Regional Integrated Multi-Hazard Early Warning System

Myanmar Department of Meteorology and Hydrology

United Nations Economic and Social Commission for Asia and the Pacific

10th MONSOON FORUM

ACTIVITY REPORT

3 MAY 2013

NAY PYI TAW, **MYANMAR**

The 10th Monsoon Forum, in Myanmar, was convened by the Department of Meteorology and Hydrology (DMH), as part of the programme *"Reducing risks of tsunamis, storm surges, large waves, and other natural hazards in low- elevation coastal zones",* with support from the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) and the Regional Integrated Multi-Hazard Early Warning System (RIMES).

Section 1

Introduction

1.1 Background

The Monsoon Forum, a platform for enhanced application of forecast application, provides opportunity for regular dialogue between Myanmar's Department of Meteorology and Hydrology (DMH) and its stakeholder institutions to promote a) enhanced understanding, by forecast user institutions, of forecast products including their limitations and uncertainties; and b) better appreciation, by DMH, of users' information requirements. The process facilitates a cycle of refinement of forecast products to suit users' needs and development of more robust information sharing system, redounding to better application of forecasts.

Introduced in Myanmar in 2007 and built around the monsoon, a regular phenomena in the country, the Monsoon Forum has taken a multi-hazard approach in May 2012, integrating issues on forecasts/warning information and other concerns regarding geological hazards, like earthquakes and tsunamis.

The 10th Monsoon Forum was organized by DMH, with support from the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) and the Regional Integrated Multi-Hazard Early Warning System (RIMES) through the project "Reducing risks of tsunamis, storm surges, large waves, and other natural hazards in low elevation coastal zones".

1.2 Objectives

The 10th Monsoon Forum was convened on 3 May 2013 in Nay Pyi Taw, Myanmar with the following objectives:

a) review the 2012-2013 winter season in terms of patterns of climate and performance of the seasonal climate and water level forecasts
b) draw feedback from user institutions on the relevance/usability of the seasonal forecast for the winter season and recommendations for enhancement of forecast products
c) present the seasonal forecast for the Southwest monsoon season
d) present sectoral potential impact outlook and response options for application by stakeholders
e) present/discuss recent issues/concerns/developments in earthquake monitoring and tsunami early warning and response

1.3. Agenda

The 10th Monsoon Forum agenda is presented below:

Agenda		
8.30-9.00	Arrival and Registration of Participants	DMH
Session 1: Opening/Inaugural Session		
9.00-9.15	Welcome/Opening Remarks	DMH
9.15-9.30	Remarks	RIMES
09.30-09.45	Introduction of Participants	
9.45-10.00	Coffee/Tea Break	
Session 2: Overview		
10.00-10.20	Summary of the 9th Monsoon Forum Recommendations	RIMES/DMH
Session 3: Verification of the Long-Range Forecast for the Winter Season		
10.20-10.35	Verification of Long-Range Climate Forecast for the Winter Season	DMH
10.35-10.50	Verification of Long-Range Water Level Forecast for the Winter Season	DMH
10.50-11.05	Review of the Agro-climatic Condition for the Winter Season	DMH
11.05-11.40	Discussion/Feedback from User Institutions on Relevance/Usability of Forecast for the Winter Season and Recommendations for Enhancement of Forecast Products	• Ministry of Agriculture • Department of Irrigation • Relief and Resettlement Department • Local Government of Kungyangon • Local Government of Pyinsalu
Session 4: Seasonal Climate Outlook for the Southwest Monsoon Season		
11.40-12.00	DMH-RIMES Engagement for Enhancement of DMH Forecast Products	DMH
12.00-13.00	Lunch	
13.00-13.25	Presentation of Seasonal Climate Outlook for the Southwest Monsoon Season	DMH
13.25-13.40	Presentation of General Long-Range Water Level Forecast for the Southwest Monsoon Season	DMH
13.40-13.50	Presentation of Agro-climatic Bulletin	DMH
13.50-14.00	Discussion	
Session 5: Group Discussion: Sectoral Impact Outlook and Response Options		
14.00-15.00	Group Discussion: Potential Impact Outlook and Response Options	To be facilitated by DMH/RIMES
15.00-15.15	Coffee/Tea Break	
15.00-15.45	Presentation of Sectoral Impact Outlook and Response Options	Group Representatives
15.45-16.00	Discussion	
Session 6: Issues and Concerns: Earthquake Monitoring and Tsunami Early Warning		
16.00-16.20	Earthquake and Tsunami Risks in Myanmar	DMH
16.20-16.30	Discussion	
Session 7: Way Forward and Closing Session		
16.30-16.40	Synthesis of Discussions	RIMES
16.40-16.50	Closing Remarks	DMH

1.4 Participants

The 10th Monsoon Forum was attended by 46 participants from government institutions, UN/international development organizations, mass-based and media institutions. These include:

Government Institutions

- Ministry of Agriculture and Irrigation
- Ministry of Commerce
- Ministry of Environment of Forestry
- Ministry of Health
- Ministry of Hotel and Tourism Services
- Ministry of Industry
- Department of Agriculture
- Department of Agriculture Research
- Department of Civil Aviation
- Department of Forest
- Department of Industrial Crops Development
- Department of Information and Public Relation
- Department of Irrigation
- Department of Relief and Resettlement
- Directorate of Water Resources and Improvement of River Systems
- General Administration Department
- Hotel and Tourism Services

UN/International Development Organizations

- United Nations Development Programme (UNDP)
- United Nations Human Settlements Programme (UN-HABITAT)
- ActionAid/European Commission Humanitarian Aid Department (DIPECHO)

Academe/Research Center

- Yezin Agricultural University

Mass-based organization

- Myanmar Red Cross Society

Media

- Myanma Radio and Television

Section 2

Opening Session

2.1 Welcome and Opening Remarks

Participants of the 10th Monsoon Forum were welcomed by Dr. Hrin Nei Thiam, Director General, DMH. She explained that the Monsoon Forum was introduced in Myanmar by DMH in 2007, and is usually conducted twice a year – before and after the monsoon season. She then thanked RIMES for facilitating the Monsoon Forum as it provided an opportunity for DMH to have productive dialogues with its stakeholder institutions.

Dr. Thiam emphasized that, being a predominantly agricultural country, the government has given emphasis on agro-based economy and development of agricultural infrastructures to increase food production. She explained that in accord with the national direction set by the government, DMH provides weather and climate information to different stakeholders, including farmers and other key stakeholders in the agriculture sector. Other sectors are, as well, availing of DMH services.

Myanmar's climate, according to Dr. Thiam, has shifted dramatically, aggravating the occurrence of hazards/disasters. She underscored that hazards could not be prevented from occurring hence, people have to put in place measures to adapt to current climate behavior and anticipate future scenarios. She continued that to enhance sectoral preparedness, the Monsoon Forum provides support to climate scientists to better understand information requirements of decision makers in various sectors and assist users to better understand and subsequently apply forecasts/warnings from DMH.

Dr. Thiam proceeded to explain the objectives of the 10th Monsoon Forum. She encouraged participants to actively share their knowledge and experiences during the winter season, identify needs and gaps, and pose forward recommendations for enhancement of forecast products and the Monsoon Forum process.

Myanmar, according to Dr. Thiam, is one of the most disaster-prone countries in Southeast Asia. She espoused that the inter- and intra-seasonal climate variations in the country had been significant. She subsequently provided the following notable observations for temperature and rainfall:

- Highest maximum temperature recorded in the country was 47.2°C at Myinmu Station (lower Sagaing Region, Central Dry Zone) on 14 May 2010. In 2012, the maximum temperature of 46.4°C was recorded at Chauk Station in Magway Division, also in the Central Dry Zone
- Very minimal rainfall for 2012 monsoon season was observed in Central Dry Zone, exacerbating increase in temperature and prevalence of drought
- 2012 Southwest monsoon intensity was moderate to strong, and frequency of storm during the period was less compared to preceding years
- In 2012, the highest water level observed at Sittaung River (Madauk Station) was 5.5 feet. This observed value is the second highest observed water level at the station in the last 47 years, and is higher than the danger level
- Highest water level at Shwegyin River (Shegwin Station) in 2012 was 4.5 feet. This observed value is the second highest recorded water level at the station in 48 years, and is likewise higher than the danger level

Dr. Thiam elaborated that about 95% of Myanmar's annual rainfall is received during the monsoon season, with rainfall variations experienced in different climatic zones in the country. She expounded that based on long-term normal values, the coastal areas receive the highest rainfall of about 200 inches annually, while the Central Dry Zone receives only about 40 inches annually.

2.2 Remarks

RIMES, represented in the 10th Monsoon Forum by Ms. Ruby Rose Policarpio, Institutional Development Specialist, thanked DMH for taking the lead in the Monsoon Forum, and the participants for their participation. She emphasized the importance of multi-stakeholder participation in the Forum as sectoral decision-makers would have to eventually provide advisories and/or implement actions for their stakeholders, based on forecast issued by DMH. She expressed her hope that the 10th Monson Forum would be useful and relevant for the different sectors represented.

2.3 Introduction of Participants

DMH facilitated the introduction of participants.

2.4 Summary of Recommendations during the 9th Monsoon Forum

Ms. Policarpio presented the summary of discussions and recommendations during the 9th Monsoon Forum. She indicated that the session was intended for participants to recall the discussions, agreements, and recommendations during the 9th Monsoon Forum. She also encouraged participants to follow-up on such agreements/recommendations during the discussions that will follow the different sessions.

She discussed that the 9th Monsoon Forum was conducted on 26 October 2012 in Nay Pyi Taw, Myanmar, through the support from UNESCAP and RIMES. She explained that the Monsoon Forum is conducted as a platform for dialogue between forecast producers and users, to facilitate better application of forecast/warning information for enhanced management of risks. She elaborated that prior to the 9th Monsoon Forum on 26 October, a preparatory meeting was conducted on 22 October, to provide more time for stakeholder-institutions to better analyze DMH's seasonal forecast for the winter season and develop impact outlook and response options. She then recalled the objectives of the 9th Monsoon Forum, which were:

- review the 2012 Southwest Monsoon in terms of patterns of climate and performance of the seasonal climate and water level forecasts
- draw feedback from user-institutions on the relevance/usability of the seasonal forecast for the 2012 monsoon season and recommendations for enhancement of forecast products
- present the seasonal forecast for the 2012-2013 winter season
- discuss and present sectoral impact outlook and response options for potential application
- present/discuss recent issues/concerns/developments in earthquake monitoring/tsunami early warning and response

- draw recommendations from stakeholders in improving the conduct of subsequent Monsoon Forums

She proceeded to elaborate the institutions represented during the 9th Monsoon Forum, which include different stakeholder institutions in the government, academe/research, mass-based, and media sectors.

The key sessions, during the 9th Monsoon Forum, include:

- verification of long range/seasonal climate and water level forecast and agro-climatic condition for the 2012 Southwest monsoon season
- feedback from user-institutions on the relevance/usability of seasonal forecast for the Southwest monsoon season and recommendations for enhancement of forecast products
- presentation of the seasonal climate and water level outlook and agro-climatic bulletin for the winter season
- group discussion and presentation of sectoral impact outlook and response options
- Estimation of Tsunami Arrival Time and Maximum Tsunami Wave Amplitude for Myanmar Coastal Areas Using TUNAMI F1 Model

She subsequently zeroed-in on recommendations made by stakeholders during the 9th Monsoon Forum, summarized as follows:

- **Enhanced generation of forecast/warning information**
  - Upgrading and expansion of weather observation and seismic monitoring stations
  - Capacity building of DMH scientists in forecasting and other concerns, especially in Agro-Meteorology Division
  - Application of modern/latest technologies in DMH research and forecasting
  - Capacity building of DMH scientists in the application of tools (i.e. GIS) for enhanced spatial analyses of agro-meteorological databases
  - Improving the spatial and temporal resolutions of forecasts
  - Strengthening collaboration between DMH and international/regional forecasting/development organizations
  - Enhancing capacity of DMH scientists in analyzing earthquake events and generation of tsunami warning
  - Development of location-specific climate change projections (region-, state-, or division-wise)

- **Development of user-friendly forecast/warning information**
  - Use of simple terminologies in forecast products

- **Building stakeholders capacity in understanding, translating, and applying forecast/warning information**
  - Strengthening capacity of user institutions in projecting impacts and responses, based on forecast information
  - Updating of agro-ecological maps by the agriculture sector
  - DMH publication of monthly journal discussing different topics of interest to stakeholders

- Provision of educational materials, e.g. posters, pamphlets, etc., to communities to increase people's awareness on disaster risks and risk management options
- DMH to develop an awareness program on weather and seismic hazards, warnings, and general precautionary measures, which can be shown in different radio and television stations (i.e. MRTV). MRTV indicated that it can give time-slots for DMH to air such programs over radio and/or television

- **Communication/dissemination of forecast/warning information**
  - Development by DMH of directory of institutional focal points in the media and other user institutions. The directory should include mobile phone numbers of focal points to ensure communication pathways in cases when landline and fax connections are down. Directory shall be provided to all concerned institutions
  - Mechanism to ensure receipt of warning information by stakeholders should be put in place. In the aviation sector, for example, problems on plane landing have been encountered because of fog
  - Dissemination by DMH of relative humidity forecast to farmers on a regular basis
  - Strengthening of collaboration between DMH and mass-based organizations, like the Myanmar Red Cross Society, to ensure speedy dissemination of forecasts, especially for hazards with short-lead time, like tsunami
  - Establish a mechanism to ensure receipt of forecasts in local areas

- **Access to DMH's historical data**
  - Participants recommended that historical data, from DMH, be provided to user-institutions for free

- **Strengthening the Monsoon Forum Process**
  - In the next Monsoon Forum, a session on definition of forecast terminologies should be included in the agenda, preferably before the main sessions begin, to facilitate better understanding among the stakeholders of the discussions.
  - Presentation of forecasts should not be very technical

Ms. Policarpio emphasized that addressing all the recommendations from stakeholders would include institutional processes, hence would take time. She then provided updates on RIMES-DMH engagements, which contribute to addressing the various recommendations.

Section 3

Verification of 2012-2013 Winter Season Forecast

3.1 Verification of the Long Range Climate Forecast for the Winter Season

Mr. Than Naing of DMH explained that the 2012 – 2013 Winter Season (November 2012 to February 2013) forecast was generated based on analog method, a process of selecting years of similar conditions as reference, for forecast analysis. DMH explained that the 2012-2013 winter season initial conditions were similar to conditions in 2004, 2010, and 2005. DMH further explained that based on analysis, 2004 was selected as analog year for the generation of seasonal outlook for November 2012 to February 2013. The selection of analog year is based on the behavior of triggers of seasonal climate variability in Myanmar, like El Niño Southern Oscillation (ENSO), as indicated in Figure 1.

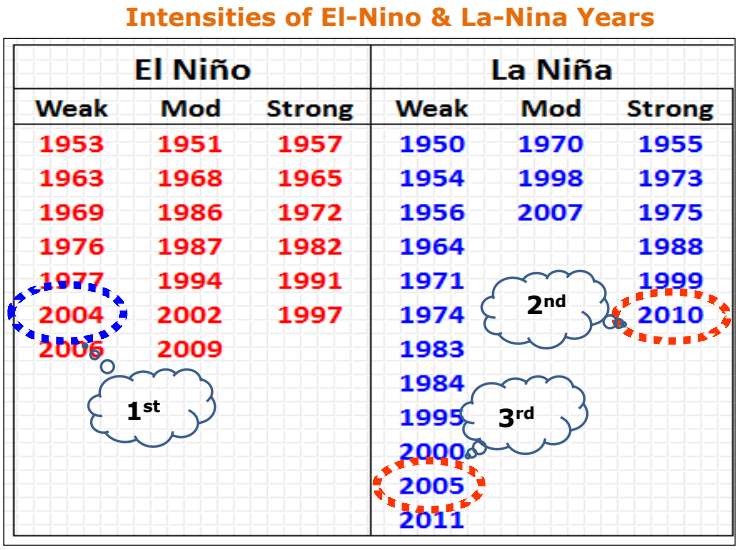
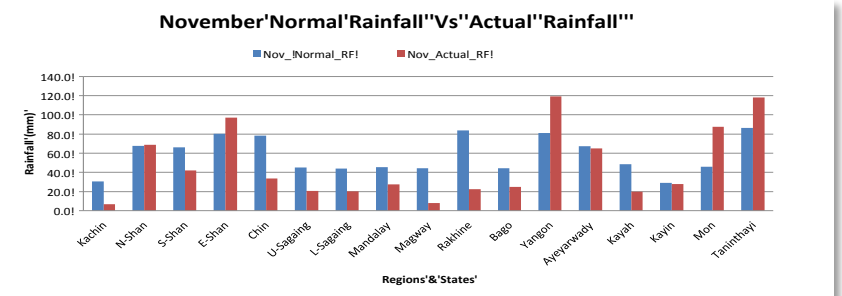


Figure 1. 2004 was selected as model year for the analysis of the 2012-2013 Myanmar winter season as ENSO behavior during the year is comparable to conditions of the 2012-2013 winter season

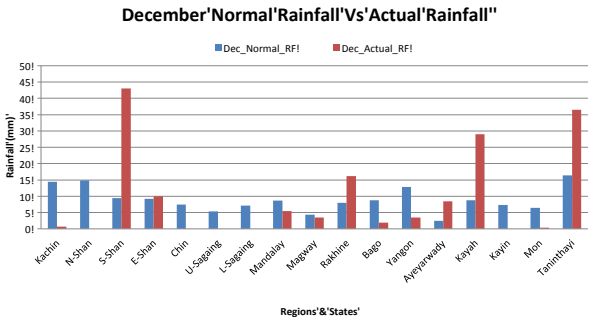
Comparison of monthly normal rainfall values vis-à-vis 2012-2013 winter season rainfall values as well as forecast and observed rainfall values followed. These comparisons are presented Figures 2 to 5.



Comparison between Forecast and Observed Rainfall for November

	Kach'!	Chin'!	Shan'!	US'!	LS'!	Mdy'!	Mgw'!	Rkh'!	Bgo'!	Aye'!	Ygn'!	Kah'!	Mon'!	Kyn'!	Tan'!
FC'!	B!	N!	A!	N!	N!	N!	N!	A'	A'	A!	A!	N!	A!	N!	A!
OBS'!	B!	B!	A!	B!	B!	B!	B!	B'	B'	N!	A!	B!	A!	N!	A!

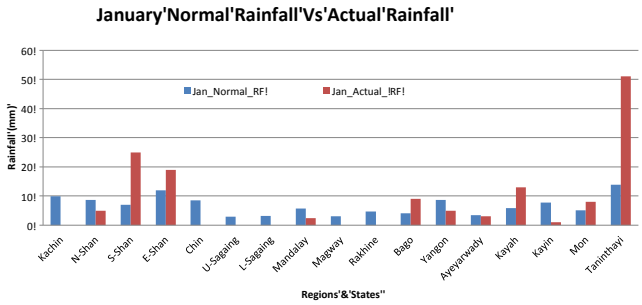
Figure 2. Below normal rainfall was recorded in most stations in the country, in November 2012, except in Northern Shan, Eastern Shan, Yangon, Mon, and Tanintharyi where rainfall was above normal; and in Ayeyarwady and Kayin where normal rainfall was observed. All stations in the Central Dry Zone registered below normal rainfall. Comparison between forecast and observed rainfall indicates correct forecast for Kachin, Shan, Yangon, Mon, Kayin, and Tanintharyi.



Comparison between Forecast and Observed Rainfall for December

	Kach'!	Chin'!	Shan'!	US'!	LS'!	Mdy'!	Mgw'!	Rkh'!	Bgo'!	Aye'!	Ygn'!	Kah'!	Mon'!	Kyn'!	Tan'!
FC'!	N!	N!	N!	B!	B!	B!	B!	A!	A!	A!	A!	N!	A'	N!	A!
OBS'!	B!	B!	A!	B!	B!	B!	B!	A!	B!	A!	B!	A!	B'	B!	A!

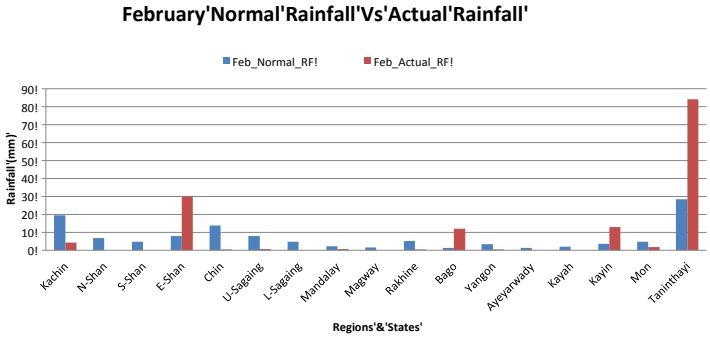
Figure 3. Except in Shan, Rakhine, Ayeyarwady, Kayah, and Tanintharyi which recorded above normal rainfall, all of the areas in Myanmar received below normal rainfall n December 2012. Validation indicated correct forecast for Upper and Lower Sagaing, Mandalay, Magway, Rakhine, Ayeyarwady, and Tanintharyi.



Comparison between Forecast and Observed Rainfall for January

	Kach'!	Chin'!	Shan'!	US'!	LS'!	Mdy'!	Mgw'!	Rkh'!	Bgo'!	Aye'!	Ygn'!	Kah'!	Mon'!	Kyn'!	Tan'!
FC'!	N!	N!	N!	N!	A!	A!	A!	N!	N!	A!	A!	N!	A!	!A!	N!
OBS'!	N!	N!	A!	N!	N!	N!	A!	N!	N!	N!	N!	A!	A!	N!	N!

Figure 4. Above normal rainfall, in January 2013, was observed in Southern and Eastern Shan, Bago, Kayah, Mon, and Tanintharyi. The rest of the stations received normal/below normal rainfall for the month. Upon validation, forecast for January 2013 for Kachin, Chin, Upper Sagaing, Magway, Rakhine, Bago, Mon, and Tanintharyi was found correct.

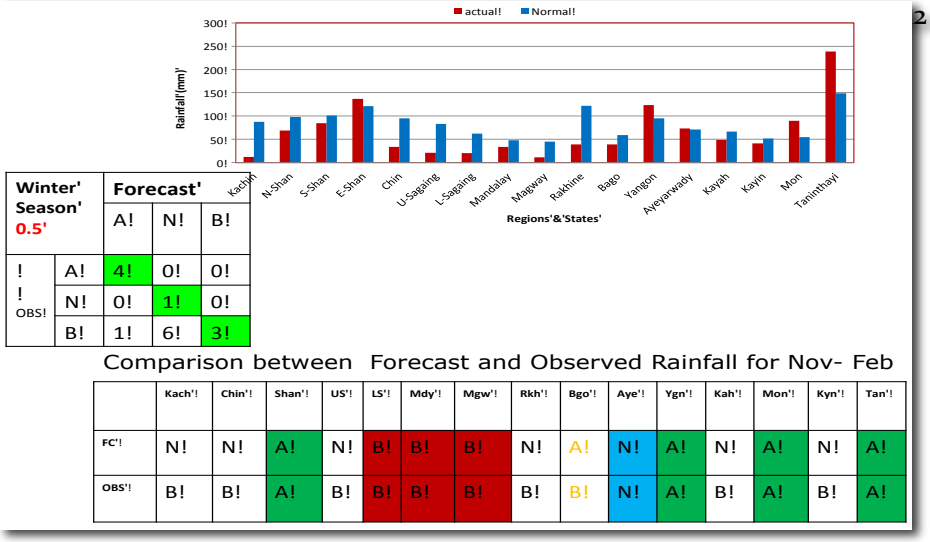


Comparison between Forecast and Observed Rainfall for February

	Kach'!	Chin'!	Shan'!	US'!	LS'!	Mdy'!	Mgw'!	Rkh'!	Bgo'!	Aye'!	Ygn'!	Kah'!	Mon'!	Kyn'!	Tan'!
FC'!	A!	N!	A!	A!	N!	N!	N!	B!	B!	N!	B!	N!	B!	B!	A!
OBS'!	B!	A!	B!	B!	B!	B!	B!	B!	A!	N!	B!	A!	B!	A!	A!

Figure 5. In February 2013, below normal rainfall was observed in all stations except in Eastern Shan, Bago, Kayin and Tanintharyi which recorded above normal rainfall; and in Ayeyarwady with normal rainfall. Correct forecast was noted for Rakhine, Ayeyarwady, Yangon, Mon, and Tanintharyi.

Verification of long-rage forecast, from November 2012 to February 2013, is presented in Figure 6.



2 to February 2013

Figure 6. Observed rainfall, from November 2012 to February 2013, was below normal in all stations except in Eastern Shan, Yangon, Mon, and Tanintharyi where above normal rainfall was recorded; and in Ayeyarwady which recorded normal rainfall. Verification of the long-range forecast indicated correct forecast for Shan, Lower Sagaing, Mandalay, Magway, Ayerarwady, Yangon, Mon, and Tanintharyi. DMH, using statistical calculation, recorded 0.5 hit rate for its long range forecast for the 2012-2013 winter season.

Mr. Naing subsequently presented the temperature verification for the 2012-2013 winter season. Figure 7 shows the monthly normal minimum temperature values against observed minimum temperature values for November 2012 to February 2013. Figure 8 illustrates forecast minimum temperature for the winter season against observed minimum temperature in different areas in the country.

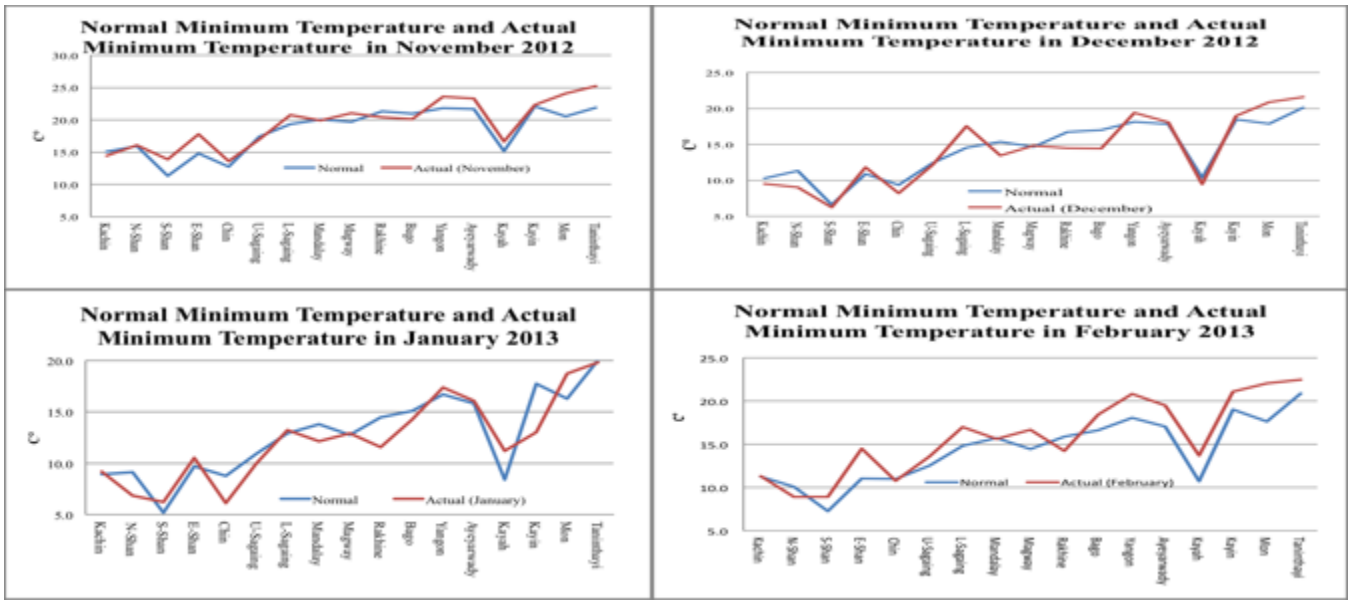


Figure 7. Variations in normal monthly minimum temperature values against observed minimum temperature values were recorded from November 2012 to February 2013.

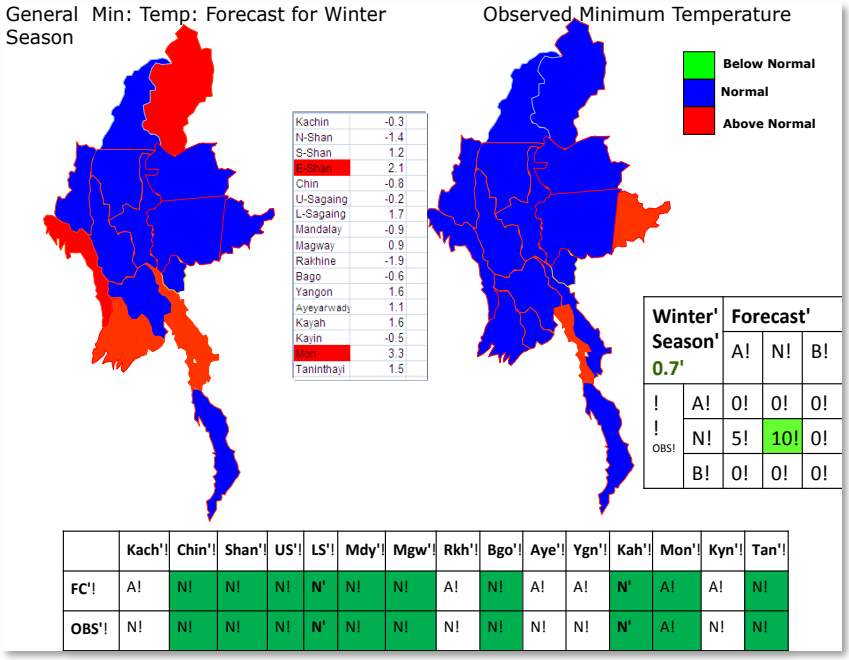


Figure 8. Observed minimum temperature during the 2012-2013 winter season indicated that except Eastern Shan and Mon States which recorded above normal minimum temperature, the rest of the country registered normal minimum temperature. Comparison between forecast and observed minimum temperature values indicate correct forecast for Chin, Shan, Upper and Lower Sagaing, Mandalay, Magway, Bago, Kayah, Mon, and Tanintharyi.

Mr. Naing then discussed forecast LPAs and depressions for the winter season against observed frequency. This is indicated in Table 1.

Table 1. Frequency of LPAs and Depressions

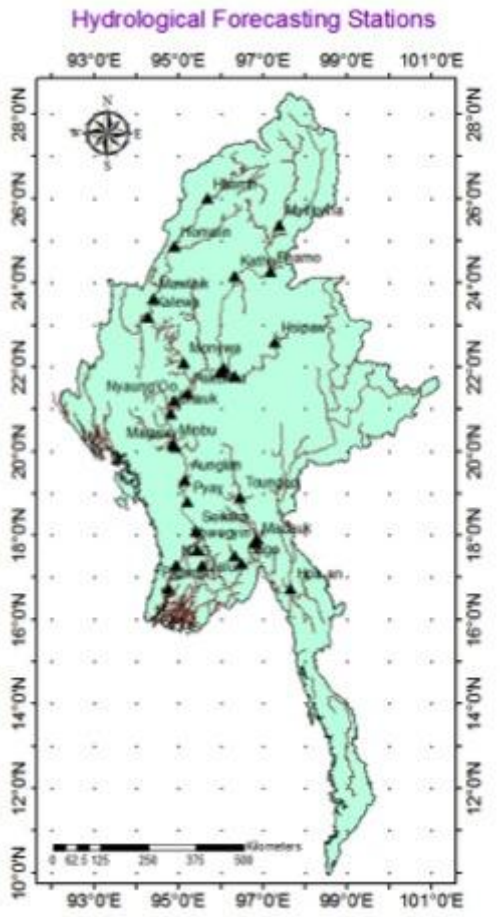
	General Winter Season Outlook LPA to Dep	Monthly updated Forecast			
		November LPA to Dep	December LPA to Dep	January LPA to Dep	February LPA to Dep
Forecast	3-2	2-1	2-1	-	1
Observed	2-1	2-1	-	-	-

Key observations, during the 2012-2013 winter season, were then enumerated:

- LPA, which later developed to depression, occurred over Southeast and Southwest Bay of Bengal on 14 to 19 November 2012
- LPA occurred over Andaman Sea on 20 November 2012
- LPA did not occur from December 2012 to February 2013
- Heaviest rainfall recorded for the season:
  - Pyapon – 113mm (4.45 inches) on 30 October 2012
  - Myeik – 83mm (3.27 inches) on 26 January 2013
- Lowest observed temperature for the season was -3°C, at Hakha, on 27 December 2012

3.2 Verification of Long Range Water Level Forecast for the Winter Season

Mr. Myo Tun Oo of the Hydrological Division, DMH, discussed the different hydrological stations in the country, indicated in Figure 9.



Ayeyarwady	**-**	**15 Stations**
Chindwin	**-**	**5 Stations**
Sittaung	**-**	**2 Stations**
Thanlwin	**-**	**1 Station**
Dokethawady	**-**	**2 Stations**
Bago	**-**	**2 Stations**
Shwegyin	**-**	**1 Station**
Ngawu	**-**	**2 Stations**

Figure 9. Hydrological observation stations established by DMH in Myanmar

Subsequently, Mr. Oo presented the trend of 40-year minimum water level observations in key stations in Chindwin River in Myanmar. As indicated in Figure 10, a downward trend in observed minimum water level was discerned for Hkamti and Monywa stations while an upward trend in observed minimum water level is indicated in the analysis of long-term data in Mawlaik station.

Comparison of daily water levels in different stations along Chindwin River during the low flow season, from 2000 to 2013, indicated that the 2012-2013 observed water level was one of the lowest observed in 13 years in Mawlaik and Monywa stations. This is indicated in Figure 11.

On the other hand, 40-year observed minimum water level data, from different stations along Ayeyarwady River, indicated variations in trends, as shown in Figure 12. Subsequently, Figure 13 indicates that the observed water level for the 2012-2013 winter season was one of the lowest, from 2000 to 2013.

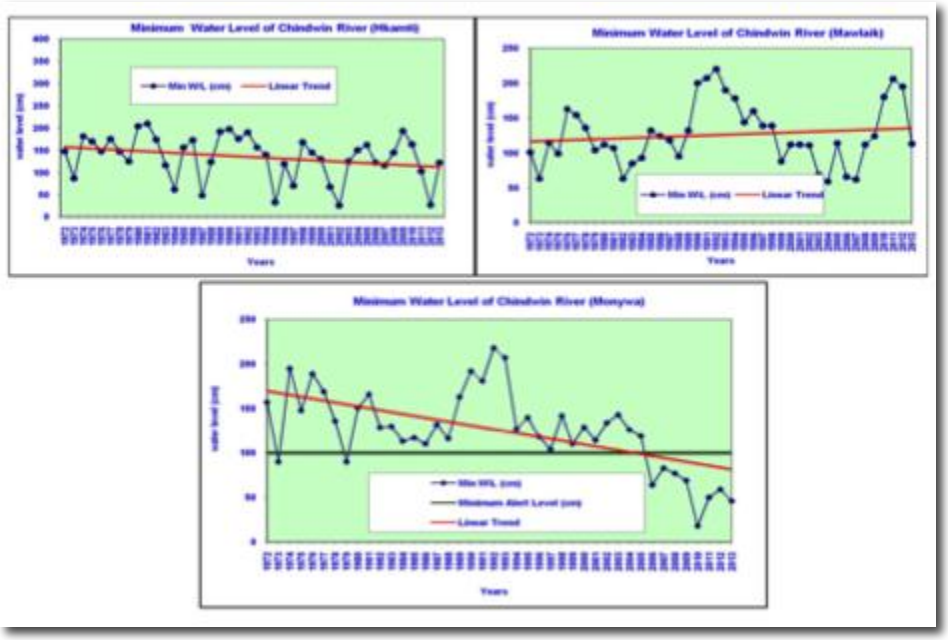


Figure 10. 40-year observed minimum water level values at Hkamti, Mawlaik and Monywa stations along Chindwin River

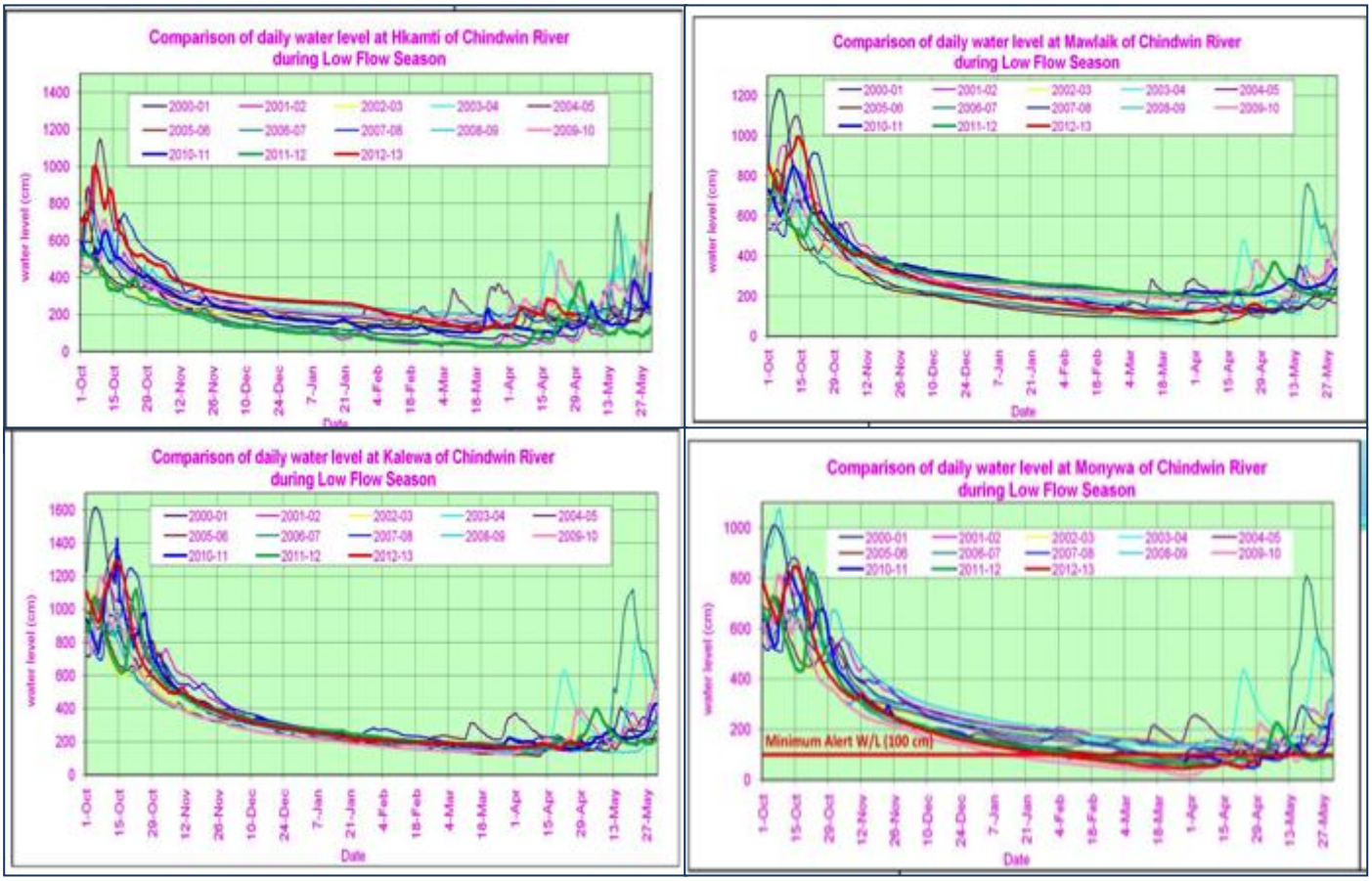


Figure 11. Observed low flow water level in Hkamti, Mawlaik, Kalewa and Monywa stations along Chindwin River, from 2000 to 2013

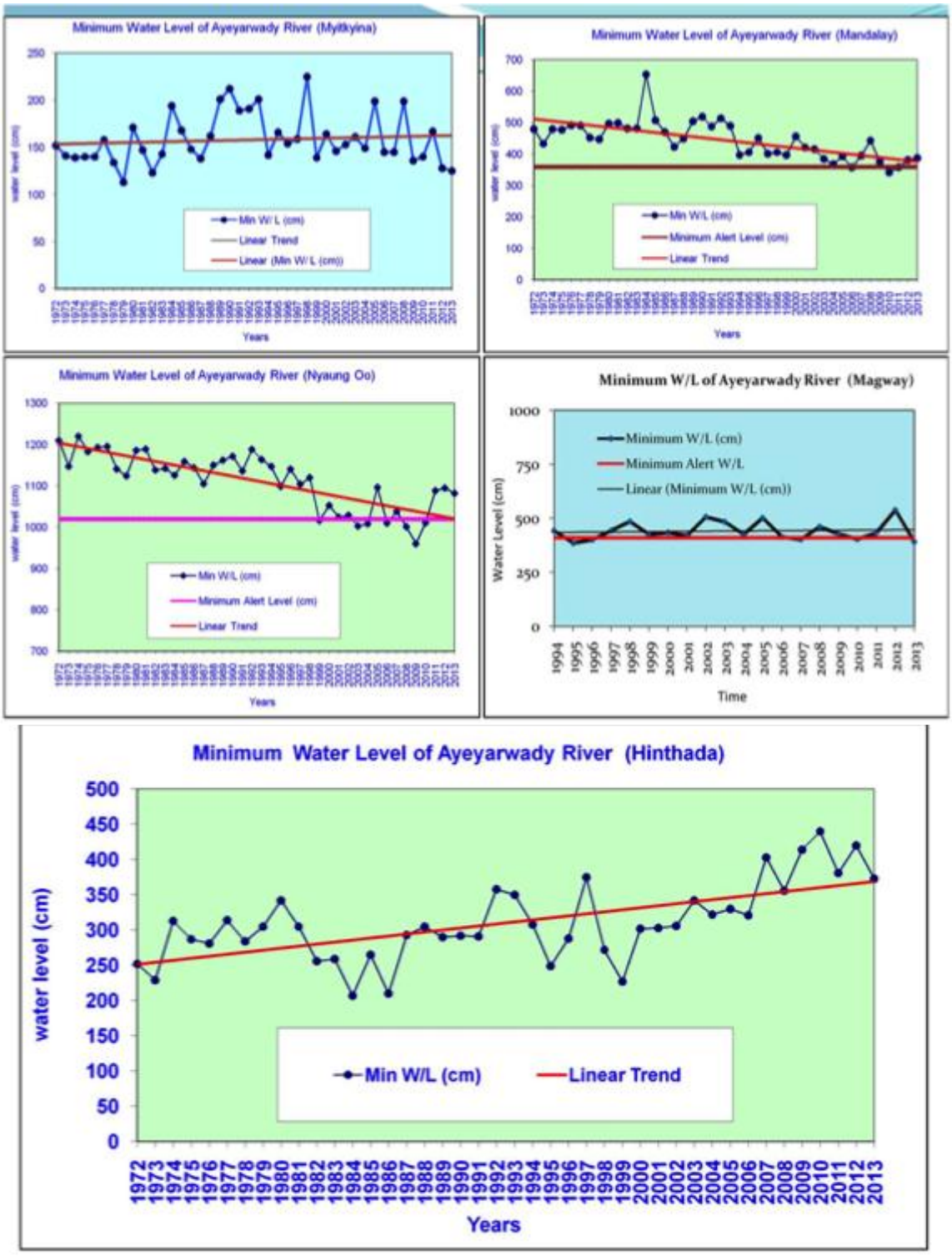


Figure 12. Observed minimum water level, within a 40-year period, in Myitkyina, Mandalay, Nyaung Oo, Magway, and Hinthada stations along the Ayeyarwady River

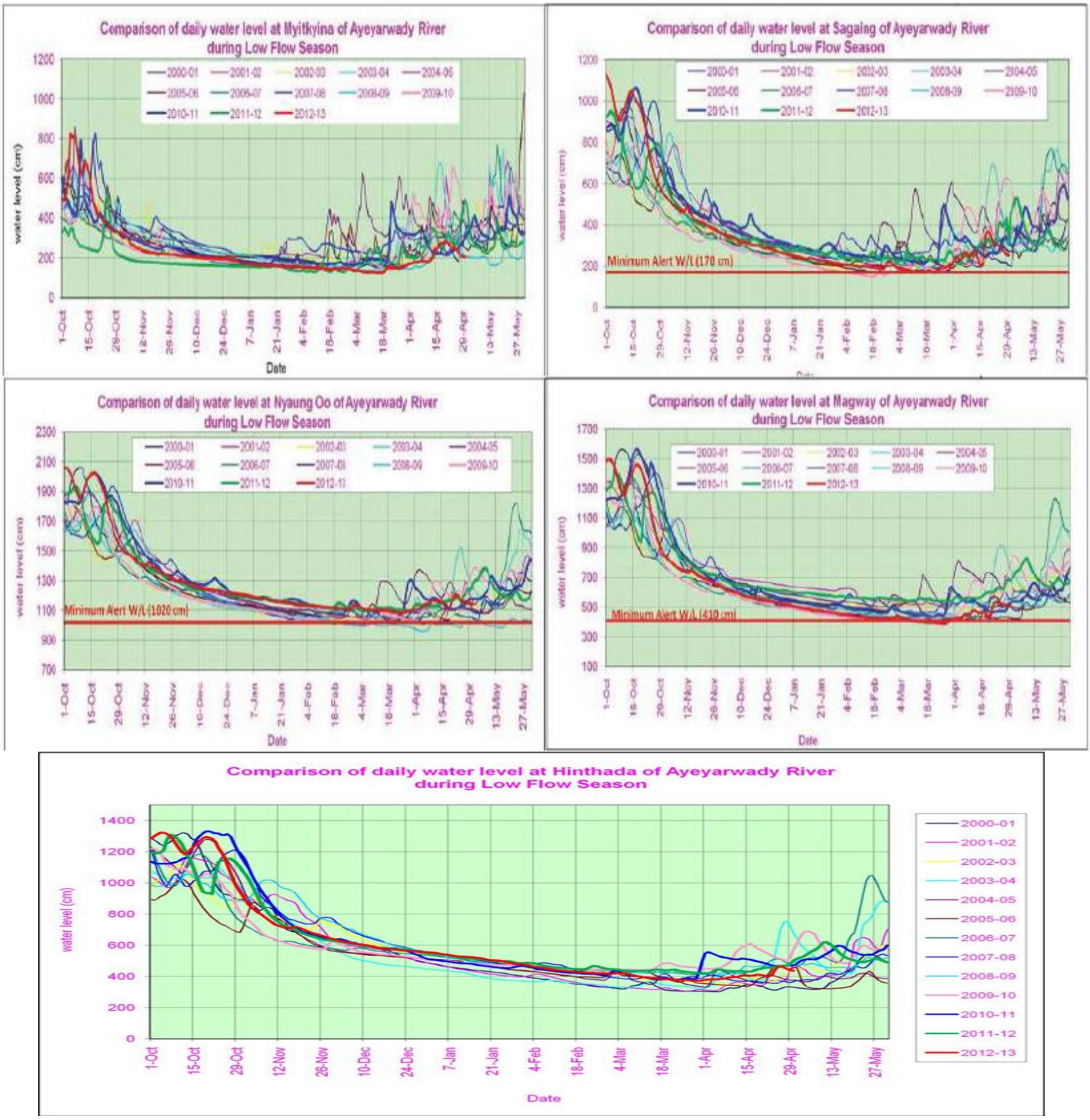


Figure 13. Observed low flow water level in Myitkyina, Sagaing, Nyaung Oo, Magway, and Hinthada stations along Ayeyarwady River, from 2000 to 2013

Mr. Oo explained that the low flow water level forecast was generated based on seasonal climate analysis anchored on analog method by DMH's seasonal climate forecasting section. It was developed using the low flow probabilistic forecast and frequency analysis, taking into consideration long-term local data. He then proceeded to explain the statistical method used by DMH in validating forecasts and proceeded to elaborate on monthly forecast and observed values, from November 2012 to February 2013, for the different water level stations. Figures 14 to 17 indicate these.

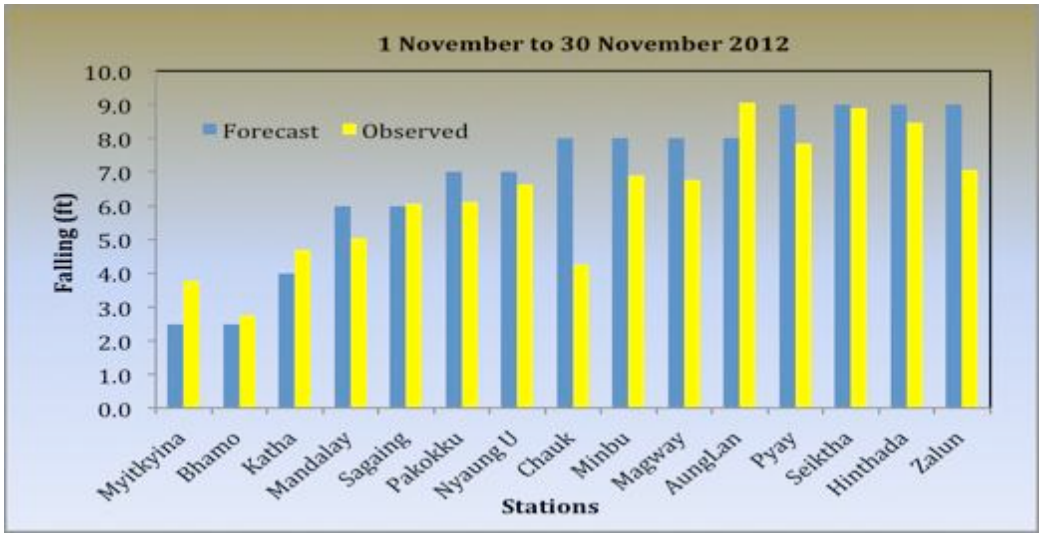


Figure 14. Comparison between forecast and observed water levels in different stations in Myanmar for November 2012

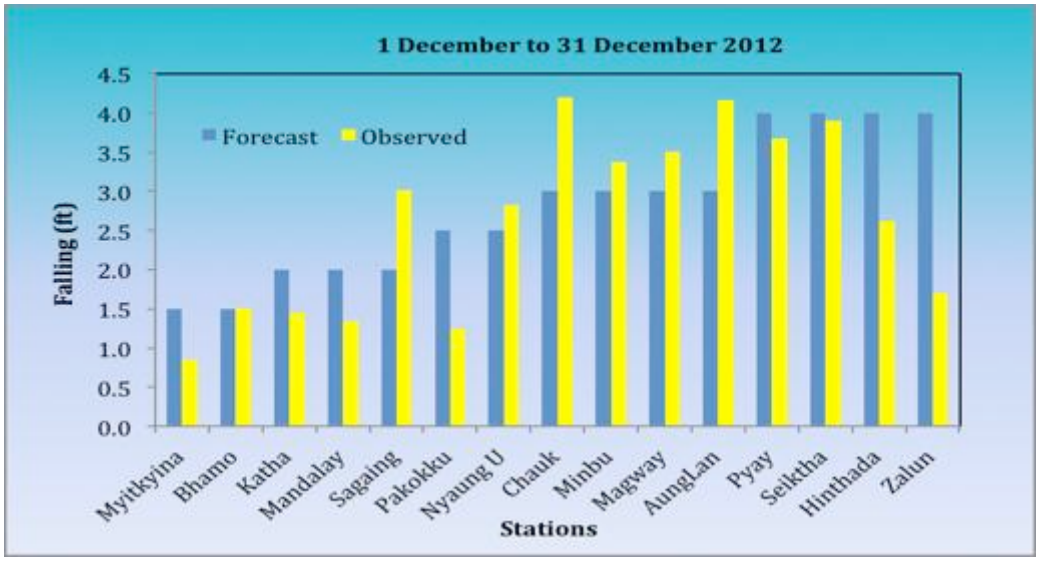


Figure 15. Forecast and observed water level comparison, for December 2012, in different stations in Myanmar

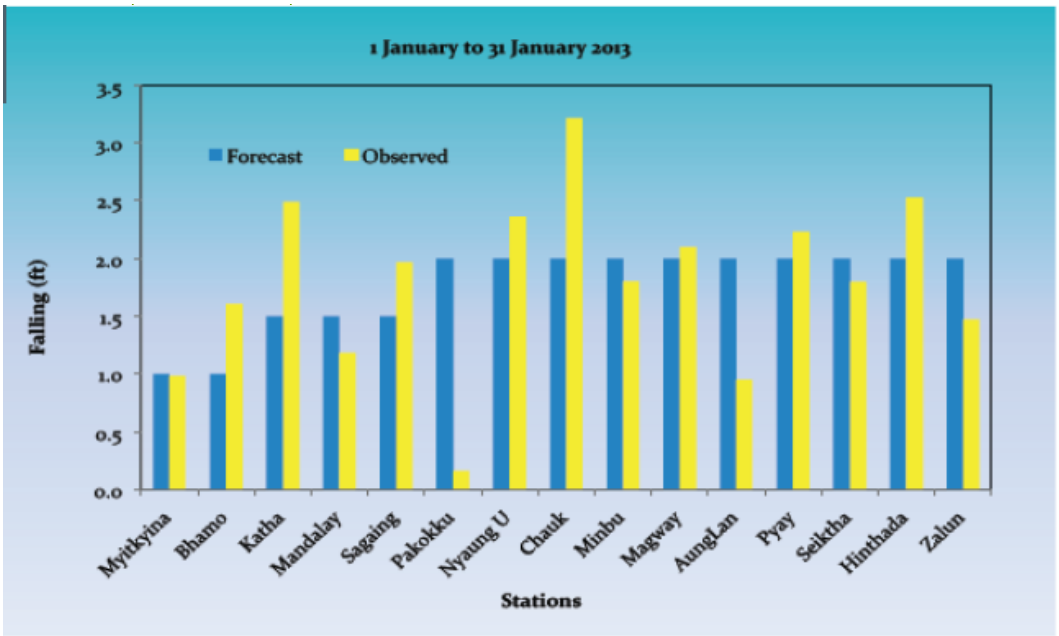


Figure 16. Comparison between forecast and observed water level in different stations in the country, for January 2013

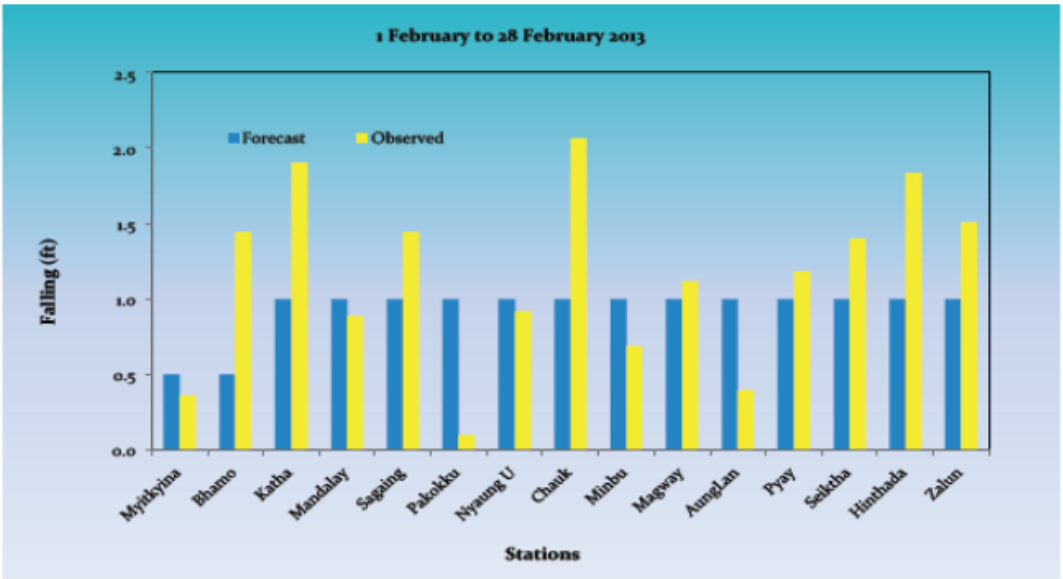


Figure 17. Forecast and observed station-wise water level values for February 2013

Further, Figure 18 provides comparison between seasonal forecast and observed water level values in different stations along Chindwin River, while Figure 19 shows comparison between seasonal forecast and observed water level values in different stations along Ayeyarwady River.

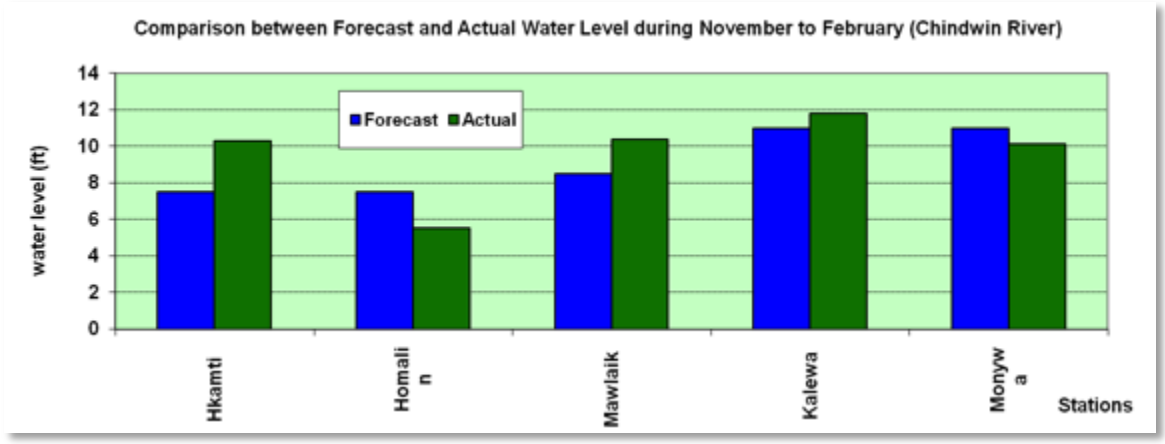


Figure 18. Comparison between forecast and observed water levels, from November 2012 to February 2013, at different stations along Chindwin River

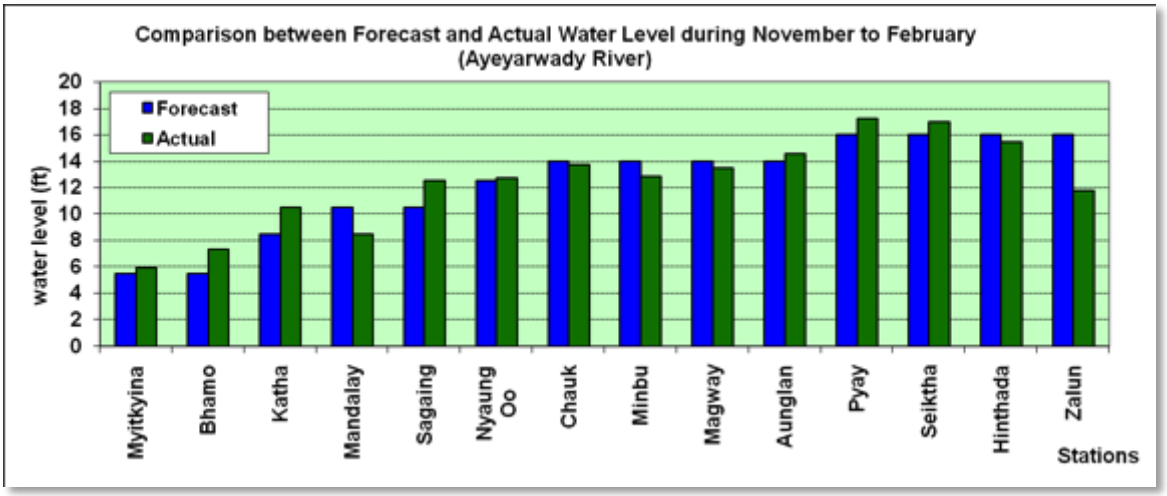


Figure 19. Comparison between forecast and observed water levels, from November 2012 to February 2013, at different stations along Ayeyarwady River

According to Mr. Oo, minimum water level alerts were issued in March 2013 for the following:

- Sagaing Station
- Magway Station
- Monywa Station

Summary of observations, for the season, was then enumerated:

- During the 2012-2013 low flow season, minimum water level in Monywa, along Chindwin River, was the second lowest recorded in the last 48 years; in Sagaing, the 3rd lowest

recorded in the same number of years; and 5th lowest recorded in Myitkyina and Katha Stations of Ayeyarwady River during the last 48 years

- In Ayeyarwady River, the lowest water levels observed in 2013 were 0.5 to 1.5 feet less than the 2012 lowest water levels, except in the upper reaches of Ayeyarwady River
- In Chindwin River, the lowest water levels observed in 2013 were about the same as the 2012 lowest water level, except in the uppermost part of the river where water level values were approximately 3 feet more
- The maximum water level condition in April 2013 was about 0.5 to 2 feet less than the maximum water level of April 2012 along Ayeyarwady and Chindwin Rivers

3.3 Review of the Agro-Climatic Condition for the Winter Season

Ms. Khin Thinn Yu of the Agro-Met Division, DMH, commenced the session by providing background information on the Division. She then explained the distribution of agro-met stations in the country, shown in Figure 20. According to Ms. Yu, a total of 17 agro-meteorological stations were established in strategic areas in the country, from 1973 to 1996.

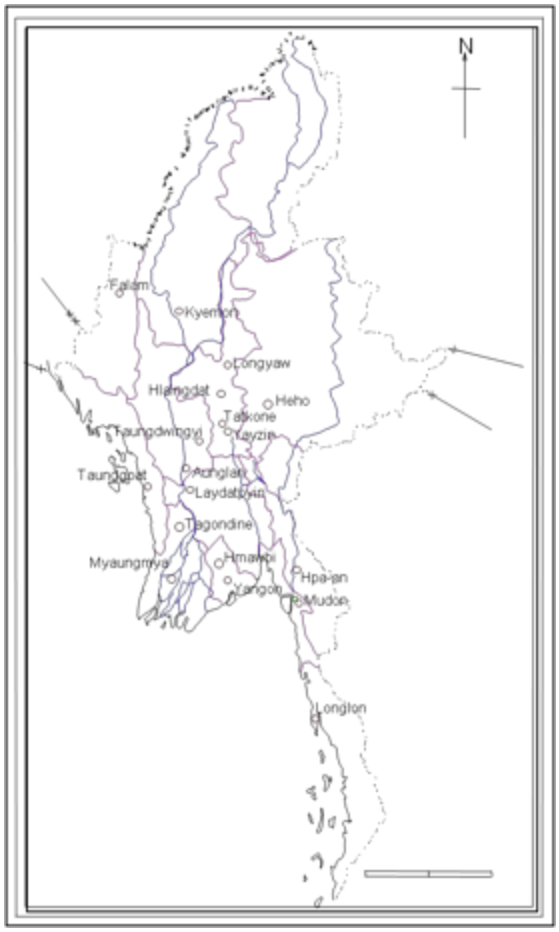


Figure 20. Distribution of agro-meteorological stations in Myanmar

She continued to explain that observations are obtained five (5) times daily in agro-met stations, involving parameters like air temperature, wind speed and direction, rainfall, evaporation, sunshine hours, radiation, soil temperature, and cloudiness. Agro-met publication and issuances were then discussed. These include the following:

- Decadal Agro-meteorological Bulletin - distributed thrice a month, this includes a) weather summary of the previous dekad[1]; b) review of agro-meteorological elements – like rainfall, temperature, humidity, evapo-transpiration, and water balance; and c) weather forecast for the next dekad. Total accumulated rainfall and departure from normal are also indicated.
- Agro-Meteorological Handbook – content is inclusive of observation procedures, observed agro-meteorological data analysis procedures, and agro-meteorological indices calculation methods
- Weekly and 15-day Agro-meteorological Forecast – issued by request, usually from agricultural journals

[1] Dekad, in agro-meteorological forecasting, is the successive 10-day period taken as a time unit.

- Crop Weather Calendar – prepared for crops like rice, cotton, jute, sugarcane, etc., to guide planners and decision-makers in the agriculture sector
- Web-based agro-meteorological information at www.moezala.com

The review of the agro-climatic condition for the 2012-2013 winter season followed. Figure 21 indicates the observed monthly rainfall condition for the winter season.

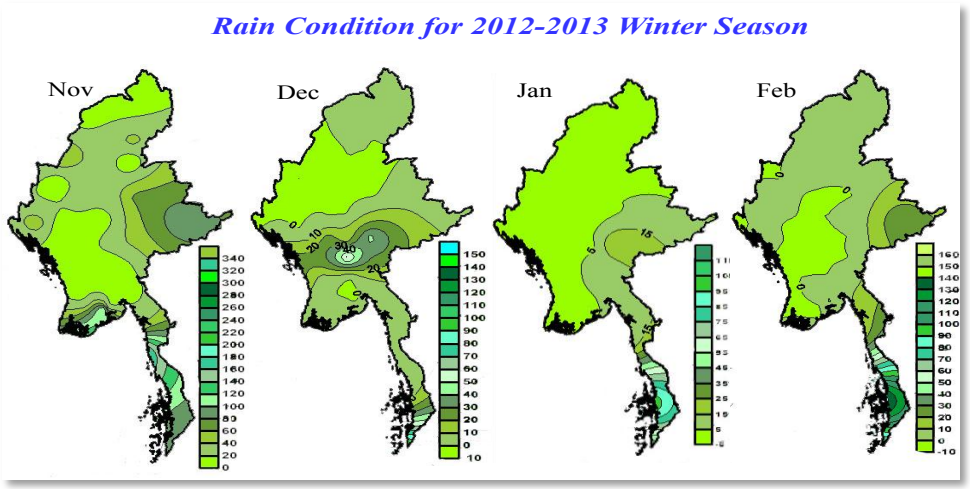


Figure 21. Observed rainfall in different agro-climatic zones in Myanmar during the 2012-2013 winter season

Following that, observed monthly minimum and maximum temperatures for the season were discussed, as illustrated in Figures 22 and 23; and monthly observed soil water balance in Figure 24.

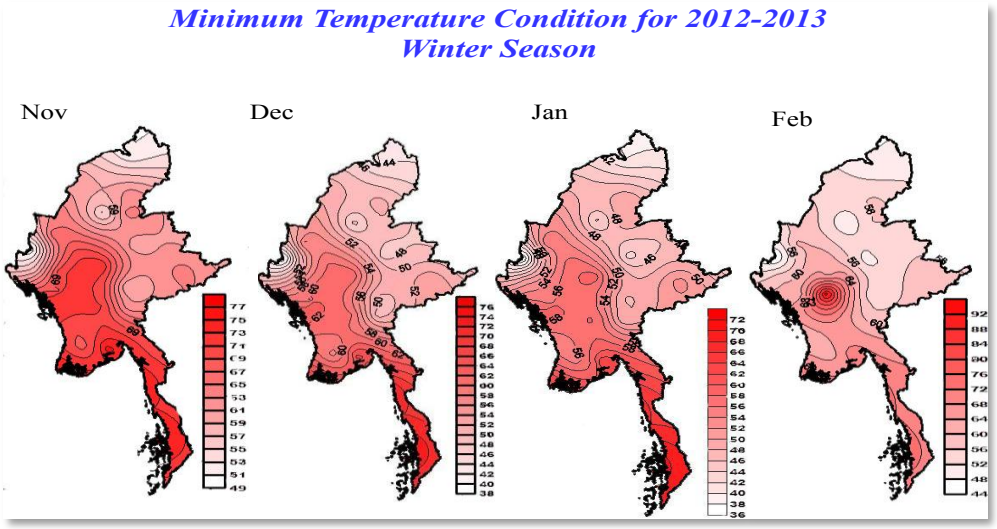


Figure 22. Observed monthly minimum temperature in different areas in the country, from November 2012 to February 2013

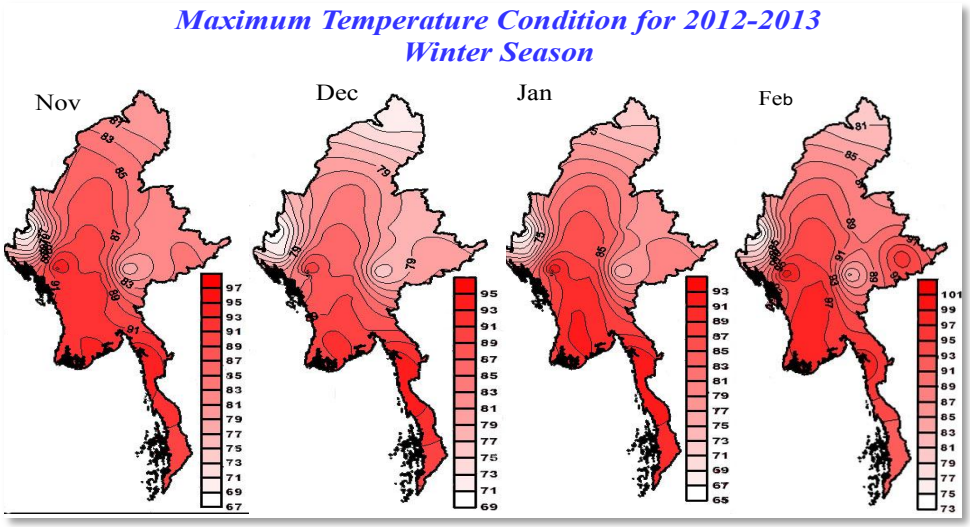


Figure 23. Observed monthly maximum temperature in Myanmar, from November 2012 to February 2013

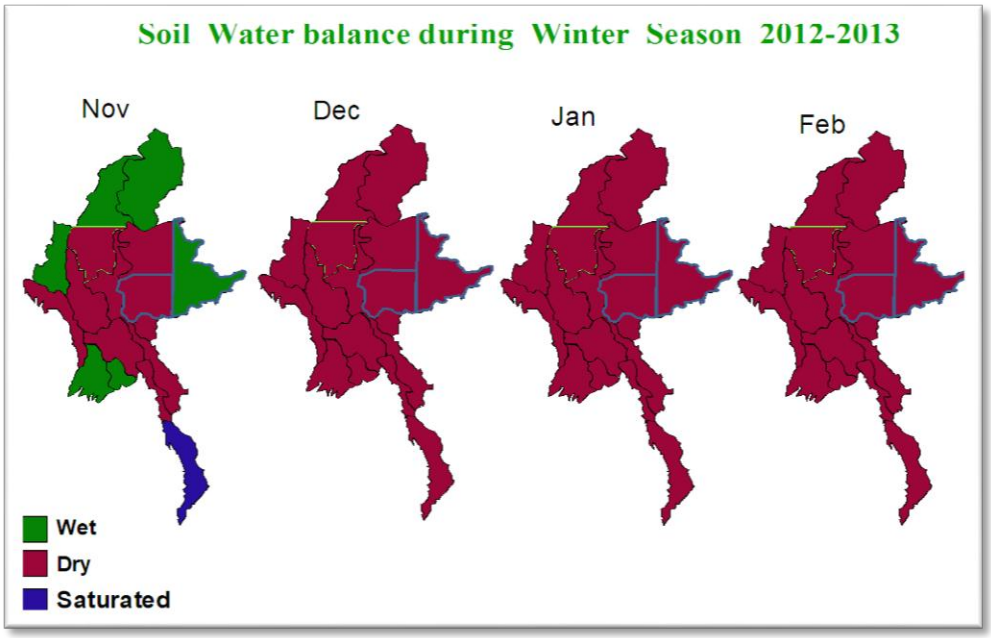


Figure 24. Observed monthly soil water balance during the 2012-2013 winter season. Water balance for December 2012 to February 2013, in all parts of the country, was notably dry

Comparisons between forecast and observed values for different agro-meteorological parameters were discussed during the session. These comparisons are illustrated in Figures 25 to 28.

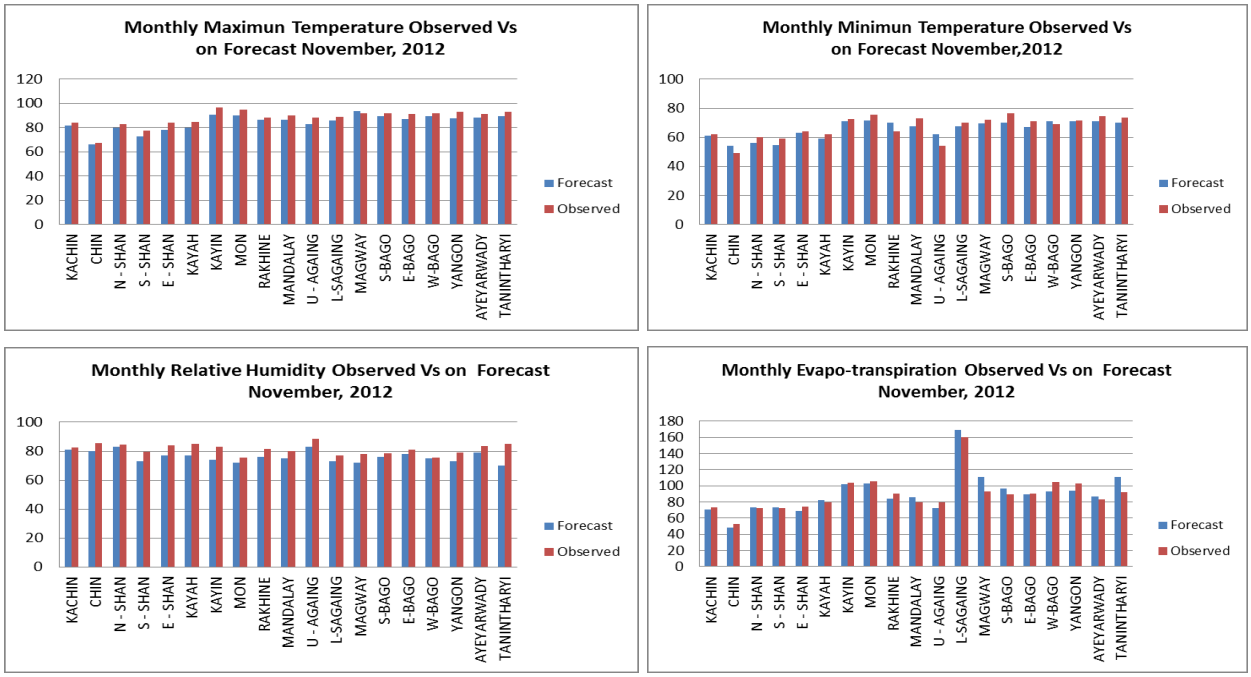


Figure 25. Comparison between forecast and observed values for different agro-meteorological parameters in November 2012

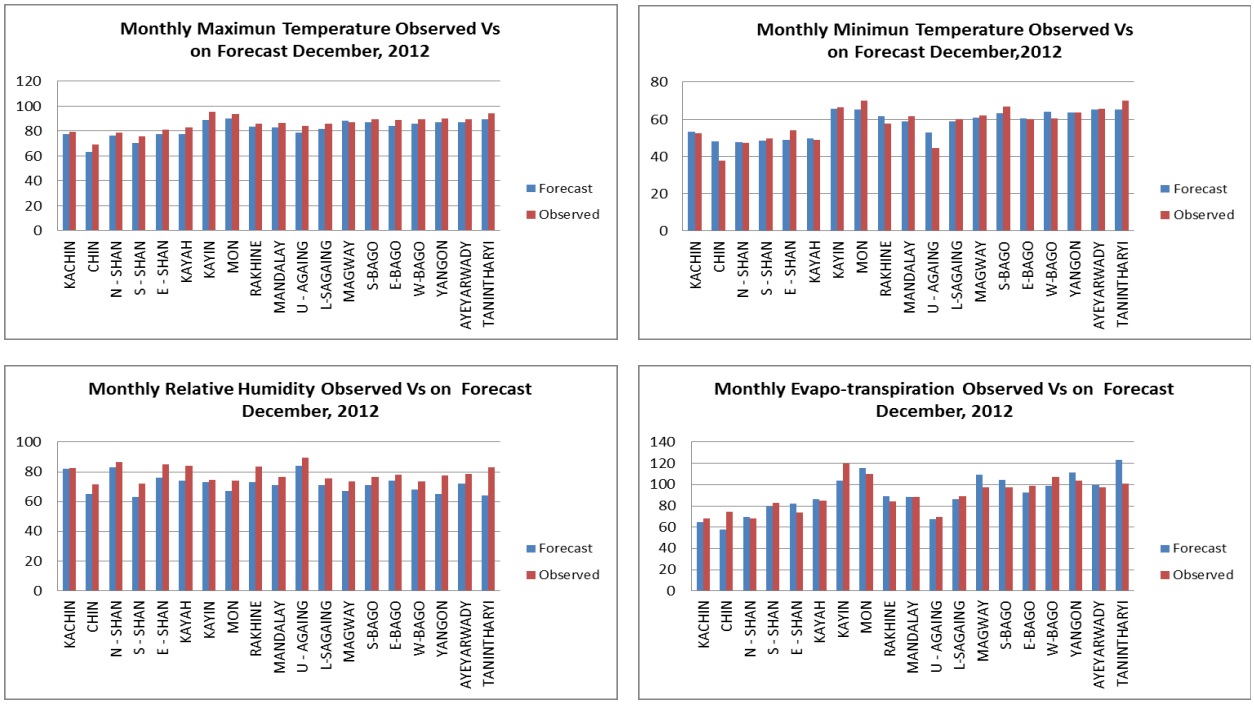


Figure 26. Monthly forecast against observed values vis-à-vis the different agro-meteorological parameters in December 2012

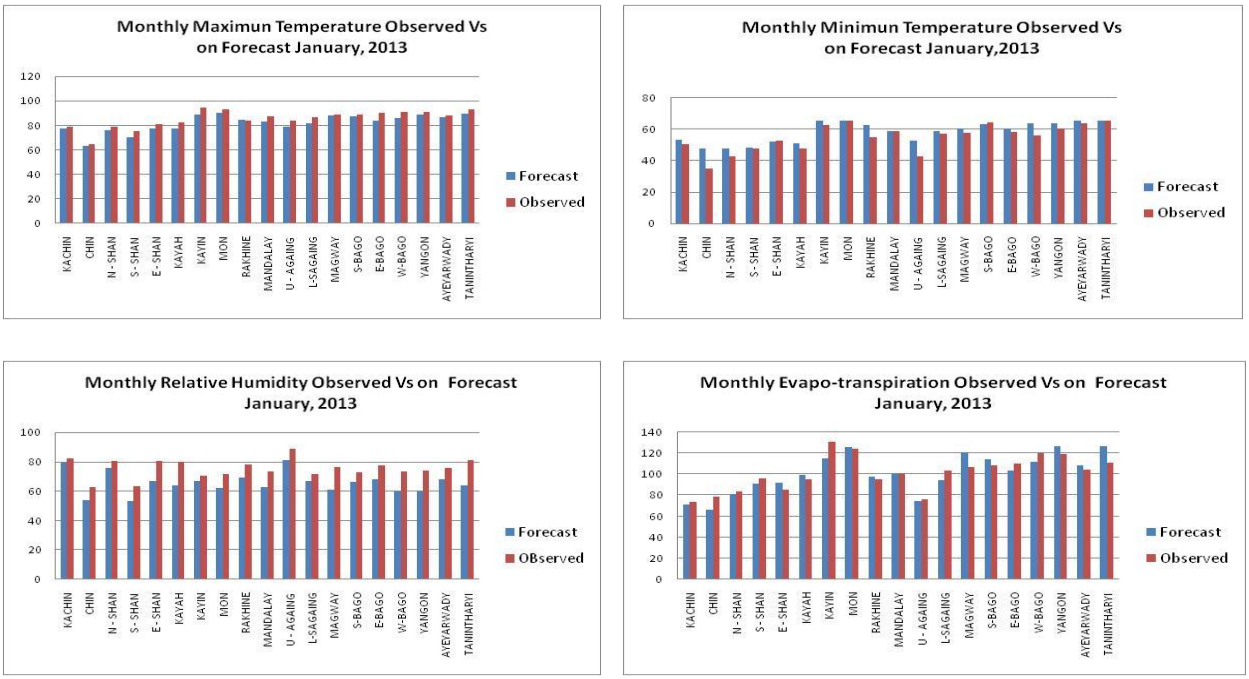


Figure 27. Comparison between forecast and observed values for various agro-meteorological parameters for January 2013

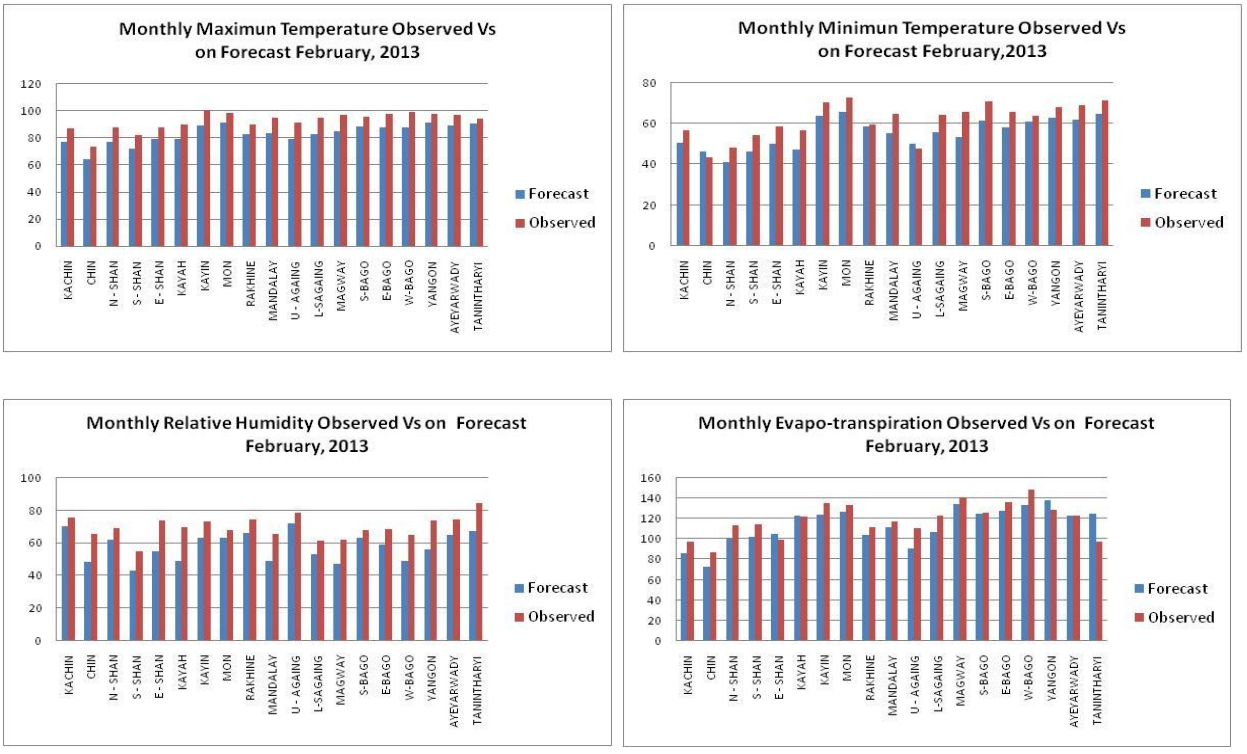


Figure 28. Comparison between forecast and observed values for different agro-meteorological parameters for February 2013

The following summary was then provided for the agro-climatic condition in the country for the winter season:

- Below normal rainfall was observed in the country during the winter season, except during the 2nd and 3rd dekads of November; 1st dekad of December; 3rd dekad of January; and 1st and 2nd dekads of February. During these periods, above normal rainfall was recorded, especially in the eastern part of the country due to remnants of disturbance/typhoon over South China Sea
- Maximum temperature during the winter season was generally high (nearly 100°F) in most parts of the country except in Chin, Kachin, and Shan States
- Maximum temperature pattern in the winter season in different parts of the country were similar (central and lower Myanmar recorded minimum temperature of above 60°F)
- Sharp increase in PET value (about 160mm) was observed at Lower Sagaing in November. Apart from this, monthly PET values are between 100mm and 120mm in other areas. In February, monthly PET value were observed to be 140mm in Magway, Bago, Mon and Kayin
- Observed soil water balance were:
    - November – wet conditions in Kachin, Chin, and Eastern Shan States; and in Upper Sagaing, Ayeyarwady and Yangon Divisions
    - Dry in the remaining areas of the country during the whole winter season

DMH also indicated its planned activities, including:

- Agro-climatic Atlas (2000-2010) to be released as guide for decision-makers in the agriculture sector. Land utilization, weather data, topographical condition and soil characteristics will be combined for mapping of agro-climatic zones
- Decadal Agro-Meteorological Bulletin contains only the agriculture-related meteorological information. It does not contain conditions and development stages of crops. In the near future, crop condition, based on satellite observation, is to be integrated into the Agro-meteorological Bulletin. DMH, with support from the Government of Japan, will soon be installing a small-sized earth observation satellite system
- Modification of Crop Weather Calendars to adapt to the changing climate. To facilitate this, phenological and agronomic data from the Ministry of Agriculture are required
- Agro-meteorological training/workshop to be conducted in DMH

3.4 Discussion/Feedback from User Institutions on Relevance/Usability of Forecast for the Winter Season and Recommendations for Enhancement of Forecast Products

3.4.1 Agriculture Sector

This session was presented by Mr. Tin Aung Shein of the Department of Agriculture. He commenced the presentation by discussing the soil types in different areas in Myanmar, indicated in Figure 29.

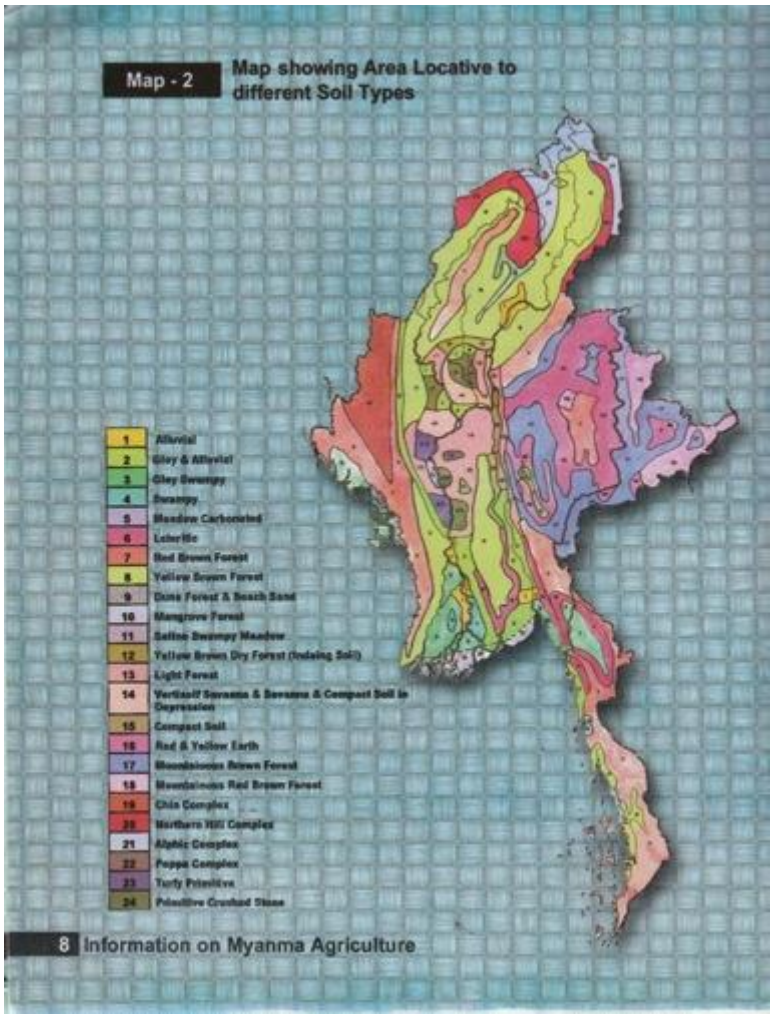


Figure 29. Soil types in different areas in Myanmar

Mr. Shein explained that per observation, the recent trend for rainy season is only 3 months. He continued that the reduction in the number of rainy days is basically due to the late onset and early withdrawal of rainfall. According to him, rice varieties in Myanmar are intended for 100 days of rain, hence, the trend of only 90 days of rainfall pose problems to farmers.

He also indicated that aside from the number of rainy days, negative departure from normal rainfall was also observed in many stations. Mr. Shein explained that because of rainfall deficit during the 2012-2013 winter season, only 68% of the arable land area was cultivated for rice.

Cropping patterns observed in Myanmar, are provided in Table 2.

Table 2. Cropping Patterns in Myanmar

First Crop	Second Crop	Third Crop
Monsoon Rice	Pulses	
Jute	Rice	Pulses
Monsoon Rice	Summer Rice	
Monsoon Rice	Pulses	Summer Rice
Monsoon Rice	Pulses	Vegetables
Monsoon Rice	Vegetables	
Monsoon Rice	Oil Seeds	
Oil Seeds	Monsoon Rice	
Oil Seeds	Oil Seeds/Pulses	

According to Mr. Shein, climate has changed, therefore, farmers have to cope. One way of coping, he suggested, would be shifting to alternative crops instead of focusing solely on rice.

He also observed that in the dry zone, there is an intensely decreased rainfall pattern.

3.4.2 Irrigation Sector

Ms. Khon Ra of the Department of Irrigation stated that in the irrigation sector, DMH forecast is very important as the sector is dependent on climate.

According to Ms. Ra, DMH precipitation outlook of below normal rainfall in the Dry Zone, for the 2012-2013 winter season, was very useful in planning for measures to mitigate adverse impacts during the season. She continued that lesser inflow was observed in most reservoirs, especially those in Mandalay, Magway, and Sagaing Regions. Rainwater was not sufficient to sustain summer paddy in most areas, hence water shortage was a problem.

She cited a very critical water-income relationship in the agriculture sector. According to her, when irrigation water supply is decreased, production is decreased and hence, income is decreased.

She explained that in Mandalay Division, more than 200 small tanks and weirs were made available, which helped farmers in storing water. These were facilitated in anticipation of the rainfall deficit for irrigation and household use, based on DMH rainfall outlook.

Ms. Ra expressed her thanks to DMH for the comprehensive climate and hydrological outlook. She also indicated that further collaboration with DMH, on forecast application, would be for the benefit of the irrigation sector.

3.4.3 Relief and Resettlement Department

Relief and Resettlement Department, represented by Ms. Khaing Mon Mon Ei, indicated that in 2012, the following hazards were recorded:

Table 3. Hazards/disasters recorded in 2012

Hazard/Disaster	Frequency	Damaged Households	Damage & Loss(Million Kyats)	Provision (Million Kyats)
Fire	71	277	72.56	6.81
Flood	44	14580	-	163.62
Strong Wind	94	1367	113.33	25.77
Others(Apr 2012-Mar 2013)	96	11870	54.53	406.33

Ms. Ei then elaborated the initiatives implemented by the department during the previous season. These include:

- Collaboration/cooperation with various institutions on preparedness and response activities vis-à-vis hazards like fire, storm, and earthquake, among others
- Preparations for seasonal hazards through dissemination of DMH forecast to stakeholders up to quarters or village tracks, including issuance for evacuation if necessary
- Coordination with authorities as to the methodologies that should be done in case of hazards/disasters
- Conducted assessment of affected population, damaged housing units, and affected households
- Conducted emergency, and search and rescue activities
- Facilitated public and professional sectors to participate in disaster risk reduction activities
- Coordinated with local government authorities and other relevant institutions in conducting awareness activities
- Coordinated with stakeholders in hazard-/disaster-prone areas in undertaking preparedness activities
- Coordinated with concerned institutions for storing of seeds as part of preparedness measures
- Preparation of shelters for evacuation
- Organized women participation in village activities
- Facilitated enhancement of communication system, particularly in delivering radios and telephones to hazard-prone states and regions

3.4.4 Local Government Unit of Kungyangon

Mr. Kyaw Zeyar Linn, Township Administrator, highlighted that Kungyangon is highly prone to both climate and geological hazards. These hazards, according to him, include temperature variations, drought, thunderstorm, cyclone, storm surge, extreme rain, strong wind, earthquakes and tsunami. He then presented the seasonal hazard calendar in Kungyangon, shown in Figure 30. He emphasized that per the hazard calendar, earthquake and tsunami were indicated as persisting throughout the year, as both hazards could occur at any time.

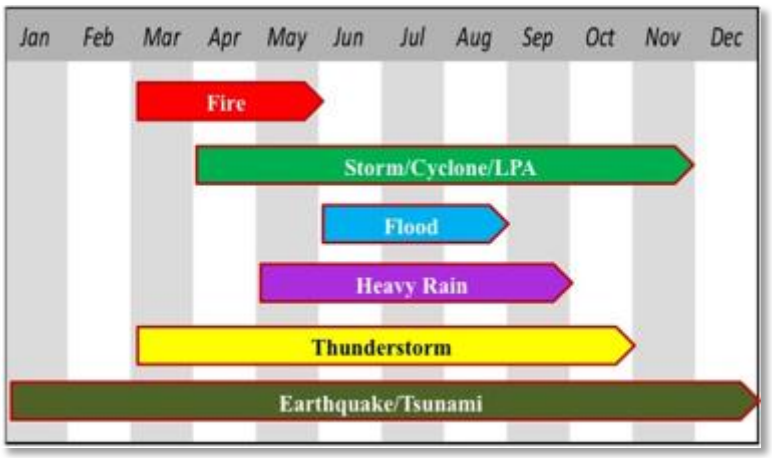


Figure 30. Seasonal hazard calendar in Kungyangon Township

Mr. Linn discussed climate-related hazards, which occurred in the township in 2012 and other years, as well as the initiatives of the township administration in connection with the said hazards. The hazards, and their damages, are presented in Table 4.

Table 4. Climate-related Hazards in Kungyangon Township

Place	Hazard	Date	Destructive		
			House	People	Animal
Kungyangon	Nargis Cyclone	2-5-2008	24243	1446	77983
Tawkalate Village	Thunderstorm	21-6-2011	7		
Saleintan Village	Flood	1-8-2011	30		
Tawkasot Village	Thunderstorm	5-5-2012		1	
Southen Ward	Thunderstorm	7-6-2012	6		
Dalaylu Village	Thunderstorm	7-6-2012	2		
Tawpya Village	Thunderstorm	7-6-2012	5		
Kanyarshae Village	Thunderstorm	20-7-2012	12		
8 Villages	Flood	August 2012	1483 acres (paddy field)		

Mr. Linn then compared observed rainfall, in Kungyangon, for 2011 and 2012. Variations in monthly rainfall values were notable, between the mentioned years, as illustrated in Figure 30.

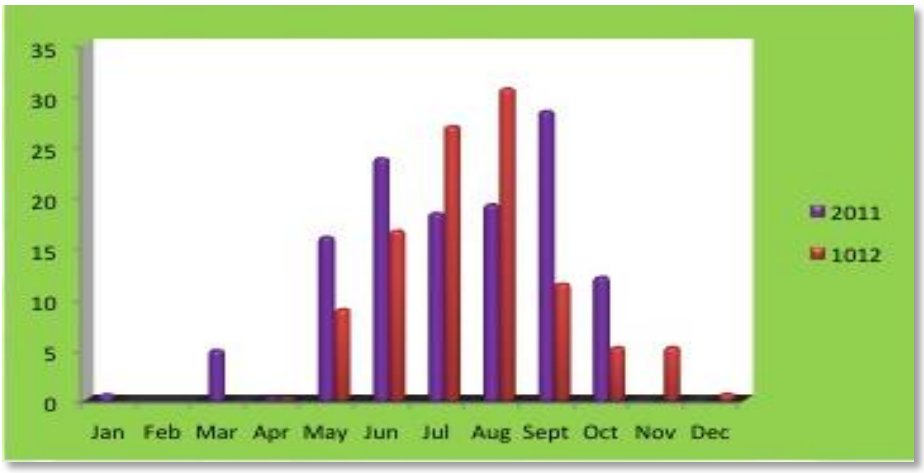


Figure 31. Observed monthly rainfall values in Kungyangon Township in 2011 and 2012

He elaborated on the agricultural production in Kungyangon, from 2006 to 2013. Within the period, the lowest production was recorded during the 2012 monsoon season, shown in Table 5.

Table 5. Paddy Production in Kungyangon, 2006-2013

Year	Monsoon			Summer		
	Plantation (acre)	Rate (basket)	Production (basket)	Plantation (acre)	Rate (basket)	Production (basket)
2006-07	102336	66.03	6757246	20043	81.36	1630698
2007-08	102415	66.79	6840709	19565	83.21	1628058
2008-09	102193	66.90	6836712	19873	88.65	1761798
2009-10	102191	67.10	6857128	20015	84.51	1691468
2010-11	102201	67.41	6889496	20169	83.34	1680884
2011-12	102200	66.21	6766433	20219	82.69	1672010
2012-13	102164	65.67	6708635			

Mr. Linn highlighted that in 2012, rainfall deficit was observed in Kungyangon during the pre-monsoon period. By mid-monsoon, he continued, there was so much rainfall. Subsequently, rainfall deficit was again observed during the post-monsoon period. The decrease in rice production in 2012 was because of the following:

- damages sustained by crops during the pre-monsoon season
- farmers planted again to recover from the damages but the intense rainfall, during the mid-monsoon, resulted to losses yet again
- rainfall was very minimal during the post-monsoon period to sustain paddy

3.4.5 Local Government of Pyinsalu

According to the Sub-Township Administrator of Pyinsalu, the normal number of rainy days for the sub-township is 124, and normal annual rainfall is 141.45 inches. In 2012 however, the number of rainy days recorded was only 93 and observed rainfall totaled to only 87.49 inches. He recalled that in contrast to 2012, 2011 recorded a total of 125 rainy days and 156 inches of rainfall.

He emphasized that in mitigating impacts of climate-related hazards in Pyinsalu, the local government is enhancing mechanisms for preparedness.

Section 4

Seasonal Climate Outlook for 2013

Southwest Monsoon Season

4.1 DMH-RIMES Engagement for Enhancement of DMH Forecast Products

Presented by Mr. Kyaw Lwin Oo, the session focused on initiatives pursued by DMH and RIMES in enhancing DMH capacity in generating forecast products of different timescales. Mr. Oo explained that DMH is engaged with various institutions, including RIMES, in the effort to enhance its forecasting capacity. He subsequently explained RIMES lengthy engagement with DMH and highlighted the simulation of monsoon onset, up to 2039 (Figure 32), as one of the outputs of Mr. Sein Maw Oo of DMH, who was trained at RIMES on secondment basis.

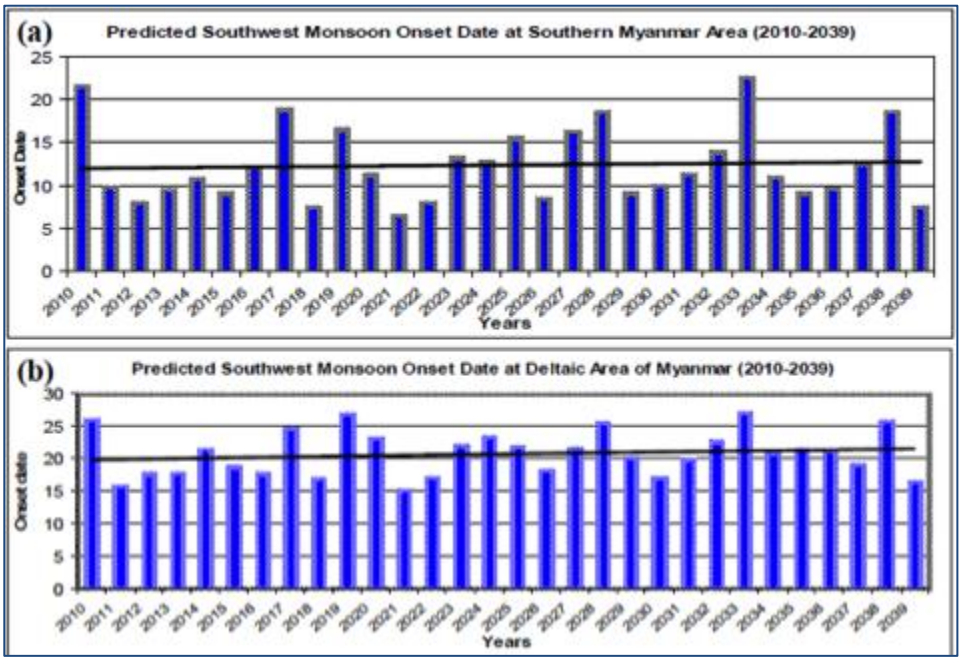


Figure 32. Simulation of Southwest monsoon onset, from 2010 to 2039, generated by DMH after training of scientists, on secondment basis, at RIMES

He then presented station-wise monthly rainfall outlook for 2013, generated at RIMES, based ECMWF Ensemble Forecast, in Table 6.

Table 6. Station-wise rainfall outlook based on ECMWF Ensemble Forecast

2013$	April$	May$	June$	July$	August$	Sept$	Oct$	Total$
Homalin$	31.8$	208.6$	371.3$	311.3$	299.3$	275.2$	102.2$	1600$
Hakha$	12.4$	129.9$	346.1$	314.5$	265.1$	272.8$	157.6$	1498$
Bago$	26.41$	147$	393$	337$	247$	200$	139$	1463$
Hpaan$	51.6$	217.1$	439.8$	420.6$	347.9$	277.8$	148.8$	1903.7$
Dawei$	87.8$	243.7$	432.7$	412.8$	394.8$	333.0$	173.2$	2078$

Mr. Oo subsequently indicated that DMH needs to enhance on the following aspects:

- continuous strengthening of partnerships with regional and international institutions
- service quality, research activities and other capacities
- user-oriented weather and climate forecast

4.2 Presentation of Seasonal Climate Outlook for the Southwest Monsoon Season

DMH commenced the presentation by enumerating forecast products of different timescales that it is generating, and dates of regular issuances thereof. These forecast products include:

- 10 days weather forecast – issued every 8th, 18th and 28th of each month
- monthly weather forecast – issued every 28th of each month
- general weather outlook for the monsoon season – issued on 28th April with updates for the peak and late monsoon period provided on 28th June and 28th August, respectively

Discussion of the different climate seasons in Myanmar followed:

- Northeast Monsoon (cold and dry season) – December to February
- Pre-Monsoon Period (hot and dry season) – March until prior to monsoon onset)
- Southwest Monsoon Season – May to September
    - Early Monsoon Period – May to June
    - Mid Monsoon Period – July to August
    - Late Monsoon Period – September until monsoon withdrawal
- Post-Monsoon Season – October and November

DMH proceeded to present the normal monsoon onset dates for different parts of the country. According to DMH, the 2013 general weather outlook for the Southwest monsoon season is based on analog method (selected analog years were 2001, 2007, and 2009), reference to international and regional climate centers, and WRF and Diana Modeling outputs. The normal onset date and onset behavior during analog years are presented in Figure 33; observed monsoon onset, from 1981 to 2012, and comparison of withdrawal dates, during analog years, in Figure 34.

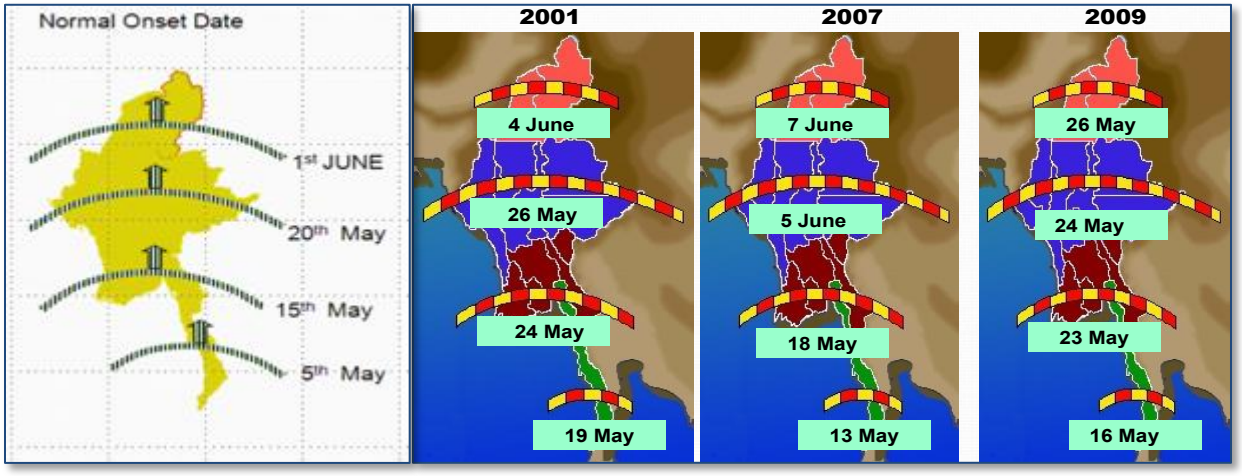


Figure 33. Left: Normal monsoon onset dates in different parts of the country; Right: Observed monsoon onset dates for chosen analog years

YEAR	OBSERVED ONSET DATE OF SOUTHWEST MONSOON			
	SOUTH	DELTAIC	CENTRAL	NORTHERN
1981	19-May	25-May	01-Jun	04-Jun
1982	24-May	27-May	02-Jun	08-Jun
1983	24-May	27-May	31-May	01-Jun
1984	20-May	21-May	26-May	29-May
1985	16-May	16-May	24-May	01-Jun
1986	11-May	17-May	03-Jun	08-Jun
1987	30-May	01-Jun	04-Jun	08-Jun
1988	15-May	15-May	22-Jun	31-May
1989	15-May	23-May	11-Jun	12-Jun
1990	15-May	20-May	20-May	04-Jun
1991	25-May	31-May	02-Jun	06-Jun
1992	16-May	17-May	15-Jun	16-Jun
1993	19-May	26-May	01-Jun	13-Jun
1994	12-May	29-May	05-Jun	09-Jun
1995	14-May	16-May	05-Jun	06-Jun
1996	23-May	24-May	27-May	02-Jun
1997	22-May	05-Jun	09-Jun	09-Jun
1998	20-May	31-May	10-Jun	14-Jun
1999	09-May	16-May	20-May	26-May
2000	13-May	15-May	20-May	24-May
2001	19-May	24-May	26-May	04-Jun
2002	26-May	29-May	05-Jun	11-Jun
2003	16-May	20-May	04-Jun	10-Jun
2004	12-May	15-May	19-May	15-Jun
2005	22-May	30-May	11-Jun	15-Jun
2006	16-May	20-May	24-May	27-May
2007	13-May	18-May	05-Jun	07-Jun
2008	11-May	14-May	28-May	31-May
2009	16-May	23-May	24-May	26-May
2010	18-May	21-May	24-May	06-Jun
2011	21-May	26-May	29-May	05-Jun
2012	18-May	28-May	30-May	03-Jun
Mean (1981-2012)	**17-May**	**22-May**	**31-May**	**05-Jun**

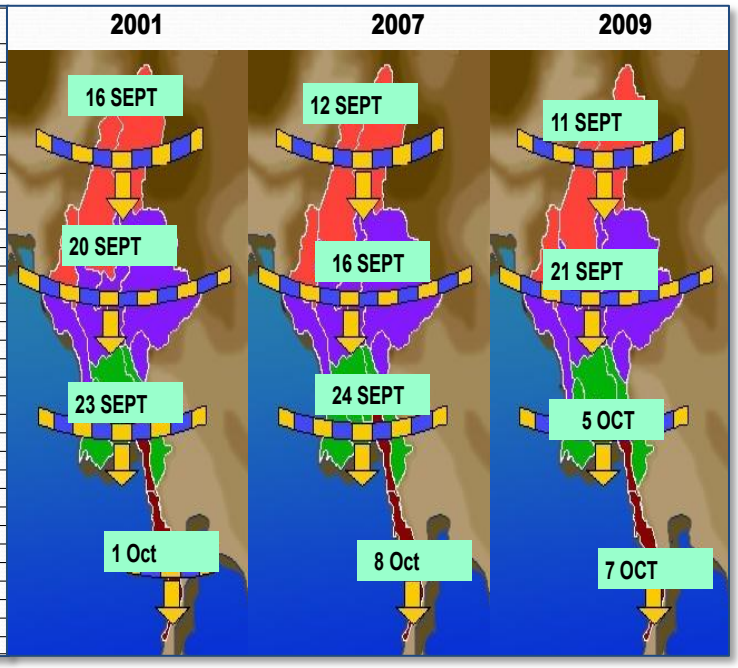


Figure 34. Left: Observed Southwest monsoon onset dates, from 1981 to 2012; Right: Observed monsoon withdrawal dates during chosen analog years

Monsoon intensity and observed occurrences of LPAs, depressions, and storms during analog years were then presented.

This was followed by discussion on probabilistic ENSO forecast for the region by the International Research Institute (IRI), indicating high probability for ENSO-neutral condition throughout the monsoon season. According to DMH, the National Oceanic and Atmospheric Administration – National Centers for Environmental Prediction (NOAA-NCEP) model likewise shows low sea surface temperature (SST) anomalies over the Andaman Sea and Bay of Bengal from May to August 2013, conforming with IRI forecast of ENSO-neutral condition over the region.

Subsequently, model outputs for precipitation in different areas in the country by different climate centers were discussed.

Based on DMH analysis of the different model outputs, analog years, and modeling methods available with the institution, DMH discussed its forecast for 2013 Monsoon Season, shown in Tables 7 and 8, and Figures 35 to 37.

Table 7. 2013 Southwest Monsoon Intensity	
Period	**Intensity**
Early Monsoon	Moderate to strong
Mid Monsoon	Moderate to strong
Late Monsoon	Moderate

Table 8. Outlook for LPAs, Depressions and Storms during the 2013 Southwest Monsoon Season	
Early Monsoon	2 LPAs
	2 may develop into Depression
Mid-Monsoon	2 LPAs
Late Monsoon	2 LPAS
	1 may develop into Depression

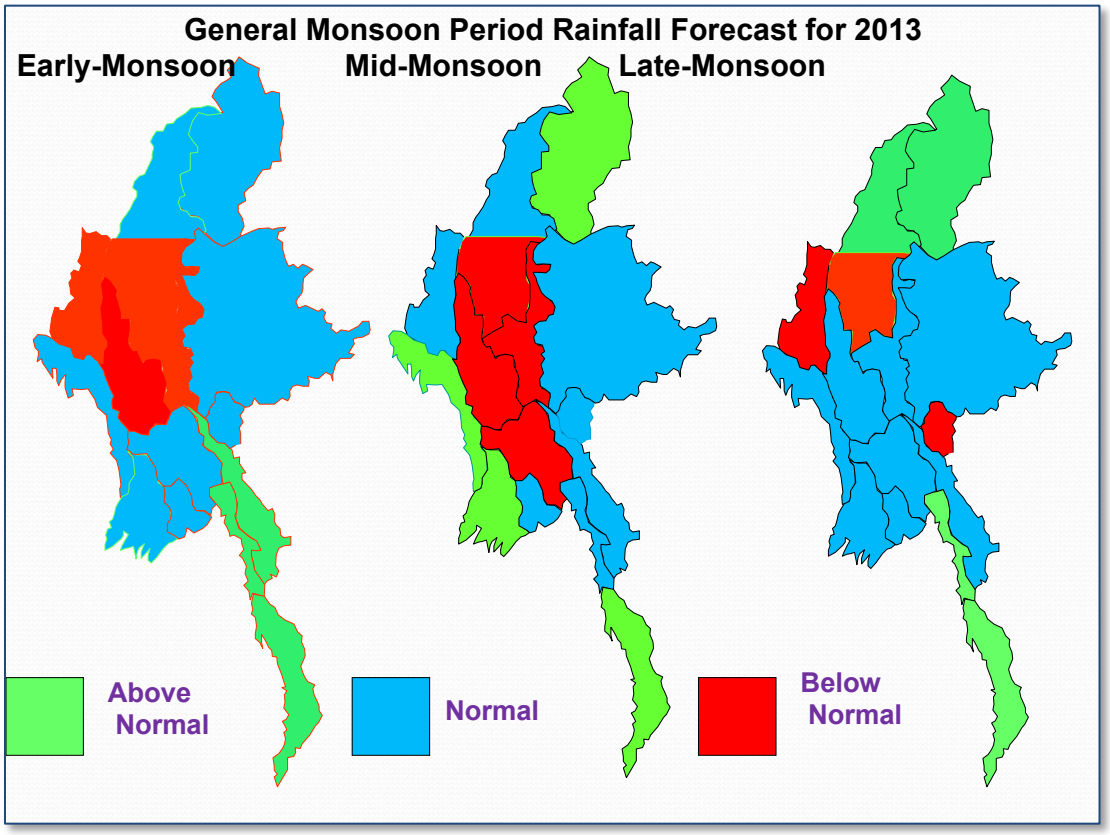


Figure 35. General rainfall outlook for the 2013 Southwest Monsoon Season in Myanmar.

Per DMH's forecast, above normal rainfall is expected in Mon and Kayin States and Tanintharyi Division; below normal in Lower Sagaing, Mandalay and Magway Divisions and Chin State; and normal in the remaining regions and states during the early monsoon period.

During the peak monsoon period, the forecast indicates above normal rainfall in Kachin and Rakhine State and Ayeyarwady and Tanintharyi Division; below normal rainfall in Lower Sagaing, Mandaly, Magway and Bago Divisions; and normal in the remaining regions and states in Myanmar.

By late monsoon period, above normal rainfall is to be anticipated in Kachin and Mon States and Upper Sagaing and Tanintharyi Divisions; below normal in Chin and Kayah States and Lower Sagaing Division; and normal in the rest of the regions and states in the country.

On the other hand, forecast for monsoon onset indicates the following:

- Southern Myanmar – 12 to 16 May 2013
- Deltaic Areas – 19 to 23 May 2013
- Central Myanmar – 25 to 29 May
- Northern Myanmar – 1 to 5 June 2013

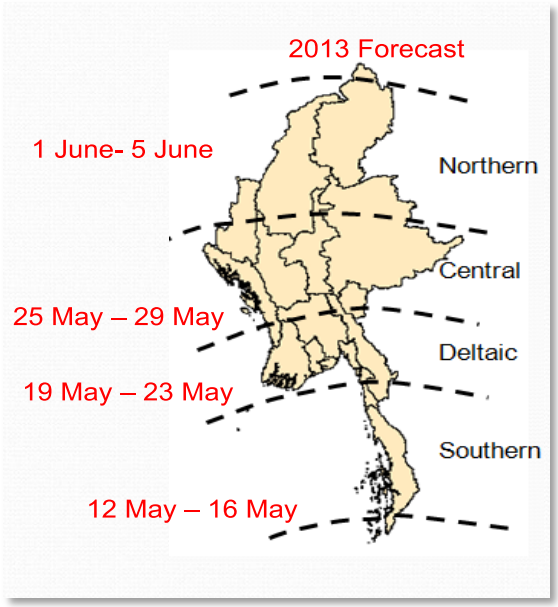
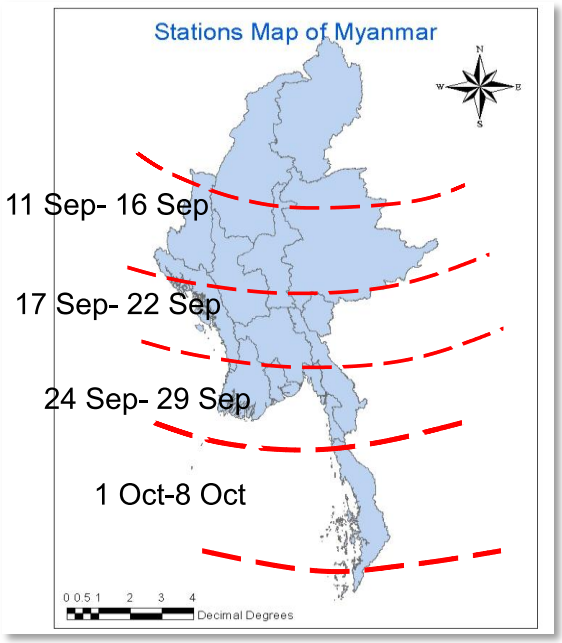


Figure 36. Monsoon onset forecast for Southern Myanmar, deltaic areas, and Central and Northern Myanmar

Further, forecast for monsoon withdrawal dates are shown below and in Figure 37:



- Northern Myanmar – 11-16 September
- Central Myanmar – 17-22 September
- Deltaic Areas – 24-29 September
- Southern Myanmar – 1-8 October

Figure 37. Forecast monsoon withdrawal dates from different parts of Myanmar

4.3 Long Range Water Level Forecast for the Southwest Monsoon Season

At the outset, Mr. Win Maw of DMH explained the hydrological monitoring network and hydrological forecast products available at DMH. The forecast products include:

- Dekad Forecast
- Monthly Water Level Forecast
- Minimum Alert Water Level Forecast and Bulletin (for Low Flow Season)
- Significant Water Level Bulletin
- General Long Range Flood Forecast
- Flood Forecast at early, peak and late Monsoon Periods
- Flood Warnings and Bulletins

Mr. Win Maw continued to discuss the causes of riverine floods in different river systems, as follows:

- Ayeyarwady and Chindwin Rivers:
    - Intense heavy rain due to pronounced monsoon trough persisting for at least three (3) days over Northern Myanmar
    - Strong to vigorous monsoon over Andaman Sea, Bay of Bengal and along the Myanmar coast
    - Heavy rainfall due to cyclonic storm crossing Myanmar and Bangladesh coasts during pre- and post-monsoon periods

- Thanlwin, Sittaung, Shwegyin, Dokehtawady and Ngawun Rivers
    - Strong to vigorous monsoon over Andaman Sea, Bay of Bengal and along the Myanmar coast
    - Rainfall associated with low pressure waves (remnants of typhoons and tropical storms over South China Sea), moving from east to west across the country

He then elaborated that the seasonal water level forecast is based on analysis of:

- Flood characteristic during chosen analog years
- Seasonal climate forecast
- 10 years low flow data
- 10 years high flow data
- flood frequency data

Based on these, DHM provided the following forecast:

Early Monsoon Period
During the months of May and June, water level along Ayeyarwady, Chindwin, Thanlwin, Sittaung, Dokehtawady, Bago, Shwegyin, and Ngawun Rivers is expected to rise above the present water levels but may not reach their respective danger levels.

Peak Monsoon Period
In July and August, water level may exceed, one time each, their respective town danger levels at Hkamti, Homalin, Mawlaik, Kalewa, and Monywa along Chindwin River; at Katha, Mandalay, Sagaing, Pakokku, Nyaung Oo, Seiktha, Hinthada, and Zalun along the Ayeyarwady River; at Myitnge of Dokehtawady River; Madauk of Sittaung River; Bago of Bago River; Ngathaingchaung of Ngawun River; and two times each at Toungoo of Sittaung River: Shwegyin of Shwegyin River; and Hpaan of Thanlwin River.

Late Monsoon Period
In September and October, water levels may exceed, one time each, their respective town danger levels at Mawlaik and Kalewa of Chindwin River; at Pakokku, Nyaung-Oo, Hinthada and Zalun of the Ayeyarwady River; at Myitnge of Dokehtawady River; at Toungoo and Madauk of Sittaung River; at Ngathaingchung of Ngawun River; and at Hpaan of Thanlwin River.

4.4 Agro-Climatic Bulletin

This session was presented by Ms. Khin Lay Nwe of the Agro-Meteorological Division, DMH. She commenced her discussion by defining terminologies used in agro-meteorological forecasts. She indicated that agro-meteorological forecast include information on Bay of Bengal condition, rainfall, night temperature, day temperature, and fog conditions.

She stressed that there is a need to facilitate better understanding among users of the agro-climatic bulletin issued by DMH in order for agriculture-related institutions and farmers to implement measures to promote yield.

Section 5

Potential Impact Outlook And Response Options

5.1 Group Discussion

Participants were divided according to sectors they represent, to discuss potential sectoral impact outlook and response options, for possible application in respective sectors.

The groups were:

a) Disaster Risk Management/Reduction, Health, and Media
b) Water Resources, Fisheries, Agriculture, Irrigation and Livestock
c) Civil Aviation, Industry, Health, and Hotels and Tourism

Scientists from DMH were made to join the groups so that they can answer questions or provide clarifications vis-a-vis the forecast.

Participants discussed, based on the following questions:

- What are the possible impacts on your sector in the next few months (May to October 2013), based on DMH's seasonal forecast?
- What can be done, in your sector, to address/mitigate the possible impacts or take advantage of the potential climate in the mentioned period? What advisories can be disseminated to stakeholders/end-users?
- How do you disseminate advisories related to the 2013 monsoon season to your stakeholders/end-users?
- What can you recommend to DMH to enhance its forecast products?

5.2 Group Discussion Outputs

The following are outputs from group discussions, based on guide questions provided to the participants.

Group I Disaster Risk Management/Reduction, Health and Media	
Potential impacts/hazards during the season	• Storms • flash floods • landslides • thunderstorms • lightning

Response Options	• Public awareness
	  ○ Before, during, and after the hazard for precautionary measures
	  ○ Deliver location-specific information using local language
	  ○ Effective media/channel/tools to be enhanced
	  ○ Disseminate DMH forecast to local communities through effective channels (GAD, FM radio)
	• Strengthening and practicing of early warning mechanisms at all levels, and equipping focal institutions with telecommunication tools
	• Community drills
	• Safe shelter to be identified for evacuation

	• Medical stockpiling
Advisories	• Activate disaster management committees at all levels • Advisory on what should be prepared in anticipation for storms, floods and landslides • Pool financial and other resources • Rainwater collection • Elevate hand pump and seed banks • Prepare for outbreak and epidemic • Stocking of seeds for cultivation after potential flood
Dissemination Mechanism	• Coordination meetings • Awareness programmes • Drills/simulations
Recommendations	• DMH to coordinate with different sectors to prepare user-friendly and sector-focused advisories

Group II **Water Resources, Fisheries, Agriculture, Irrigation and Livestock**		
Potential Impacts	Pre-Monsoon Season	
	Magway, Mandalay, Sagaing	**Below normal rainfall**
	• Cropping pattern needs to be changed as rain would not be sufficient to irrigate crops • River pumping could be promoted as alternative source of water	
	Mid-Monsoon	
	Ayeyarwady	**Above normal rainfall**
	• Rainwater is sufficient to cultivate crops, irrigation water may not be needed	
	Sagaing, Mandalay, Magway	**Below normal rainfall**
	• Rainfed agriculture would not be reliable • Lesser reservoir inflow	
	Late Monsoon	
	Irawaddy and Bago	**Normal Rainfall**
	• Regular activities can proceed	
	Lower Sagaing	**Below Normal**
	• Lesser inflow in water impoundment facilities • Impact on normal production	
Advisories	• Change cropping pattern • Develop water-use efficiency and implement water saving training • Upgrade/repair water supply system • Enhance water management through the water users association	
Recommendations	• Farmers' school to be initiated to enhance knowledge sharing with farmers • Development of agri-calendar by DOA in consultation with farmers	

Group III Civil Aviation, Industry, Health, and Hotels and Tourism	
Forecast Conditions	• Monsoon onset date is likely to be normal • Possibility of cyclone/storm in the Bay of Bengal in May, October and November • LPAs may form in the Bay of Bengal during the season, which may develop into depressions • Affected area for cyclone could be Rakhine and Deltaic Area
Potential Impact	• Water-borne, camp-based and other diseases (diarrhea, dysentery, cholera, leptospirosis, malaria, dengue fever) may arise after occurrence of hazards/disasters • Injuries and malnutrition-related ailments • Decrease in fish production, fishing boats and fishing materials losses due to adverse weather condition • Decrease in survival rate of plantation
Response Options and Advisories	• Distribution of bleaching powder, CL2 tab, water guard, ORS, and antibiotics for prevention and control of disease outbreak • Vector control activities, latrine construction, garbage disposal, safe water supply, clean and fresh foods supply, personal hygiene, hand washing training • Mobile clinic and 24-hours clinic in camps; availability of emergency health kits • Immunization of measles and tetanus • Nutrition promotions and quality foods supply • Training for rapid response team (RRT), updating of contingency plan and disaster preparedness plan • Simulations/drills • Capacity building in community-based first aid, community-based disaster risk management • Strengthening of fish pond structures • Early warning to fishermen about severe weather condition • Disaster preparedness stocks, Emergency Response Units prepositioning • Update SOPs
Communication Mechanisms	• Mobile phones, FM radio and local radio network • Extension services • Local authorities, NGOs working in local areas • Communication network with village level organizations (RRT, Myanmar Red Cross Society (MRCS), Myanmar Maternal and Child Welfare Association (MMCWA), village leaders, religious leaders, etc)
Recommendations	• Identify the gaps, in forecast application, in every sector • Promote and improve utilization of tools for forecast application • Resource mobilization • Strengthen cooperation with early warning services in other countries • Strengthening of DMH capacity • Expanding DMH in terms of human resource and presence in district/divisions

	• Utilization of WMO-standard equipment in monitoring weather parameters and modern techniques in forecasting • Establishment of facilities like radars, and enhancement of early warning network • Strengthening of cooperation with UN/International organizations

Section 6

Earthquake Monitoring and Tsunami Early Warning Issues and Concerns

6.1 Earthquake and Tsunami Risks in Myanmar

Mr. Kyaw Kyaw Lin explained the seismic network established in the country and the facilities at the National Earthquake Data Center (NEDC) in Nay Pyi Taw. He elaborated the mechanisms in DMH for receiving earthquake information from different monitoring systems in the country and in neighboring areas. Subsequently, he explained that, as part of the tsunami monitoring system, tide gauges were established at Sittwe and Mawlamyine and explained how DMH acquires sea level data.

Mr. Kyaw Kyaw Lin then discussed that one of the triggers of earthquakes in Myanmar is the subduction of the Indian plate beneath the Eurasian Plate (where Myanmar is part of), estimated at an annual rate of 3.5 centimeters. Major faults in Myanmar include the Kabaw Fault, Sagaing Fault, Momeik Fault, and Mrauk-U Fault, among others. These are illustrated in Figure 38.

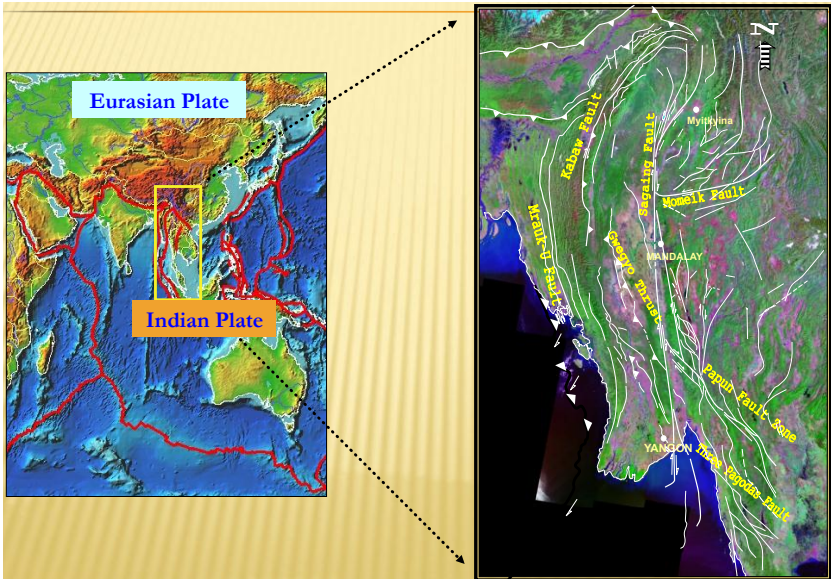
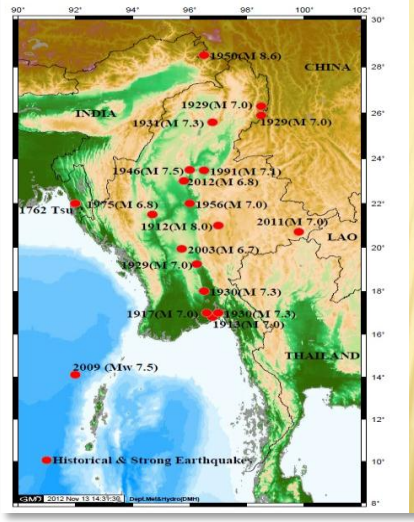


Figure 38. The subduction of the Indian Plate beneath the Eurasian Plate is one of the triggers of earthquakes in Myanmar. Within the country, various faults exist making it highly earthquake-prone

Following that, Mr. Kyaw Kyaw Lin elaborated on long-term seismic events recorded in Myanmar and neighboring areas. He then highlighted strong earthquake events in Myanmar, shown in Figure 39.

Strong EQs in Myanmar



No.	Date	Remarks
1	23-05-1912	North of Taunggyi serious landslides
2	06-03-1913	"Golden umbrella at the peak" of Shwe-maw-daw Pagoda grounded
3	05-07-1917	"Golden umbrella at the peak" of Shwe-maw-daw Pagoda grounded
4	19-01-1929	Brick building destroyed at Htaw-Gaw
5	08-08-1929	Brick building destroyed at Swa
6	16-12-1929	Landslide
7	05-05-1930	Many houses destroyed, 5oo killed in Bago. Some houses destroyed, 5o killed in Yangon.
8	03-12-1930	Some houses destroyed, about 30 killed
9	27-01-1931	Brick building collapse, Landslide
10	12-09-1946	Pagodas collapse
11	15-08-1950	Under the influence of Assam earthquake, Chindwin river at Mawlaik and Kalewa, Ayeyarwady river at Aunglan flow upstream
12	16-07-1956	Pagoda & building at Sagaing destroyed, about 40 killed Sagaing bridge, moved slightly
13	08-07-1975	Many historical pagodas at Bagan destroyed, 2 killed
14	05-01-1991	Landslide & some buildings destroyed at Tagaung and surrounding area, 2 killed
15	22-09-2003	Landslide, liquefaction and sand Eruption. Pagodas, some bridges, houses and schools destroyed at Taungdwingyi and surrounding areas. 7 killed.
16	24-3-2011	A total of 72 people were killed and 100 were injured, One bridge was collapsed and 413 buildings were damaged
17	11.11.2012	Many buildings, houses, schools, monasteries and pagodas were destroyed and some people killed

Figure 39. 100-year record of strong earthquake events in Myanmar and their corresponding damages.

He underscored the damages caused by the 2012 earthquake, and subsequently summarized the impacts of the 2004 Indian Ocean Tsunami in Myanmar, in Table 9.

Table 9. Losses due to 2004 Indian Ocean Tsunami	
Total Death	61
Injured	42
Houses Destroyed	601
Villages Affected	29
People Displaced	2592
Total Losses	Kyats 1585.56 Million

He proceeded to elaborate the mechanisms for earthquake monitoring and tsunami warning in DMH and discussed exercises/drills conducted both in the NEDC and in coastal areas. He also indicated simulation results for Magnitude 8.5 earthquake with hypocenter at 12.1 N and 92.5E, indicated in Figure 40.

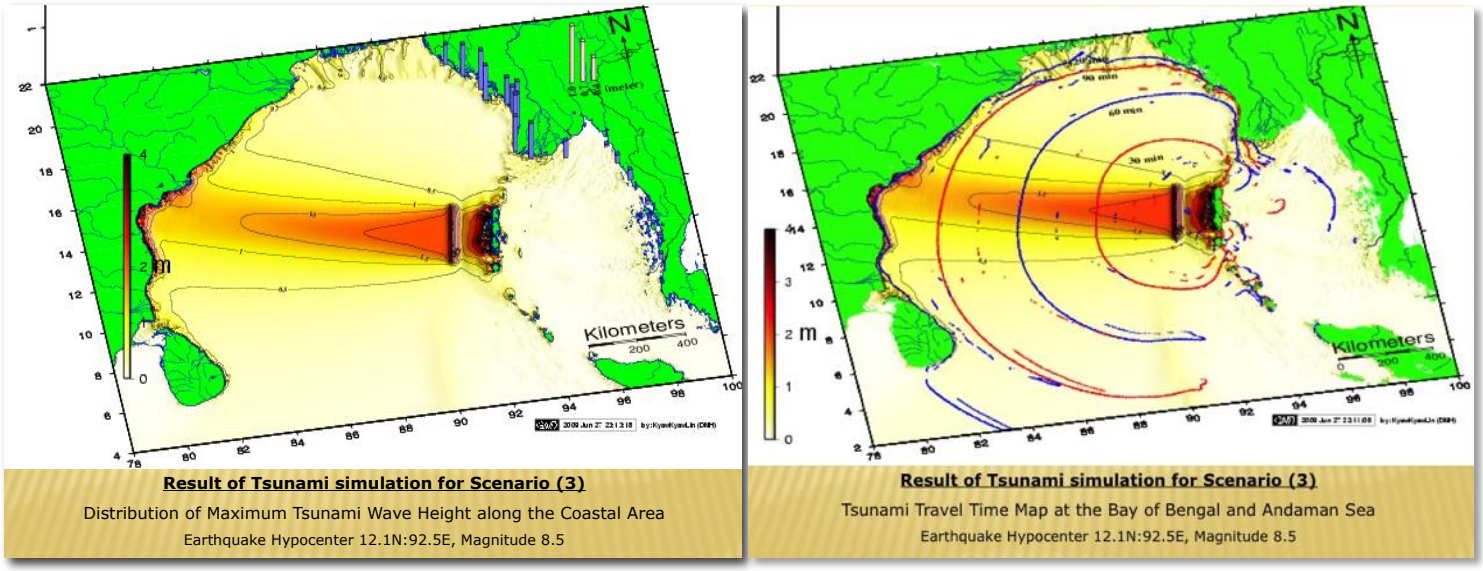


Figure 40. Tsunami simulation outputs based on magnitude 8.5 earthquake at hypocenter 12.1N and 92.5E. Output on the left shows estimated tsunami wave height in coastal areas in the country while output on the right illustrates tsunami travel time at the Bay of Bengal and Andaman Sea

Section 7

Synthesis of Discussions and Recommendations

7.1 Summary of Discussions

The following summarizes the discussions during the 10th Monsoon Forum.

- **Beneficiality of the Monsoon Forum**
  Participants from the agriculture sector indicated that the Monsoon Forum is a very good venue for understanding forecast products, hence it is very important for the agriculture sector.

- **Use of international symbols in DMH forecasts**
  In response to request for clarification from participants on the use of internationally-recognized symbols in DMH forecasts, DMH elaborated that like other international, regional and national forecast institutions, DMH employs image and data in presenting forecasts, but many users do not have thorough understanding of those images and data. It was further explained that due to the complexity of the meteorological language, DMH started to covert terminologies for meteorological phenomena into local name (e.g. using local terminology for thunderstorm).

- **Climate change and people's perception**
  The agriculture sector espoused that huge variation exists between normal monsoon duration (144 days) and recent observed monsoon duration (100 days). These variations, arguably triggered by climate change, have impacted on perceptions of people vis-à-vis forecasts.

- **Forecast application dependent on sectoral education on forecast utilization**
  Participants commented that addressing possible scenarios based on forecast, for example water deficit due to predicted below normal rainfall, depends on the education implemented in different sectors on forecast utilization/application.

- **Mechanism for forecast communication**
  According to participants, most of the people in Myanmar do not have access to television. Radio is, by far, still more useful for end-users. Weather news, though available, is issued only after 8 P.M.

- **Maximum temperature recorded in Myanmar**
  In response to query from the health sector, DHM explained that 2010 has recorded the highest temperature in the country (47.2°C in May 2010 in Lower Sagaing; the normal temperature in May in Central Myanmar is only 40-42°C). According to DMH, it is anticipated that 2013 would not be as hot as 2010.

- **Agro-meteorological observations**
  Participants were interested to know the process of observing evapo-transpiration and soil moisture. DMH explained that soil moisture is obtained through a soil thermometer while evapo-transpiration is calculated based on certain parameters. DHM indicated that in the next Monsoon Forum, it will provide an overview of the observation tools and equipment used in agro-meteorological observation and forecasting.

- **Coping mechanisms for the agriculture sector**
  Representatives from the agriculture sector espoused that based on the forecast, the kind of plants and the soil quality, they can advise farmers on the most suitable cropping pattern. However, low-income farmers, though working hard, do not have sufficient money for farm inputs, which is an impediment in implementing advisories. As a coping mechanism, they borrow money to sustain farming and their daily needs.

- **Challenges in conducting community drills**
  In response to questions from the participants, the Relief and Resettlement Department elaborated that there are difficulties in conducting drills but communities should understand that drills are undertaken for their benefit.

- **Earthquake and tsunami risks in Myanmar**
  Discussions that follow the session on Earthquake and Tsunami Risks in Myanmar indicated very low awareness, among participants, of earthquake and tsunami hazards.

7.2 Key Recommendations

- **Issuance of deterministic forecasts**
  Participants from the agriculture sector recommended that, if possible, deterministic forecasts (i.e. rainfall in inches) be issued instead of probabilistic description.

- **Enhanced utilization of forecasts through education of sectoral users**
  To maximize benefits from forecast application, sectoral users should be educated on forecast utilization.

- **Sharing of previous Monsoon Forum reports to all stakeholders**
  Participants recommended that stakeholders be provided with reports of previous Monsoon Forums.

  DMH and RIMES ensured provision of Monsoon Forum reports, including the previous ones, to stakeholders via email. DMH and RIMES requested participants to ensure that they have included their email addresses in the registration sheet so that they can be included in the email loop when sharing the reports.

  Further, participants enthused that Monsoon Forum reports be posted in DMH website to facilitate easier access by stakeholders.

- **Availability of DMH historical data, free of charge**
  Participants followed-up on this recommendation from the 9th Monsoon Forum. DHM clarified that forecasts are free of charge. It is only the long-term historical data that are available, with some charges, based on the rule/guideline established by the Ministry of Transport to support DMH's operational costs. DHM indicated though that it will try to arrange availability of historical data online.

- **Ensure receipt of forecasts by stakeholders by updating list of institutional focal persons**
  While DMH issues forecast of different timescales, some stakeholders indicated that they were not able to receive the information. DMH clarified that forecasts are sent to heads of institutions. Participants suggested that, since there are about 17 to 20 departments under one (1) ministry, it would be better if DMH could update its list of institutional focal points, if possible including departments and other levels, to ensure receipt of forecast by all concerned.

  For agro-meteorological forecasts, DMH requested participants to provide their email addresses so that forecasts could be sent by email. This is because the operational cost of using fax in sending forecasts is high, hence email would be the preferable mode of forecast communication by DMH.

- **DMH forecast to include conditions over South China Sea**
  Participants recommended that DMH forecasts include also conditions over South China Sea, in addition to conditions over Bay of Bengal.

- **Enhanced awareness of climate-related hazards**
  Awareness on climate-related hazards, like thunderstorm and lightning, is very low. As the frequency of occurrence of these hazards is increasing, there is a need to increase awareness among the constituents. Awareness on thunderstorms and lightning would be included in DMH programs aired on television.

- **Communication channel dedicated to farmers**
  Participants recommended that it would be good if DMH has a communication channel dedicated to farmers.

- **Cropping pattern modification in the agriculture sector**
  According to participants, crop diversification is needed in view of the impacts of climate variability and change. Diversification, instead of focusing only on rice, is one way of making farmers resilient. The Department of Agriculture indicated that guiding farmers in modifying their cropping patterns is also part of the institution's plan.

  Further, it was recommended that an agri-calendar and hazard calendar be developed by the Department of Agriculture with farmers. It was suggested that the Department of Agriculture/Agriculture Planning and DHM work on providing location-specific cropping calendar.

- **Establishment of farmers' school for enhanced uptake of climate information**
  It was recommended that, to facilitate better application of forecast application in agriculture sector, a farmers' school be established in Myanmar.

  RIMES and DMH indicated that this is one of the key undertakings planned in Myanmar, and the process will be commenced soon through discussion with the Ministry of Agriculture and Irrigation.

- **Improved water utilization through training of water user associations in water management**
  Participants suggested to the Department of Irrigation that a better approach to water management would be to organize and train communities in water management.

- **Enhanced collaboration between DMH and stakeholders on data sharing**
  Participants commented that the Monsoon Forum is a good venue for decision-makers to make a consensus of informed decisions based on seasonal and other forecast products. This platform for knowledge sharing should be supported by redundant mechanisms to enhance knowledge sharing between DMH and stakeholder sectors like agriculture, livestock, and fisheries, among others.

- **Participation of farmers in the next Monsoon Forum**
  The agriculture sector requested DMH to invite farmer representatives during the next Monsoon Forum.

  DMH and RIMES responded that the suggestion could be explored by taking in representatives from farmers associations as participants during subsequent Monsoon Forums.

- **Longer sessions for discussion of geological hazards like earthquakes and tsunamis**
  Participants suggested that due to the low awareness in Myanmar regarding geological hazards like earthquakes and tsunamis, sessions dedicated to discussion of issues relative to such hazards could be provided longer time slots.

- **Enhancement of forecast application**
  In an effort to better customize forecast products, DMH should identify gaps in forecast application in every sector. Coordination between DMH and sectoral institutions could also be improved for the development of user-friendly and sector-focused advisories. It was further recommended that tools, intended to promote and improve forecast application, be developed. Resources in different sectors should also be mobilized for enhanced forecast application.

- **Enhancement of DMH capacity**
  According to participants, DMH needs to strengthen its forecasting capacity by establishing latest and WMO-standard monitoring/forecasting facilities (e.g. radar), utilizing modern forecasting techniques, and enhancing its early warning network. Expansion of DMH in terms of human resources and presence in sub-national levels was also brought forward. DMH should also strengthen its coordination with international, regional and other national early warning institutions, and UN and international organizations.

Section 8

Way Forward and Closing Session

8.1 Synthesis

Ms. Ruby Rose Policarpio delivered a summary of key discussion points and recommendations during the 10th Monsoon Forum.

8.2 Way Forward and Closing Remarks

Ms. Kin Cho Cho Shein, on behalf of Dr. Hrin Nei Thiam, thanked all participants for the productive discussion. She elaborated that DMH would try its best in addressing recommendations put forward by the participants. She highlighted that the process of forecast application requires cooperation between DMH and user sectors, hence DMH expects to work closely with the different sectors.

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