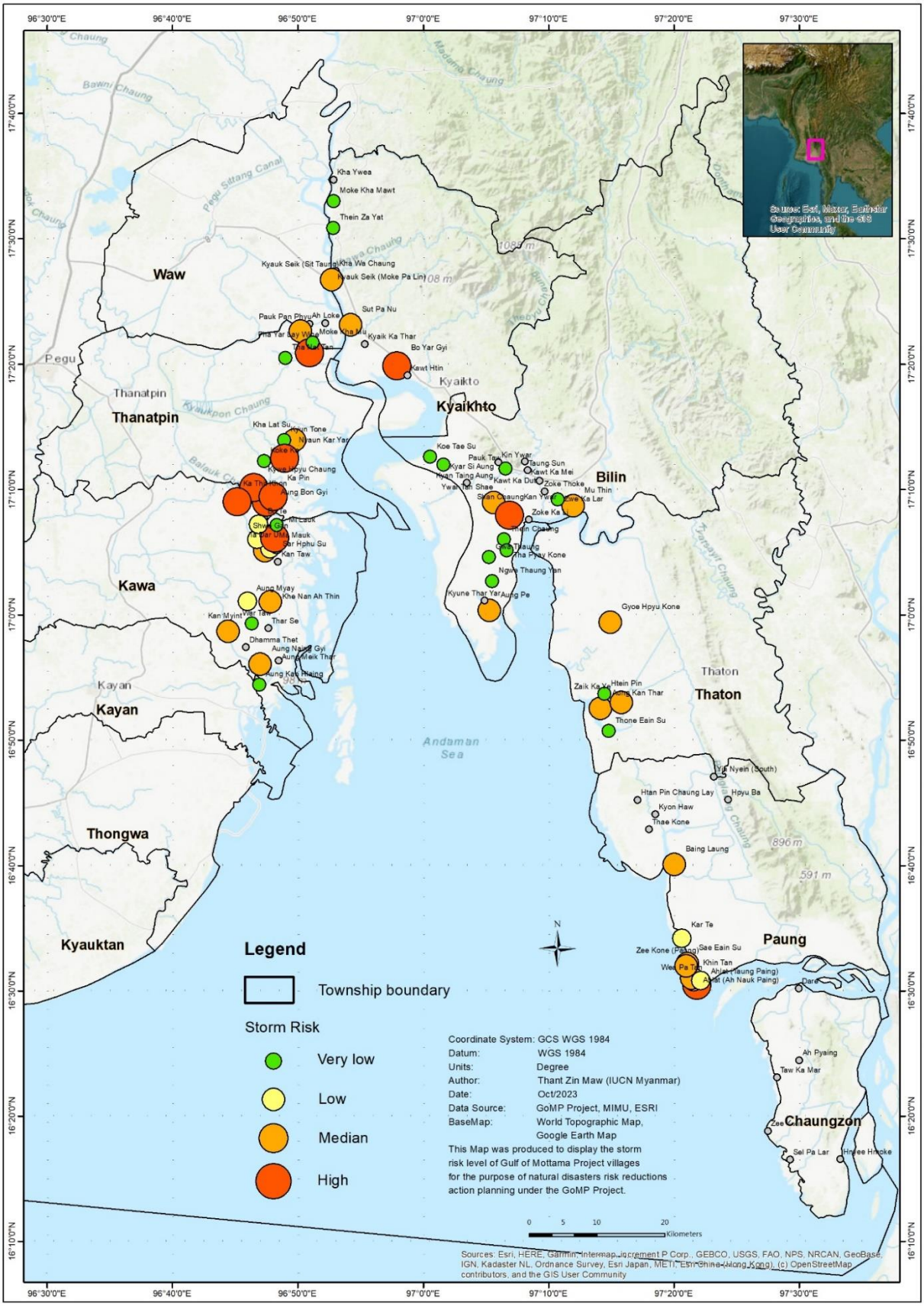

Figure 2. Map showing storm risk levels of villages in Mon and Bago in the GoM region

4.3 Assessment of Erosion Risk

We assessed that three villages seriously encountered coastal erosion, namely, Ma Mauk, Ta Dar U villages in Kawa Township and Kha Lat Su village in Thanatpin Township (Table 6). Due to the coastal erosion, they lost the village's agricultural land and did relocate their settlement from the coastline to the inner part of the land. Perhaps, there are two prominent factors affecting the coastal erosion: natural phenomenon of alternative shift of river channel and lack of long-rooted vegetation in the eroded area. We observed that 15 villages in Thanatpin, Waw, Kyaikhto, Bilin, Thaton, Paung Township suffered from significant impact of coastal erosion, as high-risk level of erosion (Figure 3). In the eight townships we studied, a total of 18 villages experienced very high and high risk of coastal erosion. Figure 3 shows that Bago and Mon sides at the moment experienced with high level of erosion risk, however, both sides are assumed prone to alternative erosion pattern in the long term. As shown in Table 6, there were 2 villages in Kawa and 1 village in Thanatpin with very high erosion risk, 15 villages (4 in Thanatpin, 1 in Waw, 3 in Kyaikhto, 4 in Bilin, 2 in Thaton and 1 in Paung) with high risk level, 10 villages with medium risk, 4 villages with low risk, and 24 villages with very low erosion risk.

Table 6. Erosion risk levels of villages in Bago and Mon in the GoM region

No.	State/Region	Township	Village	Erosion Risk
1	Bago	Kawa	Ma Mauk	Very High Risk
2	Bago	Kawa	Ta Dar U	Very High Risk
3	Bago	Kawa	Sar Hphu Su	Median Risk
4	Bago	Kawa	Khe Nan Ah Thin	Median Risk
5	Bago	Kawa	Aung Kan Hlaing	Median Risk
6	Bago	Kawa	War Taw	Low Risk
7	Bago	Kawa	Bo Te	Very Low Risk
8	Bago	Kawa	Shwe Gan	Very Low Risk
9	Bago	Kawa	Aung Myay	Very Low Risk
10	Bago	Kawa	Aung Naing Gyi	Very Low Risk
11	Bago	Kawa	Kan Myint	Very Low Risk
12	Bago	Kawa	Ngwe Taung	Very Low Risk
13	Bago	Kawa	Mi Lauk	Very Low Risk
14	Bago	Thanatpin	Kha Lat Su	Very High Risk
15	Bago	Thanatpin	Pha Yar Lay Wine	High Risk
16	Bago	Thanatpin	Ka Pin*	High Risk
17	Bago	Thanatpin	Aung Bon Gyi	High Risk
18	Bago	Thanatpin	Kyun Tone	High Risk
19	Bago	Thanatpin	Ka Thit Khon	Median Risk
20	Bago	Thanatpin	Nyaung Kar Yar*	Median Risk
21	Bago	Thanatpin	Tha Nat Tan	Low Risk
22	Bago	Thanatpin	Koke Ko	Very Low Risk
23	Bago	Thanatpin	Kywe Hpyu Chaung	Very Low Risk
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No.	State/Region	Township	Village	Erosion Risk
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46	Mon	Bilin	Pauk Taw	Very Low Risk
47	Mon	Bilin	Zoke Ka Li	No Data
48	Mon	Thaton	Thone Eain Su*	High Risk
49	Mon	Thaton	Gyoe Hpyu Kone	High Risk
50	Mon	Thaton	Zaik Ka Ye	Median Risk
51	Mon	Thaton	Htein Pin	Very Low Risk
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56	Mon	Paung	Baing Laung	Median Risk
57	Mon	Paung	Ahlat(Ah Nauk Paing)	Low Risk
58	Mon	Paung	Wea Pa Tan	Very Low Risk
59	Mon	Paung	Kar Te	Very Low Risk
60	Mon	Paung	Sae Eain Su*	Very Low Risk

** EMU villages outside of 60 GoMP target villages*

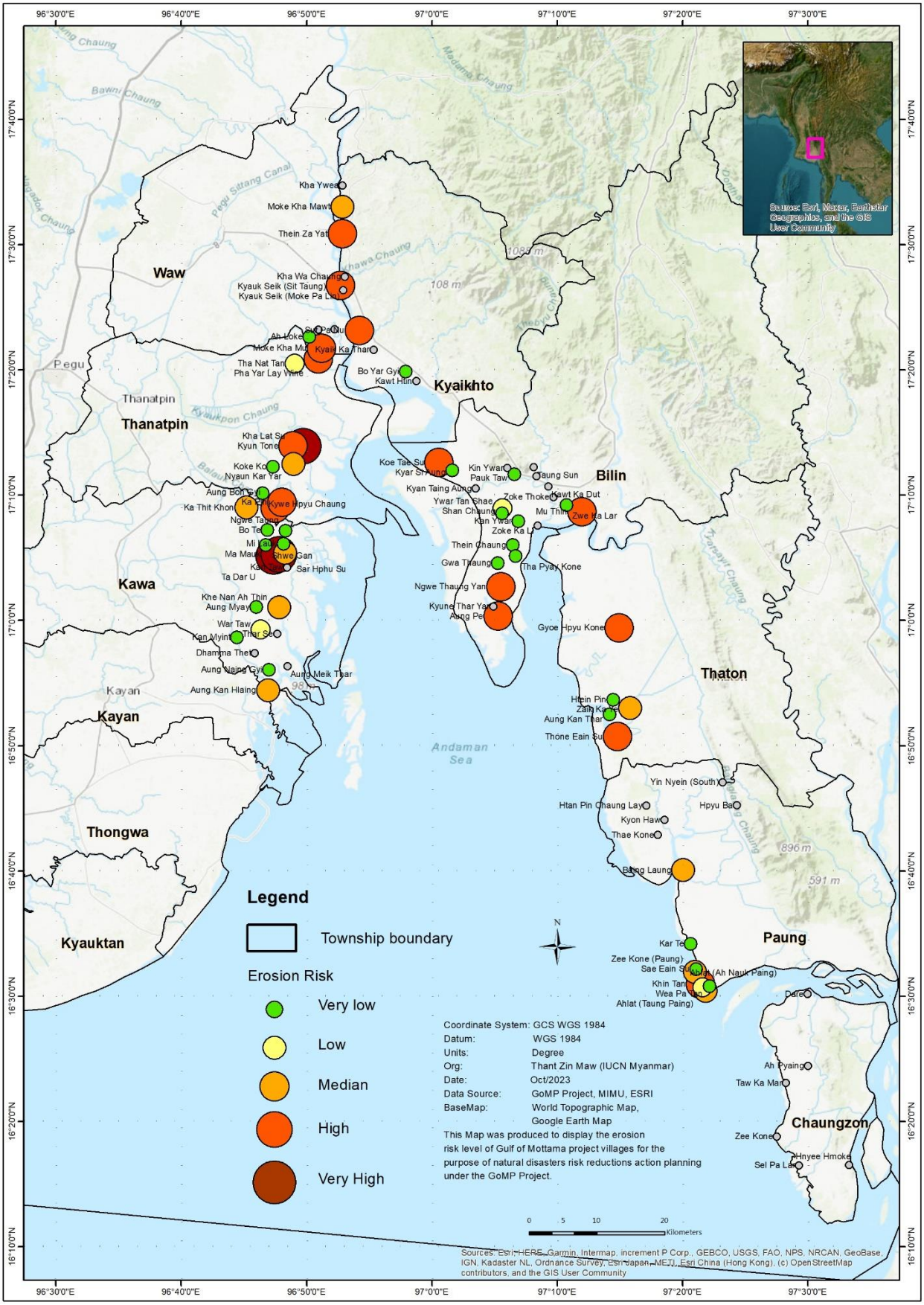

Figure 3. Map showing erosion risk levels of villages in Mon and Bago in the GoM region

4.4 Coastline changes due to erosion

Following the study by Deltares (commissioned by GoMP) CDE Myanmar supported GoMP in monitoring coastline changes as recommended by that study (Figure 4). CDE Myanmar tried to map the coastline (stable land) by on-screen digitizing of medium resolution satellite imagery at the end of the dry season (Landsat (2015) and Sentinel (2019, 2020, 2021, 2022, 2023). Deriving coastline change/change of stable land by analyzing the difference between them. This method has some digitizer bias for “gain” as its sometimes not easy to decide when unstable and becomes stable land. Furthermore, the study did not look at the years prior to 2015 which have reportedly also been characterized by strong erosion on the Bago side. Erosion in northern Bago side started as early as 2007 while erosion in southern Bago area started in 2013.

This shows that there was large scale erosion on the western side of the GoM with erosion rates of over 1km/year and in peak years 2016 and 2019 even exceeding 2 km/year at some sites. From 2020 onwards, it seems that the main flow channel has changed and much of the Bago side experiences sediment accumulation with the formation of new unstable land, some of which likely will become stable land soon. The change of the main flow channel leads to the shift of the large-scale erosion to the Mon side, reversing the process of sedimentation and formation of new lands there. From 2020 to 2022, most of the large-scale erosion affected unstable land ("unstable land" as mapped here is NOT mudflats. Unstable land is defined as land that has vegetation growth but is not yet used for agricultural production) and had thus not yet a grave impact on people and productive land. Nevertheless, since 2023, it is expected that the erosion front has reached stable land at the coast of Bilin and will likely lead to loss of land and property for as long as a new tipping point have been reached and the main channel changes its course again. Besides this large-scale erosion and sedimentation process is not evenly along the whole coast and in some areas the pattern can be locally different.

Generally, the GoM area is a highly dynamic area, and historic coastlines from the 1920s and 1940s (derived from topographic maps) as well as more recent satellite imagery analysis starting in the mid 1970ies show that much of the land in the upper GoM has at some time been either water or land and that natural processes play a major part in those coastal dynamics making this area an unsecure area for the long-term establishment of settlements and expensive infrastructure. How much the impacts of climate change and land use change in the Sittaung watershed effects those processes remain unclear and no study to date has been able to assess and estimate their impacts.

Additionally, CDE also analyzed Sentinel-2 and Landsat imagery in Google Earth Engine using an NDVI threshold of 0.23 as a proxy of vegetate land (differentiating it form periodically flooded mud-flats). The map below shows the development of land (stable and unstable). The maps (Figure 4) visualizes net change of land loss and gain and how different parts of the GoM are affected differently.

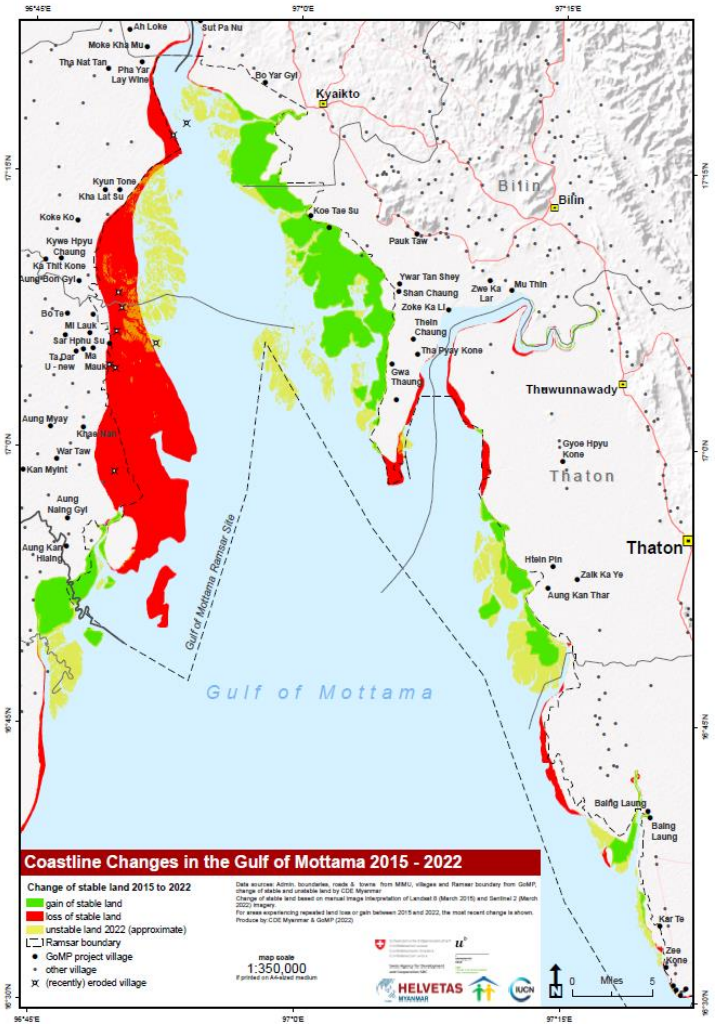

Figure 4. Map showing the change of stable land 2015 to 2022 in the Gulf of Mottama region, produced by CDE Myanmar for GoMP

4.5 Assessment of Drought Risk

As presented in Table 7 and Figure 5, most villages did not face severe impact of drought measured by drinking water shortage/ scarcity.The commonly cited cause of insufficient drinking water in many areas is often linked to the intrusion of saltwater into groundwater sources. In these regions, villages typically rely on communal ponds for their drinking water supply. However, to prevent contamination from saltwater, these ponds are usually dug at shallow depths. Consequently, the ponds have limited capacity for storing drinking water, leading to shortages, particularly during the pre-monsoon or hot seasons. In some cases, the communities do not have suitable land for construction of drinking water pond in their village vicinity to ensure sufficient drinking water for the whole community. We found that two villages in Thanatpin, namely Kyun Tone and Aung Bon Gyi, and one village in Waw Township, namely Ah Loke reached to the very high risk of drinking water shortage. A total of 7 villages faced high-risk level of drought and these villages require urgent attention and intervention. When we compared the results of drought risk for drinking water shortage in the dry season, villages in Bago Region along coastline suffered the drought risk with high level to very high-risk level than villages in Mon State. As described in Table 7, there were 3 villages with very high drought risk, 8 villages with high risk level, 16 villages with medium risk, 9 villages with low risk, 20 villages were reached with very low drought risk during the dry season, derived from CBDRM plans.

Table 7: Drought risk levels of villages in Mon and Bago in the GoM region

No.	State/Region	Township	Village	Drought Risk
1	Bago	Kawa	Ma Mauk	High Risk
2	Bago	Kawa	Khe Nan Ah Thin	High Risk
3	Bago	Kawa	Aung Naing Gyi	High Risk
4	Bago	Kawa	Ta Dar U	High Risk
5	Bago	Kawa	Kan Myint	Median Risk
6	Bago	Kawa	Aung Kan Hlaing	Median Risk
7	Bago	Kawa	Sar Hphu Su	Low Risk
8	Bago	Kawa	Shwe Gan	Very Low Risk
9	Bago	Kawa	Aung Myay	Very Low Risk
10	Bago	Kawa	Bo Te	Very Low Risk
11	Bago	Kawa	Ngwe Taung	Very Low Risk
12	Bago	Kawa	War Taw	Very Low Risk
13	Bago	Kawa	Mi Lauk	Very Low Risk
14	Bago	Thanatpin	Kyun Tone	Very High Risk
15	Bago	Thanatpin	Aung Bon Gyi	Very High Risk
16	Bago	Thanatpin	Ka Thit Khon	High Risk
17	Bago	Thanatpin	Pha Yar Lay Wine	High Risk
18	Bago	Thanatpin	Nyaung Kar Yar*	High Risk
19	Bago	Thanatpin	Tha Nat Tan	Median Risk
20	Bago	Thanatpin	Koke Ko	Very Low Risk
21	Bago	Thanatpin	Ka Pin*	Very Low Risk
22	Bago	Thanatpin	Kha Lat Su	Very Low Risk
23	Bago	Thanatpin	Kywe Hpyu Chaung	Very Low Risk
24	Bago	Waw	Ah Loke	Very High Risk
25	Bago	Waw	Moke Kha Mu	Low Risk
26	Mon	Kyaikto	Moke Kha Mawt	Median Risk
27	Mon	Kyaikto	Sut Pa Nu	Median Risk
28	Mon	Kyaikto	Bo Yar Gyi	Very Low Risk
29	Mon	Kyaikto	Thein Za Yat	Very Low Risk
30	Mon	Kyaikto	Kyauk Seik (Sit Taung)	Very Low Risk
31	Mon	Kyaikto	Kha Wa Chaung	No data
32	Mon	Kyaikto	Kha Ywea	No data
33	Mon	Kyaikto	Kyauk Seik (Moke Pa Lin)	No data
34	Mon	Bilin	Shan Chaung	High Risk
35	Mon	Bilin	Gwa Thaung	Median Risk
36	Mon	Bilin	Mu Thin	Median Risk
37	Mon	Bilin	Ngwe Thaung Yan	Median Risk
38	Mon	Bilin	Pauk Taw	Median Risk
39	Mon	Bilin	Koe Tae Su	Low Risk
40	Mon	Bilin	Aung Pe*	Low Risk
41	Mon	Bilin	Ywar Tan Shae	Very Low Risk
42	Mon	Bilin	Kyar Si Aung	Very Low Risk
43	Mon	Bilin	Zwe Ka Lar	Very Low Risk
44	Mon	Bilin	Tha Pyay Kone	Very Low Risk
45	Mon	Bilin	Kan Ywar	Very Low Risk

No.	State/Region	Township	Village	Drought Risk
46	Mon	Bilin	Thein Chaung	Very Low Risk
47	Mon	Bilin	Zoke Ka Li	No data
48	Mon	Thaton	Zaik Ka Ye	Median Risk
49	Mon	Thaton	Gyoe Hpyu Kone	Median Risk
50	Mon	Thaton	Aung Kan Thar	Low Risk
51	Mon	Thaton	Thone Eain Su*	Low Risk
52	Mon	Thaton	Htein Pin	Very Low Risk
53	Mon	Paung	Ahlat (Taung Paing)	Median Risk
54	Mon	Paung	Kar Te	Median Risk
55	Mon	Paung	Zee Kone (Paung)	Median Risk
56	Mon	Paung	Ahlat(Ah Nauk Paing)	Median Risk
57	Mon	Paung	Sae Eain Su*	Median Risk
58	Mon	Paung	Baing Laung	Low Risk
59	Mon	Paung	Khin Tan	Low Risk
60	Mon	Paung	Wea Pa Tan	Low Risk

**EMU villages outside of 60 GoMP target villages*

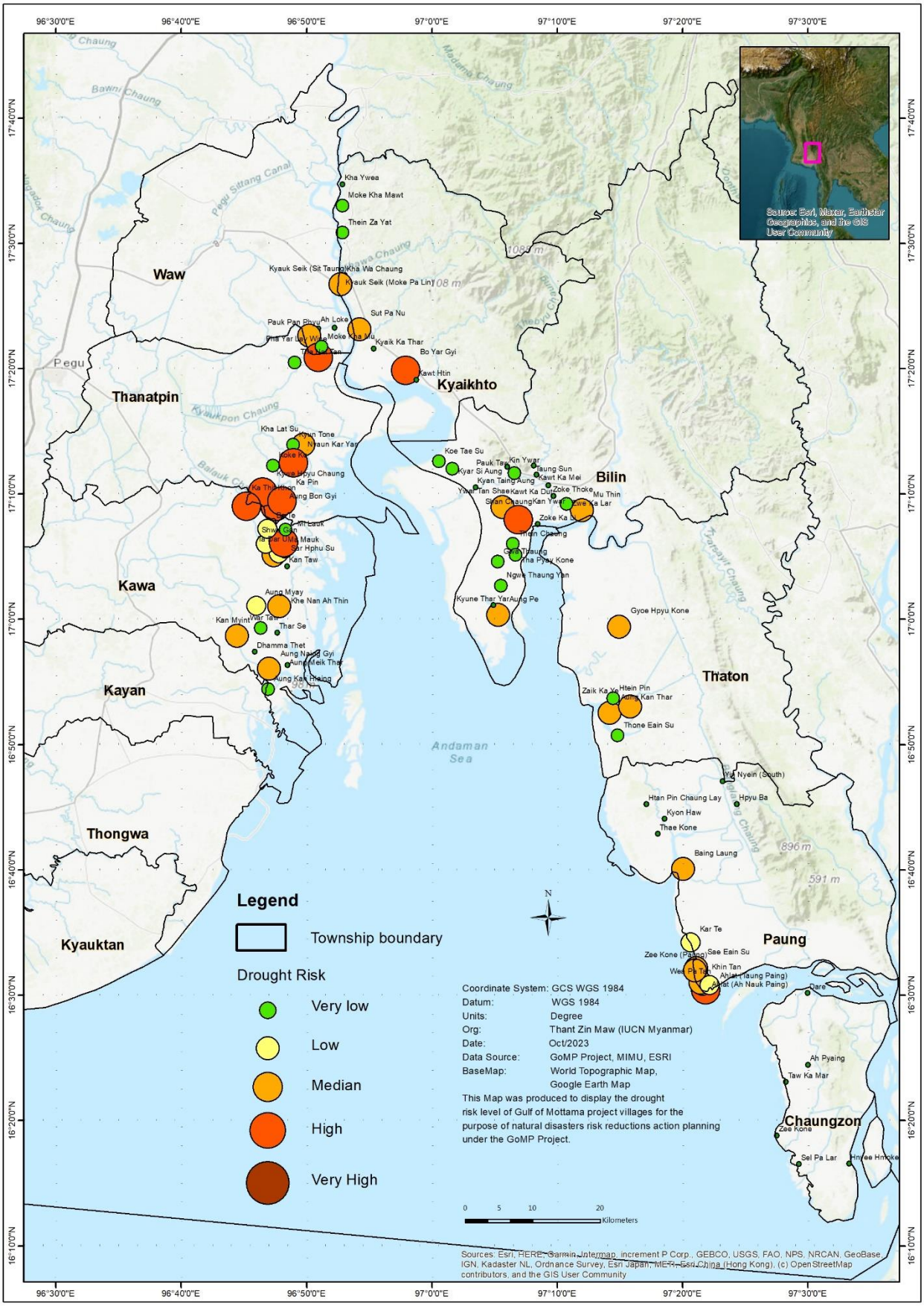

Figure 5. Map showing drought risk levels of villages in Mon and Bago in the GoM region

4.6 Overall Assessment of Disaster Risks

This work is the combination of four types of disasters, described as overall disaster risk assessment (Figure 6). Based on the findings of this assessment, Table 8 describes and prioritizes the villages that need immediate attention and intervention. Notably, the villages in Thanatpin, Kawa and Waw Townships face challenges associated with medium to very high levels of risks pertaining to the disasters, such as flood, and storm, coastal erosion. In the case of coastal erosion risk, Bago and Mon sides have high erosion risk level, besides, both sides are prone to severe erosion at the highest risk of future erosion under the unpredictable circumstances at long time. This assessment revealed that seven villages are particularly susceptible to disaster at very high-risk level. These villages include Ta Dar U, Khe Nan Ah Thin and Ma Mauk, villages in Kawa Township and Aung Bon Gyi, Pha Yar Lay Wine, Ka Thit Khon and Nyaung Kar Yar (non-GoMP) villages in Thanatpin Township. Although certain villages in Bilin experience no occurrences and exhibit no severity of hazards, however, primarily faced with the high flood risk in Bilin. Additionally, among villages in Mon side, villages in Kyaikhto were fallen within in median and low disaster risk. Based on level of combination of four types of disasters, it showed that 4 villages (1 in Kawa, 3 in Thanatpin) were experienced the disasters with very high risk, 11 villages (2 in Kawa, 4 in Thanatpin, 1 in Bilin, 2 in Thaton and 2 in Paung) with high risk level, 17 villages with medium risk, 18 villages with low risk, 6 villages with very low risk due to alternative natural phenomenon and anthropogenic impacts along the coastal area, during the previous 10 years.

Table 8. Overall disaster risk level of villages in Mon and Bago in the GoM region.

No.	State/ Region	Township	Village	Flood	Storm	Erosion	Drought	Overall Risk Level
				Risk Level	Risk Level	Risk Level	Risk Level	
1	Bago	Kawa	Ta Dar U	High	Median	Very High	High	Very High
2	Bago	Kawa	Khe Nan Ah Thin	Very High	Median	Median	High	High
3	Bago	Kawa	Ma Mauk	High	Low	Very High	High	High
4	Bago	Kawa	Aung Naing Gyi	High	Median	Very Low	High	Median
5	Bago	Kawa	Aung Kan Hlaing	High	Very Low	Median	Median	Median
6	Bago	Kawa	Sar Hphu Su	High	Very Low	Median	Low	Median
7	Bago	Kawa	Kan Myint	Median	Median	Very Low	Median	Median
8	Bago	Kawa	Mi Lauk	Low	High	Very Low	Very Low	Low
9	Bago	Kawa	War Taw	Median	Very Low	Low	Very Low	Low
10	Bago	Kawa	Shwe Gan	Median	Low	Very Low	Very Low	Low
11	Bago	Kawa	Aung Myay	Median	Low	Very Low	Very Low	Low
12	Bago	Kawa	Bo Te	Median	Low	Very Low	Very Low	Low
13	Bago	Kawa	Ngwe Taung	Median	Very Low	Very Low	Very Low	Very Low
14	Bago	Thanatpin	Aung Bon Gyi	Very High	High	High	Very High	Very High
15	Bago	Thanatpin	Pha Yar Lay Wine	Very High	High	High	High	Very High
16	Bago	Thanatpin	Nyaung Kar Yar*	Very High	High	Median	High	Very High

17	Bago	Thanatpin	Ka Thit Khon	High	High	Median	High	High
18	Bago	Thanatpin	Kyun Tone	High	Very Low	High	Very High	High
19	Bago	Thanatpin	Kha Lat Su	High	Median	Very High	Very Low	High
20	Bago	Thanatpin	Ka Pin*	High	High	High	Very Low	High
21	Bago	Thanatpin	Tha Nat Tan	High	Very Low	Low	Median	Median
22	Bago	Thanatpin	Kywe Hpyu Chaung	High	High	Very Low	Very Low	Median
23	Bago	Thanatpin	Koke Ko	High	Very Low	Very Low	Very Low	Low
24	Bago	Waw	Moke Kha Mu	Very High	Very Low	High	Low	Median
25	Bago	Waw	Ah Loke	Low	Median	Very Low	Very High	Median
26	Mon	Kyaikto	Kyauk Seik (Sit Taung)	High	Median	High	Very Low	Median
27	Mon	Kyaikto	Sut Pa Nu	Very Low	Median	High	Median	Median
28	Mon	Kyaikto	Thein Za Yat	High	Very Low	High	Very Low	Median
29	Mon	Kyaikto	Moke Kha Mawt	Very Low	Very Low	Median	Median	Low
30	Mon	Kyaikto	Bo Yar Gyi	Very Low	High	Very Low	Very Low	Low
31	Mon	Kyaikto	Kha Wa Chaung	No Data	No Data	No Data	No data	No data
32	Mon	Kyaikto	Kha Ywea	No Data	No Data	No Data	No data	No data
33	Mon	Kyaikto	Kyauk Seik (Moke Pa Lin)	No Data	No Data	No Data	No data	No data
34	Mon	Bilin	Mu Thin	High	Median	High	Median	High
35	Mon	Bilin	Aung Pe*	Median	Median	High	Low	Median
36	Mon	Bilin	Shan Chaung	High	Very Low	Very Low	High	Median
37	Mon	Bilin	Ywar Tan Shae	High	Median	Low	Very Low	Median
38	Mon	Bilin	Ngwe Thaung Yan	Very Low	Very Low	High	Median	Low
39	Mon	Bilin	Pauk Taw	Median	Very Low	Very Low	Median	Low
40	Mon	Bilin	Koe Tae Su	Very Low	Very Low	High	Low	Low
41	Mon	Bilin	Kan Ywar	Very Low	High	Very Low	Very Low	Low
42	Mon	Bilin	Kyar Si Aung	Median	Very Low	Very Low	Very Low	Very Low
43	Mon	Bilin	Gwa Thaung	Very Low	Very Low	Very Low	Median	Very Low
44	Mon	Bilin	Tha Pyay Kone	Low	Very Low	Very Low	Very Low	Very Low
45	Mon	Bilin	Zwe Ka Lar	Very Low	Very Low	Very Low	Very Low	Very Low
46	Mon	Bilin	Thein Chaung	Very Low	Very Low	Very Low	Very Low	Very Low
47	Mon	Bilin	Zoke Ka Li	No Data	No Data	No Data	No data	No data
48	Mon	Thaton	Gyoe Hpyu Kone	High	Median	High	Median	High
49	Mon	Thaton	Zaik Ka Ye	High	Median	Median	Median	High
50	Mon	Thaton	Thone Eain Su*	Low	Very Low	High	Low	Low

51	Mon	Thaton	Htein Pin	High	Very Low	Very Low	Very Low	Low
52	Mon	Thaton	Aung Kan Thar	Very Low	Median	Very Low	Low	Low
53	Mon	Paung	Ahlat (Taung Paing)	High	High	Median	Median	High
54	Mon	Paung	Khin Tan	High	Median	High	Low	High
55	Mon	Paung	Zee Kone (Paung)	Median	Median	Median	Median	Median
56	Mon	Paung	Baing Laung	Median	Median	Median	Low	Median
57	Mon	Paung	Ahlat(Ah Nauk Paing)	Median	Low	Low	Median	Median
58	Mon	Paung	Wea Pa Tan	Median	Low	Very Low	Low	Low
59	Mon	Paung	Sae Eain Su*	Very Low	Median	Very Low	Median	Low
60	Mon	Paung	Kar Te	Very Low	Low	Very Low	Median	Low

** EMU villages outside of 60 GoMP target villages*

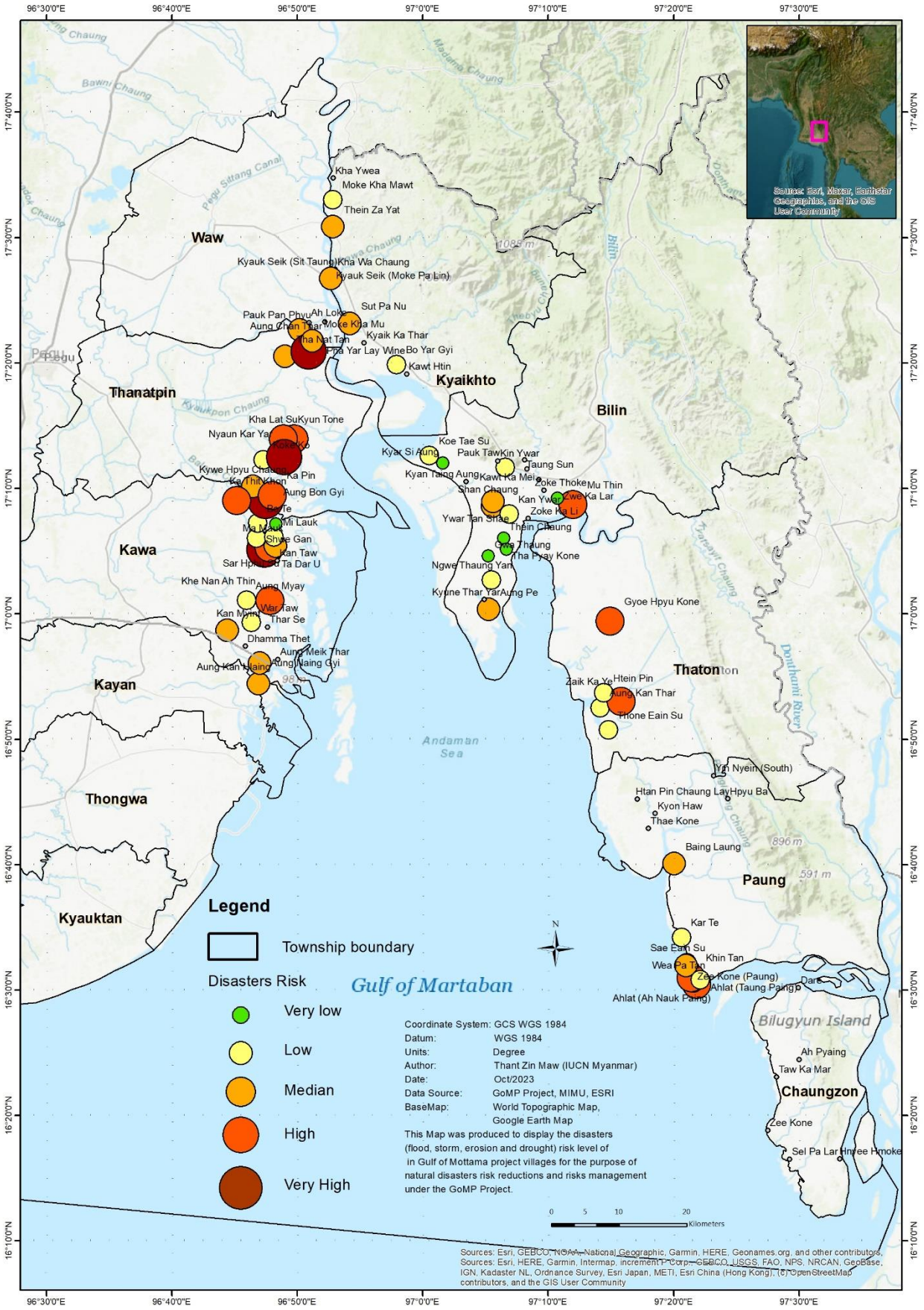

Figure 6. Map showing overall disaster risk in villages of Mon and Bago in the GoM region

5 DISCUSSION AND CONCLUSIONS

In Bago region, a majority of villages face frequent and high flood risks due to its flat and lowland topography, compared to those in Mon State. According to the group work discussion in CBDRM planning, the flood risk is associated with climate change impacts such as prolonged heavy precipitation, as well as human activities like construction of dykes to block tidal water drainage, and poor drainage systems in agricultural fields. Coastal erosion emerged as a second hazard, posing a significant threat to the villages, resulting in the loss of agricultural lands and the need for village relocation in some instances. The villages on Bago side exhibit medium to very high levels of risks to disasters, including flood, coastal erosion and drought. We observed coastal erosion high risk on both Bago and Mon sides, particularly, 15 villages in Thanatpin, Waw, Kyaikhto, Bilin, Thaton, Paung Townships suffered from significant impact of coastal erosion, as high-risk level of erosion. Due to the coastal erosion, they lost the village's agricultural land and did relocate their settlement from the coastline to the inner part.

Findings from CDE Myanmar in 2022 reveal that some villages in Thanatpin and Kawa Townships faced a more significant loss of stable land than Mon side over the past decade, aligning with the results of disaster risk assessment in this study. Nevertheless, since 2023, it is expected that the erosion front has reached stable land at the coast of Bilin and will likely lead to loss of land and property for as long as a new tipping point will have been reached and the main channel will change its course again. Besides, this large-scale erosion/sedimentation process is not evenly along the whole coast and in some areas the pattern can be locally different. Variations in geography and livelihoods between Bago and Mon cause differing vulnerability, with some coastal communities in Bago, encountering more challenges, including village relocation and limited infrastructure development. This assessment report serves as valuable inputs for coastal disaster risk reduction, adaptable to various coastal environments. The results can inform management plans to reduce disaster risks and impacts in villages, enhancing community resilience to endure catastrophic events.

5.1 Flood

Among the villages studied, 35 of them have implemented flood risk reduction measures such as the construction of sluice gates and water canals, participation in disaster risk preparedness and reduction training, mangrove restoration activities and the creation of high land topography. Along the coastline, many villages built the dykes to safeguard against salt water intrusion into agricultural lands. However, these protective measures lead to accumulation of rain water in rainfed agricultural fields during the rainy season, causing prolonged inundation and economic loss on a large scale.

The GoMP supported important agricultural practices (clean seeds and techniques, home garden, seed bank). Recognizing the necessity of supporting livelihood resilience, particularly in the renovation or construction of dykes through Cash for Work, is vital to minimize the losses of agricultural products due to flood hazards. Additionally, enhancing early warning mechanism is also crucial to empower communities in their preparedness efforts and reduce the risk of flood-related disasters.

5.2 Storm

The villages under this study often experience strong winds like tornados, however there was a notable absence of storms with high risk in eight townships. In 15 villages, safety activities and preparedness strategies are implemented to to protect from strong winds, including the construction of cyclone shelters, planting mangrove and windbreak trees, and participating in preparedness training. An early warning system, disseminated through social media such as Facebook or radio programs, plays a crucial role in reducing the loss of human lives and property. This approach diminishes the likelihood of the storm hazard evolving into disasters.

5.3 Erosion

A significant portion of the land cover in the region has undergone transformation, primarily converted to agricultural land. This has resulted in areas with limited accessibility and lower level of infrastructure development. Notably, the landscape in these coastal villages of Bago region exhibits variations in livelihood pattern, with a distinctive scarcity of forests compared to Mon State. In the coastal villages of Mon State, the presence of mangrove and trees cover emerges as a critical factor for minimizing vulnerability to disasters. For instances, Aung Kan Thar in Thaton Township, Kar Te and Welpatan villages in Paung Township, highlight the beneficial impact of mangrove existence on disaster resilience. This study identified that 17 villages among 56 villages have already possessed the coastal erosion risk reduction schemes such as mangrove conservation, utilization of rocky surface, and construction of retaining wall or embarkment wall. These proactive measures could strengthen the coastal communities in their resilience against coastal erosion risks.

5.4 Drought

Drought has been assessed with a specific focus on drinking water shortage and impact level on society during the previous 10 years. The risk assessment revealed that drought comparatively poses the least challenge in the majority of villages. Encouragingly, 41 villages have already implemented preventive measures and preparedness actions to mitigate drought-related risks. These measures include initiatives such as pond renovation, construction of new ponds and dug wells, installation of water tank for rain water storage, as well as sourcing water through buying water or donation from neighbouring villages. The GoMP has supported infrastructure development related to drought risk reduction. This support is manifested through annual efforts directed at improving water-related infrastructure. To reduce the risk of drought-related disasters, it is recommended that the projects strategically identify the vulnerable villages or communities, as indicated in the drought risk map. Targeted interventions may include the construction of small water reservoirs, the construction of durable ponds and wells, the extension of pipelines from the borehole, etc. By implementing such measures, the project aims to enhance resilience in selected areas and fortify communities against the potential impacts of drought.

6 RECOMMENDATIONS

The assessment of disaster risks at the community level stand as a fundamental element for the development of disaster risk reduction and resilience-building initiatives. Through prioritizing local perspectives, fostering collaboration, and embracing comprehension of vulnerability, the following recommendations are provided to make a meaningful contribution to the pursuit of establishing communities that can not only withstand the impacts of disasters but also thrive in the face of uncertainty, ultimately paving the way for a more sustainable and resilient future.

6.1 Community engagement and awareness

Community members are encouraged to engage in discussions regarding the support for solutions, considering both individual households and collective capacities. It is vital for the communities to embrace the ownership and a shared sense of responsibility by encouraging active participation in implementation of CBDRM plan. This necessitates effective communication that leaves decision-making in the hands of the community. Sustaining this approach involves empowering community-based teams to continue leading CBDRM initiatives, fostering awareness through regular community events. A collaborative

coalition formed by bringing together community members and local authorities provide valuable supports for CBDRM efforts.

6.2 Promoting disaster preparedness and mitigation

A sustained collaboration between Village Development Committees (VDCs) and other community members is imperative for systematically planning and prioritising vulnerable households within the community. The VDCs are supposed to play an important role in raising awareness and serving as intermediaries between other partners and the local community. Additionally, the emphasis is on supporting and strengthening community-based organizations to implement disaster preparedness, disaster risk reduction and management.

6.3 Investment in capacity building

It is recommended to provide training programs to enhance the skills of community members in emergency responses, first aid and basic search and rescue operations. It is also important to build the technical capacity of local professionals and organizations involved in disaster risk management through specialized training and workshops.

6.4 Promotion of sustainable land management

The communities are encouraged to adopt ecosystem-based solutions such as mangrove restoration and sustainable land management practices, to ensure the community`s resilience to natural disasters. In this aspect, community-based conservation initiatives could contribute to both disaster risk reduction and environmental sustainability.

6.5 Enhancing early warning systems

Early warning systems should be developed, especially for storms, depending on local context, to ensure accessibility for all community members, including those with special needs. A clear communication channel should be established for disseminating timely and accurate information during emergencies.

ACKNOWLEDGEMENT

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