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| DMH Capacity Assessment: Meteorology |

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| Parameters | Current Capacity | Minimum Requirements | Optimum Requirements |
| Number & Distribut-ion | Manual/Automatic  | Recording Frequency | Transmission | Number & Distribut-ion | Manual/ Automatic | Recording Frequency | Transmis-sion | Number & Distribut-ion | Manual/ Automatic | Recording Frequency | Transmis-sion |
| Observing and monitoring system |
| Surface | (119)stations | Onlymanual | (5) observations per day, (18) stations observed (8) times a day. | (43) stationsuse SSB radio,(59) stations use telephone, and other station use mail and/ or telegram | (324) meteorological observatories. | (224)meteorological observatories (manual), and (100)automatic weather stations | (8) times a day for manual stations and continuously for AWOS | SSB/Telephone/GSM/SMS | (324) meteorological observatories | (224)meteorological observatories(manual), and (100)automatic weather stations | (8) times a day for manual stations and continuously for AWOS | SSB/Telephone/GSM/SMS |
| Upper Air  |  | Manual | Once per day | Phone | (10) stations | Manual pilot balloon observation and/or radiosonde observation | (2) times per day | SSB/Telephone/GSM/SMS | (20)stations | Manual pilot balloon observation and/or radiosonde observation | (2) times per day | SSB/Telephone/GSM/SMS |
| Satellite  |  | Satelliteimage receiving system (MTSAT, CMACast) | Every half and hourly | Satellite link via Japan and China | (7) | Satellite images receiving ground station | Every half and hourly | VPN, dedicated link | (10) | Satellite images receiving ground station | Every half and hourly | VPN, dedicated link |
| Analysis of gaps and related impacts: Existing observational networks and data availability are the major challenges for generating real time weather information and warning. During the time of very high impact weather system, e.g. severe cyclone, lack of accurate surface wind speed observations from coastal regional station, leads to delayed and inaccurate warning. Lack of upper air observations results to poor quality of aviation weather forecast. Coastal weather observations, wave height, and swell are necessary for marine forecast and bulletin. Most of the time, large error between wave forecast and actual report from a vessel exists. Process of standardization of weather instruments is not systematic for the long time. So, accuracy and quality of weather observations are reduced, which will affect long-term climate data. Lack of calibrated weather instruments in aviation weather observatories also affects air operation. |
| Ongoing and planned capacity building initiatives by other organizations: JICA-supported project to establish severe weather monitoring system was initiated in 2012, and is expected to be completed in 2020. This includes installation of (3) radars and (30) AWOS in different areas of Myanmar. DMH submitted to the Ministry of Transport a Long Term (30 years) Development Plan to address gaps in monitoring of marine weather and aviation weather, with advanced instruments like radar, wind profiler, radiosonde, lightning detection, wind shear sensor, evaporation sensor, high gust anemometer, ozone, sunshine and solar radiation recorders, and automatic rain gauges. The Plan also includes establishment of new Aeronautical Meteorological Forecasting Offices in Bago, Lashio, Heho, Putao, Loikaw and Myeik airports within the next (15) years. DMH looks forward to funding assistance from Overseas Development Assistance (ODA) program, UN specialized agencies such as WMO, UNDP, UNEP, RIMES, and international nongovernmental organizations. |
| Recommendations to address gaps, including opportunities for research: DMH is the only single nodal agency in the country for providing weather forecast and issuing meteorological warning; hence, observations are very important and are the basic foundation of forecasting. Methods of standardization on weather instruments, weather stations, operating procedures, method of exchanging weather observations, and warning system should be carried out to strengthen quality assurance of meteorological observation system. This shall benefit specific users and the general public. |

| Parameters | Current Capacity | Minimum Requirements | Optimum Requirements |
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| Data processing and management  |
| Data receipt (timeliness) | DMH receives meteorological data, news, bulletin, and warning via GTS, particularly from RTH New Delhi and RTH Bangkok. Yangon and Mandalay Airport Meteorological Forecasting Office receives latest weather and warning from neighboring countries and designated aerodrome via AFTN. National data exchange system relies only on SSB Radio for real time transmission to GTS. At the same time, the National Meteorological Center (NMC) monitors the latest weather information from local stations every (3) hourly. | As meteorological data, news, bulletins, and warning are essential for the NMHS, we need to maintain status of existing GTS and AFTN link for real time information update, with good internet speed and ftp access. Computerized exchange of national meteorological observations needs to be set up for Nay Pyi Taw-Yangon-Mandalay-Pathein-Sittwe. | Myanmar DMH should extend its GTS nodes with Nay Pyi Taw-New Delhi, Nay Pyi Taw- Bangkok, Nay Pyi Taw-Tokyo, Nay Pyi Taw- Beijing, NayPyi Taw-Seoul through WIS activities. Computerized exchange of national meteorological observations need to set up for Nay Pyi Taw-Yangon-Mandalay-Pathein-Sittwe-Dawei-Myitkyina-Kengtung-Hakha-Co Co Island. |
| Data format (consistency) | National meteorological observations are routinely reported as by WMO Code. | Code format and amendments recommended by WMO, IOC, and/or ICAO should be followed regularly. | National Data Exchange Network should be set up by all possible communications. |
| Data storage  | Local observation data were not archived systematically. Soft data beyond a week were automatically deleted. | National Weather Observation data archiving system should be managed systematically. | Small server should be set up for data rescue and management. |
| Software  | **NetSYS** GTS Software installed at Yangon and Yangon Int’l Airport and GTS Server at Nay Pyi Taw installed by Oriental Electronic Co.Ltd Japan. | Set up for regional exchange of meteorological data and observations, including Radar, Upper Air, AWOS, warning, etc. | Set up for regional exchange of meteorological data and observations, including Radar, Upper Air, AWOS, warning, etc. |
| Skilled manpower  | High number of university level Meteorological Graduates from universities both abroad and locally.  | Need to recruit qualified human resource for Meteorology. WMO Classified Meteorologists and Technicians should be emphasized as per WMO.No258 recommendation. | New generation ICT specialized technicians should be recruited for professional and skilled manpower. |
| Analysis of gaps and related impacts: A key gap is lack of computerized data exchange system between remote stations, regional offices, and Head Office. Observation reports are delayed in some stations due to lack of electric power/solar power, and busy telephone lines. This also prevents the communication of real time weather observations to the GTS via Head Office. During severe weather, hourly observations are critical for early warning. Most weather stations, however, do not have good communication links for exchanging observations, forecasts, and other instructions. Other key gaps include: a systematic climate data archiving system for both hard and soft data, quality control of climate data and reports, and weak control and check system in GTS Message Switching System. |
| On-going and planned capacity building initiatives by other organizations: GTS data in Myanmar DMH was very sparse and connection was slow for a long time. WMO’s Project on GTS Implementation was established timely before Cyclone Nargis. JICA’s Project on Storm Forecasting Development started in 2010 and finished in 2012. GTS facility was one of the major developments for DMH under the project. DMH will consider, in future, GTS links between Yangon-Bangkok GTS and Yangon-New Delhi GTS, and initiate Nay Pyi Taw-Bangkok, Nay Pyi Taw-New Delhi, Nay Pyi Taw-Tokyo.  |
| Recommendations to address gaps, including opportunities for research: Meteorological data handling and graphical visualization works need to be established. This is a priority for the weather forecast section. Currently, there are no ongoing activities on meteorological data handling and graphical visualization, including printing of weather maps and upper air charts, using advanced printers. Specialized technicians, engineers, information and communication staffs should be recruited and managed systematically. Communication system among local, regional and Head offices should be developed. Training of relevant staffs and technicians on meteorological instruments maintenance, calibration, standardization, coding, decoding, and dissemination procedures should be conducted. |
| Prediction and forecasting  |
| Computing capacity  | Only PC-based computing facilities are used for daily weather forecasting, including storm surge prediction, since March 2012. There is no computing facility at the Aviation Meteorological Services.  | Server type high-computing facilities need to be established for daily weather forecast, aviation meteorological services, seasonal weather forecast, and climate modeling. | High Performance Computing System should be established for Regional Climate Modeling, High Resolution Weather Forecast Modeling, and Seasonal Weather Forecasting. |
| Modeling software  | WRF Model has been running since November 2012. JMA and IIT Storm surge model have been operational since 2009. | WRF Model, storm surge model, GFS Model, Regional Climate Model, PRECIS Model, Wave Forecasting Model | WRF Model, storm surge model, GFS Model, Regional Climate Model, PRECIS Model, Wave Forecasting Model, WAFS Model |
| Skilled manpower  | (10) to (15) forecasters for daily weather forecasting, (5) to (10) forecasters for aviation weather. (5) to (8) peoples were trained to run WRF Model. Only (3) to (5) people experienced in Regional Climate Modeling. | (15) to (20) forecasters for daily weather forecasting, (10) to (15) forecasters for aviation weather.  | (20) to (30) forecasters for daily weather forecasting, (15) to (20) forecasters for aviation weather.  |
| Operating hours  | Centers at Nay Pyi Taw, Yangon International Airport, and Yangon Office run (24) hour weather monitoring and forecasting.  | Offices in cities in the Coastal Regions should have round the clock monitoring capacity for local severe weather. | All weather stations and forecasting centers should be run (24) hours a day, with satellite, AWOS, and Radar Images. |
| Use of thresholds  | DMH use location-specific pressure threshold values for forecasting of Monsoon intensity and heavy rains. Empirical technique for storm surge prediction is used. No other threshold values are used. | Threshold values for heat wave and cold wave, Intensity of heavy rain should be calibrated and validated with respect to time and space.  | Threshold values for Cyclone, Radar, and Satellite, Weather elements, heavy rain, pressure and temperature should be utilized systematically. |
| Analysis of gaps and related impacts: Shortage of skilled manpower and advanced computing facilities caused inaccurate warning and information. Skills of forecasters and observers are essential during the warning generation process. Shortage of forecasters and senior forecasters is one the gaps for maintaining quality of forecast products. Rendering (24)-hour duty during severe weather events takes a toll on forecasters, resulting to errors/negligence of duty. Utilization of useful software to support weather and seasonal forecasting is still not yet developed.  |
| On-going and planned capacity building initiatives by other organizations: DMH actively cooperates with regional partners to develop skilled manpower in weather forecasting. WMO, Norwegian Government, JMA, KMA, TMD, IMD, CMA, ADPC, and RIMES are providing assistance to strengthen DMH young generation of human resources, especially in the field of weather forecasting, climate and climate change, disaster risk reduction, instruments, surface and upper air observations, and communication. |
| Recommendations to address gaps, including opportunities for research: Forecasting and prediction techniques should be developed for daily weather forecast, aviation weather, medium range weather, ensemble forecast, and seasonal weather forecast. Methods of climate application, climate change analysis, Radar data, Automatic Weather Observation Systems and calibration on weather instrument should be carried out. DMH needs to set up a regular program for fellowship study abroad for advanced theory and practical knowledge. On-the-job training and hands-on training should be performed regularly, both at DMH and abroad. Also, policies and guidelines on specialized technicians and professionals for each sector of meteorology (i.e. Satellite, Weather Forecast, Climate, NWP, Instruments, Aviation weather, marine weather, etc), needs to be established. |
| Bulletin development  |
| Parameters  | Coastal weather, cyclone news, warning, heavy rainfall, strong monsoon, high and low temperature, rain scarcity warning, storm surge warning, strong wind and high wave warning, special weather news, new record of rainfall and temperature. | Coastal weather, cyclone news, warning, heavy rainfall, strong monsoon, high and low temperature, rain scarcity warning, storm surge warning, strong wind and high wave warning, special weather news, new record of rainfall and temperature. | Weather outlook at district level; coastal weather forecasts for Northern and Southern Rakhine states, deltaic coast (Yangon-Haigyi), Mon-Taninthayi coast (Mawlamyine-Kawthoung), including wave forecast, surface wind, expected weather, and synopsis. Probable storm surge prediction, heavy rainfall warning, cold wave and heat wave warning and advisory, and localized severe weather warning system based on radar and AWOS observations. |
| User list (availability, frequency of updates, classified by user groups/sectors?) | Higher Authorities including Presidential Office, Chief of Military, Navy and Air Force Office, Disaster Relief and Resettlement Ministry and relevant Ministries. Air/Navy, State media, electronic, print and broadcast media, mass media, Myanmar NGOs, UN organizations, hot line and web users. Warning is updated (4) to (6) hours, based on severity of weather conditions. | Currently, warnings are disseminated by fax and phone. In future, most warnings should be disseminated mainly by email, website, and SMS. Local people help provide in real time information on hazards, which is useful in updating warnings and advisories. CCTV and camera, dense AWOS network, and good telecommunication system are needed for preparing timely early warnings. Sports and recreation weather forecasts are also required.  | Satellite-based remote observations and remote sensing observations on sea and ocean state need to be established, for providing warning to coastal communities. Warning dissemination system and color coding scheme should be maintained and developed further. |
| User-specific bulletins  | Untimely rainfall, heavy rainfall, cold and hot weather, coastal weather warning, storm surge warning, fog warning, SIGMET, Ports Warnings, and VVIP special weather forecasts. | Wind shear alert and warning system for aerodromes, coastal zone weather forecast and wave forecast, and VVIP special weather forecast. | Wind shear alert and warning system for International Airport and aerodromes, coastal zones weather forecast and wave forecast should be routinely issued. |
| Analysis of gaps and related impacts: Generating accurate and timely warning for severe weather and other high impact weather phenomenon is still a challenge, mainly due to gaps in observation system and networks, advanced instruments, high resolution satellite images, AWOS, and radar, upper wind, and wave measurements. Telecommunication and networking speeds are currently very slow/have poor connection, causing delays on website uploading, data downloading, information compilation, and running the NWP Model. Few well-trained cyclone forecasters were highly confused with other responsibilities during emergency, which could lead to biased decisions. |
| On-going and planned capacity building initiatives by other organizations: DMH has ongoing program on capacity development and infrastructure. DMH staffs participate in regular training programs on weather forecasting, cyclone, storm surge, climate, NWP, instruments, communication, and satellite images, arranged by WMO, regional WMO member countries, ADPC, RIMES, and Norwegian Meteorological Institute. Departmental meteorological training courses for senior observers and new generation forecasters were also conducted annually as per WMO’s Education and Training guidelines.  |
| Recommendations to address gaps, including opportunities for research:  |
| Dissemination system |
| Warning focal points  | Meteorological warnings are disseminated to higher authorities, Minister and Deputy Ministers of Transport, Relief and Resettlement, and General Administration; TV, FM radio, Newspapers, Journals, DM Hotline Phone, and Website. | Number of warning recipients should increase to include concerned decision makers. | Warning should be disseminated timely and effectively from national, regional, and grass root levels by all possible means. |
| Communication channels  | Warnings are disseminated by fax to higher authorities, Relief and Resettlement and General Administration Departments, TV, FM radio, Newspapers, and journals. | Sending to users take time, within (1) to (2) hours. Email or other electronic media could be used for dissemination to decision makers, DRR agencies, and the media.  | All possible communication channels, such as radio transceiver, telephone, fax, email and SMS systems should be maintained for effective early warning. |
| Confirmation of receipt by users  | Warning messages are confirmed by recipients, after receiving the warning. | Acknowledgement or confirmation messages are a priority for early warning providers. | Acknowledgement or confirmation messages are a priority for early warning providers. |
| User feedback  | The general public frequently comments on weather forecast and warning. Departmental officials make comments during the Monsoon Forums. | DMH need to establish a feedback receiving system, e.g. by phone, email, social network, face book, website. | DMH need to establish a feedback receiving system, e.g. by phone, email, social network, face book, website. |
| Communication tests (mode, frequency) | No communication test for meteorological warning system. | National, provincial level table-top exercise and/or drill for cyclone and storm surge should be conducted annually before the cyclone season. | National, provincial level table-top exercise and/or drill for cyclone and storm surge should be conducted annually before the cyclone season. |
| Analysis of gaps and related impacts: Gaps include limited number of technical staffs and experts, advanced communication system, and financial support, including operational system for feedback and response and evaluation procedures. |
| On-going and planned capacity building initiatives by other organizations: Projects with RIMES, ADPC, and Norwegian Meteorological Services that link DMH with the local people at selected pilot sites have been carried out. |
| Recommendations to address gaps, including opportunities for research DMH needs to establish a feedback receiving system, e.g. by phone, email, social network, face book, and website. |