Flood Risk Management in Delta Areas of Myanmar

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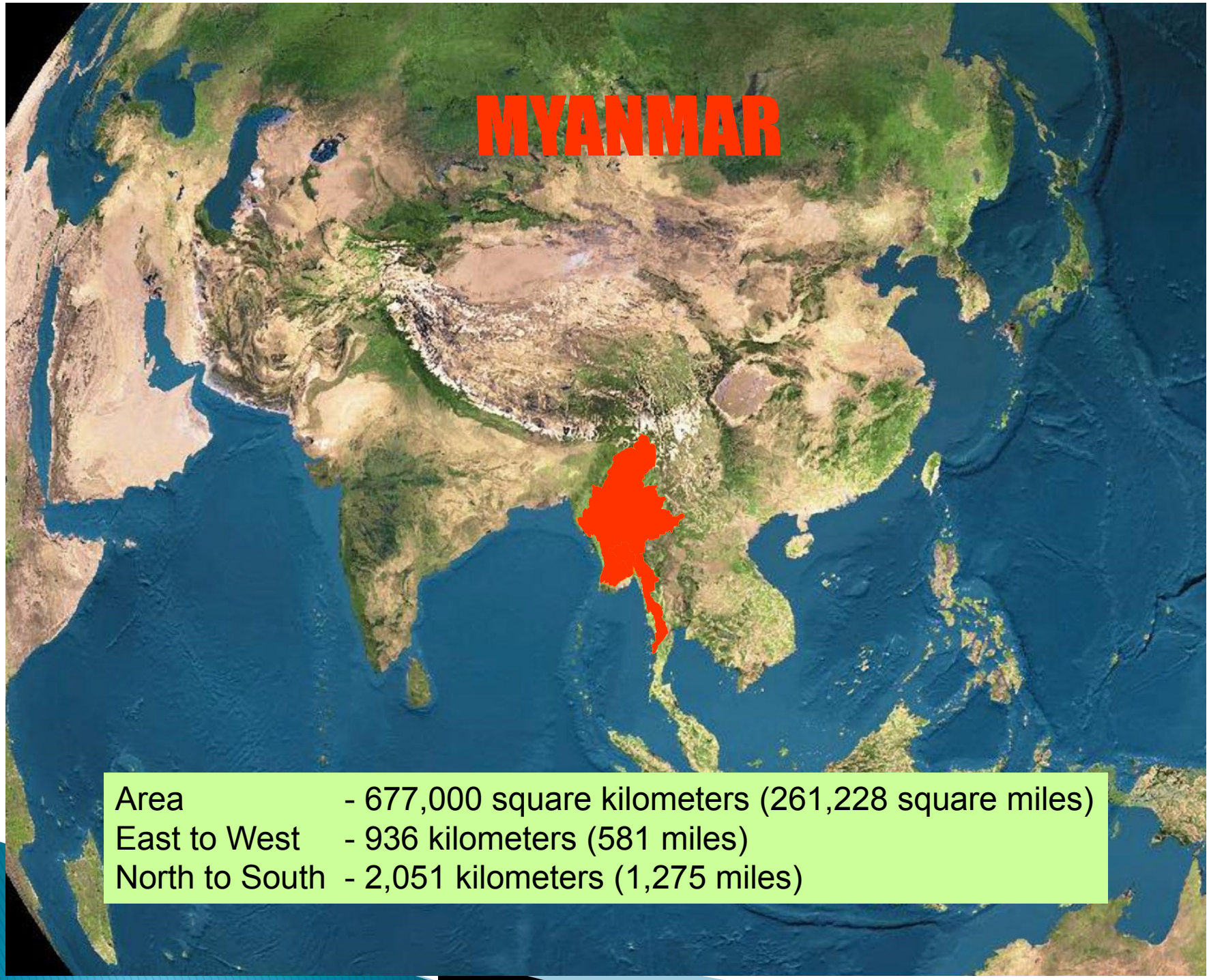
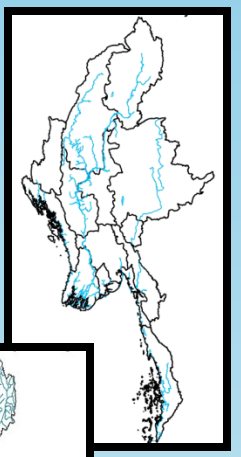
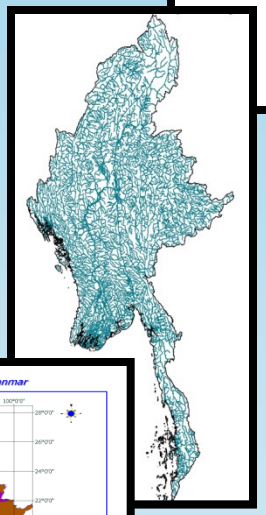


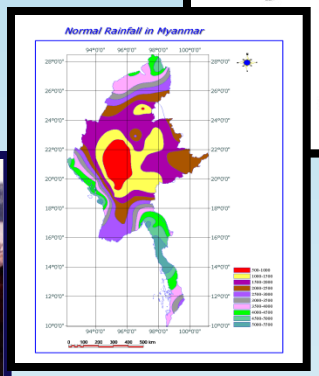
Area	- 677,000 square kilometers (261,228 square miles)
East to West	- 936 kilometers (581 miles)
North to South	- 2,051 kilometers (1,275 miles)

Content

- Topography
- Rainfall Distribution
- River System
- Runoff
- Floods in Delta Area
- Flood Management in Delta Area

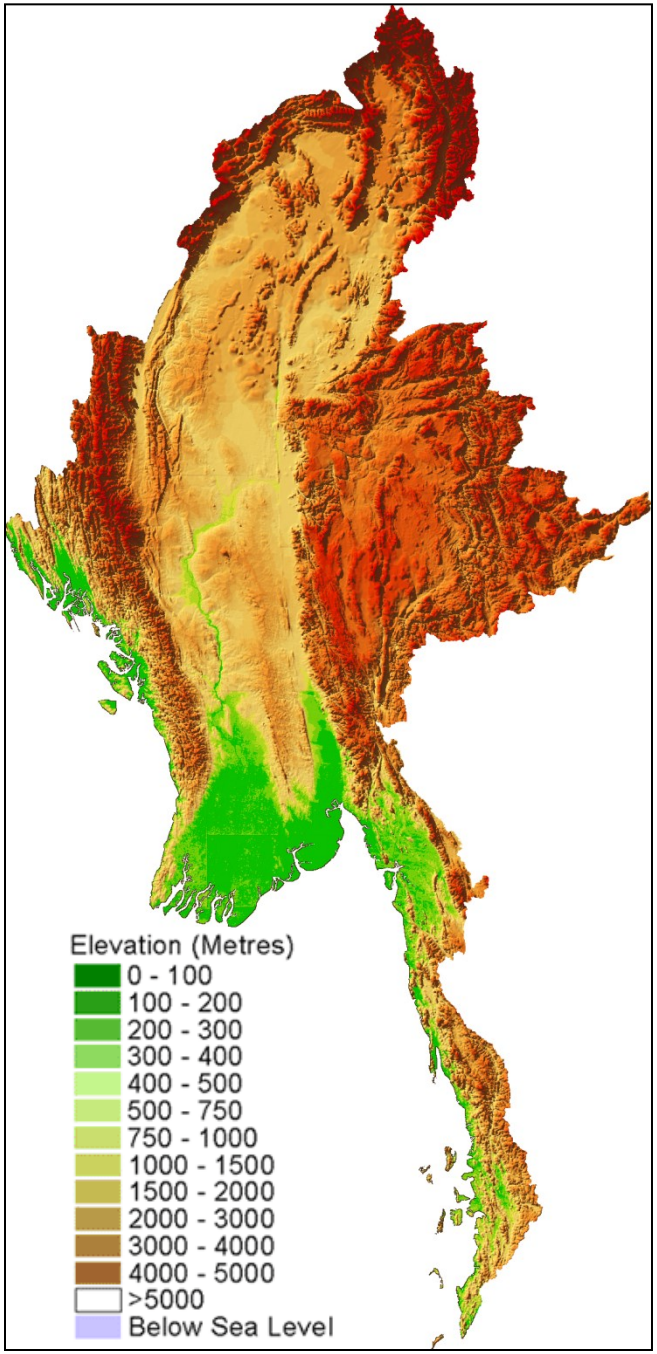




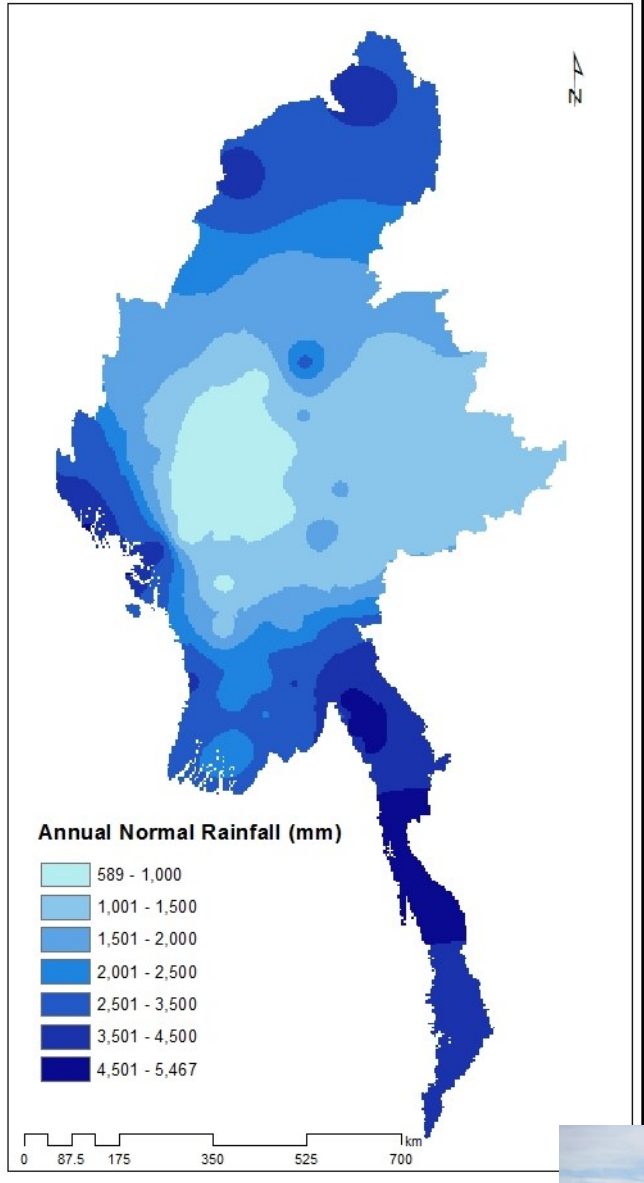


Topography

- The country is mountainous in north and northwest. The eastern region has a plateau of about 3,000 ft above mean sea level. It has hilly and flat terrain in central and southern areas.
- The flat lands of Ayeyarwaddy, Chindwin and Sittaung Rivers valleys where most of the country's agricultural land and population are concentrated.
- Myanmar is well endowed with natural river resources.
- The lower region of Myanmar, the delta is crisscrossed with many rivers and creeks. It is obviously lowland and flat terrain and inundation can happen in many areas in the rainy season.
- In the coastal zone about 5200 km^2 are below high spring tide level and are subject to flooding with more or less saline water.



Annual Normal Rainfall



- Range from minimum 600 mm to maximum 5500 mm.
- The lowest annual normal rainfall occur in central part of Myanmar
- The highest annual normal rainfall occur in Coastal, Northern and Southern part of Myanmar.

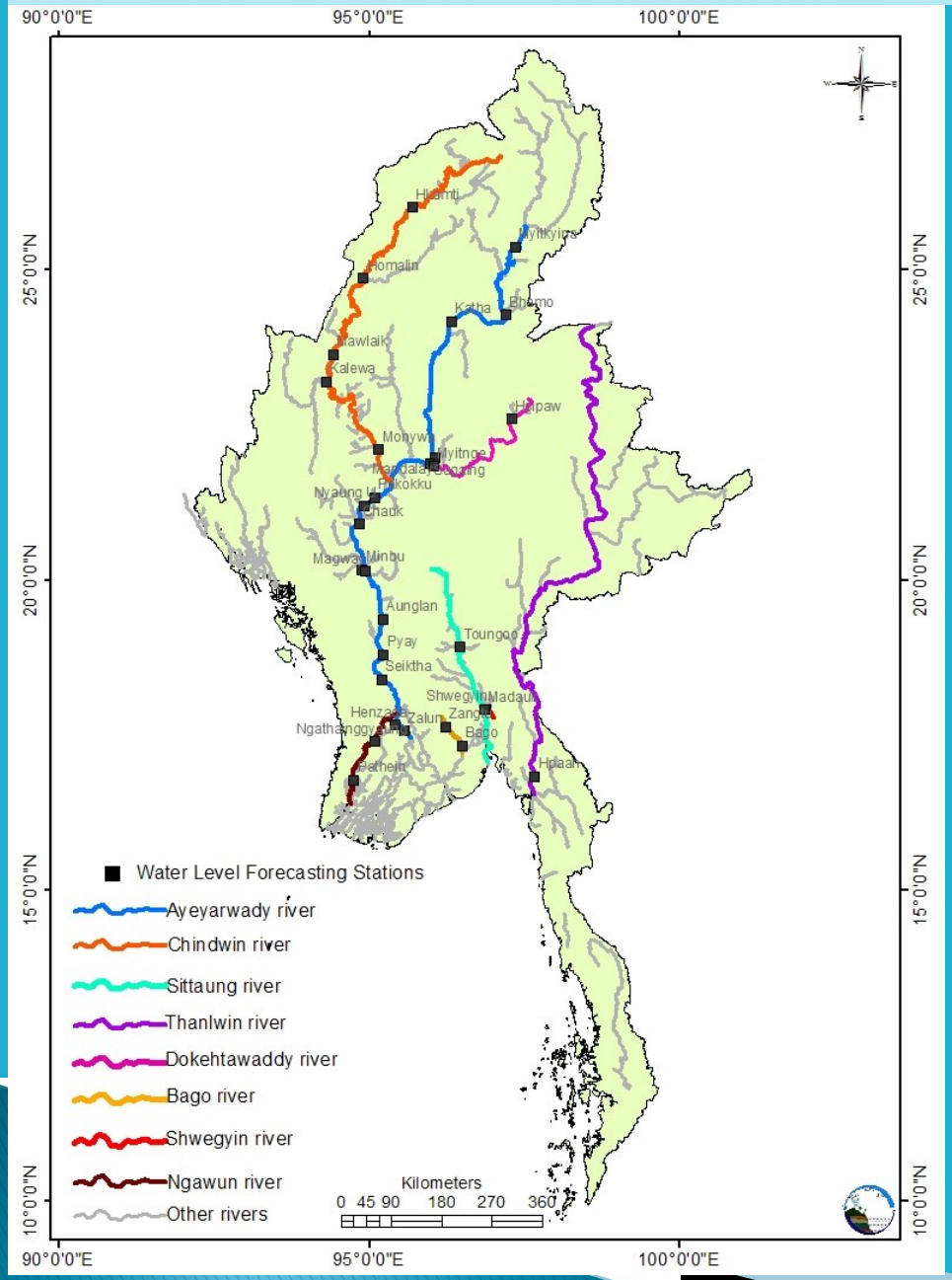
Decadal Variation of extreme rainfall 1951-2014

	1951-1960	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-2014
(24)Hr Heaviest Rainfall (Inches)	13.90	22.36	16.61	20.75	21.61	17.60	29.10
Date	18-7-1956	4-9-1965	5-6-1980	29-6-1989	24-8-1997	4-7-2006	21-7-2011
Location	Thandwe	Kyaukpyu	Sittwe	Hkamti	Dawei	Dawei	Taungkok

Decadal Variation of extreme Temperature 1951-2014

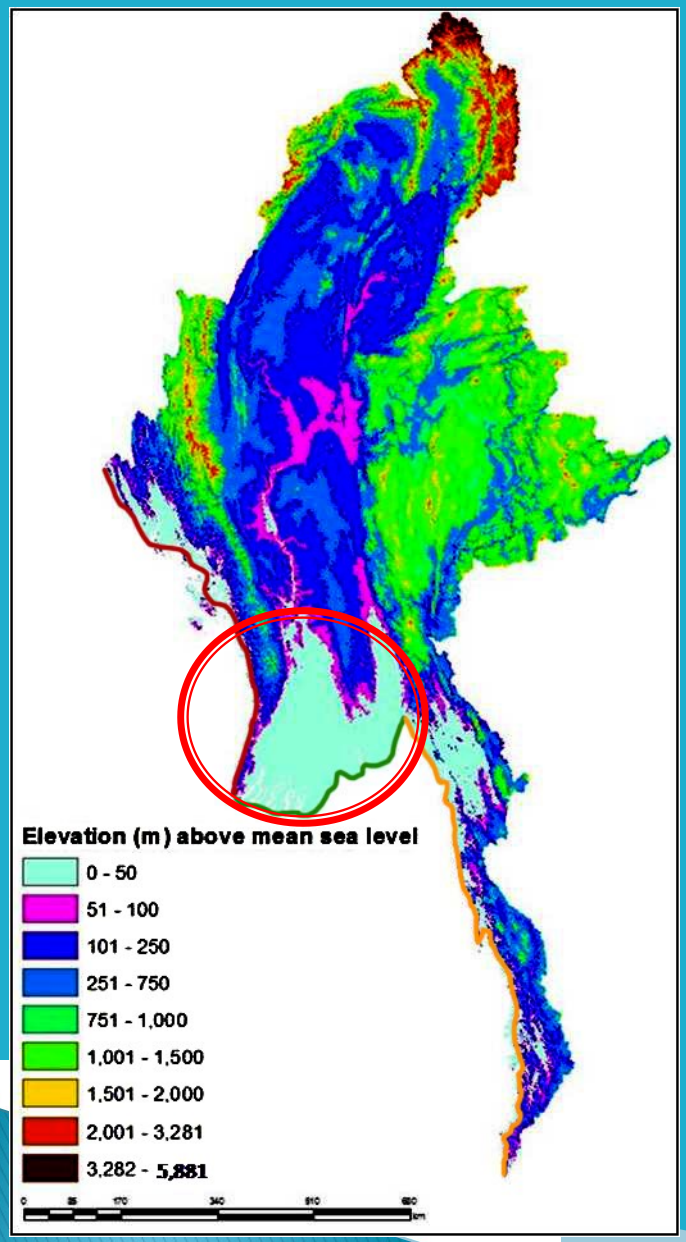
	1951-1960	1961-1970	1971-1980	1981-1990	1991-2000	2001-2014
Highest Day Temperature (□C)	43.3° C	45.0° C	46.0° C	45.0° C	46.4° C	**47.2° C**
Date	18-4-1954	17-5-1969	13-4-1980	20-4-1989	30-4-1999	**14-5-2010**
Location	Mandalay	Monywa	Magway	Myingyan	Gangaw	**Myinmu**

Myanmar Rivers



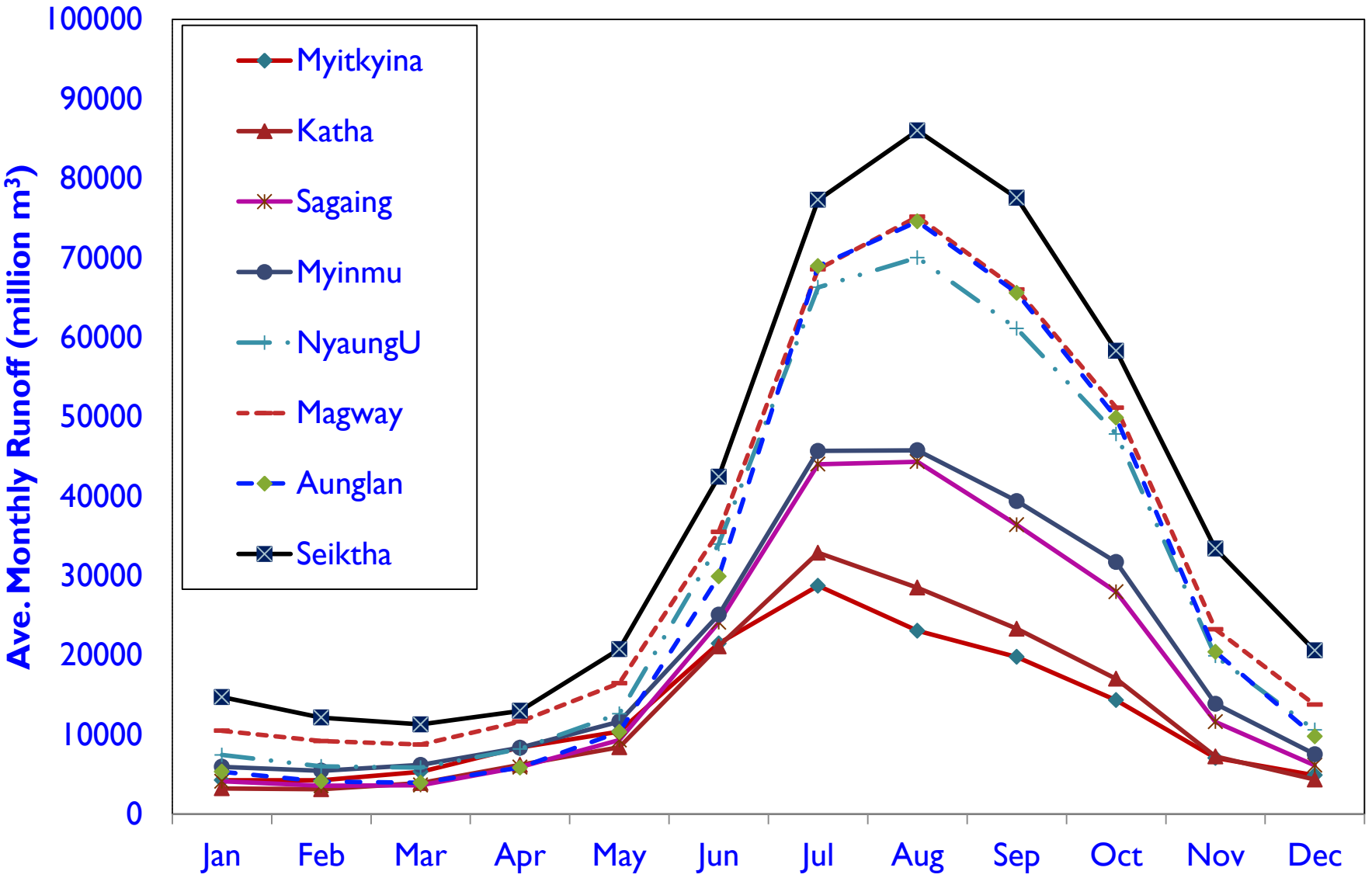
- Ayeyarwady River 2100 km
- Chindwin River 1100 km
- Sittoung River 420 km
- Thanlwin River 2410 km

Coastal and Delta Areas

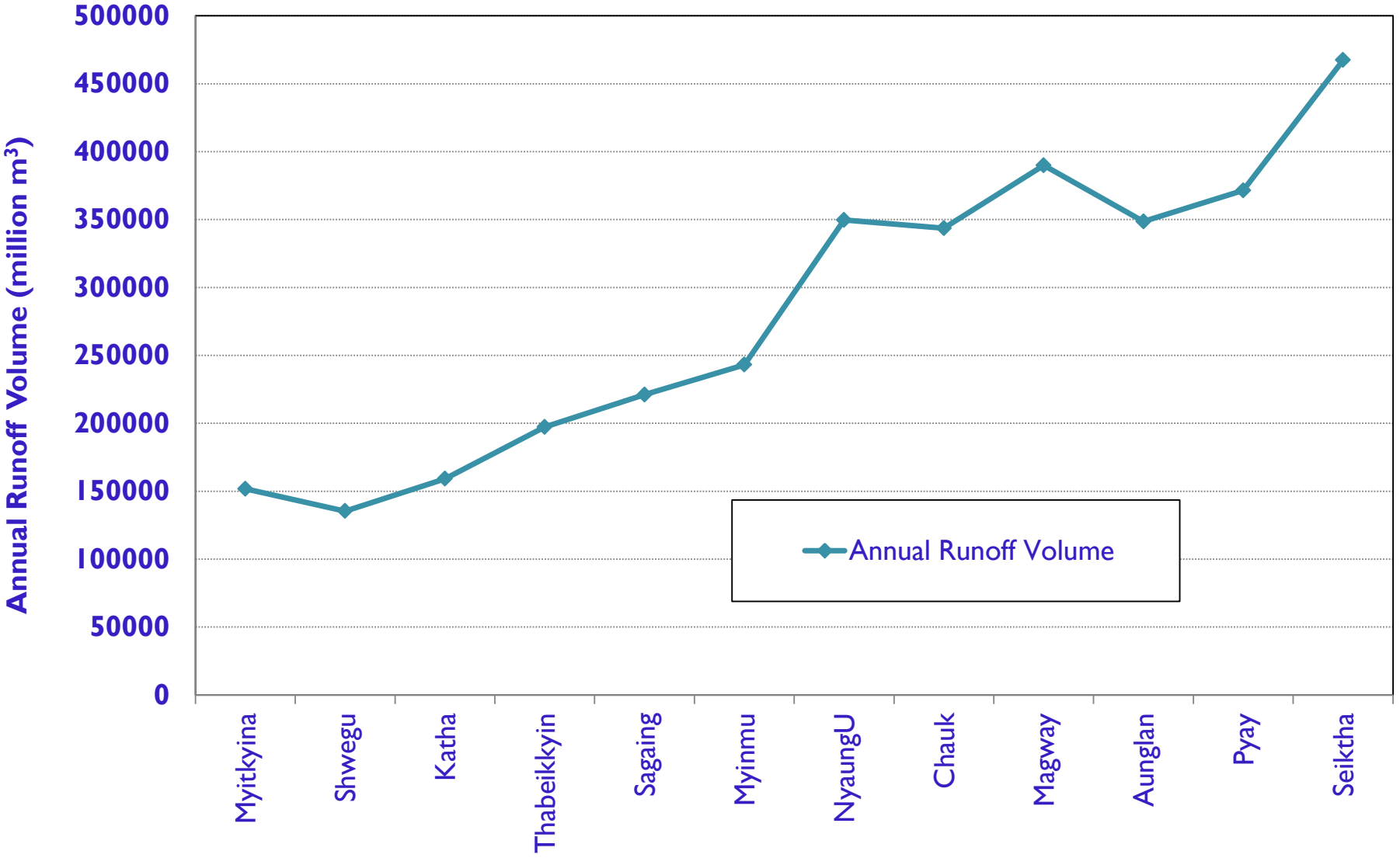


- Covers an area of about 35,000 square kilometer, including 26 townships.
- The population is estimated at about 6.8 million, maximum population among States and Regions of the Republic of the Union of Myanmar.
- Population density 194 person / sq km.
- Coastal length is estimated about 2832 km.
- Total navigable waterways - about 2400 kilometer.
- Ayeyarwady Delta which is one of the rice granaries of Myanmar.
  (26 % of total Paddy field acreage of the nation)

Comparison of Annual Monthly Runoff Volume along the Ayeyarwady River

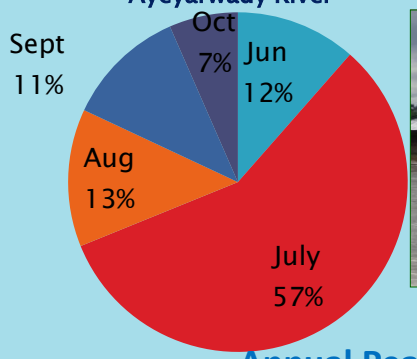


Comparison of Annual Runoff Volume along the Ayeyarwady River



Flood Disaster in Myanmar

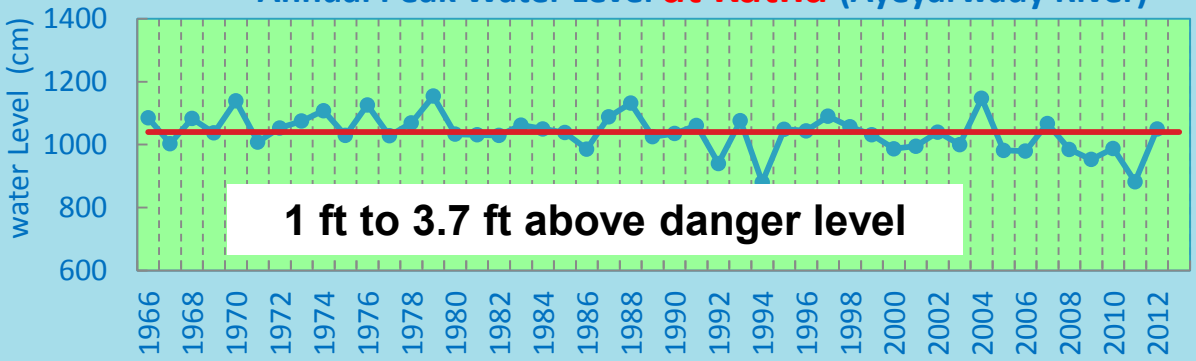
Monthly Flood Percentage at Upper Ayeyarwady River



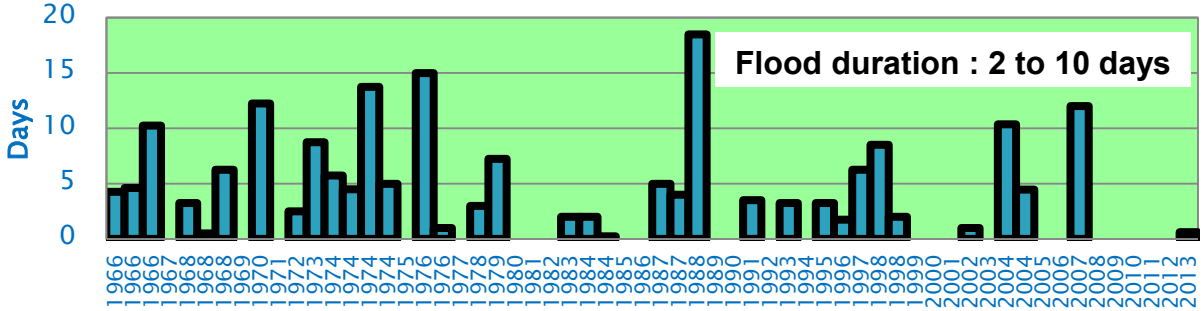
2004 Flood View at Bhamo

2013 Flood View at Katha

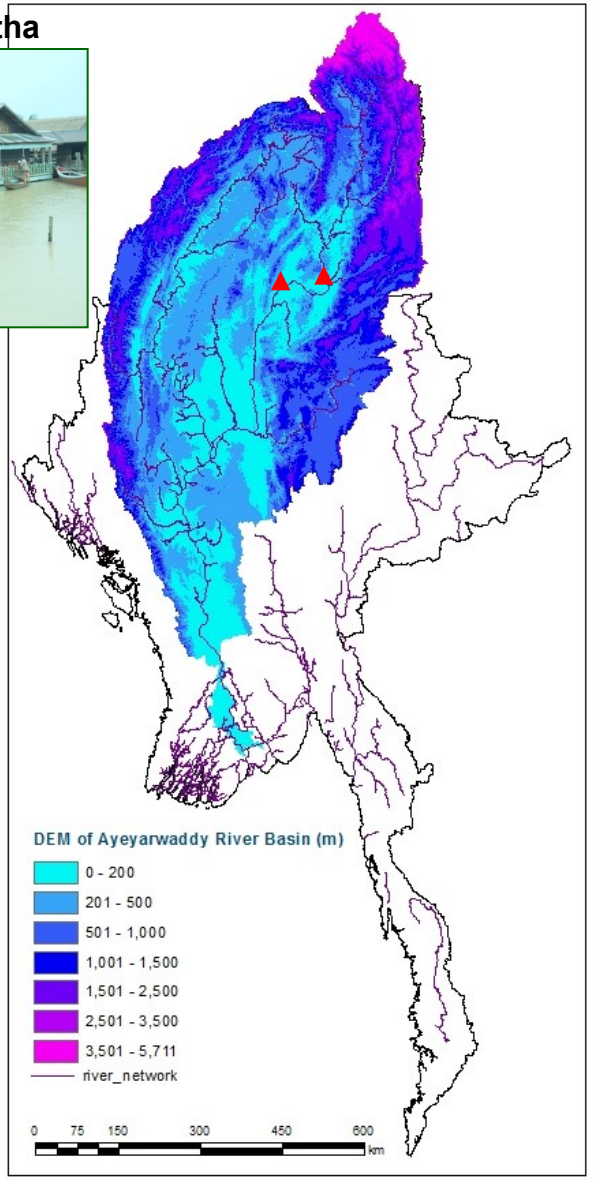
Annual Peak Water Level at Katha (Ayeyarwady River)



Flood Duration at Katha (Ayeyarwady River)

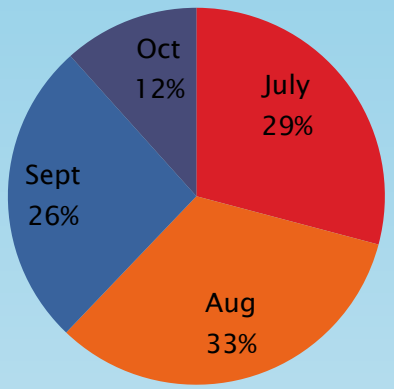


Ayeyarwady Catchment



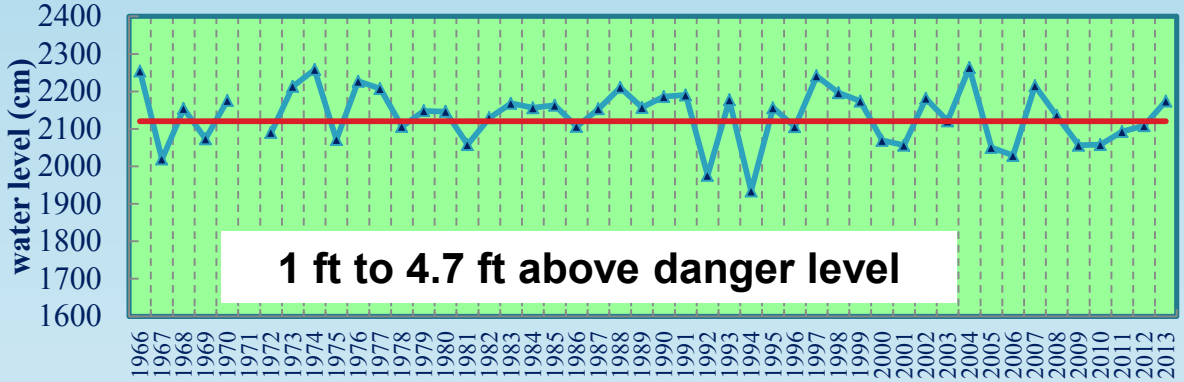
Flood Disaster in Myanmar

Monthly Flood Percentage at Middle Ayeyarwady River

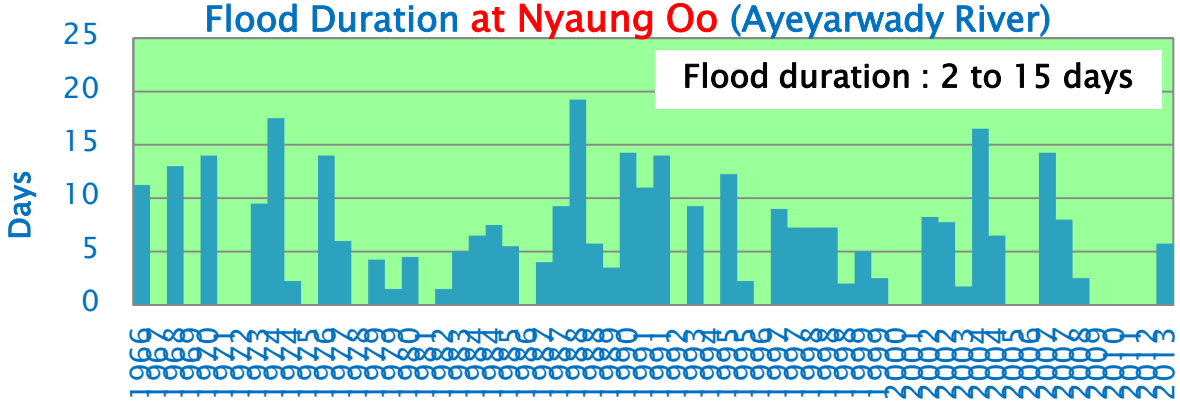


2010 Flood View at Mandalay

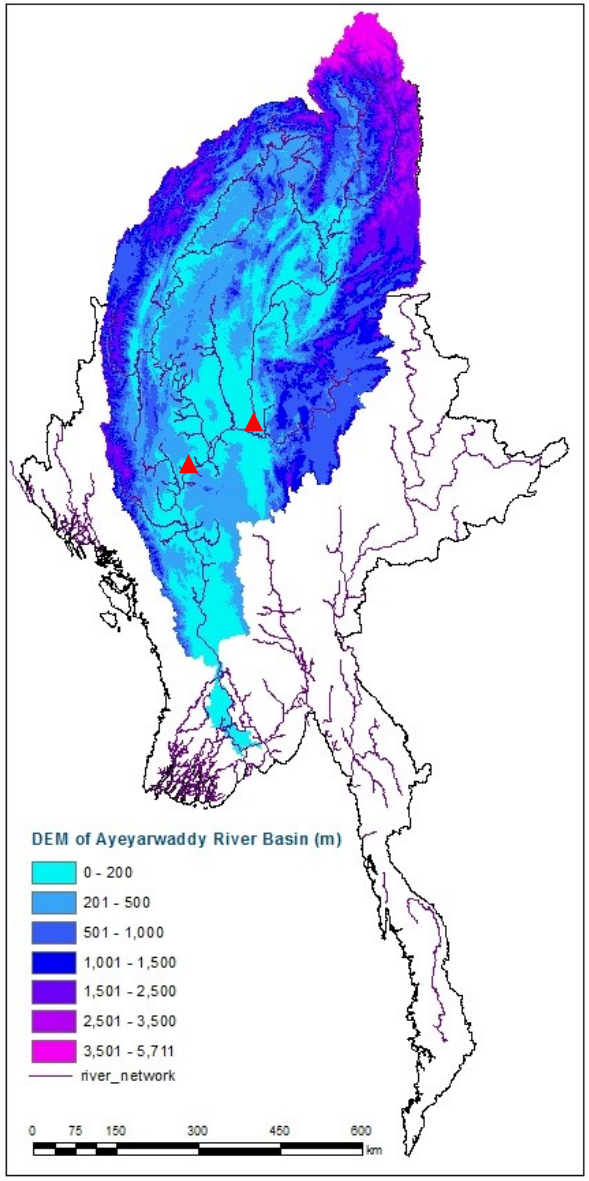
Annual Peak Water Level at Nyaung Oo (Ayeyarwady River)



Flood Duration at Nyaung Oo (Ayeyarwady River)

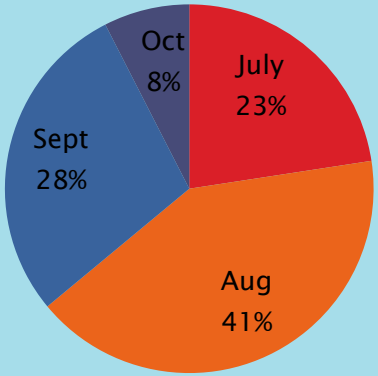


Ayeyarwady Catchment



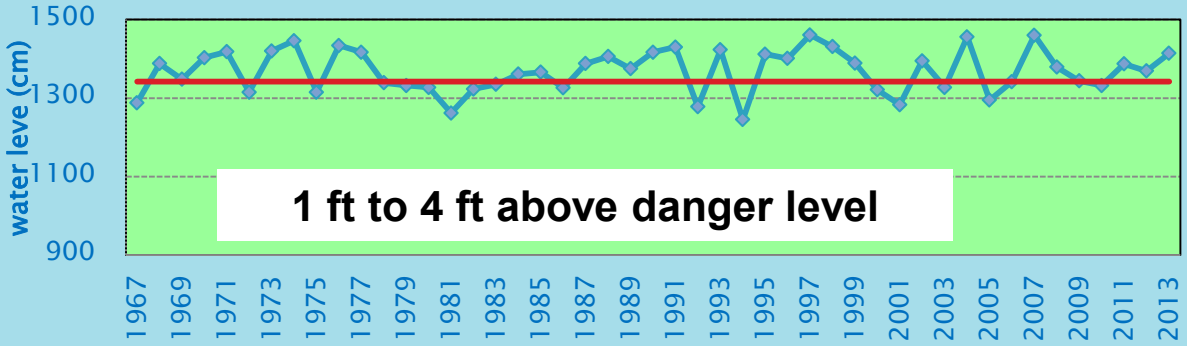
Flood Disaster in Myanmar

Monthly Flood Percentage at Lower Ayeyarwady River

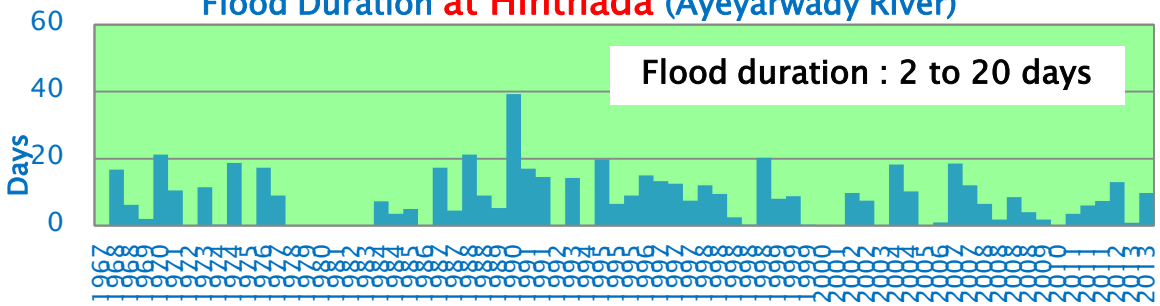


Flood View at Hinthada

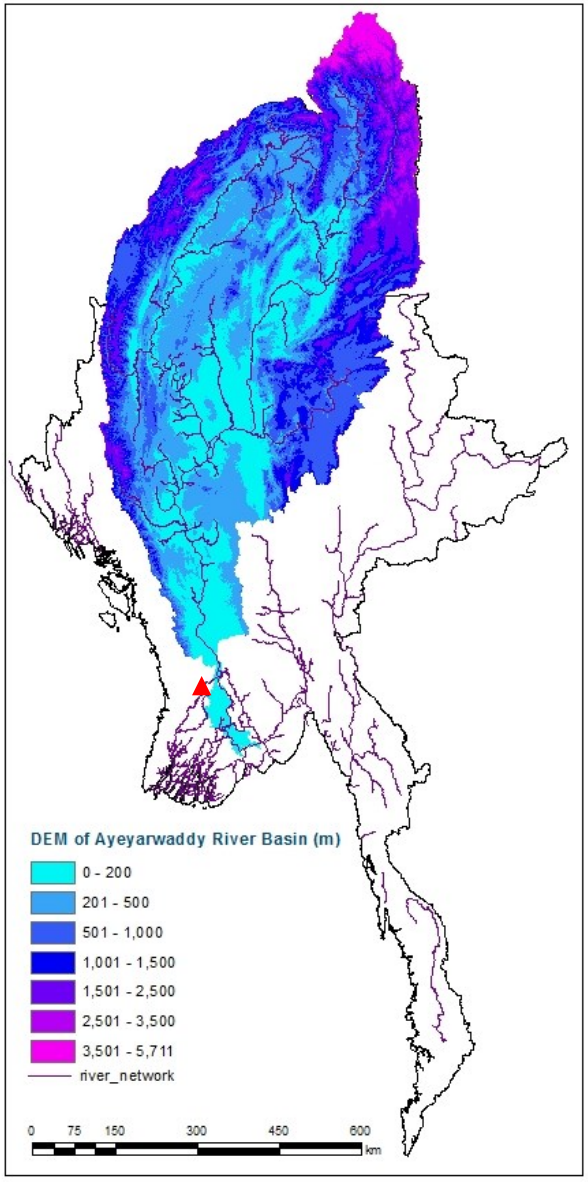
Annual Maximum Water Level at Hinthada (Ayeyarwady River)



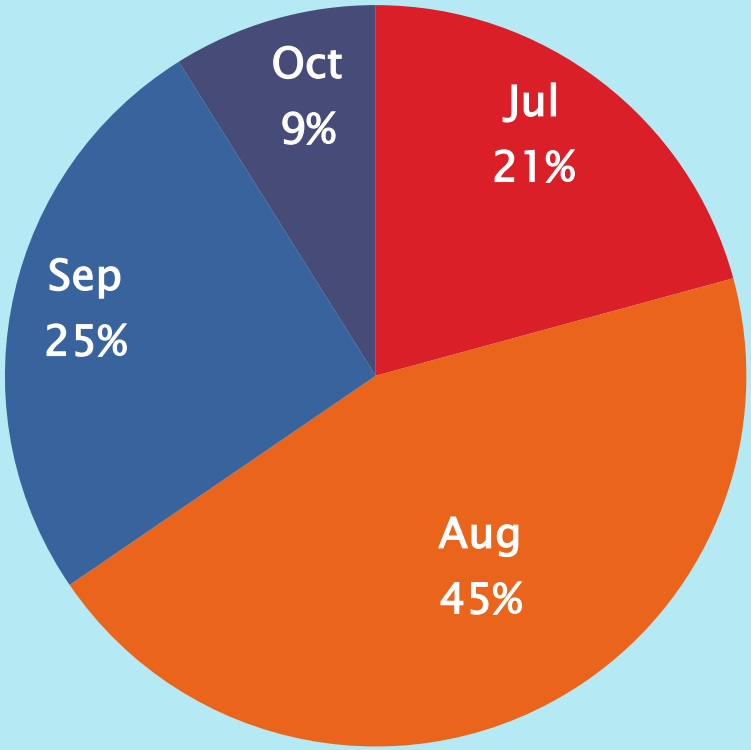
Flood Duration at Hinthada (Ayeyarwady River)



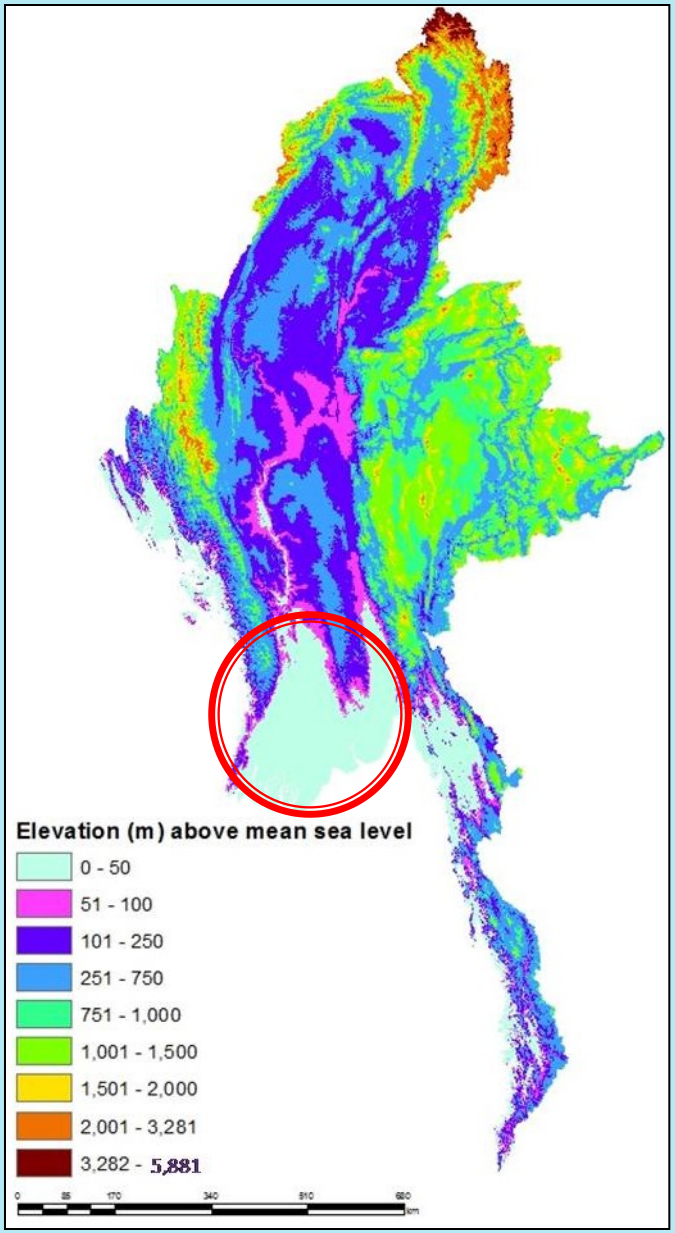
Ayeyarwady Catchment



Monthly Flood Percentage at Deltaic Area



Flood experienced twice a year



Annual Max and Min water level of Hinthada (Ayeyarwady

Year	Flood Peak (cm)	Date of occurrence	Flood Duration above T.D level	Start & End Date	Min W\L (cm)	Date of occurrence
1996	1401	30. 7.96	15 Days 0 Hrs	26. 7.96 – 10. 8.96	288	26.3.96
1997	1461	6.10.97	13 Days 6 Hrs	1.10.97 – 14.10.97	375	20.12.97
	1449	26. 7.97	12 Days12 Hrs	21. 7.97 – 2. 8.97		
	1376	26. 8.97	7 Days12 Hrs	22. 8.97 – 29. 8.97		
1998	1431	15. 9.98	12 Days 0 Hrs	9. 9.98 – 21. 9.98	272	11.3.98
	1401	29. 7.98	9 Days12 Hrs	23. 7.98 – 1. 8.98		
	1380	3. 8.98	2 Days12 Hrs	3. 8.98 – 5. 8.98		
	1347	7. 8.98	0 Days 6 Hrs	7. 8.98 – 7. 8.98		
	1388	28. 8.98	20 Days 6 Hrs	14. 8.98 – 3. 9.98		
1999	1389	8. 9.99	8 Days 0 Hrs	1. 8.99 – 9. 8.99	227	7.4.99
	1381	4. 8.99	8 Days18 Hrs	5. 9.99 – 14. 9.99		
	1383	17. 9.99	0 Days 6 Hrs	17. 9.99 – 0. 0.99		
2000	1321	9.10.00	Below D.L		302	13.3.00
2001	1283	12. 8.01	Below D.L		303	4.4.01
2002	1395	26. 8.02	9 Days18 Hrs	22. 8.02 – 1. 9.02	306	26.3.02
	1376	10. 8.02	7 Days12 Hrs	5. 8.02 – 13. 8.02		
2003	1327	24. 7.03	Below D.L		342	12.4.03
2004	1456	2. 8.04	18 Days 6 Hrs	23. 7.04 – 10. 8.04	322	31.3.04
	1420	22. 9.04	10 Days 6 Hrs	17. 9.04 – 27. 9.04		
2005	1295	6. 9.04	Below D.L		330	2.4.05
2006	1342	26.9.06	1 day	26.9.06–26.9.06	321	10.5.06
2007	1460	8.8.07	18 Days 12 Hrs	31.7.07–18.8.07		
	1438	23.9.07	12 Days	17.9.07–29.9.07	403	6.4.07
2008	1379	18.7.08	6 Days 12 Hrs	15.7.08–21.7.08		
	1343	6.8.08	1 Day 19 Hrs	6.8.08–8.8.08		
	1370	30.8.08	8 Days 12 Hrs	25.8.08–2.9.08		
	1351	15.9.08	4 Days	13.9.08–17.9.08	356	24.4.08
2009	1344	3.9.09	1 day 20hrs	3.9.09–5.9.09	414	9.4.09
2010	1332	19.10.10	Below D.L		440	1.3.10
2011	1347	30–7–11	3 days 12 hrs	29.7.11– 2.8.11	381	23–3–11
	1373	20–7–11	6 days 1 hr	15.8.11– 21.8.11		
	1387	20–7–11	7 days 9 hrs	29.8.11– 5.9.11		
2012	1369	7.8.12	13 days 10 hrs	1.8.12– 15.8.12	420	31.3.12
2013	1344	23.8.13	22 hrs	22.8.13 – 23.8.23	373	29.3.13
	1414	20.9.13	9 days 19 hrs	15.9.13–25.9.13		

Severe Flood in Myanmar (2004)

Stations	above/below Danger Level (ft)	Flood Duration above Danger level	Record
Myitkyina	6.8	2 Days 0 Hrs	2nd
Bhamo	6.2	8 Days 2 Hrs	1 st
Katha	3.5	10 Days 9 Hrs	2nd
Mandalay	4.0	16 Days 0 Hrs	1st
Sagaing	4.1	17 Days 6 Hrs	1st
Pakokku	4.4	15 Days 0 Hrs	
Nyaung Oo	4.7	16 Days12 Hrs	1st
Chauk	1.5	13 Days12 Hrs	4th
Minbu	7.4	17 Days 0 Hrs	2nd
Magway	6.4	15 Days 23 Hrs	1st
Aunglan	3.2	9 Days12 Hrs	3rd
Pyay	2.3	9 Days 0 Hrs	2nd
Seiktha	1.8	9 Days 0 Hrs	
Hinthada	3.7	18 Days 6 Hrs	4th
Zalun	3.7	19 Days 0 Hrs	
Hkamti	9.3	16 Days23 Hrs	3rd
Homalin	4.3	17 Days 0 Hrs	
Mawlaik	7.0	16 Days12 Hrs	
Kalewa	5.9	16 Days 0 Hrs	
Monywa	1.8	14 Days12 Hrs	
Myitngwe	5.0	14 Days 0 Hrs	2nd
	5.0	20 Days18 Hrs	2nd
Toungoo	0.8	5 Days 9 Hrs	
Madauk	5.2	0 Days 6 Hrs	2nd
Shwegyin	2.4	7 Days12 Hrs	
Bago	0.5	1 Days 14 Hrs	
Hpa-an	4.5	16 Days 0 Hrs	
NTG	3.8	34 Days 0 Hrs	

Damage caused by flood along the Ayeyarwady River in 2004

No	Station	Affected population	Affected houses			Affected Crops in Acres		Costs of damages (million kyats)
			Houses		Family Group	Coverage (acres)	Damage (acres)	
			Coverage	Damaged				
1	MYITKYINA	64561	8080	742	8429	11450	-	207.92
2	BHAMO	7014	1351	17		2508	579	-
3	KATHA	-	2765	-	-	269	575	-
4	SAGAING	-	-	-	-	33569	-	-
5	PAKOKKU	9802	-	-	2496	26427		-
6	MINBU	-	-	-	-	2844	1494	-
7	AUNGLAN	17620	3752	-	3467	-	-	-
8	PYAY	71696	14916	-	6091	10039	-	-
9	HINTHADA	-	-	-	-	-	-	-
TOTAL		170,693	30,864	759	96,347	87,106	2,648	207.92

Flood Management in Delta Areas (Structural Measure)

- Coastal dikes are constructed in coastal regions in Rakhine State, Ayeyarwady and Sittaung delta, Mon State and Tanintharyi Region

- There are altogether 225 dykes in 2473 miles(3980 km) in Myanmar, among these 97 are for flood protection, 7 are for urban protection and the others are sea water protection dikes

Investigation of Dikes in Myanmar

Investigation is needed to determine the weak portions of the dikes for rehabilitations and appropriate maintenance measures

- In Myanmar, dikes inspection is divided into three parts,
  - Before monsoon,
  - During monsoon and
  - Post monsoon
- Weak portions and points are exposed during the flood of monsoon season

Investigation before monsoon

Especially, flood protection dikes are needed to investigate and inspect for the whole year

- Before monsoon, inspection is made along the dikes to ascertain where the maintenance and rehabilitation works are required

- Engineering staff and his labour groups inspect along the dikes to find out
  - Weak portion of embankments
  - Bank erosion

- Settled portion in crest level,
- Holes made by insects or animals
- And also, bushes growing on the slope and the toe of the dikes on land side are also cleared
- so that seepage, sand boils and any other fault, can be seen

Investigation during monsoon

Engineers and workmen are deployed at temporary huts when flood level reaches or above the danger level.

- Embankments are watched both day and night.
- During daylight Engineers are on inspection, one or two of labours are deputed to walk along the dikes for their assigned portion
  - generally 4 mile in length,
    once or twice during the day.

- During the night
  - Walk and search carefully slip, leakage and other weak points along the dikes
    slip or piping or bank failure occurred frequently during the last monsoon or flood period

- Temporary huts (beats) are built at 4 mile (6.4 km) interval along the embankments for resting of the inspectors and all necessary emergency materials are collected so that emergency counter measure can be taken without delay.

- Each patrol team consists of two men who carry tools such as a torch, a sword and some pegs
- The distance covered by a patrol team is 4 miles (6.4 km) and the team covered that distance twice during the night

- Patrol team of different sections and of different subdivisions meet at temporary huts and exchange information about the dike

- If the patrol team finds a leak or other damage to the embankment they have to decide whether immediate action is needed to repair or not, and report back immediately to the engineers

- Intelligent, trained and experienced workmen or labours are therefore required to tackle such kinds of problems

- Engineers concerned scrutinize all the collected information passed through during the night and check carefully early each morning.

- Soldiers are also usually stationed near dikes and put them on alert when flood condition is considered crucial.

- All the locations of weak points found are marked carefully to take adequate repair works in dry season, following immediate action is taken as necessary.

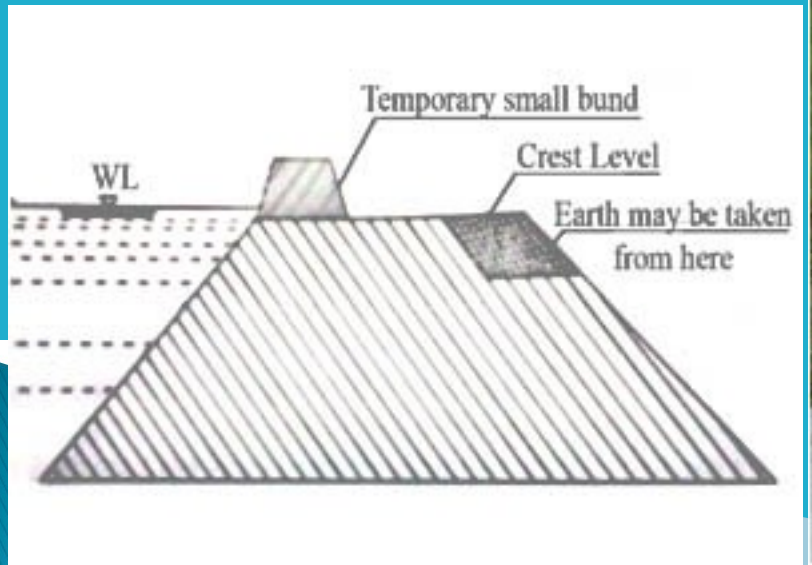
- ✓ Protection work to prevent bank erosion is done before the flood season,
  - ➢ Constructing deflection spurs
  - ➢ Construction diamond spurs (Silting spurs)

Construction diamond spurs(Silting spurs)

- ✓ Clearing bushes and grass at the land side of dike slope
- ✓ Repairing of water level gauge
- ✓ Re-sectioning and strengthening of dikes

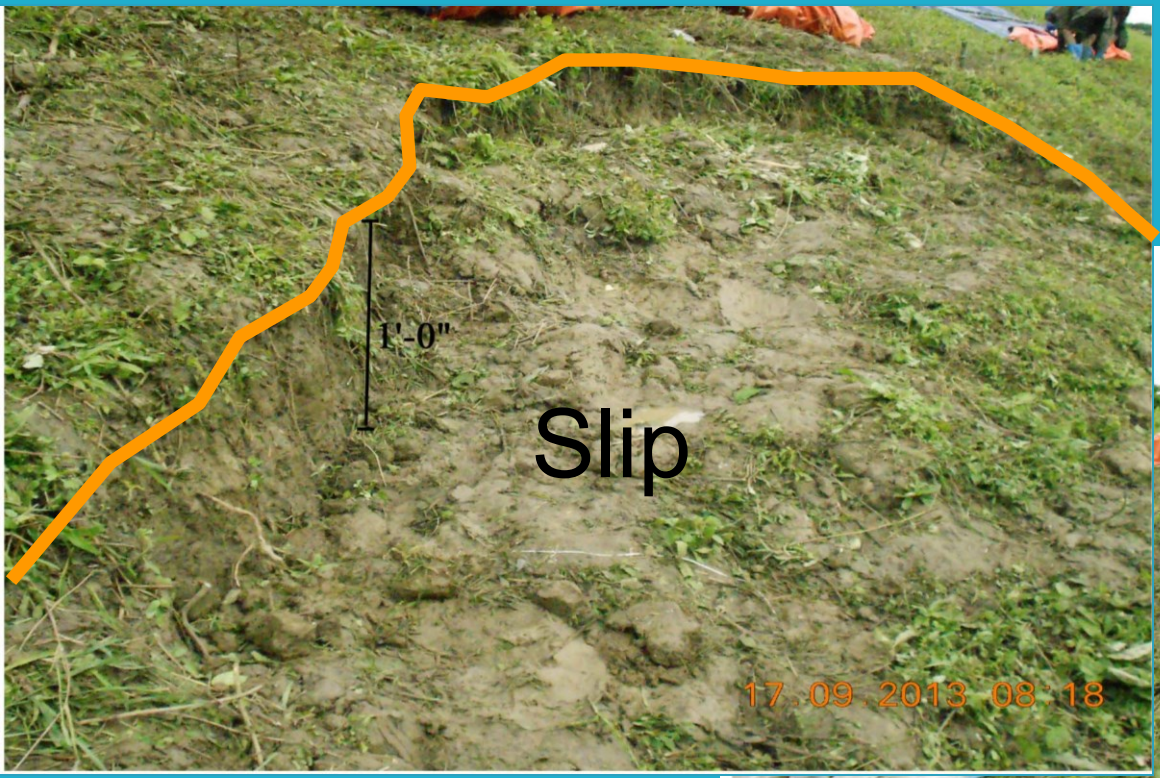
During the rainy season

If **overtopping** occurs it is prevented from flowing over the bund, by exacting a small bund or *Kazin*
If soil is not available from elsewhere in time it can be obtained safely from the land side edge of the crest or raised by sand bags



- Patrol teams inspect along the dike to see all leaks, slips, piping, seepage and wave wash, etc., which may or normally occur during flood

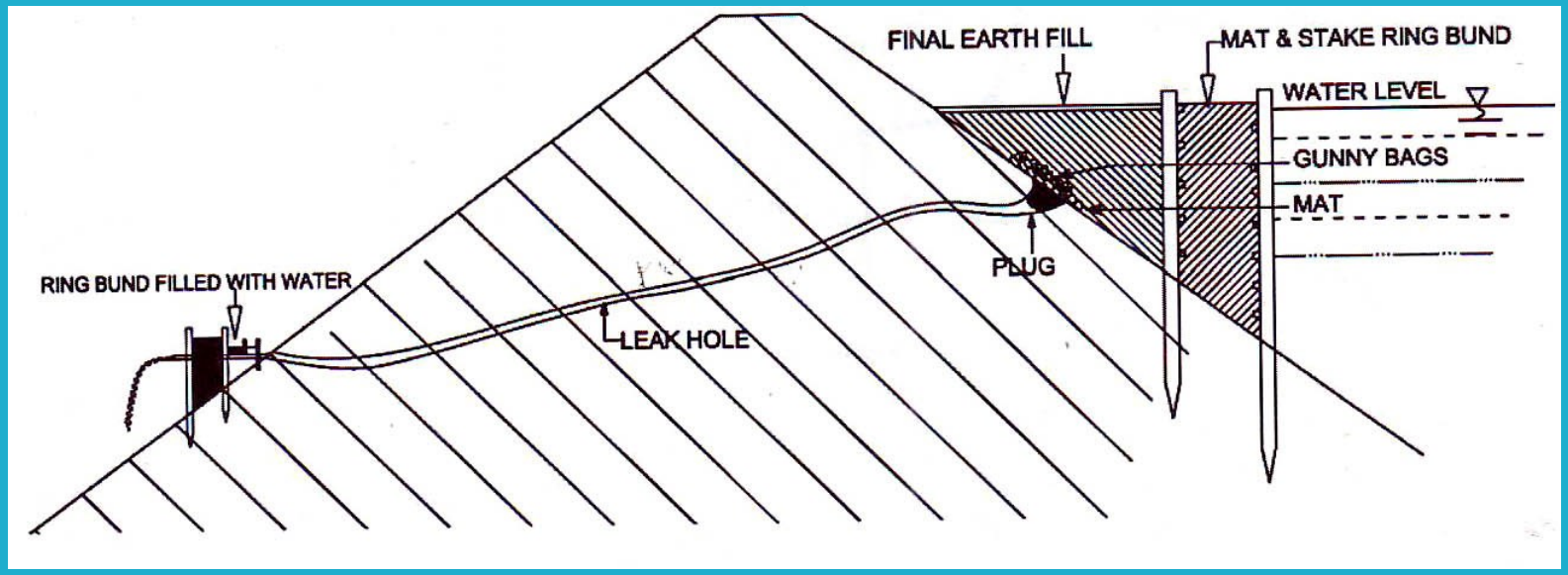
If **slip** occurs, to maintain the section and to weight the toe, countermeasure is taken by flattening the slopes or by providing a banquette cover by waterproof material to prevent from entering of rain water into the crack of the slip.



Protection from Slip

If the river side hole or vortex is found

it would be plugged with some soft material, like bundles of grass or straw(stones or bricks must not be used).



If the hole is large

gunny bag partly filled with earth used for plugging. After plugging the hole, a mat should be spread over it, and weighted down well with packed soil or sand bags

If the leak is serious,

a **ring bund** filled with earth is normally built over the mouth of the leak and filled with water to balance the water head

Traditional Measure

Investigation post monsoon

After the monsoon period

- Crest levels of the embankment are taken at every 200 feet (60 m)
- Cross-sections are taken at every half mile (0.8 km)

- Weak portions of embankments are also determined in order to take necessary repair for strengthening
- Weak points marked during monsoon season are repaired thoroughly in dry season

Challenges in maintenance of dykes

- Possibility of overtopping of embankment increases due to heavy deposition of in the river as a result of deforestation in catchment area
- Continuous and gradual rising of river bed level that would entail the raising of dikes
- Limited funding for strengthening, rehabilitation and maintenance of embankments
- Likelihood of occurrence of more severe floods and cyclone due to climate change, that necessitates both raising and strengthening of the embankments
- Lack of technical knowhow and equipments for application of new modern technology for investigation of embankments
- Shortage of qualified staff in using geophysical instruments and interpretation of measured data

Requirement

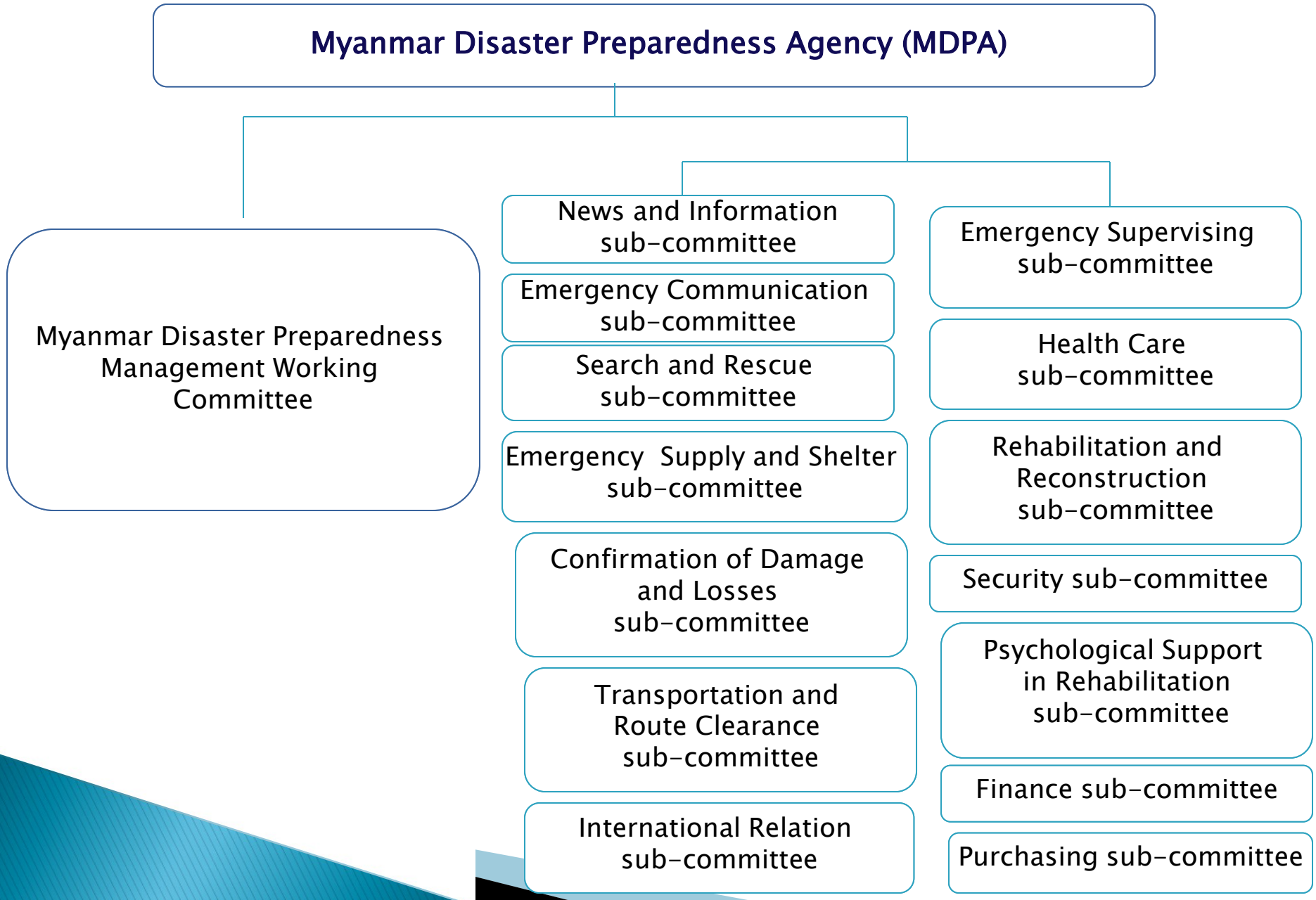
- Present technology is found inadequate to cover all the dikes in detecting the weak zones. Continuous urbanization, expansion of agricultural land and development of industrial complex in delta area demand safety of dikes through strengthening of existing dikes and utilization of new innovative technology in dike maintenance.

- Dissemination of innovative technology that can cover long distance of dikes in investigation and detection of dikes will surely relieve heavy financial burden spent on investigation works of dikes and ensure the safety.

Flood mitigation and preparedness in Myanmar

- Dept. of Meteorology and Hydrology (DMH)
- Dept. of Irrigation
- Directorate of Water Resources and Improvement of River System (DWIR)
- Dept. of Relief and Resettlement

Organization Chart of MDPA, Management Working Committee and (14) Sub-committees



Relief Items to the Flood Victims by the Vice President (Hpaan in Aug, 2013)

Inspection to the Flood Victims by the Vice President

Conclusion & Recommendation

- Strengthening the storm and flood forecasting and warning capacity
- Near real time rainfall and rainfall estimation for flood forecasting
- Strengthening Hydro-meteorological network
- Dissemination of flood warning to local levels in time

- Construction of dike or levee to control flood waters
- Planting forests in upstream areas
- Cleaning riverbed (dredging)
- Upgrading, monitoring and managing the dike systems
- Enhancing the community awareness of flood preparation and avoidance
- Encouraging public participation in monitoring, management and resolution of flooding


Thank You