A Geographical Study of Flooding in Laymyethna Township, Ayeyarwady Region

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Abstract

Laymyethna Township is located in Ayeyarwady Region to the West of Hinthada Township. It experiences two types of flooding: overbank flooding and flash flooding. With the exception of 4 years, from 1980 to 2018, the water level of Ngawun River reached danger level (34 feet above sea level) and above danger level in the Laymyethna Township. In the 39 years period, only 4 years, 2000, 2001, 2009 and 2010, were free from flooding, but the remaining 35 years witnessed overbank flooding. In addition, the large amount of heavy rain rushing down along the slope of Rakhine Yoma causes flash flood over the area between the Yoma and the Ngawun River. The township suffered the impact of floods almost every year. The study focuses on the causes of flooding in the study area. To know the causes of flood, flood risk map was prepared by seven parameters: water level of Ngawun River, flow accumulation, distance from river, road and embankment, land use and land cover, population density and soil and then analysed by weighted overlay using raster calculator. The result shows high risk area (0.5%), risk area (19.3%), moderate risk area (14.8%), low risk area (20.4%) and no risk area (45%) in the study area. The result validates with village tracts of flooded monsoon paddy and school from 2015 to 2018 in the study area. It reveals that risk area coincides with Village tracts of flooded paddy fields and schools.

Key words: Flooding, causes of flood, Flood risk map, weighted overlay, raster calculator, Laymyethna Twonship

Introduction

Flooding has always been one of the hazards in Myanmar, accounting for 11% of all disasters, second only to fire. Flood in the Ayeyarwady Region is third of all disasters, after fire and storms**.** Laymyethna Township is one of the townships in Ayeyarwady Region. The Ngawun River flows from north to south meandering across the eastern part. The high meandering of Ngawun River channel reduces the flow velocity thereby, depositing large amount of sediments during flooding in the rainy season. The low-lying areas along the banks of Ngawun River are vulnerable to severe flooding. Flooding caused the destruction of monsoon paddy cultivation, school, housing, and health and transportation. Therefore, the study focuses on causes of flooding in the study area.

Study Area

Laymyethna Township is located in Ayeyarwady Region to the West of Hinthada Township. It lies between north latitude 17°24' and 17°46' and between east longitude 94°97' and 95°17'. The area of the township is 1033.5 squares kilometers, comprising 43 village tracts made up of 283 villages in the rural area and 5 wards in the urban area. Laymyethna Township can be divided into three divisions. These are, (1) the western Rakhine Yoma, (2) the area between Rakhine Yoma and Ngawun River and (3) the eastern part of Ngawun River. The land is higher in the west and is lower gradually toward the east. The Ngawun River flows from north to south meandering across the eastern part. Other locally important creeks are Khattu, Paukyo, Ketky, Mazali, Yinsel, Lakhogyi, Kakholay, Htawla, Minywin,Chin, Pawbyin, Myauk, Nigwin, Thinda and Gyat. According to Koppen's Climatic classification, the type of climatic is tropically Monsoon (Am) characterized by alternate wet

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and dry period in response to seasonal shifting of monsoon wind is dominant, bringing in a large amount of Rainfall, particularly in June, July and August. Heavy incessant rain occurs when monsoon is strong to vigorous, especially when a deep low pressure or a cyclone is formed in the Bay of Bengal. Such heavy rains are the chief cause of Ngawun River flood.

In 2018, 3043 people were living in the urban area and the great majority or 106803 (97%) were the rural inhabitants. The rural dwellers mostly depend on farm work for their livelihood.
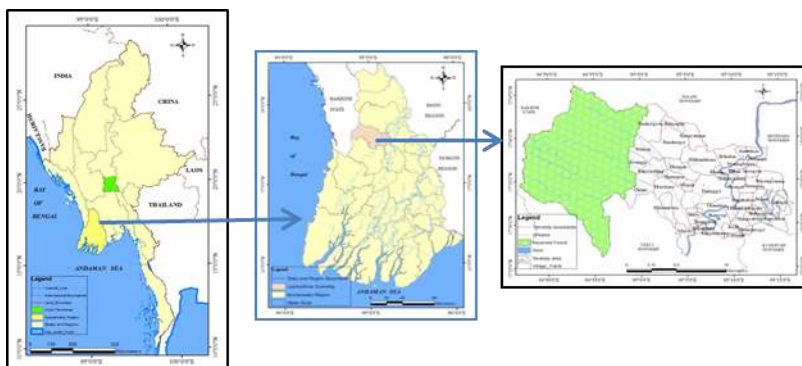

Figure (1) Location of Laymyethna Township.

Source: Land Records Department, Laymyethna

Research Questions

- What are the causes of flood in Laymyethna Township?
- Where are the flood risk areas in the Study Area?

Aim and Objectives

The main aim of this study is to find out the causes of flood in Laymyethna Township. The objectives of this paper are;

- to present the water level of Ngawun River and duration and frequencies of flood period and
- to find out causes of flood and develop a flood risk map of the study area.

Previous Investigation and Literature Review

Nyunt Nyunt Htwe, (2006) wrote a thesis on "Physical Bases of Laymyethna Township, Hinthada District" for a MA Degree in which physical base, flooding, erosion, problems of navigation of Ngawun River and socio-economic problems of Laymyethna Township and protection of flood by embankment were presented.

Aung Swe (2007) carried out a research on "Flood Analysis on the Western Tributaries of Upper Ngawun River in Ayeyarwady Division" for a PhD Dissertation which includes morphometric analysis and erosion of the river.

Hein Min Htet (2017) did a research on "Flood Risk Mapping Using Satellite Images and GIS Tools: A study on flood analysis of Thabaung, Kangyidaunt, Pathein Areas" submitted in The First Myanmar National Conference on Earth Science, University of Monywa. In this paper, flood hazard map is derived from slope, rainfall, distance from active river channel and Vulnerability map is acquired from population density and land use and

land cover and finally flood hazard map and vulnerability maps are combined to produce flood risk map.

Pan Ei Phyu, (2017) wrote a thesis on "Geographical assessment of Socio-economic Conditions in Laymyethna Township" for a MA Degree. It includes physical factors, social factors, agriculture crop, livestock and fisheries, transportation from geographic point of view.

Su Hlaing Thin, (2019) carried out a research on "A Geographical Study of Flood-related Problems in Laymyetna Township: A focus Study on Paddy Cultivation" for a MA Degree. It includes flood-related problems, and flood effect on paddy cultivation.

Khin Thandar Win *et.al*., (2014) did a research on "Vulnerability of Flood Hazard in Selected Ayeyarwady Delta Region, Myanmar" submitted in International Journal of Science and Engineering Applications, Volume(3), Issue(3). Hydrologic Engineering Center's River Analysis (HEC-RAS model), GIS, and RS are used to develop a flood hazard map in this paper.

Data and Method

Both primary data and secondary data are used in this research. Elevations, flow accumulation of water are derived from SRTM DEM (30 metres) resolution. Land use and Land cover are acquired from Satellite Image (2018), 133,048 (30 metres resolution). Road, embankment, river and streams are obtained from UTM Topographic map (2005). Soil types are derived from Ministry of Agriculture and Irrigation (2004), Myanmar. Water level of Ngawun River at Laymyethna gauge (6 AM records) are derived from Irrigation Department, Hithada. Population data is obtained from General Administrative Department, Laymyethna. Flooded monsoon cultivated areas are derived from Land Records Department, Laymyethna.

Supervised Classification method is used to present land use and land cover types. Buffer is used to search distance from the river. Weighted overlay using raster calculator is used to find risk map of the study area.

Results and Discussion

Figure (2) shows the water level of Ngawun River from 1980 to 2018 in Laymyethna. In the study area, danger level of Ngawun River is 34 feet (10.36 m) above the sea level. During the 39 years period, four years, 2000, 2001, 2009, and 2010, were free from flooding. The remaining 35 years reached danger level and above danger level. Therefore, Laymyethna Township suffered the flooding in most of the years.
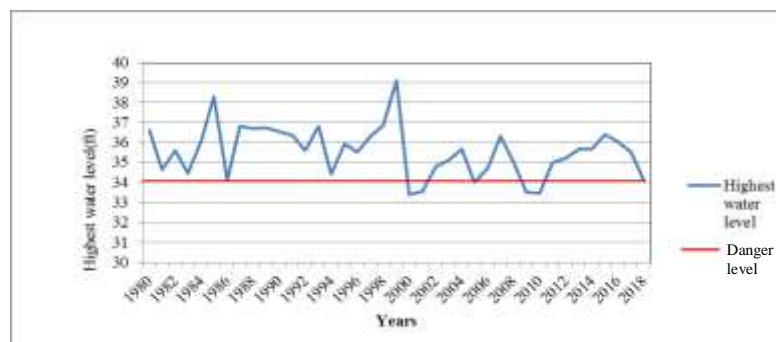

Figure (2) Water level of Ngawun Riner at Laymyethna from 1980 to 2018.

Source: Irrigation Department, Hinthada

Figure (3) presents the duration of flood period per year and frequency of flood during 39 years from 1980 to 2018. According to the figure, water level was the highest in 1999 with 39.1 ft (11.917m). In 1999, frequency of flooding was 3 times and duration of flooding period was 61 days. The second highest of water level was 38.3 ft (11.67 m) in 1985. The water level was lowest 33.4 ft (10.18 m) in 2000. Flooding frequency is not more than 3 times per year, especially in July, August, and September. In these months, the amount of rainfall is the highest in the study area.

The relation of flood frequencies of Ngawun River and average monthly rainfall is presented in figure (4). In this figure, the frequency was the highest in August, the second highest in July and September. July, and August were the months in which there was the highest rainfall, but the rainfall was low in September. It shows that the flooding is not only related to local rainfall but also up-flow of water and storms. Therefore, local rainfall is assumed constant in this study.
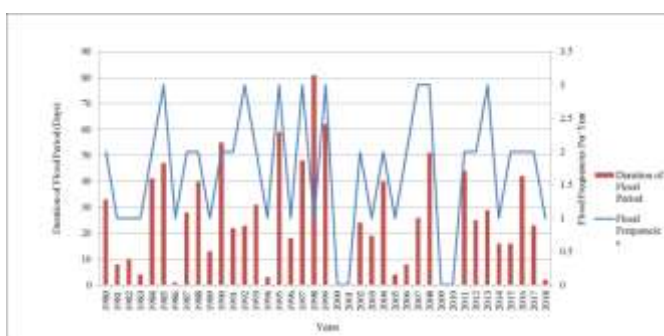

Figure (3) Duration of Flood Period and flood frequencies per year of Ngawun River

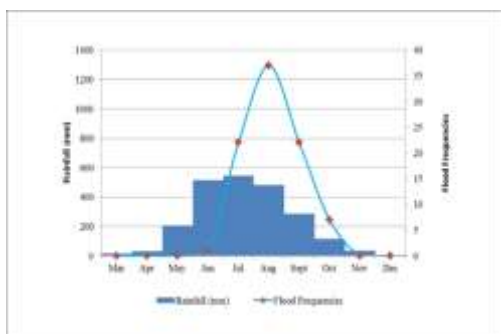(1980-2018). Source: Irrigation Department, Hinthada

Figure (4)   Average Monthly Rainfall (1991- 2018) and flood frequencies of Ngawun River

(1980-2018).

Source: Meteorology and Hydrology Department, Hinthada and Irrigation Department, Hinthada

Water level of Ngawun River, flow accumulation of water, distance from the river, Road and Embankment, land use and land cover, population density and soil are included as decisive parameters in flood risk mapping. Parameters, data sources, classes, rating, and weight are shown in table (1). Weights are calculated by rank sum method.

Table (1) Parameters, data sources, classes, rating, and weight

No	Parameters	Sources	Classes	Rating	Weight (%)
1	Water Level of River	SRTM DEM, Irrigation Department, Hinthada	15.1 - 625	1 (not risk)	25
			11.9171 - 15	3 (moderately risk)	
			-4 - 11.917	5 (high risk)	
2	Flow accumulation	SRTM DEM (30 metres resolution)	0	1 (not risk)	21
			0.1 - 41101.67	2 (low risk)	
			41101.671 - 82203.33	3 (moderately risk)	
			82203.331- 123305	4 (risk)	
			123305.01- 419237	5 (high risk)	
3	Distance from the River	UTM Topo map (2005)	0.1- 1000	5 (high risk)	18
			1000.1-3000	4 (risk)	
			3000.1-4000	3 (moderately risk)	
			4000.1-5000	2 (low risk)	
			>5000	1 (not risk)	
4	Road & Embankment	UTM Topo map (2005)	Area between western Rakhine Yoma and Road & Area within Embankment	1 (not risk)	14
			Area between Road and Embankment	5 (high risk)	
5	Land use and Land cover	Landsat 8ETM+(30) 133,48 (30 metres resolution) 2018	Forest land	1 (not risk)	11
			Settlement area	3 (moderately risk)	
			Agriculture area	4 (risk)	
			Water bodies	5 (high risk)	
6	Population Density	General Administrative Department, Laymyethna	0	1 (not risk)	7
			0.1-248	2 (low risk)	
			248.1 - 960	3 (moderately risk)	
7	Soil	Ministry of Agriculture and Irrigation (2004)	Yellow brown forest soil & Red brown forest soil	1 (not risk)	4
			Gley and gley swampy soil & Swampy Soil	5 (high risk)	

Source: Prepared by researchers

Water level of river is one of the important factors of flooding. Water level rises in monsoon period, especially June, July, August and September due to rainfall and storms. In addition, up-flow of river causes to raise the water level in the river. From 1980 to 2018, the highest water level of Ngawun River reached 39.1 ft. (11.9172 m) above sea level during 39-year period. The lowest level reached 33.4 ft. (10.18 m). Water levels are classified into 3 classes: -4 - 11.917 (high risk) due to the highest water level in 39 years, 11.9171-15 (moderate risk) due to flash flood by heavy local rainfall and storm, 15.1-625 (not risk). Weight of the parameter is 25 percentages, calculated by rank sum method. Water level of Ngawun River is presented in figure (5).

Second important parameter is flow accumulation of water in the study area. Flow accumulation is derived from DEM. It is grouped into five types: 0 (not risk), 0.1-41101.67

(low risk), 41101.671-82203.33 (moderate risk), 82203.331-123305 (high risk). Weight is 21 percentages. Figure (6) shows the flow accumulation of water in the study area.

Distance from the river is one of the important factors of flooding. It is divided into 5-classes depending on the nearness to the river: 0.1-1000 (high risk), 1000.1-3000 (risk), 3000.1-4000 (moderate risk), 4000.1-5000 (low risk), >5000 (not risk).The weighted percentage is 18 in this analysis. Distance from the river are shown in figure (7).

Road and embankment is the barrier of flooding, it is important in flooding. In the study area, Pathein -Monywa Road is located in the western part of the River. Along the eastern part of Ngawun River, embankment was built to protect the flood water of the River, which has a length of 19 miles and 7 furlongs was established between1869-1884. (Imperial Gazetteer of India,1881) The study area is grouped into two: area between western Rakhine Yoma and Pathein_Monywa Road, and area within embankment (not risk), area between road and embankment (high risk).Weight percentage is 14. Figure (8) presents the road and embankment of the study area.

The fifth important parameter is land use and land cover in this analysis. Image is classified into four types by maximum livelihood classification. They are forest land, settlement area, agriculture area, and water bodies. In this study, forest land is assigned not risk because of forest absorbed water and fixed the soil, settlement area assigned moderate risk due to human impact, agriculture area assigned risk because of plowing for agriculture, and water bodies assigned high risk because of low elevation. Weighted percentage is 11. Land use and land cover of the study area are presented in figure (9).

Population density is important in flooding. It is classified into three classes: 0 (not risk), 0.1-248 (low risk), 248.1-960 (medium risk) due to high density. The weighted percentage is 7. Figure (10) shows the population density of Laymyethna Township in 2018.

Soil is important in flooding, because of the infiltration intensity of water. Solis map shown in figure (11) is acquired from Ministry of Agriculture and Irrigation (2004) in which the soil types are characterized as follows.

(1) Gley and gley swampy soils

(2) Swampy Soils

(3) Yellow brown forest soils and

(4) Red brown forest soils.

Among these 4 types, red brown forest soil and yellow brown forest soil have been found in the western part of the Township. The texture is Clay loam, Sity loam, and Sandy clay. Gley and gley Swampy Soils and Swampy Soil are found over the flood plain of the Ngawun River. The texture of Gley and gley swampy soils and swampy soils is Clay and the depth is thick. Clay and thickness favour low infiltration rate. Low infiltration causes the flooding in the study area. In the analysis, soil types are grouped into two: red brown forest soil and yellow brown forest soil (no risk), and Gley and gley swampy soil and swampy soil (high risk). Weighed percentage is 4% in this analysis.
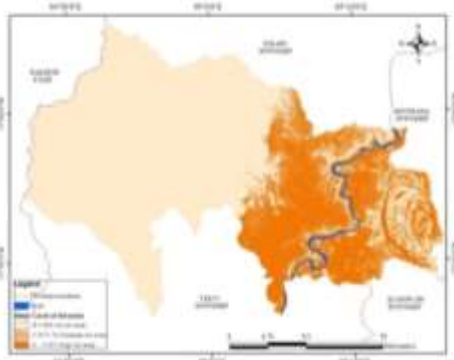
Figure (5) Water Level of Ngawun River at
Laymyethna Gauge (6 AM) from 1980 to 2018
Source: Irrigation Department, Laymyethna and
SRTM DEM (30 metres)resolution

Figure (6) Flow accumulation of Water the Study Area
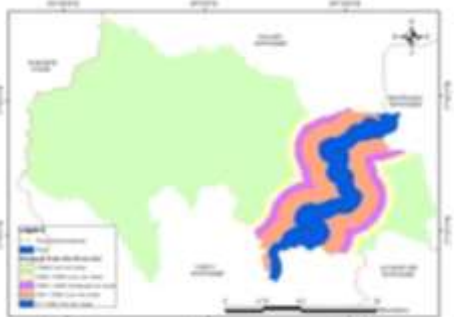Source: SRTM DEM (30 metres) resolution

Figure (7) Distances from River
Source: UTM Topo Map (2005)

Figure (8) Road and Embankment in the Study area
Source: UTM Topo Map (2005)

Figure (9) Landuse and land Cover of the Study area
Source:Satellite Image 2018 (30 m resolution) 133,048

Figure (10) Population Density of the Study area (2018)
Source: General Administrative Department,
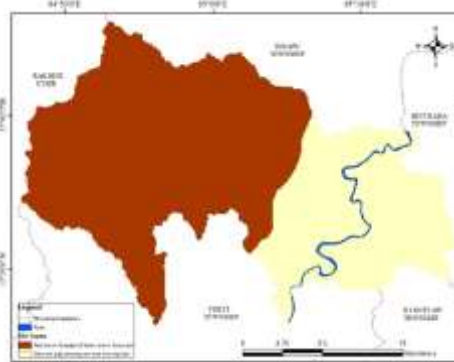Laymyethna

Figure (11) Soil Types of the Study area.
Source: Ministry of Agriculture and Irrigation (2004)

Seven parameters mentioned above are used to search for flood risk area by using weighted overlay using raster calculator. Figure (12) and table (2) show the result of this analysis. Flood Risk Index shows 100 to 461, high risk area (0.5%), risk area (19.3%), moderate risk area (14.8%), low risk area (20.4%) and not risk area (45%) of the study area. In high risk area, Mezali, Yinze, Thaungbok, Kattu village tracts are found. Hledaukwin, Hlawkata, Daunggyi, Chaukse, Mogok, Kyiboukkone, Bithalun, Bokchaung, Shamywa, Lethama(Myanmar), Lethama (Kayin), Thonzet, Thakutchaung, Nyaungbinwe, Hteingu village tracts and urban area lie within the risk area. Moderate risk area includes 13 Village Tracts such as Kungyongon, Kadetkon, Thenugon, Chingon, Aingthabyu, Sayegyin, Lahagyi, Sayegyin, Gyogyakwin, Kode, Yenauk, and Hteindawgyi village tracts. Theingon, Wayongyaing, Peinin, Kamauksu, Wadawkwin, Bebyagon, Pandawgyi, Wetkon, Kwingyi, Kanyindaing, Chinle are found in low risk area. In the western Rakhine Yoma, forest area is of no risk in Laymyethna Township. Figure (13) presents the flood risk area and village tracts of the study area.

The result is validated with the village tracts of flooded monsoon paddy from 2015 to 2018. It shows that the risk area coincides the village tracts of flooding paddy field and school. Therefore, water level of Ngawun River, flow accumulation of water, distance from the river, Road and Embankment, land use and land cover, population density and soil are the chief causes of flooding in the study area.

Table (2) Flood Risk Area, Percentage and Village Tracts of flooded paddy Fields and School of the Laymyethna Township

Flood Risk Area	%	Village Tract	Village Tracts of Flooding Paddy Field and School (2015-2018)
Not Risk Area	45	Forest area (Western Rakhine Yoma)	Mezali, Yinze, Thaungbok, Kattu, Hledaukwin, Hlawkata, Daunggyi, Chaukse, Mogok, Kyiboukkone, Bithalun, Bokchaung, Shamywa, Lethama(Myanmar), Lethama (Kayin), Thonzet, Thakutchaung, Ahabyugyin Nyaungbinwe, Kungyongon, Kadetkon, Thenugon, Chingon, Aingthabyu, Sayegyin, Lahagyi, Yenauk, Bebyagon, Pandawgyi Peinin, Wayongyaing, Theingon, Aingthabyu, Hteingu, Kanyinthaung
Low Risk Area	20.4	Theingon, Wayongyaing, Peinin, Kamauksu, Wadawkwin, Bebyagon, Pandawgyi, Wetkon, Kwingyi, Kanyindaing, Chinle (11 Village Tracts)	
Moderate Risk Area	14.8	Kungyongon, Kadetkon, Thenugon, Chingon, Aingthabyu, Sayegyin, Lahagyi, Gyogyakwin, Kode, Yenauk, Hteindawgyi, Kanyinthaung and Shabyugyin (13Village Tracts)	
Risk Area	19.3	Hledaukwin, Hlawkata, Daunggyi, Chaukse, Mogok, Kyiboukkone, Bithalun, Bokchaung, Shamywa, Lethama (Myanmar), Lethama (Kayin), Thonzet, Thakutchaung, Nyaungbinwe, Hteingu, Urban (15 Village Tracts, 1 town)	
High Risk Area	0.5	Mezali, Yinze, Thaungbok, Kattu (4 Village Tract)	

Sources: Result of Analysis and Land Records Department, Laymyethna

Figure (12) Flood Risk Map of the Study Area
Source: Result of the Analysis

Figure. (13) Flood Risk Area and Village Tracts of the Study Area
Source: Result of the Analysis and Land Records Department, Laymyethna

Conclusion

Laymyethna Township faces flooding in the lowland areas of western Ngawun River and eastern Rakhine Yoma. The study area experiences flooding almost every year. Flood frequency is not more than three times per year, especially in July, August and September. High water level of Ngawun River causes flooding in low-lying area, near to the river, the areas between road and embankment, water bodies and agriculture land and settlement area, densely populated area, and clay soil. These factors are the main causes of flooding in this study area. Non-flooded areas are found in Forest land in the western part. Risk areas are found in all village tracts of Laymyethna Township. To protect the flooding, it needs to construct the embankment, reduce deforestation, systematic ploughing and systematic planning of land use in the study area.

Acknowledgement

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