Identification of flood prone areas in the Gulf of Mottama area, Myanmar using GIS-integrated multi-criteria decision approach

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Gulf of Mottama Project (GoMP)

Contents

1 Introduction

The Gulf of Mottama (GoM) is intertidal wetlands with dynamic geophysical features which inhabiting coastal wetland ecosystems, species of conservation concern and coastal communities. Similarly, to other coastal region, the GoM is especially vulnerable to climate-induced hazards such as cyclones, tidal surges, floods, saline intrusion, and droughts. The three consortium partners (Helvetas, NAG and IUCN) have been implementing the Gulf of Mottama Project (GoMP) in Mon State and Bago Region with the financial support of SDC. One of the project outcomes is to enhance livelihoods of local communities. If disaster prone areas can be identified and effective disaster risk reduction measures can be undertaken, it can improve well-being, strengthen livelihoods and contribute to sustainable development.

Predicted rises in temperature and more frequent intense precipitation events mean these risks will increase, and thus disaster risk reduction is incorporated into project activities. However, in order to effectively conduct project activities for disaster risks and climate change mitigation, there are still major gaps in identifying disaster-prone areas and understanding the disaster risks in the respective areas. Therefore, in this analysis, we identified flood prone areas using GIS-integrated multi-criteria decision approach. The results from this analysis will contribute to disaster risk reduction and climate change mitigation measures in the GoM area. Regarding flood prone area, GIS data were be mainly applied to analyse the risk level and qualitative data will be applied to validate the result.

2 Objectives

This analysis is aimed at identifying flood-prone areas with levels of flood risk in the GoM area.

3 Methodology

Analyzing flood risk zones requires different factors to integrate as a single layer. In this research, different 6 layers are utilized to generate the flood risk map, which are digital elevation model (DEM), slope, distance to water, drainage density, land cover and precipitation. Important level (weighted percentage) of each data is decided by the contribution and consultation of local experts, climate focal officer and other project members.

3.1 Data collection and preparing

a) DEM layer was downloaded from ALOS
b) Slope layer was generated from DEM
c) Distance to water layer was generated from DEM
d) Drainage density layer was generated from DEM
e) Land cover layer was analyzed Sentinel-2 satellite imageries
f) Precipitation layer was downloaded from CRU and prepared in ArcGIS

3.2 Preparing of DEM layer

Elevation of terrain plays an important role in deciding the flood risk as flood will happen mainly in low land and quite safe in high elevation area. DEM layer was freely downloaded from ALOS and created a mosaic layer for mapping. The, elevation values were reclassified by natural breaks into 5 classes (Figure 1) to apply in the weighted sum of all 6 layers. In this map, very low land area is defined as very high risk (level 5), low land area is defined as high risk (level 4), moderate high area is defined as median risk (level 3), high land area is defined as low risk (level 2) and very high land area is defined as very low risk (level 1). Values of height in meter are mentioned in the map below.

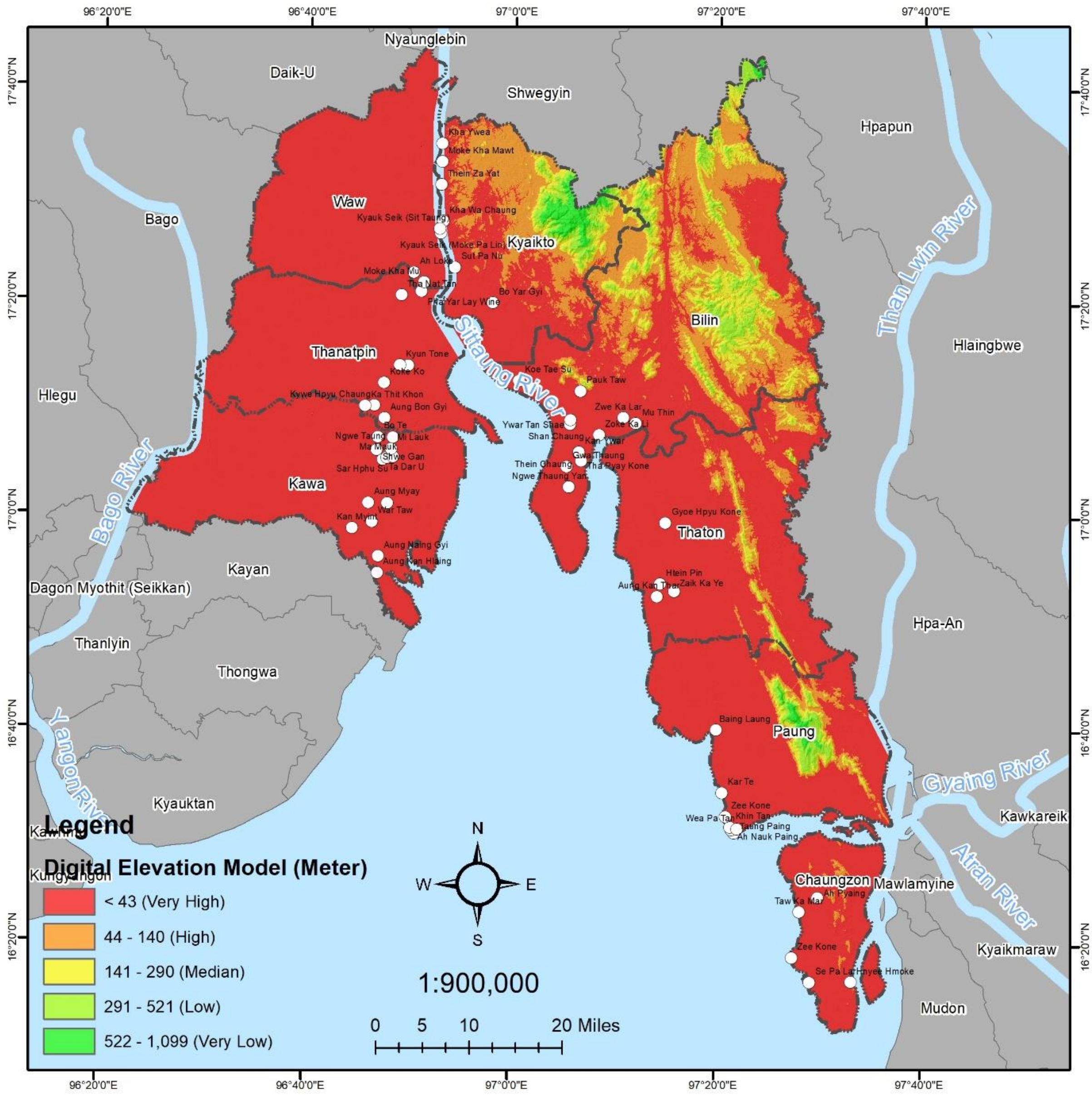

Figure 1: Flood risk level of elevation map

3.3 Preparing slope layer

The slope is the ratio of a feature's steepness or degree of inclination to the horizontal plane. Slope is an important indicator of flood-prone surface zones. Slope is an important factor in determining the rate and duration of water flow. Water moves more slowly, collects for a longer period of time, and accumulates on flatter surfaces, making them more vulnerable to flooding than steeper surfaces. Slope layer was created from DEM by slope tool in ArcMap (3D Analysis Tools/ Raster Surface/ Slope). Then, it was reclassified by natural breaks into 5 (Figure 2) for weighted sum. In this map, very steep area can flow out water faster than other areas. In the map, very high is risk level 5, high is risk level 4 = 2, Median is risk level 3, low is risk level 2 and very low is risk level 1.

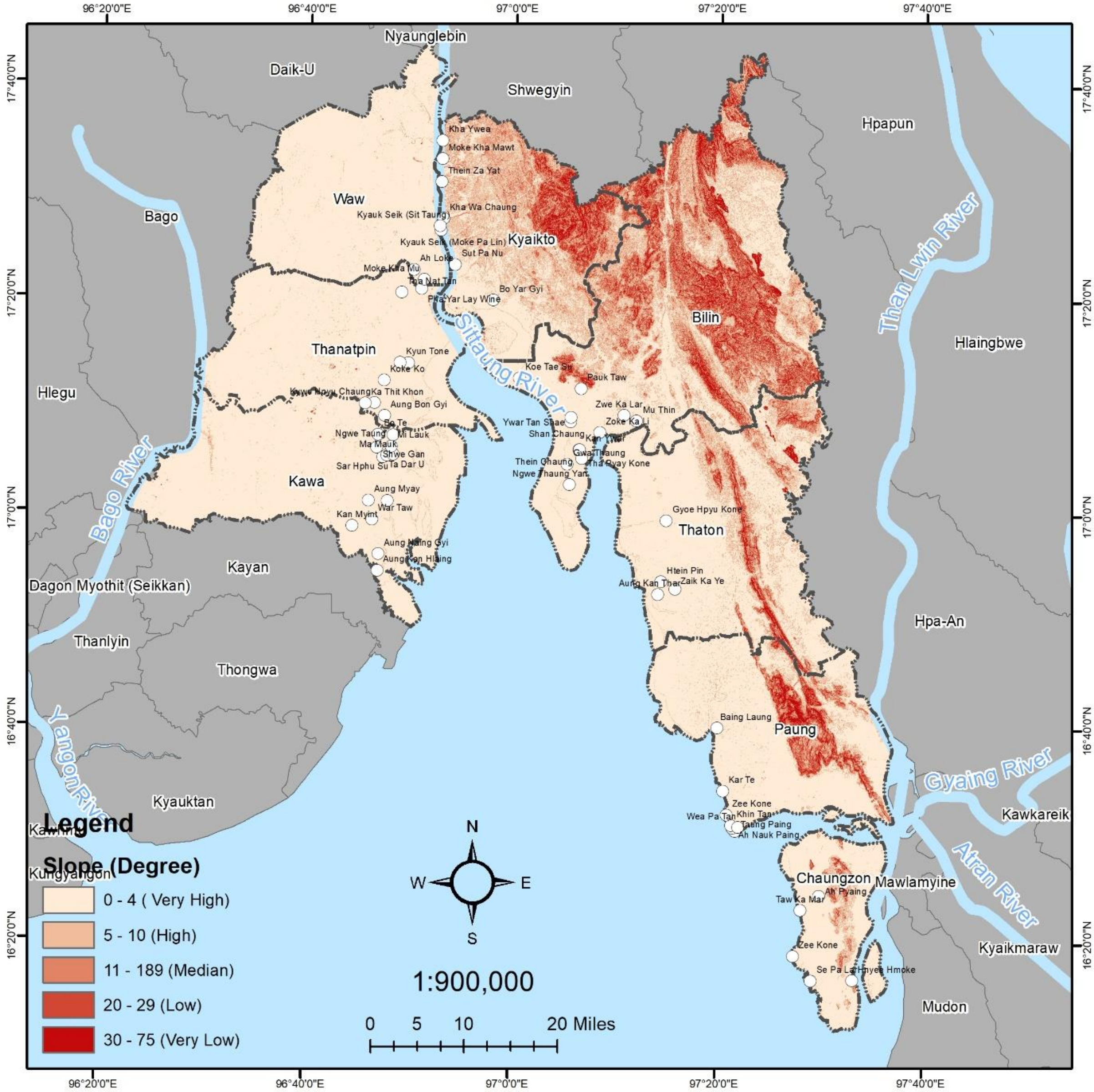

Figure 2: Flood risk level of slope map

3.4 Preparing distance to water layer

To evaluate flood hazard map, water proximity is also a primary criteria because buffer zones of water area are experiencing the most flooding issues than other areas. Water proximity layer was created in ArcMap by different tools (DEM> Fill> Flow Direction> Flow Accumulation> Reclassify> Euclidean Distance) and the result was finally reclassified into 5 classes (Figure 3) like other layers.

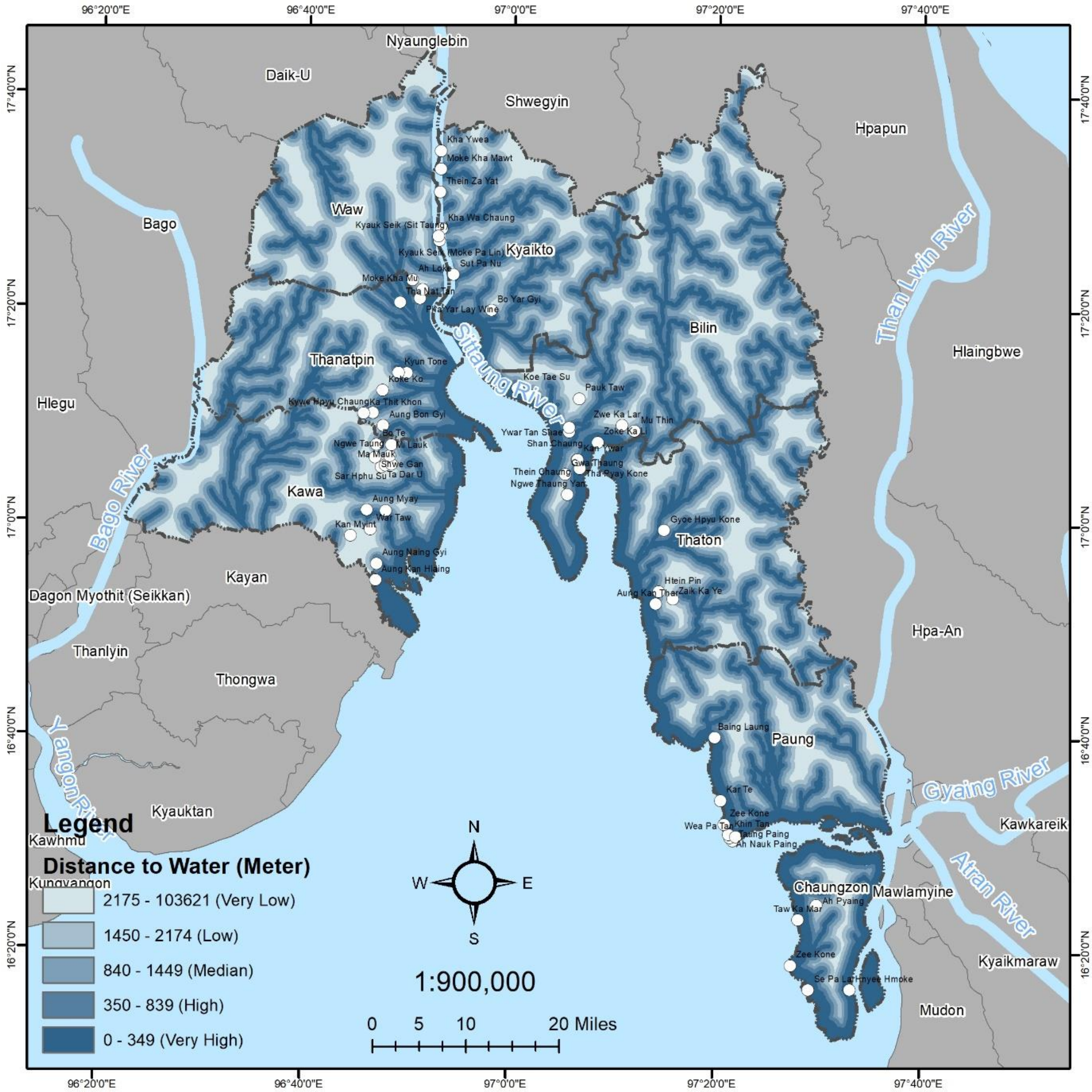

Figure 3: Flood risk level of distance to water map

3.5 Preparing drainage density layer

Drainage density also decides flood hazard as it participates in water flow and accumulation. The more drainage system in the area, the more water flow out quickly. Drainage density layer was built from DEM by different tools (DEM> Fill> Flow Direction> Flow Accumulation> Reclassify> Stream Order> Stream to Feature> Line Density). Lastly the result was classified into 5 classes (Figure 4). The most drainage dense area is the easiest place to rush out water, so it is defined as very low risk and the least drainage dense area is defined as very high risk area.

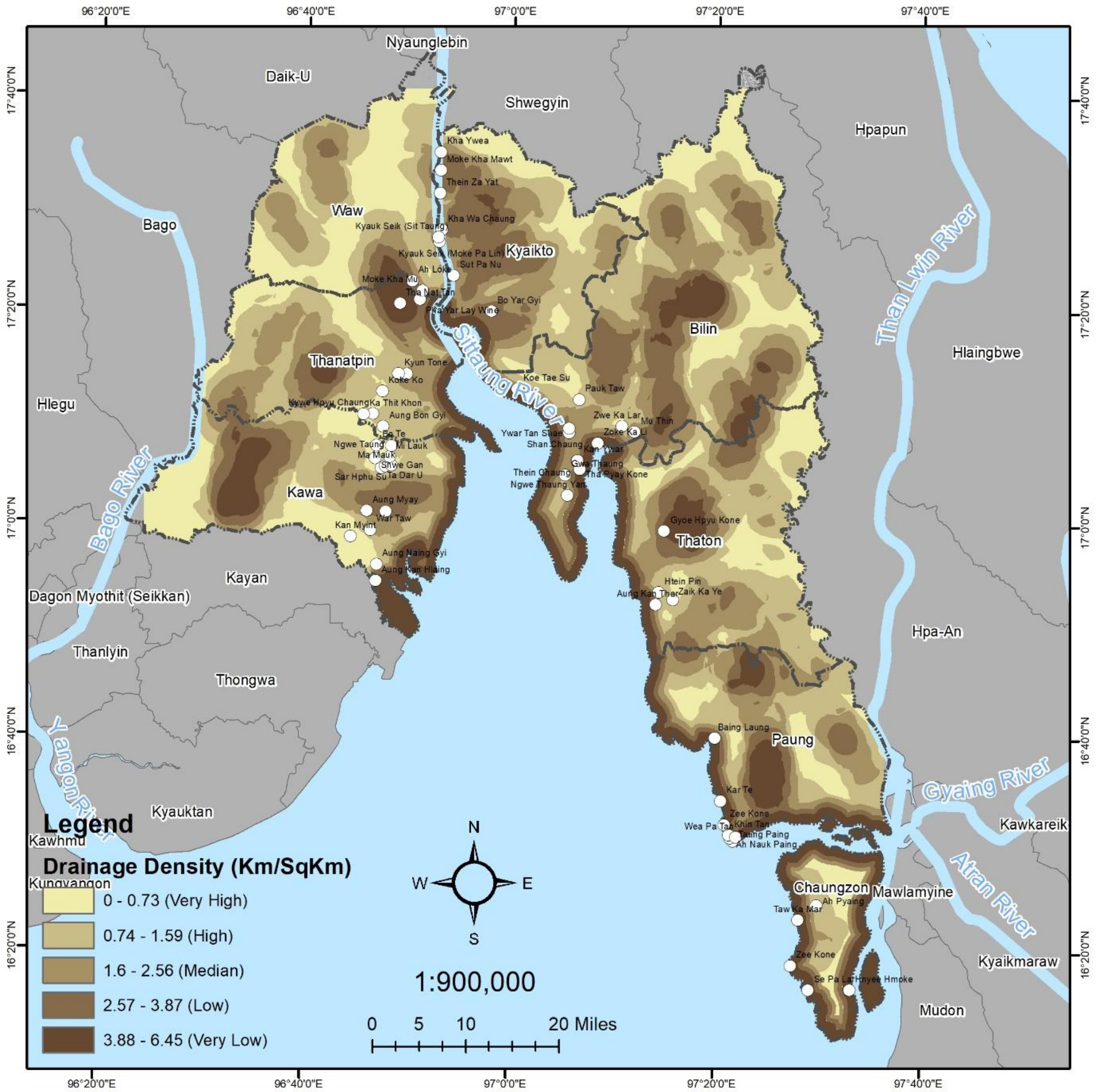

Figure 4: Flood risk level of drainage density map

3.6 Preparing land cover layer

Land cover means different type of land we can find in GoM, which are water body, mudflat, grass land, mangrove, crop land and forest. Land cover also contributes a certain role in flood water movement. Sentinel-2 imageries were analyzed to detect the land covers mentioned about and they were classified into 5 classes. According to field experiences and social survey to local communities, forest which is situated on high land is defined as very low risk class while crop land, mangrove and grass land are defined as high risk class because they lie at low land and some are located at coastal line. Mudflat and water are defined as very high risk as they already reach to sea.

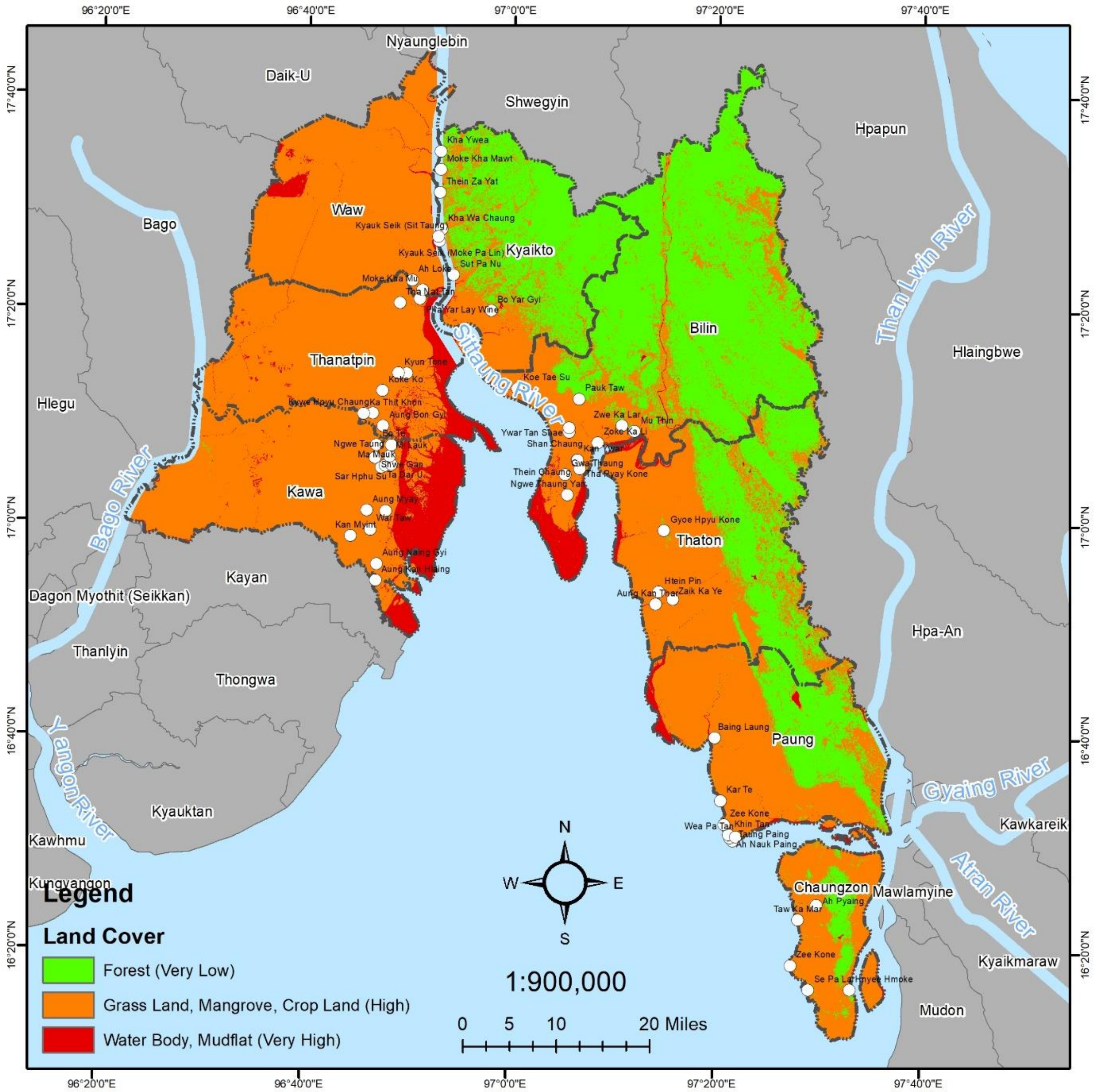

Figure 5: Flood risk level of land cover map

3.7 Preparing precipitation layer

Rainfall is a vital factor in creating flood danger map. The intensity of rainfall is causing flooding, the greater the amount of rainfall, the greater the flood-producing runoff, and vice versa. Rainfall data of 2021 was downloaded from Climate Research Unit website and processed in ArcGIS to classify into 5 classes (Figure 6).

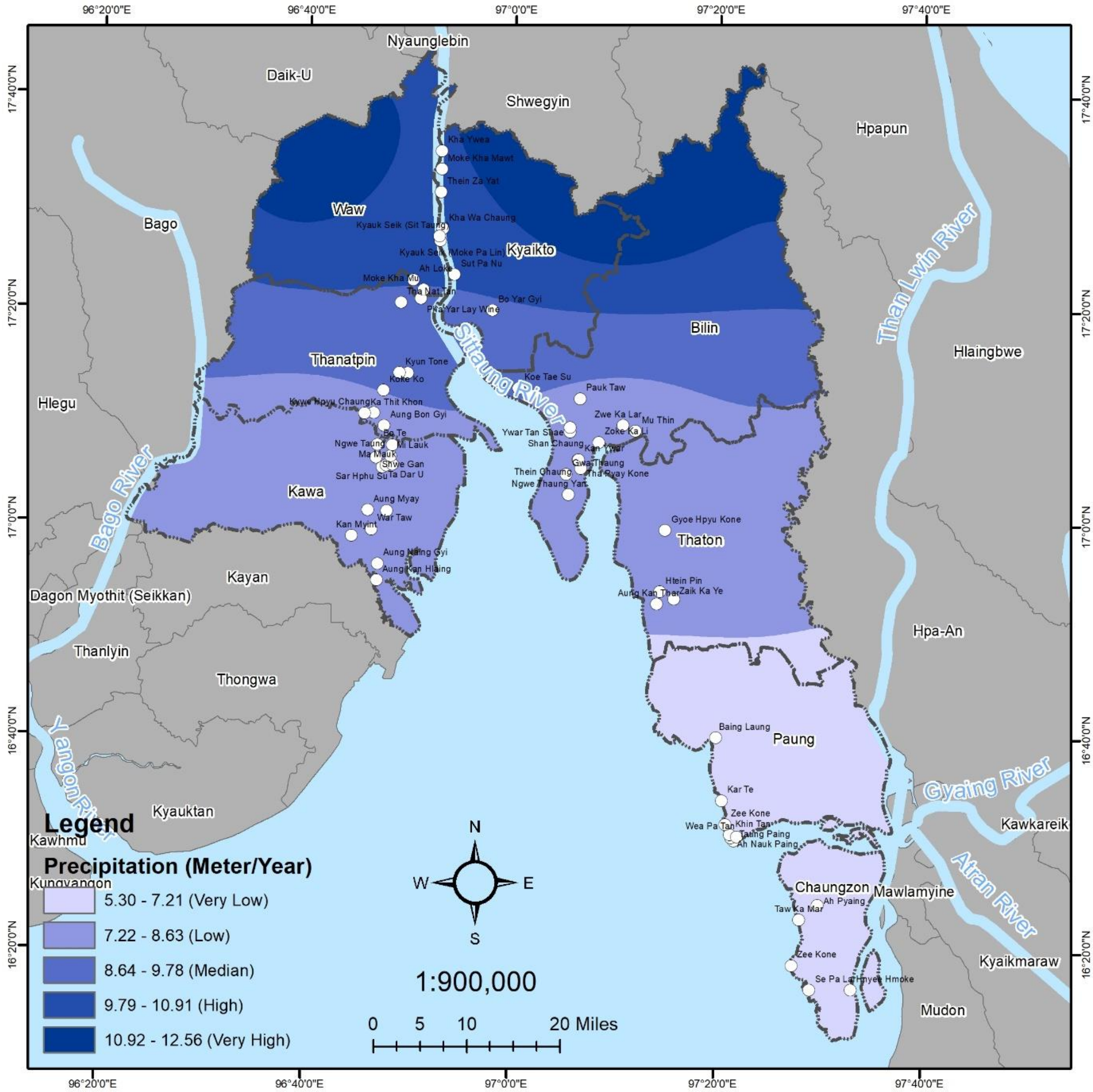

Figure 6: Flood risk level of precipitation map

Table 1: Risk level classification for each layer and their weight for overlaying

Layer	Values	Risk	Weighted %
Elevation (m)	< 43	Very High	25%
	44 - 140	High	
	141 - 290	Median	
	291 - 521	Low	
	522 - 1,099	Very Low	
Distinct to Water (m)	0 - 349	Very High	25%
	350 - 839	High	
	840 - 1449	Median	
	1450 - 2174	Low	
	2175 - 103621	Very Low	
Slope (degree)	0 - 4	Very High	20%
	5 - 10	High	
	11 - 189	Median	
	20 - 29	Low	
	30 - 75	Very Low	
Precipitation (m)	5.30 - 7.21	Very High	15%
	7.22 - 8.63	High	
	8.64 - 9.78	Median	
	9.79 - 10.91	Low	
	10.92 - 12.56	Very Low	
Land Cover	Water, Mudflat	Very High	10%
	Grass Land, Mangrove, Crop Land	High	
	Forest	Very Low	
Drainage Density (km/sqkm)	0 - 0.73	Very High	5%
	0.74 - 1.59	High	
	1.6 - 2.56	Median	
	2.57 - 3.87	Low	
	3.88 - 6.45	Very Low	

3.8 Weighting layers and combining

To create the flood risk zones map, all six layers were combined into single file by different weight depending on how important each layer is. To decide weight percentage of each layer, I consulted different project members who have local knowledge of topography, flood, climate, history and etc. By the decision of some project members, weighted percentage of each layer was given as in the table above (Table 1). Although precipitation should be weighted high percentage as it as significant effect in flood, the data quality is a bit low. So, we decided to rank it as a low rated factor. Besides, there is no proper drainage system on ground, so the team decided not to rely on the data too much and keep it as low contribution.

4 Results

We have produced the map showing flood prone areas in the GoM using a multi-criteria decision approach. In the map, red areas are very high zones of flooding, most of them are found along the coastal line and most of the project villages are situated in red areas. In Bago region, there is no green areaes or low risk areas as it is quite flat. Most of the agricultural areas in both Mon and Bago side, locate in median risk areas as they are in low land. According to map (Figure 7), very low and low risk areas can be found in mountainous area in Mon state.

Table 2: Project villages with flood risk level

No	State/Region	Township	Village	Flood Risk Level
1	Bago	Kawa	Aung Kan Hlaing	Very High Risk
2	Bago	Kawa	Aung Myay	Very High Risk
3	Bago	Kawa	Aung Naing Gyi	Very High Risk
4	Bago	Kawa	Bo Te	Very High Risk
5	Bago	Kawa	Kan Myint	Median Risk
6	Bago	Kawa	Khe Nan Ah Thin	Very High Risk
7	Bago	Kawa	Ma Mauk	Median Risk
8	Bago	Kawa	Mi Lauk	Median Risk
9	Bago	Kawa	Ngwe Taung	Median Risk
10	Bago	Kawa	Sar Hphu Su	Median Risk
11	Bago	Kawa	Shwe Gan	Median Risk
12	Bago	Kawa	Ta Dar U	Median Risk
13	Bago	Kawa	War Taw	Median Risk
14	Bago	Thanatpin	Aung Bon Gyi	High Risk
15	Bago	Thanatpin	Ka Thit Khon	High Risk
16	Bago	Thanatpin	Kha Lat Su	Very High Risk
17	Bago	Thanatpin	Koke Ko	High Risk
18	Bago	Thanatpin	Kyun Tone	Very High Risk
19	Bago	Thanatpin	Kywe Hpyu Chaung	Very High Risk
20	Bago	Thanatpin	Pha Yar Lay Wine	High Risk
21	Bago	Thanatpin	Tha Nat Tan	Very High Risk
22	Bago	Waw	Ah Loke	Very High Risk
23	Bago	Waw	Moke Kha Mu	High Risk
24	Mon	Bilin	Gwa Thaung	Median Risk
25	Mon	Bilin	Kan Ywar	Very High Risk
26	Mon	Bilin	Koe Tae Su	Very High Risk
27	Mon	Bilin	Kyar Si Aung	Very High Risk
28	Mon	Bilin	Mu Thin	Median Risk
29	Mon	Bilin	Ngwe Thaung Yan	Median Risk
30	Mon	Bilin	Pauk Taw	Low Risk
31	Mon	Bilin	Shan Chaung	Very High Risk
32	Mon	Bilin	Tha Pyay Kone	Very High Risk
33	Mon	Bilin	Thein Chaung	Very High Risk
34	Mon	Bilin	Ywar Tan Shae	Very High Risk
35	Mon	Bilin	Zoke Ka Li	Very High Risk
36	Mon	Bilin	Zwe Ka Lar	Low Risk
37	Mon	Chaungzon	Ah Pyaing	Median Risk
38	Mon	Chaungzon	Hnyee Hmoke	Median Risk
39	Mon	Chaungzon	Se Pa Lar	Very High Risk
40	Mon	Chaungzon	Taw Ka Mar	Very High Risk
41	Mon	Chaungzon	Zee Kone	High Risk
42	Mon	Kyaikto	Bo Yar Gyi	High Risk
43	Mon	Kyaikto	Kha Wa Chaung	Very High Risk

44	Mon	Kyaikto	Kha Ywea	Very High Risk
45	Mon	Kyaikto	Kyauk Seik (Moke Pa Lin)	Very High Risk
46	Mon	Kyaikto	Kyauk Seik (Sit Taung)	Very High Risk
47	Mon	Kyaikto	Moke Kha Mawt	Very High Risk
48	Mon	Kyaikto	Sut Pa Nu	Very High Risk
49	Mon	Kyaikto	Thein Za Yat	Very High Risk
50	Mon	Paung	Ah Nauk Paing	Very High Risk
51	Mon	Paung	Baing Laung	Very High Risk
52	Mon	Paung	Kar Te	High Risk
53	Mon	Paung	Khin Tan	High Risk
54	Mon	Paung	Taung Paing	High Risk
55	Mon	Paung	Wea Pa Tan	Very High Risk
56	Mon	Paung	Zee Kone	Very High Risk
57	Mon	Thaton	Aung Kan Thar	Very High Risk
58	Mon	Thaton	Gyoe Hpyu Kone	High Risk
59	Mon	Thaton	Htein Pin	High Risk
60	Mon	Thaton	Zaik Ka Ye	Median Risk

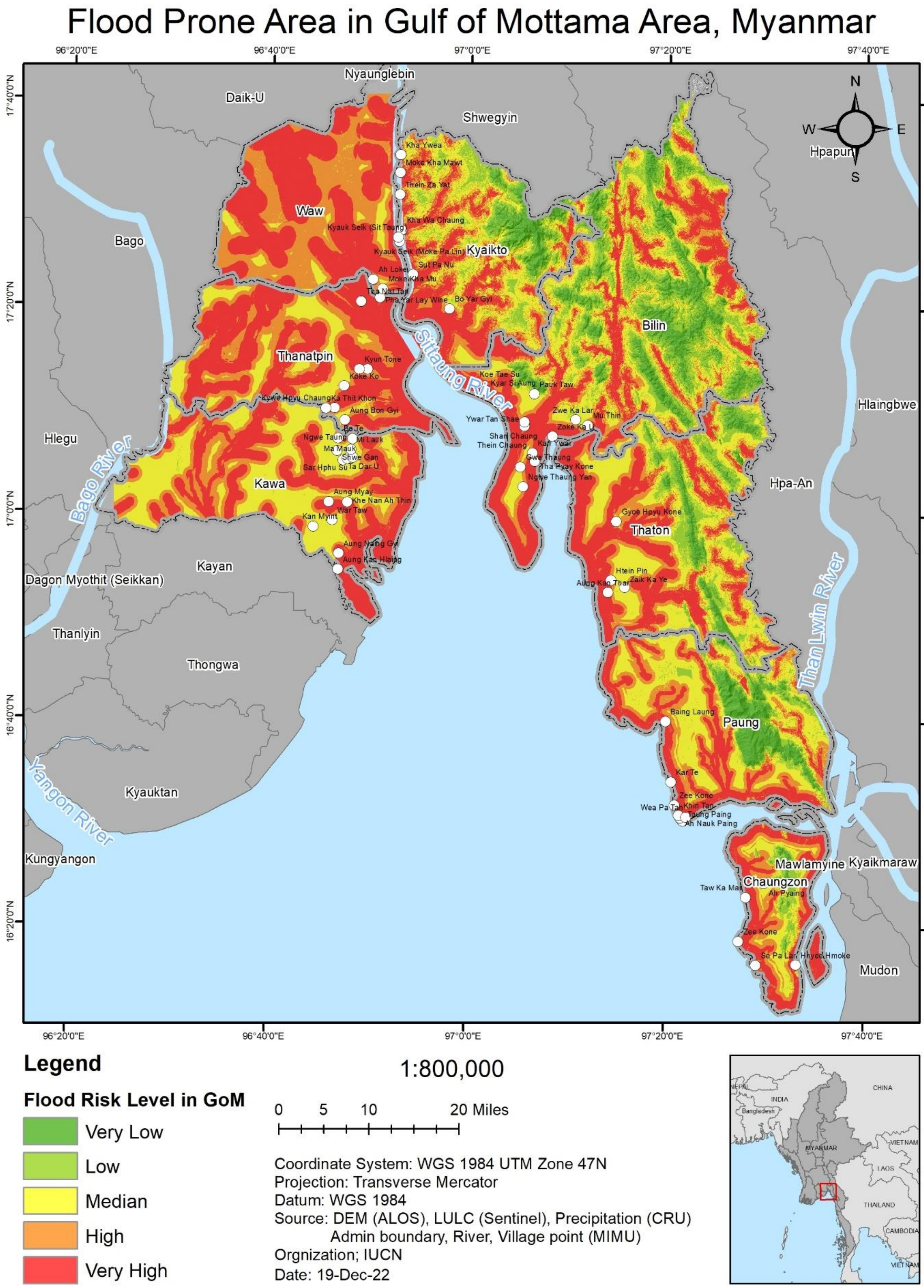

Figure 7: Map showing flood prone areas in the GoM area.

5 Validation

Since all the data utilized in the analysis were remote sensing data, which cannot be 100% relied, the result needs to be validated with ground data and local experts. Firstly, the result was reviewed by two project members from Bago and Chaungzon, two local people from Thaton and Paung and they confirmed the map reflects real ground condition. Besides, I randomly selected 17 villages with different levels of flood risks to conduct an interview on how often they experienced flood during the past 10 years. As shown in Table 3, most of the villages with high risk and very high risk had experienced frequent flood more than other villages with low risk and median risk.

Table 3: Comparison of flood risk level and flood frequency in selected villages

No	Township	Village	Flood Risk Level (Map)	Flood Freqnency (10 years)
1	Bilin	Zwe Ka Lar	Low Risk	0
2	Bilin	Pauk Taw	Low Risk	0
3	Kawa	Shwe Gan	Median Risk	3
4	Kawa	Ngwe Taung	Median Risk	4
5	Kawa	Ta Dar U	Median Risk	5
6	Kawa	Ma Mauk	Median Risk	5
7	Kawa	Sar Hphu Su	Median Risk	5
8	Thanatpin	Ka Thit Khon	High Risk	6
9	Thanatpin	Aung Bon Gyi	High Risk	8
10	Thanatpin	Pha Yar Lay Wine	High Risk	8
11	Paung	Taung Paing	High Risk	10
12	Paung	Khin Tan	High Risk	10
13	Kawa	Khe Nan Ah Thin	Very High Risk	9
14	Chaungzon	Se Pa Lar	Very High Risk	10
15	Kawa	Bo Te	Very High Risk	10
16	Kyaikto	Sut Pa Nu	Very High Risk	10
17	Kyaikto	Kyauk Seik (Moke Pa Lin)	Very High Risk	10

6 Conclusions

The present study is mainly to identify flood prone areas in the Mon State and Bago Region. Six criteria or factors have been used to determine flood risk level with a weight of the relative importance. We applied GIS environment to model the map integrating topographic parameters with land use land cover. The results revealed that villages in Bago are more susceptible to flood because the topography is flat and close to water source. In Mon State, villages near the coast are more prone to flood whereas low risk areas can be found in mountainous areas. Based on validation results, the flood prone area map produced in this analysis could provide a reliable information, to some extent, for undertaking disaster risk reduction in the villages in the GoM area. Future work will be investigation on other disaster types such as storm, drought and coastal erosion.