



Climate Information and Services Survey Results

REVIEW ON THE CURRENT STATUS OF CLIMATE INFORMATION AND SERVICES PROVIDED BY THE NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICES OF SOUTHEAST ASIA

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Executive Summary

At the last meeting of the WMO RA V Working Group on Climate Services held on 2-4 February 2016 in Singapore, it was agreed to review the current status of climate information and services provided by the National and Meteorological and Hydrological Services (NMHSs) of Southeast Asia. In line with the implementation of the Global Framework for Climate Services (GFCS), the review aims to establish the baseline status of the region's NMHSs in providing climate information to the user community through identifying gaps and needs for improvements. To achieve this, a survey was conducted covering 8 broad areas:

- General information about the Service
- Observation Network, Data Management, Data Exchange
- Climate Products (Dissemination of Products)
- Climate Services
- Research
- User Interface
- Capacity Building
- Gaps and needs

Out of the 10 Southeast Asian countries, 8 responses were garnered from Brunei, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam. Subsequent paragraphs provide a summary of the responses, **focusing on the gaps and needs** which is in line with the purpose of this survey.

All of the NMHSs have the mandate to provide climate products and services in their countries through dedicated units set up. Alongside these services, there are other private and commercial entities that also provide alternatives to end users. Most NMHSs highlighted that their organisation's visibility to the general public could be further improved.

For observation networks, geographical coverage and technical staff to operate or maintain these networks have been indicated as less than adequate among other factors. The level of maintenance, calibration and checking of observation instruments are considered only marginally adequate. While some meteorological observation data is being shared across boundaries, there are still policies in place that restrict free and open-sharing. Across the region, there are very few observation stations with records more than 70 years and among the variables surveyed, surface radiation budget and water vapour are being monitored by significantly fewer stations. Although homogeneity tests and data rescue activities are conducted on the data, these are considered not adequate.

In delivering climate products and services, capacities in *communication means* and *software tools* are considered less adequate than *personnel* and *computing capacities*. Of the various *products* surveyed (Annex A), the 5 considered to be most in need of capacity development are:

- Information related to the uncertainties, skill, etc. of monthly to seasonal climate forecasts
- ENSO (El Niño Southern Oscillation), SST (Sea Surface Temperature) and intraseasonal variability products
- Downscaled global climate change projections
- Review and assessment of past climate patterns
- National scale monthly and seasonal climate forecasts and outlooks in probabilistic format

Of the various *services* surveyed (Annex B), the 5 considered to be most in need of capacity development are:

- Access to and use of monthly to seasonal and longer climate predictions, provided by WMO's Global Producing Centres (GPCs)
- Leading and coordination of Regional Climate Outlook Forum (RCOF)
- Running Global and/or Regional Climate Models
- Interpolation/gridding of observation data
- Homogeneity test and adjustment of time series

All NMHSs have the mandate to carry out research activities. All but one have dedicated units to cater to research needs. In general, these units are staffed more by BSc and MSc degree holders than PhDs. Staff's access to research literature sources are considered adequate by only 2 of the NMHSs surveyed. Capacities in human resources, models and software available for research are considered less adequate relative to computing resources. Compared to the areas of agriculture, health and water, tourism is the downstream application least researched for its links to the climate. Vulnerability assessment is also not a commonly researched area among the NMHSs.

In its interaction with users, respondents indicated that their organisations are marginally or fairly equipped with capabilities for engagement. There are frequent engagements through forums and surveys or direct meetings. But none, except one, of the NMHSs conducts regular market study as platform to engage users and conduct socio-economic study of their climate services to demonstrate their value to users. Also, only a few of the NMHSs proactively market their climate services and products to users. Among the user sectors surveyed, the least served are those from the tourism, transport, and sports and recreation sectors. On matters related to climate change, only half of the NMHSs provide users with risk assessment, risk management, and risk transfer information to accompany climate information.

For education and training (capacity building), training courses and conferences offered through WMO platforms are more utilised than fellowships, e-learning and curriculums. Poor knowledge of the language(s) in which the training programmes were conducted has been the factor to limit staff participation. Of the training courses surveyed (Table 3), all are still in demand despite some of them having already received training offered through WMO or

other organisations. Across all the courses, very few NMHSs have the capacity to conduct the training or provide the expertise themselves.

Majority of the NMHSs feel the need to be more visible and recognised as climate services provider by their government authorities and there is a need to enhance the understanding of the socio-economic benefit from the use of climate services. There are also opportunities for improving organisational structure and roles with respect to climate services. In countries where the meteorological and hydrological services are separate, the need is recognised for better coordination and administrative arrangements between the two agencies.

Several key sources of gaps in generating and delivering climate products and services were highlighted. Commonly cited sources are (1) lack of staff and their training, (2) limited computing facilities, network equipment and instruments, as well as (3) the lack of accessible (local, regional and international) observations and model data and (4) the associated quality control activities. There are also opportunities for improvements in engagement with users by enhancing their awareness through dedicated training programmes.

Introduction

The World Meteorological Organization (WMO) Regional Association V (RA V) Working Group on Climate Services (WG CLS) agreed at a meeting held on 2-4 February 2016 in Singapore to *review the current status of climate information and services provided by the National and Meteorological and Hydrological Services (NMHSs) of Southeast Asia*. In line with the implementation of the Global Framework for Climate Services (GFCS), the review aims to establish the baseline status of the region's NMHSs in providing climate information to the user community through identifying gaps and needs for improvements. The outcomes of the review will inform decisions in mobilising resources to the region for capacity-building activities conducted by WMO and thereby helping countries to be more self-sufficient in providing climate information and services in the long-term.

The survey platform and questions were provided by WMO and these were circulated ahead of the Seventh Session of the ASEAN Climate Outlook Forum (ASEANCOF-7) in November 2016 in Manila, Philippines to NMHSs representatives. Preliminary results were presented at the Forum based on provisional responses. Further responses were solicited after the Forum and key findings were summarised in subsequent sections of this report.

Survey Questions

The survey comprised a comprehensive list of questions organised into the following 8 areas:

- Area 1: General information about the Service (Institutional and Legal Framework, Visibility of the Service, and Personnel and Premises)
- Area 2: Observation Network, Data Management, Data Exchange (Operation and Maintenance of National Observing System, Data Exchange, and Data Management)
- Area 3: Climate Products (Dissemination of Products)
- Area 4: Climate Services
- Area 5: Research
- Area 6: User Interface (Communicating Climate Information to Users)
- Area 7: Capacity Building (Education and Training, and Training Courses)
- Area 8: Gaps and Needs

In what follows, the responses to questions in each section were analysed and key conclusions were drawn. A total of 8 countries (Brunei, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam) responded to the survey and instead of providing the details of the responses, the results are presented as broad summaries.

Area 1: General Information about the Service

All respondents indicated that their NMHSs have the mandate to provide climate services in their respective countries and have dedicated units for this purpose. The climate services include sector-specific monitoring and prediction activities for monthly to seasonal timescales. All but one organisation have the sole authority for providing climate services and half of the responses specified that there are other private or commercial entities providing climate services and meteorological or hydrological observations. In providing their services, all NMHSs maintain links with international and regional organisations such as through WMO Climate Outlook Forums or through bilateral cooperations.

Various media channels (e.g. web, press, TV, and radio) are used widely by the NMHSs to disseminate climate information and deliver their services. However, a majority mentioned that the visibility of their services to the general public could be further improved. In terms of infrastructure, all of the respondents indicated that their office space and amenities for the headquarters and specifically the climate unit are marginally or fully adequate with the exception of a few responses indicating space constraints (1 response for the headquarters and two responses for the climate unit).

Area 2: Observation Network (Data Management & Exchange)

Observation network and data accessibility

For observation networks respondents highlighted that, among other operational and maintenance factors, geographical coverage of the observation stations as being the least adequate followed by the number of technical staff available to operate or maintain the observations stations. Availability of technical equipments for the observations stations and the communication means for transmission of data were considered generally adequate. All except one NMHS have reference climatological stations but indicated that the coverage of their stations to be only marginally adequate (average '3' on a scale of '1' to '5').

All NMHSs implement policies to ensure continued improvements of station networks' densities (although these are still considered inadequate as indicated above) and they adhere to climate standards for observations (GCOS¹, climate monitoring principles, CCI²) and instruments for measurement (CIMO³, CBS⁴, CCI). The level of maintenance, calibration and checking of observation instruments (according to the WMO Guide to Meteorological Instruments and Methods of Observations) are considered marginally adequate by most of the respondents. Even though majority of the NMHSs have policies that restrict free and

¹ GCOS: Global Climate Observing System

² CCI: Commission for Climatology

³ CIMO: Commission for Instruments and Methods of Observation

⁴ CBS: Commission for Basic Systems

open-sharing of meteorological data, over 300 SYNOP, 100 CLIMAT, and 50 TEMP stations across the region are shared on the Global Telecommunication System (GTS) network. Historical and real-time data are provided freely on the GCOS Surface Network (GSN) site or to the WMO Regional Climate Centres (RCCs) for all except two NMHSs. Only half of the NMHSs mentioned the capability to design and implement large scale (regional or global) remote sensing and other observation systems (e.g. satellite and buoys) and less than half develop and manage regional or global specialised climate databases and archives. A majority of the NMHSs have access to observation data from neighbouring countries and all respondents highlighted that they have access to gridded interpolated data, satellite data, reanalyses data and model data, e.g. from Regional Climate Models (RCMs) and Global Climate Models (GCM).

Among the 10 station variables surveyed, none of the NMHSs has stations with more than 70 years of records (Table 1). Only half of the NMHSs have stations with records that are more than 50 years and these stations make up only a small percentage (approximately 20%) of the total number of stations. Of the 10 variables, Table 1 also shows that the surface radiation budget and water vapour density variables have the least number of stations available. All other variables have comparable numbers of observing stations.

Meteorological Variables	Length of Station Records in Years								
	<30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	>100
Precipitation	30.3	14.0	15.5	8.0	4.9	0.0	0.0	0.0	0.3
Temperature max	23.8	12.5	14.4	8.7	4.6	0.0	0.0	0.0	0.0
Temperature mean	23.8	12.5	14.4	8.7	4.6	0.0	0.0	0.0	0.0
Temperature min	23.8	12.5	14.4	8.7	4.6	0.0	0.0	0.0	0.0
Wind direction	23.9	12.5	14.3	8.7	4.6	0.0	0.0	0.0	0.0
Wind speed	23.9	12.5	14.3	8.7	4.6	0.0	0.0	0.0	0.0
Relative humidity	23.8	12.5	14.4	8.7	4.5	0.0	0.0	0.0	0.0
Pressure	23.0	12.5	14.3	8.7	4.6	0.0	0.0	0.0	0.0
Surface radiation budget	7.6	4.8	8.9	2.4	0.0	0.0	0.0	0.0	0.0
Water vapor density	2.6	0.3	0.5	0.0	0.1	0.0	0.0	0.0	0.0

Table 1: Average number of stations across the region partitioned by meteorological variables ordered from most common (top) to least common (bottom), and by length of station records (years) ordered from shortest (left) to longest (right). Warm (red) shades indicate larger number of stations among NMHSs while cool (green) shades indicate fewer stations.

Climate database and data rescue

All NMHSs implement climate database systems using a variety of software combinations and hardware configurations. These databases are password protected and implement firewall security and have adequate backup and quality-control policies in place.

Just over half the respondents indicate that homogeneity tests (manually or automatically) are performed on their data. All NMHSs conduct data rescue activities and respondents indicate that current activities only marginally meet the needs of their NMHSs in data rescue. Approximately half of data available are stored in modern electronic data and the remaining are in the process of being digitised. For staff performing data management and data rescue, a majority received relevant training and education.

Area 3: Climate Products (Dissemination of Products)

Products provided

All NMHSs have dedicated units to generate and deliver climate products for use nationally. Of the 27 products that were surveyed (Annex A), historical oceanic (product 17 in Annex A), global seasonal climate updates (14), reanalysis (23), and global and hemispheric analyses (13) datasets are the least common with only one-third of the NMHSs providing. These are followed by historical terrestrial (18), gridded/interpolated data (15), application products (5), and satellite data (25) for which half the NMHSs provide. Most, if not all of the NMHSs, provide all the other products surveyed.

Capacities in delivering the products

The participants were also asked on the level of capacities for delivery of the products in terms of the (a) communication means, (b) personnel, (c) software/tool and (d) computing capacities. On average (over all the products listed in Annex A), participants indicated in the order of least to most adequate capacities: *communication means*, *software tool*, *personnel*, and *computing capacities* (Chart 1).

Of the commonly provided products referred to in Annex A, the top 5 products that were specified to have fairly adequate capacities are:

- Basic statistics on climate extremes (e.g. for temperature, precipitation, humidity, sunshine duration, etc.) frequency of occurrence, spatial mean
- Historical atmospheric datasets
- Monthly seasonal outlooks
- Spatial patterns of temperature, precipitation, etc. their anomalies, climatic zoning
- Climate summaries, bulletins, reports, drought/flood, other special statements for severe weather

At the other end, the top 5 products identified with inadequate capacities are:

- Information related to the uncertainties, skill, etc. of monthly to seasonal climate forecasts
- ENSO, SST and intraseasonal variability products
- Downscaled global climate change projections
- Review and assessment of past climate patterns
- National scale monthly and seasonal climate forecasts and outlooks in probabilistic format

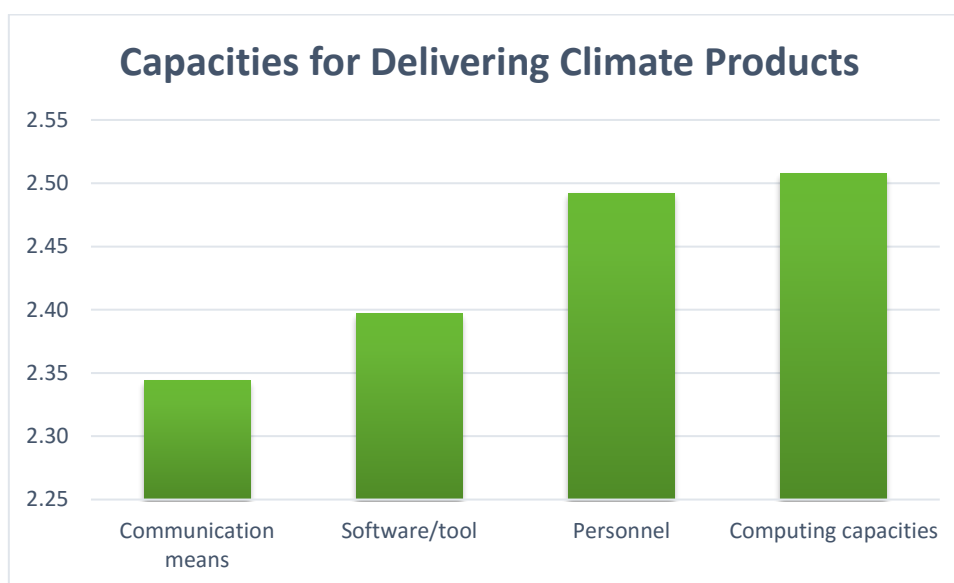


Chart 1: Average adequacy in capacities for delivery of the products averaged across all products and all NMHSs from scale 1 (lowest adequacy) to 5 (highest adequacy).

Dissemination of the products

All of the NMHSs disseminate their products in a variety of formats (data tables, flat files, maps, images, graphs, diagrams, text description) with one of the respondents also indicating the use of 'infographic and simplified materials'. Emails and websites are more popular modes of dissemination, although facsimile, hardcopies of printouts, FTP, and recorded media (e.g. CDs and DVDs) are still extensively used.

Area 4: Climate Services

Services provided

Respondents were also surveyed on a list of 28 potential services (Annex B). The least commonly provided were high density, small scale specialized data resources (product 23 in Annex B), sophisticated climatological statistics (28), and development and provision of decadal scale products (9) with less than half the NMHSs providing. These are followed by (with just over half of the NMHSs providing) the leading and coordination of RCOF (18), sharing/exchanging information, products, services to other countries in the region (27), homogeneity test and adjustment of time series (14), running Global and/or Regional Climate

Models (26), and interpolation/gridding of observation data (16). The rest of the products in Annex B are fairly common among the NMHSs.

Capacities in delivering the services

The responses on capacities in delivering services are similar to that of delivering products (previous section) where the least adequate to most adequate capacities are: *communication means, software, personnel, and computing facilities*. Of the commonly available services referred to in Annex B, the top 5 products (Chart 2) that were considered to have fairly adequate capacities are:

- Development and provision of prediction products on monthly scale
- Participation in and contribution to RCOF
- Development and provision of prediction products on seasonal scale
- Provision of simple statistics based on observed data
- Development and provision of specialized climate analysis, prediction and monitoring products, tailored to the needs of specific users

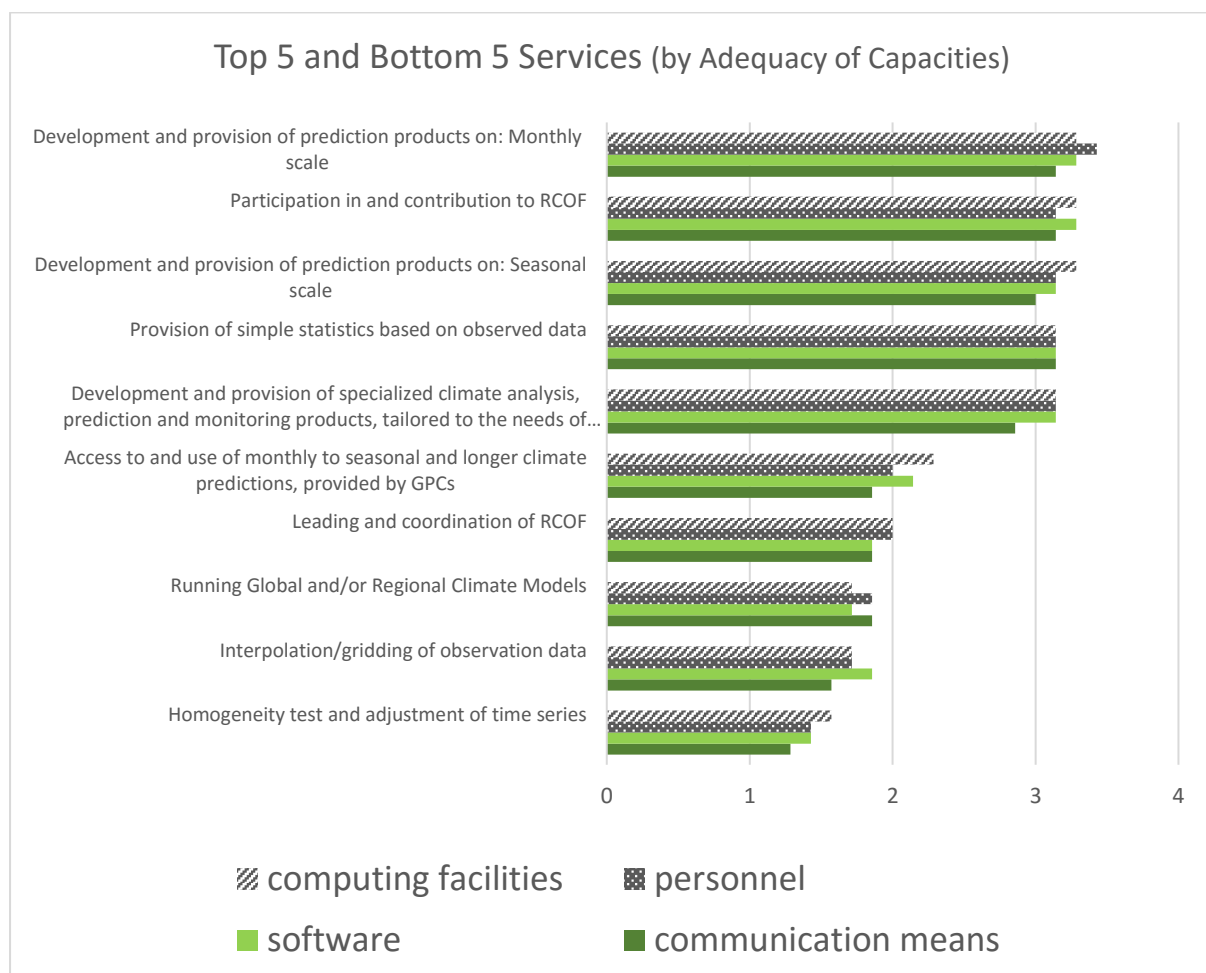


Chart 2: Average adequacies of capacities across NMHSs in the various capacity categories for top 5 and bottom 5 services from scale 1 (lowest adequacy) to 5 (highest adequacy).

At the other end, the top 5 products identified with less than adequate capacities are:

- Access to and use of monthly to seasonal and longer climate predictions, provided by GPCs
- Leading and coordination of RCOF
- Running Global and/or Regional Climate Models
- Interpolation/gridding of observation data
- Homogeneity test and adjustment of time series

Area 5: Research

Research capacity

All respondents indicated that their NMHSs are mandated to carry out research, and all but one have dedicated units for that. In these units, a majority of the NMHSs have more staff who are either BSc or MSc degree holders than PhD holders.

Accessible resources

All NMHSs have links with *national* research organizations, institutions, and universities for conducting research, and all but one have links with *regional* research organisations. A majority of the NMHSs have access to online research literature sources, but only 2 NMHSs consider the access level to be adequate. Majority of the NMHSs conduct, initiate, or participate in research projects and are also involved in preparation of the National Communication under the UNFCCC⁵. Common contributions to the National Communication include statistical assessments, analysis, climate change scenarios, but not vulnerability assessment. Most of the NMHSs considered their computing resources in research to be only marginally adequate, and less adequate in the areas of models, software and human resources.

Research activities

A majority of the NMHSs lead or contribute to national, regional and global research projects to (1) improve understanding of the climate system, (2) better prediction and projection skills (e.g. for tropical and extratropical latitudes), and (3) understanding and communicating uncertainty in climate prediction. Few organisations undertake research to assess the impacts of reductions in surface or upper air observations, and the impact of automation of measurements. In the area of applied climate research, most of the NMHSs undertake research to understand the links between climate and agriculture, health and water but not tourism (Chart 3). Other areas of research activities that respondents noted are the links between climate and environment, energy, or socio-economic impacts. A majority of the NMHSs are also involved in the development of new methods and tools for climate services but only half partake in model development activities.

⁵ United Nations Framework on Convention on Climate Change

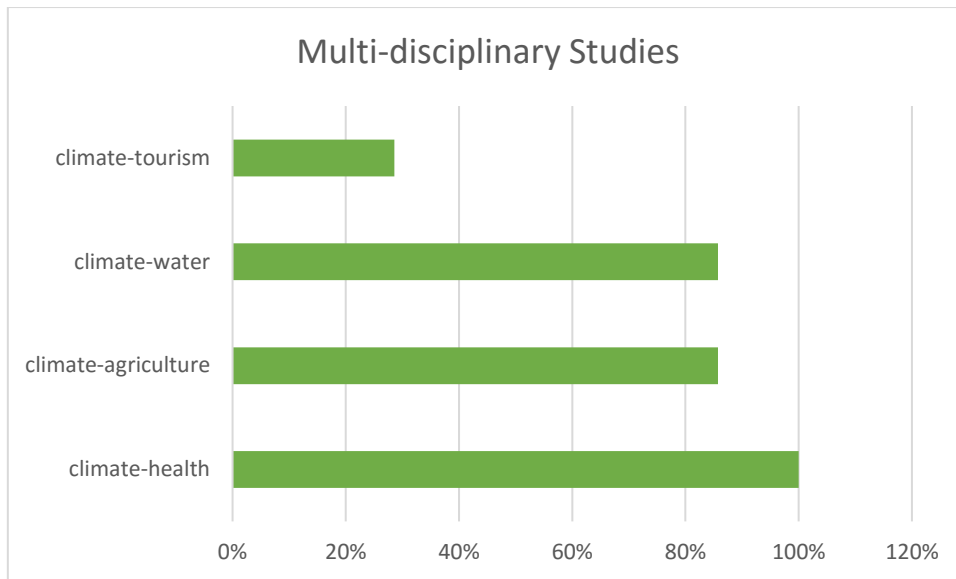


Chart 3: Percentage of NMHSs who take part in multi-disciplinary studies linking climate and downstream applications.

Area 6: User Interface (Communicating Climate Information to Users)

Interaction with users

All of the NMHSs have dedicated units to interact with users to provide climate services and information although one of them do not have a mandate to interact with them. The respondents indicated that these units are either marginally or fairly equipped with capabilities to interact with users.

NMHSs typically get the information on user needs from the users directly (who came with specific requests or problems), through surveys and forums, and through WMO mechanisms such as RCOFs and NCOFs. Only one of the NMHSs gets information on users' needs through regular study of the market.

For interactions with users, the factors common among NMHSs that drive the need for continuous engagement are: (1) to meet the user requests and identify their requirements for climate information, (2) to gather their feedback on the usefulness and effectiveness of the information provided, and (3) also to provide advice and guidance in the interpretation and application of their products. Only a few NMHSs market their climate services and products to users proactively and none except one of the NMHSs conduct socio-economic study of the climate services to demonstrate the value of their products to the users.

All respondents indicated that their NMHSs have mechanisms to facilitate interactions with their countries' media during periods of high risk for potential climate extremes, and they seek to enhance awareness on the available climate services and products. A majority of the NMHSs also implement NCOFs as a mechanism for interacting with users, enhance their

awareness, and provide tailored information for specific user groups. All of them also participate in RCOFs to communicate seasonal outlooks to users.

On the climate change front, all but one of the NMHSs promote societal awareness of climate change issues and all provide climate information to policy development and National Action Plan. In communicating this information, only half of the NMHSs provide users with risk assessment, risk management and the guidance for risk transfer to downstream applications.

User sectors and information provided

Respondents were asked on the user sectors that they serve. Out of those that were listed (Annex C), transport and tourism are the sectors served by only a few NMHSs while the other sectors were covered by a majority of the NMHSs. The respondents were also asked to rank the sectors. The top 3 sectors considered most important are emergency planning and response, government, and water resources while the bottom 3 are tourism, transport and sports and recreation (Chart 4).

User-sectors (ranking by importance)

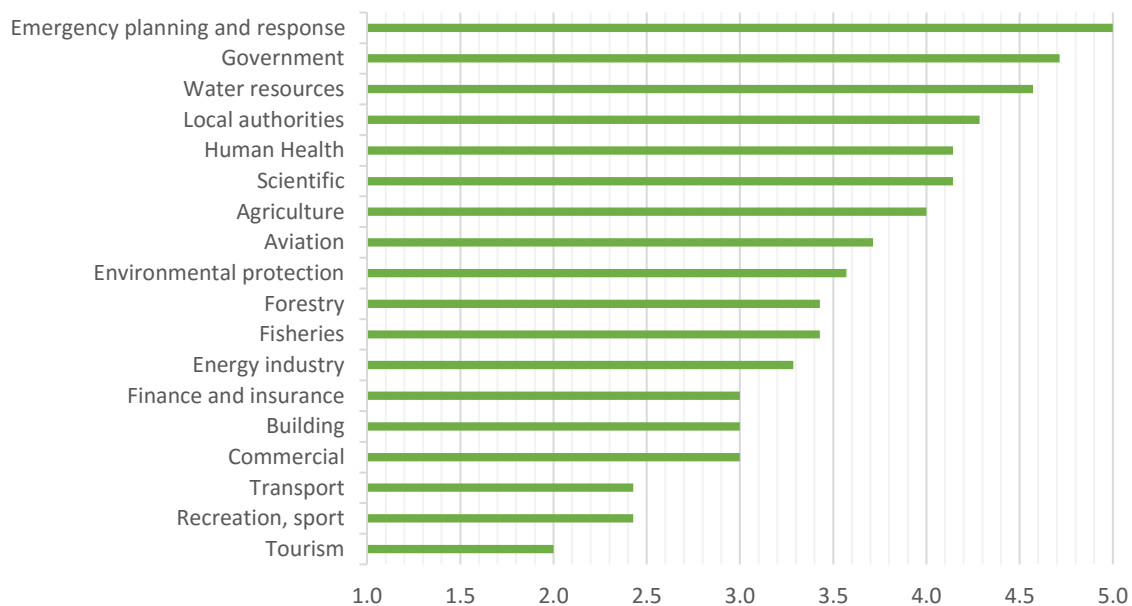


Chart 4: Average ranking across NMHSs of user sectors based on importance on the scale of 1 (“least important”) to 5 (“most important”).

Based on the number of NMHSs providing specific services to the different sectors (Table 2), data services are most common, followed by (seasonal) climate predictions and climate monitoring (from left to right in Table 2) and generally applies across all sectors (from top to bottom in Table 2). Climate change projections and tailored products are relatively less

common for a majority of the sectors except for water resources, government, and emergency planning and response.

Sectors	Services					
	Data services	(Seasonal) Climate predictions	Climate monitoring	Climate analysis & diagnostics	Tailored products	Climate change projections
Water resources	7	6	7	6	6	6
Government	6	7	6	6	7	5
Emergency planning and response	7	6	6	6	5	5
Human Health	7	7	6	6	5	4
Local authorities	6	7	6	6	5	5
Agriculture	6	6	6	5	6	5
Scientific	7	5	6	5	5	6
Environmental protection	6	6	4	5	5	5
Energy industry	6	5	5	5	3	4
Forestry	6	5	5	5	2	4
Fisheries	6	4	6	4	3	3
Commercial	5	4	5	4	4	2
Building	6	4	3	4	2	2
Finance and insurance	6	4	3	3	2	3
Transport	5	4	4	3	2	3
Aviation	6	3	2	3	4	2
Tourism	4	4	3	3	2	2
Recreation, sport	5	4	2	3	1	1

Table 2: Number of NMHSs providing climate services partitioned by sectors ordered, according to the total number for each row, from most common (top) to least common (bottom) and by services ordered, according to the total number for each column, from most common (left) to least common (right). Warm (red) shades indicate more commonality between NMHS while cool (green) shades indicate less commonality.

Area 7: Capacity Building (Education and Training Courses)

Education and training

Respondents were asked on the types of courses available in the universities of their countries. Geography was most commonly offered, followed by agro-meteorology, meteorology, hydrology, climatology, and then atmospheric physics being the least common. For most of these courses, PhD level is more common than MSc or BSc.

All of the NMHSs have policies to build capacity of their staff and to continuously renew their qualifications. Their observers are also trained and certified in order to make observations to the required standard. All of them also utilise regional and international training programmes offered through WMO. Of the training programme types available, training courses, and

conferences were well-utilised by all of the NMHS but fellowships, e-learning, and curriculums were not as commonly utilised. Almost half of the NMHSs indicated that there are personnel involved in climate activities who are not able to participate in the regional or international training programmes due to poor knowledge of the language in which the trainings were conducted.

Only two the NMHSs are host to the WMO Regional Training Centre (RTC). All except one have training programmes for user communities but just over half of the NMHSs felt that these programmes meet their current user requirements.

Training courses

The subsequent questions covered on the type of training courses, and the current level of capacity of NMHSs, i.e. either (1) already conducting the training or providing the expertise themselves, (2) currently undergoing training, or (3) requires training to build capacity in those aspects. Table 3 indicates that there is still demand from NMHSs for all the training courses to be conducted despite some of them having already received training offered by WMO or other international/regional organisations, or through internal capacity building programme of the NMHSs. Across all courses, generally very few activities where the NMHSs themselves conduct the training or provide the expertise.

Courses	Capacity Level			
	Require training on the courses listed	Received training during last "n" years, offered by WMO or other international/regional organization	Receives ongoing training through internal capacity building programme of NMHS	Conducts or provides expertise to training for national and international participants
Basic climate analysis	7	7	6	5
Data management	7	6	7	4
Preliminary training for use of climate prediction products	7	7	6	3
Basic downscaling techniques	7	7	5	3
Climate services, incl. seasonal prediction	7	7	5	3
Fundamentals for climatology	6	7	5	4
Advanced techniques for climate applications, monitoring	7	5	5	3
Advanced techniques for climate prediction, projection	6	5	5	4
Advanced modelling and statistical procedures	6	5	5	3
Data rescue	6	5	4	4
Quality Management Framework (QMF) principles	6	5	4	2
Applied climate practices	6	5	4	1
Methods of time series homogeneity control	6	3	3	3

Table 3: Number of NMHSs requiring or providing climate services partitioned by training type ordered, according to the total number for each row, from most common (top) to least common (bottom) and by

capacity level ordered according to the total number for each column. Warm (red) shades indicate more commonality between NMHSs while cool (green) shades indicate less commonality.

Popular courses are basic climate analysis, data management, preliminary training for use of climate prediction products, basic downscaling techniques, climate services (including seasonal prediction), and fundamentals for climatology.

Technical capacities and telecommunication

Respondents indicated that personnel involved in climate activities are either marginally or adequately equipped with computers, and computing facilities of the climate unit are upgraded around every 5-7 years. Current computing facilities are thought to be either partially or fully adequate for their needs. For PCs and workstations, they are upgraded over a wider range of frequencies across NMHS, from every 2 to every 10 years. Internet connection available at each NMHSs can range from 2 Mbps to 200 Mbps and a majority have either unlimited or limited access to the internet.

The gaps and needs identified in technical capacities include efficient network management, integrated High Performance Computing system, development of gridded precipitation and temperature data for climate monitoring and prediction, high speed internet connection, skilled staff, advanced climate model, applications, and training.

Area 8: Gaps and Needs

Organisational structure

A majority of the NMHSs noted that there is a need for them to be more visible and recognised as a climate services provider by their government authorities and there is a lack of understanding at the ministerial level of the socio-economic benefits from the use of climate services. More than half of the NMHSs indicated that there is a lack of policies regarding their role in providing climate services and there is a need to improve their organisational structure.

All but two of the NMHSs have their hydrological services separate from their meteorological service. NMHSs recognised that there is a need to strengthen the partnership agreements to define the roles of each service and there is a need for better administrative arrangements and coordination between the two agencies.

Sources of gaps

A majority of the NMHSs indicated that there are limited resources and infrastructure to generate climate products and provide better climate services. Key to these gaps are financial resources, professional staff with appropriate training, application software, communication facilities, computing facilities (not available for all the staff), methodological guidance, and network equipment. A majority of the NMHSs also indicated that there are gaps in available data which limit their ability to generate climate products. These gaps arose mainly from lack of homogenisation of time series, professional staff with appropriate training for quality

control and for handling data, availability of appropriate software, limited access to global and/or regional data, and limited computing facilities. A majority of the NMHSs also felt that there is a lack of appropriate observing network (reference stations) which limits the provision of climate products and services. These are due to financial resources, limited number (or absence) of stations which meet the requirements of a climate reference network, limited human resources (trained observers, personnel maintaining AWS, etc.), poor spatial coverage of observation networks, and limited technical resources (e.g. replacement parts and new instruments) for maintaining the networks. Less than half of the NMHSs indicated that the lack of appropriate database management limits the production of climate products.

A majority of the NMHSs also indicated that:

- they have limited human capacities to deal with climate services,
- there is a lack of appropriate training of their staff which reduces the effectiveness and quality of climate services and products,
- there is a lack of interaction with users which limit the effectiveness of the use of climate information,
- there is lack of users' awareness on the value of climate information which limits the use of this information,
- there is the lack of appropriate training programme for users which limits their understanding on the application of climate information, and
- they have limited physical resources (building, infrastructure, and technical capacities) for climate services unit.

Of the areas that need staff recruitment, data management, products, interaction with users, and climate services were common requirements among NMHSs. Only 2 of the NMHSs cited the need for recruitment in the area of research and development. An additional recruitment area suggested are in regional climate modelling and dynamical downscaling.

Annex A

Products surveyed

The surveyed products as they appear in the questionnaire are:

- Monthly - Seasonal outlooks
- Advanced climate statistics and graphical products (including maps, analysis and graphs of precipitation, temperature, relative humidity, evapotranspiration, sunshine duration, cyclones etc.)
- Advisories on the evolving climate extremes
- Analysis and interpretation of climate statements or products for general public or specific users
- Application products, e.g. probable maximum precipitation, probable maximum floods, intensity duration frequency, etc.
- Assessment of current (monthly) climate conditions in terms of averages, variance, thresholds, percentiles in weekly, 10-days, monthly, seasonal and annual time scale
- Basic assessments and analysis (diagnostics) of spatial and temporal factors and processes involved in observed climate patterns (e.g. tropical cyclones, monsoon, synoptic scale storms etc.)
- Basic statistics on climate extremes (e.g. for temperature, precipitation, humidity, sunshine duration, etc.) frequency of occurrence, spatial mean
- Climate summaries, bulletins, reports, drought/flood, other special statements for severe weather
- CLIMATE WATCH Analysis on climate extremes, maps, graphs, images (e.g. satellite)
- Downscaled global climate change projections (based on model outputs through WCRP CMIP archives)
- ENSO, SST and intraseasonal variability products
- Global and hemispheric MSLP analysis, geopotential height, etc.
- Global Seasonal Climate updates
- Gridded/interpolated data
- Historical datasets for: Atmospheric
- Historical datasets for: Oceanic
- Historical datasets for: Terrestrial observation
- Information related to the uncertainties, skill, etc. of monthly to seasonal climate forecasts
- Model data
- National scale monthly and seasonal climate forecasts and outlooks in probabilistic format
- Products derived from satellite data for monitoring activities
- Reanalysis

- Review and assessment of past climate patterns, e.g. WMO reports on the State of Climate
- Satellite data
- Spatial patterns of temperature, precipitation, etc. their anomalies, climatic zoning
- Tailored products for national scale users.

Annex B

Services surveyed

The surveyed services as they appear in the questionnaire are:

1. Access to and use of monthly to seasonal and longer climate predictions, provided by GPCs
2. Access to and use of monthly to seasonal and longer climate predictions, provided by RCCs
3. Access to and use of monthly to seasonal and longer climate predictions, provided by RCOFs
4. Add value from national perspective to the products received from RCOFs, RCCs and GPCs
5. Advanced climate assessments, including analysis and diagnostics
6. Analysis and provision of products relevant to El Nino and La Nina updates, Global Seasonal Climate Updates (GSCU), containing information on ENSO and other climate extremes and variations driving phenomena, e.g. NAO, PNA, IOD, etc.
7. Applying dynamical and/or statistical downscaling of GCM runs
8. Basic climate monitoring, assessment
9. Development and provision of prediction products on: Decadal scale
10. Development and provision of prediction products on: Monthly scale
11. Development and provision of prediction products on: Seasonal scale
12. Development and provision of specialized climate analysis, prediction and monitoring products, tailored to the needs of specific users
13. Development and/or interpretation of climate change scenarios
14. Homogeneity test and adjustment of time series
15. Implementation of Climate Watch System, issuing and disseminating specific advisories to the user community
16. Interpolation/gridding of observation data
17. Leading and coordination of NCOF
18. Leading and coordination of RCOF
19. Participation in and contribution to NCOF
20. Participation in and contribution to RCOF
21. Provision of data services (if permitted under the current legislation of the Service),
22. Provision of global and/or regional scale data resources as input to modelling, research, applications
23. Provision of high density, small scale specialized data resources used for studies of small scale processes, urban environment
24. Provision of satellite and other global and regional scale monitoring products
25. Provision of simple statistics based on observed data
26. Running Global and/or Regional Climate Models

27. Sharing/exchanging information, products, services to other countries in the region, during the periods of significant climate anomalies
28. Sophisticated climatological statistics, incl. indices for specific users, complex characteristics for building design codes, etc.

Annex C

Sectors surveyed

The surveyed sectors as they appear in the questionnaire are:

1. Government
2. Local authorities
3. Scientific
4. Commercial
5. Water resources
6. Agriculture
7. Fisheries
8. Forestry
9. Transport
10. Energy industry
11. Human Health
12. Tourism,
13. Recreation, sport
14. Aviation
15. Environmental protection
16. Building
17. Finance and insurance
18. Emergency planning and response.