

# **ASSESSMENT REPORT**

## **ASSESSMENT OF CAPACITIES AND NEEDS OF PROVIDERS (NATIONAL CENTER FOR HYDROLOGY AND METEOROLOGY) AND USERS (AGRICULTURE SECTOR) FOR CLIMATE SERVICES**

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## **Executive Summary**

Bhutan is an agrarian country. According to the Department of Agriculture (DoA), Ministry of Agriculture and Forests, the farming environment spreads from the warm subtropical to the cool alpine climatic zones and engages more than 69% of the total population. 8% of the entire geographic area of the country is the arable land of which, irrigated comprises 18%, and more than 70% is under rainfed or dryland cultivation. Rice and maize are prominent cereal crops while essential cash crops include potato, vegetables, citrus, and apple. Bhutan's agriculture sector is highly exposed to the vagaries of weather and climate system. Also, with climate change, the frequency and intensity of extreme events are expected to increase. Therefore, provision of timely, reliable and accurate climate services to the users of the agriculture sector has become critical.

Provision of climate services to minimise the impact of the climate-related disaster in agriculture is imperative; it is also equally important to understand the capacities and needs of both climate services providers and users. Subsequently, the National Center for Hydrology and Meteorology under the aegis of the World Meteorological Organization (WMO) has organized a stakeholder workshop to assess the capacities and needs of providers and users of climate services in support of decision-making by the agriculture sector in Bhutan in Thimphu, Bhutan during 7-9 November 2017. The stakeholder workshop brought together participants mainly from Department of Agriculture, Department of Disaster Management, Educational Institutes, Media Houses, Donor Agencies (World Bank, JICA, UNDP) and NCHM. The workshop focused on providing awareness of climate services for agriculture which are available at global, regional and national scales. At the same time, the workshop emphasised on understanding the requirements of Bhutanese agricultural sector users through group discussions and consultations with individual participants.

## **Scope and Objective**

The primary objective of this report is to assess the capacities and needs of providers (NCHM) and users (agriculture sector) of climate services in Bhutan. The analysis is based on the outcomes and recommendations of stakeholder workshop to assess the capacities and needs of providers and users of climate services in support of decision-making by the agriculture sector in Bhutan. This report proposes a roadmap to carry out some of the

requirements of NCHM and DoA within the phase of WMO Canada Project on GFCS and some long-term recommendations which are to be implemented over 2-5 years.

### **Approach and Process**

The report starts with the analysis of capacities and needs of NCHM and DoA. The capacities and requirements of both NCHM and DoA were studied in-depth based on the outcomes and recommendations of the stakeholder workshop to assess the capabilities and needs of providers and users of climate services in support of decision-making by the agriculture sector in Bhutan in Thimphu, Bhutan during 7-9 November 2017. At the same time, the extensive consultations were carried out with the workshop participants of both NCHM and DoA. The participants mainly from DoA comprised of different agriculture professionals working at various levels such as Policy Level, Research Centers, Extensions and Community Level.

## **Recommendations and Road Map**

Development of climate services and use of the said services should be a continuous process. Both NCHM and DoA are still at the starting point of providing climate services and using of services mentioned above. This task entails both agencies to work in close coordination. While the process should continue over a long run, some of the urgent actions must be undertaken in short to medium term.

### **Short-term actions (Deliverable within Phase of WMO Canada Project on GFCS)**

#### **i. Data Rescue and Assessment of Climate Data Management systems (CDMS)**

It is recognised that consistent and quality climate data is indispensable for efficient generation of accurate and reliable climate products and services. At the same time, a stable and secure climate data management system is crucial for archival and dissemination of quality climate data. Data quality was one of the leading issues raised and discussed during the workshop between NCHM and the agriculture stakeholders. To aid this process, the NCHM will formally seek the assistance of WMO both financially and technically.

The NCHM should plan the works in close coordination with WMO to ensure that the data rescue and establishment of CMDS are completed successfully and delivered before the end of March 2018.

#### **ii. Customization of Climate Services Toolkit**

WMO has already developed a web portal for Climate Services Toolkit (CST) under GFCS activities. However, for efficient use of CST in Bhutan, there is a need to customize some of the toolkits for Bhutan. For instance, a seasonal climate prediction toolkit is tailored for Bhutan, which allows NCHM to upload the local data and compare with global data in a single window. This customization of CST will enable NCHM to generate sector-specific climate products and services. To speed up the process of customization of climate services toolkit for Bhutan, NCHM should immediately seek the financial and technical assistance from WMO. Both NCHM and WMO should ensure that the customization of CST should be sustainable in the long run.

### **iii. Capacity development of NCHM and DoA**

Limited knowledge and skill in the generation of climate services and analysis and practical use of climate services are one of the drawbacks of both NCHM and DoA respectively. The workshops are being organised by NCHM to build the capacity of the agriculture sector, and this should continue. In this context, that WMO could support the capacity development training workshops and seminars for both NCHM and DoA in Bhutan or outside Bhutan within the phase of WMO Canada Project on GFCS.

### **iv. Climate data and product sharing by IMD and RIMES**

Climate products and services available with India Meteorological Department (IMD), New Delhi, were presented, and their use in Bhutan was discussed at length during the workshop. While IMD share some of the climate information services on the website, it is not sufficient for Bhutan. Therefore, NCHM should prepare a list of immediate data and products/services requirement from IMD and should route the request through WMO. WMO shall assist in expediting data and product sharing from IMD.

NCHM will also request the sharing of ECMWF data available with Regional Integrated Multi-Hazard Early Warning System (RIMES), Bangkok to Bhutan. To aid this process, NCHM will formally write to RIMES on this matter.

### **Other medium-term and long-term actions**

#### **i. Establish the medium and extended range forecasting**

Through the discussions during the workshop and consultation with individual participants, there is a high demand for medium and extended range forecast products. The availability of such products will help DoA in more effective planning and decision making. NCHM should explore with IMD and Regional Climate Centers of WMO for possible assistance in the development of medium and extended range weather forecasting for Bhutan. Plans are already in place for NCHM to start extended range weather forecasting. Extended range forecasting should be fully operational with trained staffs and necessary infrastructures.

## **ii.Strengthen the capacity of NHCM in delivering climate services**

Delivering climate services to agriculture sector has become an important mandate for NHCM. As NCHM is a relatively new agency and there is a lack of human resource and infrastructures in delivering climate services, it should focus on the development of human resources capacity, knowledge and skill on weather and climate science through short-term and long-term training. Over the long run, NCHM should further carry out analytical work and consultation to assess the strengthening of institutional capacity for climate services both concerning human capacity and infrastructures.

## **iii. Strengthen the capacity of DoA in utilising climate information services**

One of the critical issues that were raised and discussed was the lack of ability of DoA to discern the climate information services that are disseminated by NCHM. For efficient utilization of climate information services and converting them into useful information for decision making, the capacity of DoA needs to be developed. The proposal of establishment of Agro-met Unit under DoA may aid in filling some of the gaps in utilization and understanding of climate services.

## **iv.Use of mobile apps and other social media to disseminate climate information services**

How climate information services are reached out to the farmers and the general public was discussed. Through presentations by some participants and discussions in the group, accessibility to the available climate information services was crucial. The climate information services reach best through use of mobile apps; social media such as Facebook and Wechat and mass media such as newspapers and television. NCHM and DoA should work in collaboration in future for the development of mobile apps so that climate information services are easily accessible by the users.

## **v.Installation of agro-met stations in the vicinity of farming areas**

Through analysis in this report, it was found that most of the existing agro-met stations with NCHM are located in semi-urban areas or away from the farming lands. The stakeholders from agriculture have expressed the need to install agro-met stations in the vicinity of farming areas. NCHM and DoA should work in collaboration to install station based on the

requirement of agriculture. Both agencies need to decide over the long run, how the installation of agro-met stations in required sites can be sustainable.

#### **vi.Training of community representatives in understanding and utilization of climate services**

Through the analysis of this report, it was learnt that even though users have access to climate services, there is lack of skill in the communities to understand and communicate the climate information services. DoA in collaboration with NCHM should look at ways to train community representatives in understanding the climate information services and relate this to their locality for their decision making.

#### **vii.Climate projection data for long term planning and research**

Through the analysis of this report, the requirement of climate projection data in the agriculture sector was discussed. The availability of information on climate variability and climate change will help the agriculture sector in their long term plans and research works. To aid this process, NCHM has to build capacities to deliver climate projection data.

#### **viii.Strengthen the institutional linkages**

Through analysis of this report, the strengthening of institutional linkage between NCHM and DoA is required. A strong institutional linkage between NCHM and DoA will enable proper network planning for agro-meteorological stations; utilization and dissemination of climate information services more effectively and efficiently.



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## 1.Introduction

Bhutan is an agrarian country. The farming environment spreads from the warm subtropical to the cool alpine climatic zones and engages more than 69% of the total population. 8% of the entire geographic area of the country is the arable land of which, 18% is irrigated, and more than 70% is under rainfed or dryland cultivation. Rice and maize are prominent cereal crops while essential cash crops include potato, vegetables, citrus, and apple. Bhutan's agriculture sector is highly exposed to the vagaries of the climate system. Also, with climate change, the frequency and intensity of extreme events are expected to increase. Therefore, provision of timely, reliable and accurate climate services to the users of the agriculture sector has become critical.

Provision of climate services to minimise the impact of the climate-related disaster in agriculture is vital; it is also equally important to understand the capacities and needs of both climate services providers and users. Subsequently, the National Center for Hydrology and Meteorology (NCHM) under the aegis of the World Meteorological Organization(WMO) has organized a **stakeholder workshop to assess the capacities and needs of providers and users of climate services in support of decision-making by the agriculture sector in Bhutan** in Thimphu, Bhutan during 7-9 November 2017. The stakeholder workshop brought together participants mainly from Department of Agriculture (DoA), Ministry of Agriculture and Forests, Department of Disaster Management, Educational Institutes, Media Houses, Donor Agencies (World Bank, JICA, UNDP) and NCHM. This assessment report is one of the outcomes of the workshop as mentioned earlier.

### Scope and objective

The scope and purpose of this Assessment Report are to assess the capacities and needs of providers (NCHM) and users (agriculture sector) of climate services in Bhutan. It is based on the outcomes and recommendations of stakeholder workshop to assess the capacities and needs of providers and users of climate services in support of decision-making by the agriculture sector in Bhutan. Outputs from this assessment report are expected to help NCHM to implement some of the much need actions within the phase of WMO Canada Project on GFCS.

## **Deliverable**

As mentioned in the objective, the outcome of this assessment report is to help in drawing implementation plan to develop a customized Climate Services Toolkit and develop the capacity to deliver operational climate services in support of the agricultural sector in Bhutan.

## **Consultation Partners**

The NCHM and DoA are the main counterparts for this report and more than 25 agriculture professionals, and 15 hydro-meteorological officials were consulted during the workshop.

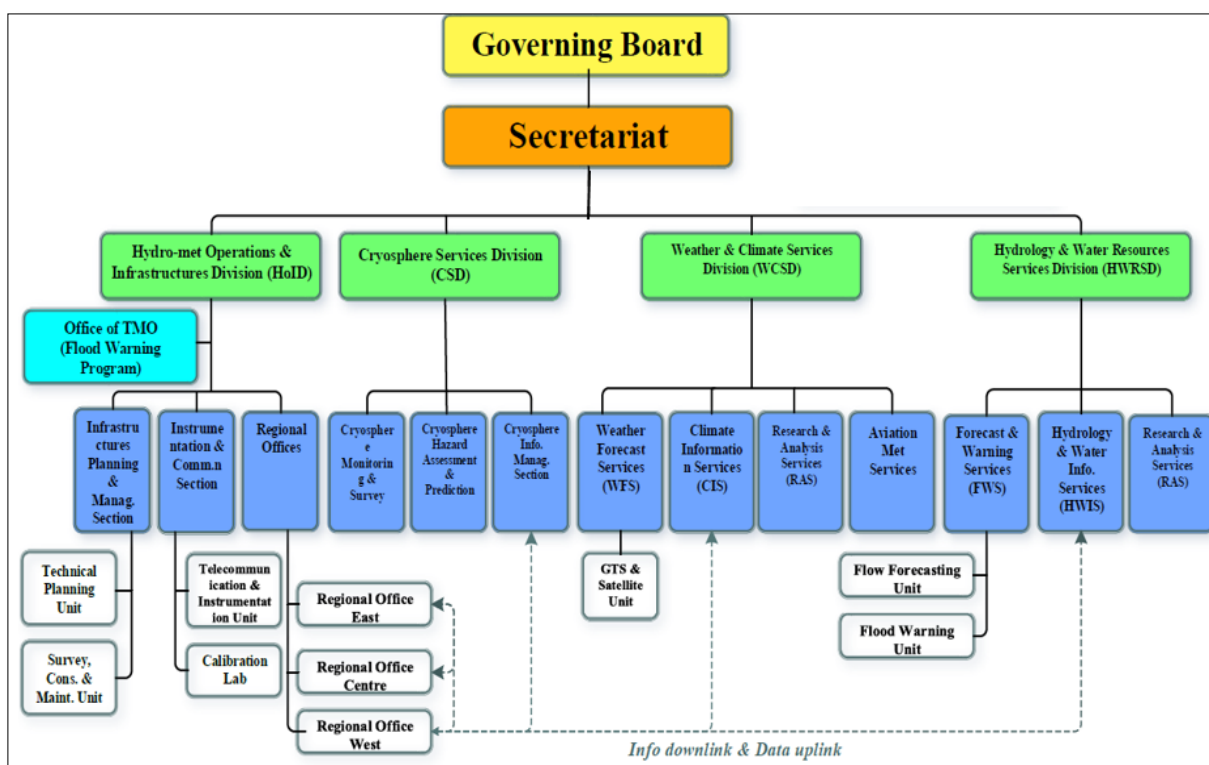
## **Organization of the Report**

Following this introduction, the report assesses the capacities and requirement of NCHM. It is followed by an assessment of capabilities and needs of agriculture and some of the climate services related activities and projects implemented by DoA. Finally, the report outlines the recommendations and the roadmap.

## **2.National Center for Hydrology and Meteorology – Climate Services Provider**

### **Background**

The National Center for Hydrology and Meteorology (NCHM) is the national focal agency responsible for collection and dissemination of information on weather, climate, hydrology, water and Cryosphere (ice, glaciers, snow, etc.). Thus, the center is mandated to provide reliable and timely hydro-meteorological information and services to various agencies, users and the public. Provision of agro-meteorological services or climate services to the agriculture sector is also one of the important mandates of the NCHM.



**Figure 1 Organogram of NCHM**

The NCHM is structured into five divisions: Hydro-met Operations and Infrastructure Division (HOID) which looks after the hydro-meteorological networks and other infrastructures; Cryosphere Services Division (CSD) responsible for generation of products and services on snow, ice and glaciers; Weather and Climate Services Division (WCSD) responsible for providing products and services on weather and climate; Hydrology and Water Resources Services (HWRSD) responsible for delivering products and services on hydrology and water; Information and Communication Services Division provides support on system administration and IT services to the center.

NCHM has reached out to most of the users in providing crucial hydro-meteorological information, and there are still gaps that need to be addressed. Development and strengthening gaps of climate services for agriculture is a priority for NCHM and the stakeholder workshop conducted during 7-9 November 2017 at Jambayang Resort, Thimphu has paved the way to it.

### **Status quo of Functions and Services of NCHM**

As mentioned above, NCHM's primary objective is to provide timely and reliable hydro-meteorological information to agencies, users and the public so that impacts of hydro-

meteorological hazards are reduced to the extent possible. A brief overview of the status of current functions and services provided by NCHM is given below.

- Operation and maintenance of 20 Class A and 59 Class C meteorological stations and 82 Automatic weather stations.
- Operation and maintenance of 16 principal and 9 secondary hydrological stations and 59 Automatic water level stations.
- Operation and maintenance of 14 manual snow stations and 20 (including NAPA II) automatic snow stations (snow incidence and depth, SWE).
- Maintaining inventory of climate data( processing, storing, retrieving and publication) and dissemination to users
- Providing weather forecasts information and warnings
- Providing seasonal climate information
- Managing inventory of hydrological data( processing, storing, retrieving and publication) and dissemination to users
- Providing Early Warning on Glacier Lake Outburst Flood (GLOF) and Rainstorm Flood based on the principle of the water level detection system in three (03) main river basins in Bhutan as follows;
  - ✓ Punatsangchhu River Basin in 2011 under UNDP GEF (NAPA-I Project)
  - ✓ Mandgechhu Basin in 2015 under JICA supported Project
  - ✓ Chamkharchhu Basin in 2015 under JICA supported Project
- Maintaining inventory of glacial and glacial lakes, DGM-ICIMOD 2001.
- Undertaking glacial mass balance studies

## Weather and Climate Services provided by NCHM

At present NCHM uses Weather Research and Forecast (WRF) model and Himawaricast Satellite to produce 1-3 days weather forecasts. Regarding climate forecast, NCHM provides a seasonal forecast for summer monsoon (June-September). Specifically for agriculture, the seasonal forecast is only the primary service provided by NCHM as of now; however, NCHM delivers 1-3 day forecast with warning services to farming during severe weather events. Starting this 2017 winter season, NCHM has begun issuing winter season outlook both for precipitation and temperature. NCHM provides historical climate data to the agriculture sector and publishes annual climate databook.

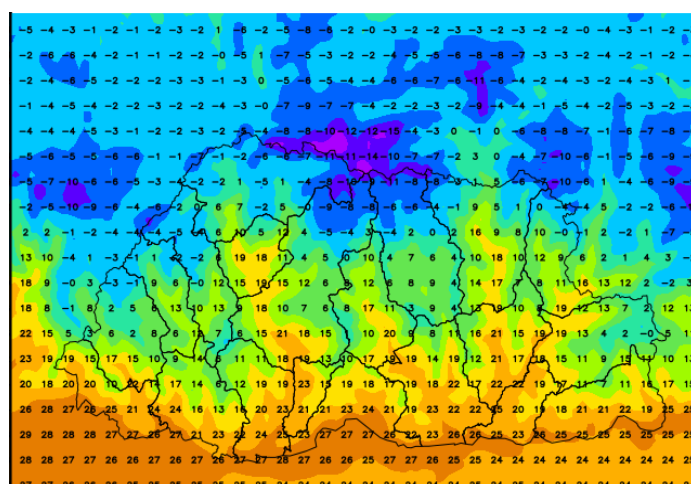


Figure 2 Example of WRF output for weather forecasting (24-72)

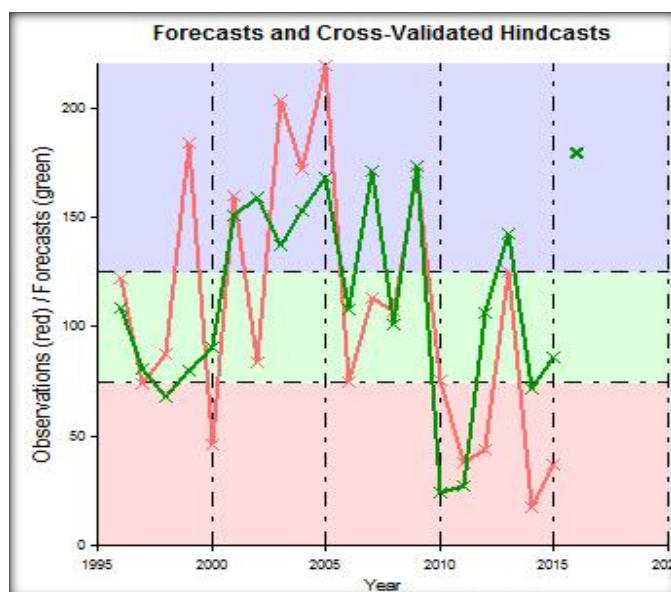
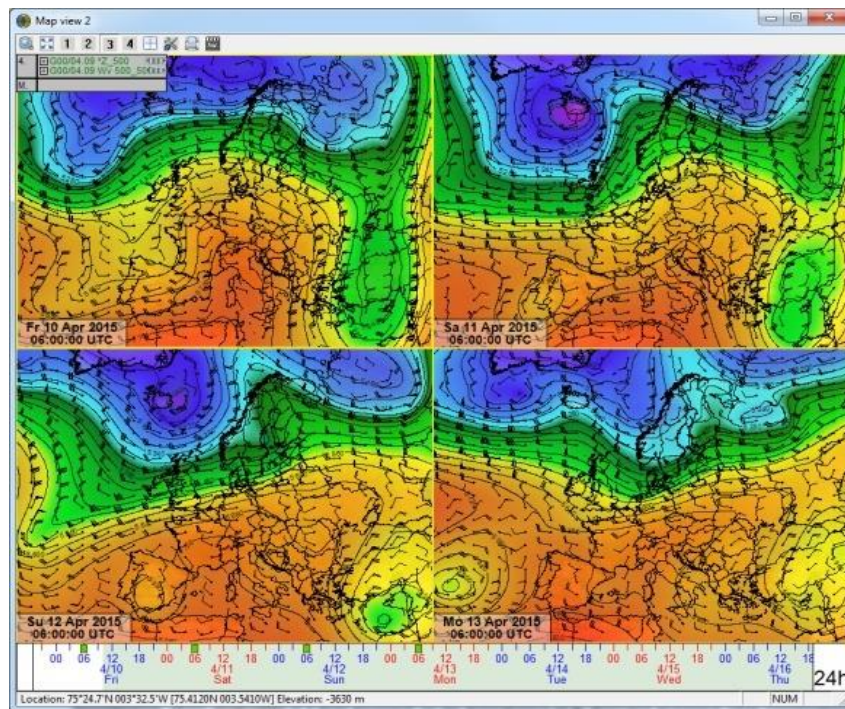


Figure 3 Example of seasonal forecast output

Also, through the help of UNDP funded NAPA-II Project, NCHM has installed a workstation called SMARTMET, which is a product of Finnish Meteorological Institute, Finland. The said workstation is cable of integrating various inputs such as WRF output, observed data, satellite data and image, etc., into one platform and helps the weather forecaster in generating multiple products and services to different sectors. In a nutshell, the SMARTMET functions as a Common Operating Platform (CPO).



**Figure 4 A screenshot of SMARTMET**

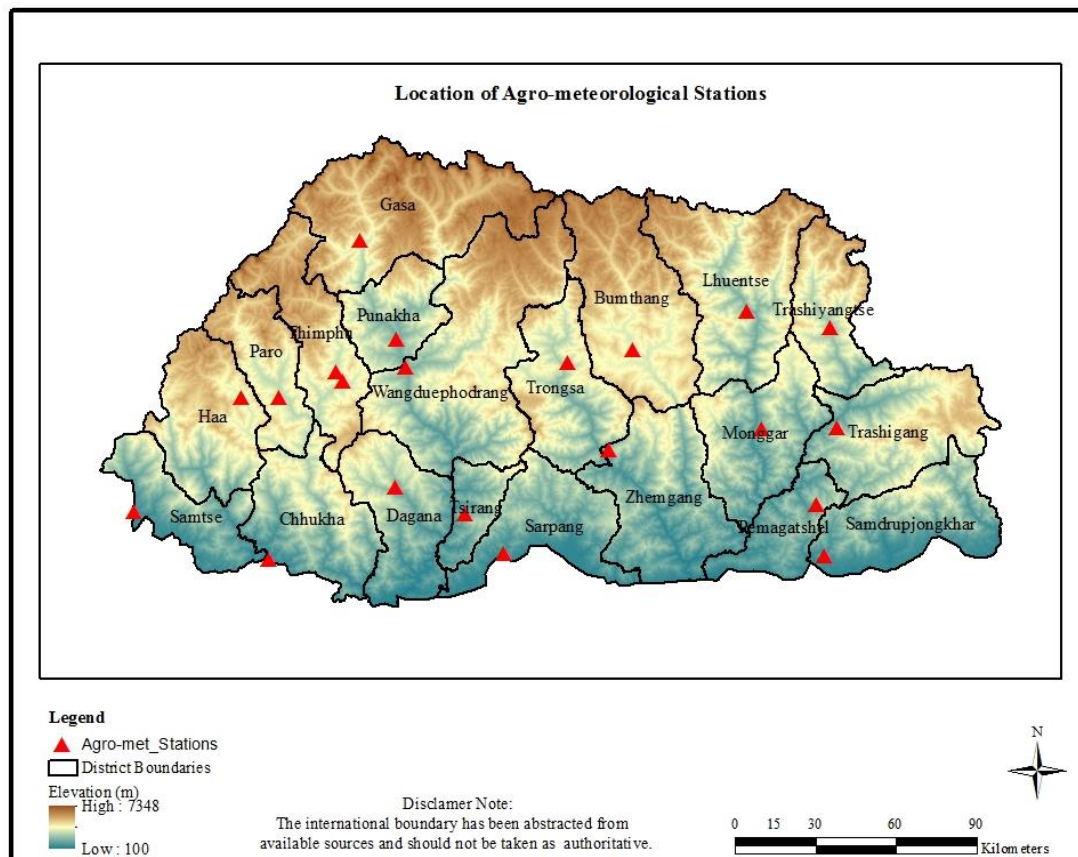


**Figure 5 SMARTMET Work Station**



## Agro-meteorological station network

Currently, NCHM operates and monitors 20 Class A meteorological stations located in each of the 20 districts/dzongkhags of Bhutan. Each of these 20 agro-met stations is regularly monitored by trained meteorological technicians and data are recorded daily. Most of the 20 agro-met stations have data available from 1996 to present (few of them has started collecting data in the early 2000s).



**Figure 6 Location of Agro-meteorological stations**

The following weather variables are observed:

- i. Rainfall
- ii. Temperature
- iii. Relative Humidity
- iv. Wind speed and wind direction (2m)
- v. Sunshine hours
- vi. Soil temperature (5 cm,10cm,15cm)
- vii. Evaporation



The data for the parameters mentioned above are available daily, monthly and annually. The data from the agro-met stations are transferred every month to the Center in Thimphu. Data is archived both in hard copy and in digital format.



**Figure 7 Picture of Class A Meteorological Station**



**Figure 8 Picture of Class C Meteorological Station (records Rainfall & Temperature)**

## **Analysis of capacities and requirements of NCHM**

### **Capacities**

Of the four divisions under NCHM, Weather and Climate Services Division is the main branch in catering the weather and climate services. At present, the division has 17 staff among which 8 of them are officers and rest are meteorological technicians. Of the eight officers 1 has post-doctorate in Climate Science and 2 with master's degree in meteorology, and GIS and Climate respectively. Rest of the officials are undergraduates with different backgrounds in Engineering.

Regarding climate services, the Division is capable of producing and disseminating seasonal climate outlooks. The seasonal forecasts are communicated through National Climate Outlook Forums (NCOFs) and Media. Over the years, the center has noted a high demand for climate service especially seasonal and sub-seasonal forecast from the agriculture sector. Recently, the Division also issued the 2017 Winter Season outlook for both precipitation and temperature.

Also, the NCHM has improved the capacity regarding both human resource skill and technology in weather forecasting. At present, the Division can provide 24-72 hours weather forecast with better accuracy and reliability. The Division also monitors the occurrences of extreme weather events with a lead time of 5 days and over the past few years, the division was successful in providing early warnings of extreme weather events which helped in saving lives and properties. Similarly, such services have helped the agriculture sector immensely.

The Division provides historical climate data and also renders assistance in analysis of climate data for different stakeholders and users.

### **Requirements**

#### **i. Enhancing forecast skills(Weather and Climate)**

While NCHM's weather and climate forecast have improved, owing to the mountainous topography of the country and the limited capacity of models performance in such complex terrain, enhancing forecast skills through continuous verification processes with improved IT infrastructure and forecaster's expertise and knowledge is required.

## **ii. Increasing the lead time of forecast or introduction of seamless forecast**

Currently, the NCHM provides 24-72 hours weather forecast and seasonal forecast (3months) for precipitation. The changing climate has increased the susceptibility of our farming sector towards the vagaries of weather and climate. Thus there is an increased demand for seamless forecast services. The limited services provided by NCHM will not be enough to fulfil the needs of the increasing demand of users. Thus, there is a high requirement of introducing seamless forecast services. The weather forecast range may extend from an hour to 7 days.

In terms of climate services, there is a need to introduce medium-range forecast, extended range forecast and provision of climate change projection information in addition to seasonal forecast.

## **iii. Improved data quality and stable climate data management system**

Bhutan's historical climate data range from 1996 to present. Limited skill in data collection and management and lack of technical skills in maintenance of meteorological equipment has resulted in low-quality data. Thus it is crucial that the quality of the climate data is enhanced. Therefore, there is an immediate requirement of data rescue and quality control of data.

How data is maintained, and their quality monitored also depends on a stable database system. It is noted that NCHM at present does not have good and stable climate database system. An assessment is required to assess the climate database management system for NCHM.

## **iv. Climate services toolkits**

To enable the production of sector-specific products and services, access to climate toolkits that allow easy, quick and efficient analysis of climate data and information; and generation of products and services is required.

## **v. Human resource development**

Almost all the officials come from engineering background; it is vital that both short term and long term training provided in the field of weather and climate science. Short training workshops should regularly be conducted, or WMO should support brief training workshops to fill the gaps and meet the immediate requirements.

## **vi. IT infrastructures**

While NCHM has commendable IT infrastructures, to meet the increasing demand of users and to embark on the generation of new products and services, up-gradation of existing IT infrastructure is required. For example, the existing servers may not support the installation of WRF model capable of generating now-casting and medium-range forecasts. To start other services such as customization of climate services toolkits and the introduction of extended range forecast, installation of new IT infrastructure is required.

### 3. Department of Agriculture-Climate Services User

#### Background

The Department of Agriculture (DoA) under the Ministry of Agriculture and Forests, Royal Government of Bhutan is mandated to reduce poverty and increase food self-sufficiency and security. DoA's programs aimed at ensuring food security and increasing income through improved management of arable, horticulture crops and medicinal plants. Some of the prioritised areas include increasing access to markets, construction of farm roads and selection of advanced technologies.

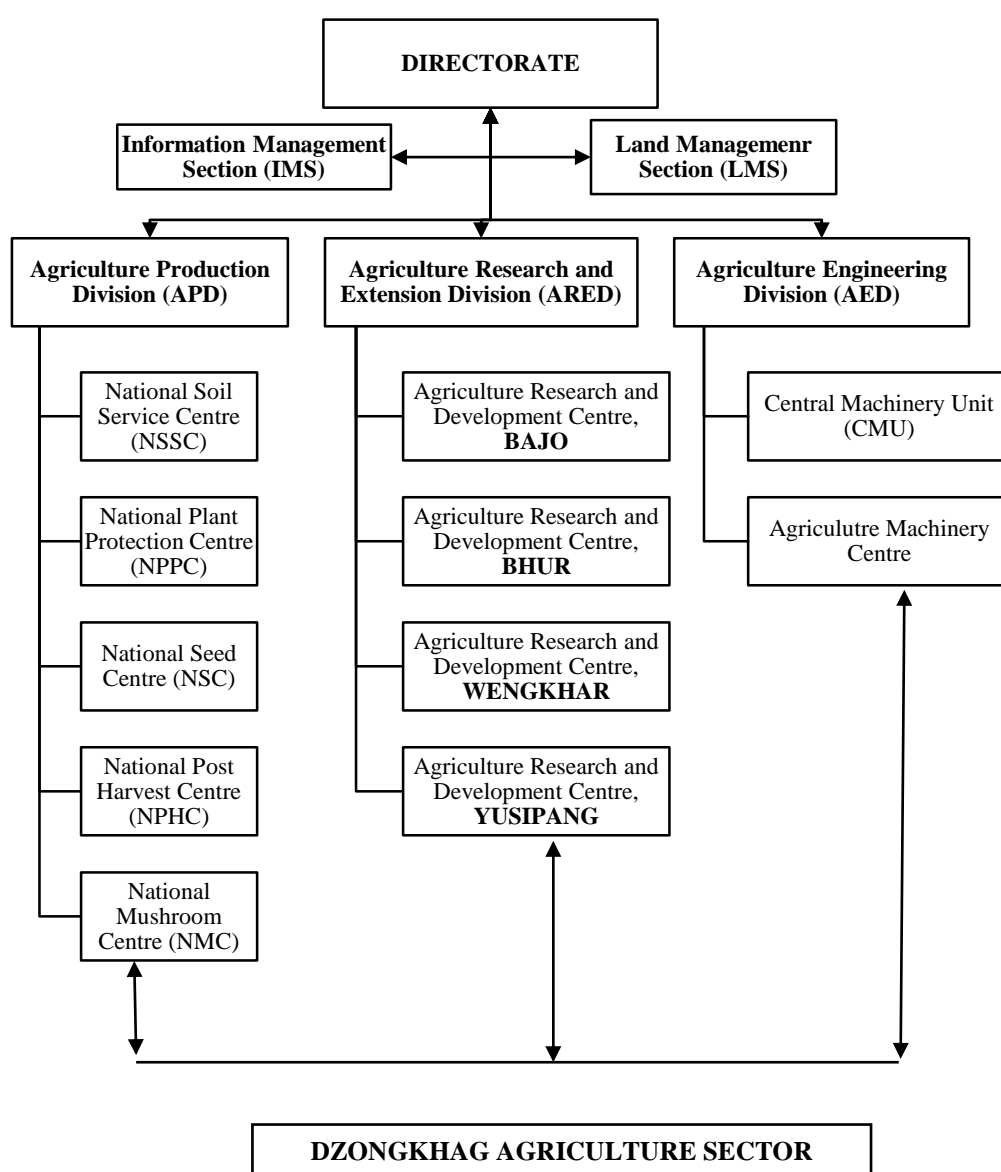


Figure 9 Organogram of Department of Agriculture

Department of Agriculture is one of the biggest departments under the Ministry of Agriculture and Forests with total staff strength of more than 750 personnel. The agency reaches out to clients through a network of Extension, Research and Central program offices established at strategic locations throughout the country, taking services closer to the clients. At the policy and coordination, the DoA HQ comprise Agriculture, Horticulture and Engineering Divisions including Extension Information System.

### **Extension Services**

The Department of Agriculture has deployed 20 Dzongkhag Agriculture Officers (DAO), 20 Assistant Dzongkhag Officers (ADAO), and 205 Extension Officers in the 20 Dzongkhag (Districts). There is more than 300 agriculture staff in these Dzongkhags to support the farming communities to increase food production and manage local resources. These agriculture officers technically work with DoA, the Research Centres and Central Programs to provide assistance to address the agriculture production challenges of the local farming communities.

### **Research & Development Services**

The Department of Agriculture took administrative and technical responsibilities of the Research and Development Centres (RDC) Wengkhari in the east, Bajo in the west central, Bhuri in the south and RDC Yusipang (arable and horticulture programs) in the west. These RDCs support the farming communities' and address their specific needs. Each centre continues to have both its national as well as regional research mandates. The RDCs, provide technical support to the research and extension needs of the centres.

### **Central Programs**

There are five central programs under DOA namely Agriculture Machinery Centre (AMC), National Post Harvest Centre (NHPC), and National Seed Centre (NSC) based in Paro; and National Soil Services Centre (NSSC) and National Plant Protection Centre (NPPC) based in Thimphu. The National Mushroom Centre (NMC) based in Yusipang now reports directly to the Horticulture Division of DOA. Similarly, the Central Machinery Unit (CMU) based in Bumthang that leads farm road construction, reports directly to the Engineering Division of DoA. These Centres provide extension and research services in consultation with RDCs and Dzongkhag extension system. There is currently 265 agriculture staff in these centres.

## **Challenges of Department of Agriculture**

Coping with crop damages by wildlife, frequent droughts, pests and diseases outbreaks, and rise in farm labour cost are some of the main challenges in meeting the food demands. Also, limited skills and knowledge in analysis and use of climate information services add to the growing problem.

## **Requirements of Climate Services for Agriculture**

Weather, climate and water play an important role in the agriculture sector. From planting through irrigation to crop harvesting, farmers and pastoralists need weather and climate information. Moreover, pest infection and crop diseases are often associated with a change in weather and climate. Extreme weather events and flash floods can cause massive damage to crops and incur massive losses to the farming communities. For example, a substantial rainfall during the time of harvesting can create a considerable damage to the crops and incur losses to the affected farming communities.

### **Requirements**

#### **i. Requires high quality climate data**

High quality data is needed for research and analysis in agriculture. Quality climate data will enhance the outputs of the studies in agriculture and will help in delivering better services.

#### **ii. Weather Forecast (3-7 days)**

At present, the NCHM provides weather forecasts for up to 3 days. While the weather forecast information for three days has been helpful, forecast for more than 3 days preferably 5 to 7 days is required for better planning and decision making as more lead time gives more time to make well-informed decisions.

#### **iii. Sub-seasonal to seasonal forecasts**

Currently, NCHM provides a seasonal forecast with more focus on precipitation. While the seasonal climate information has been useful, there is a requirement to fill the gap between the weather forecast and seasonal forecast. Therefore, medium to extended range forecast is required so that the DoA and the farming community has enough lead time to make better informed and correct decisions.

#### **iv. Customized climate services**

For better management of crops, there is a requirement to provide crop specific climate services. For instance, agro-met bulletins with information specific to different crops may be produced in various agro-ecological zones. Frost advisories, drought and wind forecasts are also required.

#### **v. Climate change projection**

The information on climate variability and change is needed for agriculture for long-term planning and research. As of now, there is no information or data on climate projection of Bhutan.

#### **vi. Increase the number of weather parameters**

The existing parameters which are currently collected and archived by NCHM are not sufficient for the agriculture sector. There is need to increase the parameters of observation. The parameters required are Soil moisture and temperature at different depths; Solar intensity; Solar radiation; Leaf wetness; UV; Lysimeter.

#### **vii. Installation of agro-met stations in specific areas**

The location of the existing agro-meteorological stations is not so useful to agriculture as the areas around the current agro-met stations have turned into urban place. Except for few, most of the Class A stations for agro-met are now located away from the farming areas. There is a requirement to install agro-met stations in the vicinity of the farming areas especially in the areas of the commercial cropping farms.

#### **viii. Training and capacity development in climate science**

While most of the staff under the Department of Agriculture have basic knowledge in climate science, there is a limited or lack of knowledge and skill in analysis and understanding of different weather and climate information services provided by NCHM. Thus, there is a crucial need to train and build capacities of agriculture officers in the knowledge of weather and climate information for efficient use in planning and decision making.



## Climate Services related activities and programs of Department of Agriculture

The fact is, all the programs and activities carried out by Department of Agriculture are now somehow linked to climate-resilience. One of the prominent programs focused on climate services is the support provided by a World Bank Project “Hydro-met Services and Disaster Resilience Regional Project”. Under this said project the Department of Agriculture has one component of US 2.50K, which will be used to develop Agriculture Decision Support System. The tender to hire a consultant to develop the decision support system was floated, and the Department of Agriculture with support from NCHM is currently evaluating the proposal of the interested consultants. Under the same activity, it is also planned to establish an agro-met unit that will communicate with NCHM to receive weather and climate information and operate the agriculture decision support system. However, as the works of the project has been just started, the functions and duties of the proposed agro-met unit are not explicit.

Besides, some of the Research and Development Centers under the department has initiated installation of small weather stations and started using in their planning and decision making. One prominent example is the work done by the Research and Development Center of Wengkhar in Mongar Dzongkhag. In Wengkhar, the Agriculture Researchers have installed Davis Weather Stations, and the data has been used for Smart Irrigation System. Smart Irrigation System uses real-time climatic data such as temperature, humidity, rainfall and soil moisture to control irrigation system in agriculture.



**Figure 10**Example of SMART Irrigation at Wengkhar ARDC



**Figure 11 Picture of one of the weather stations installed by Wengkhar Agriculture Research and Development Centre**

#### **4. Recommendations and Road Map**

As discussed in the previous topics, both NCHM and Department of Agriculture are relatively new regarding the provision and use of climate information services. While NCHM has improved a lot both in human capacity and infrastructures for climate services production and delivery compared to previous years, there is much remains to be done when it comes to catering of climate services for agriculture. Similarly, for DoA there is a lot to be done to improve the capacity in analysis and dissemination of climate services to the farmers.

Based on the analysis in this report, this report concludes with some recommendations and a roadmap, which could be achieved and delivered within the phase of WMO Canada Project on GFCS. Some recommendations for the long term which will entail into the conceptualisation of more significant projects in future for the development of climate services for agriculture in Bhutan.

#### **Short-term actions (Deliverable within Phase of WMO Canada Project on GFCS)**

##### **i. Data Rescue and Assessment of Climate Data Management systems (CDMS)**

Consistent and quality climate data is recognised as indispensable for efficient generation of accurate and reliable climate products and services. At the same time, a stable and secure climate data management system is crucial for archival and dissemination of quality climate data. Data quality was one of the leading issues raised and discussed during the workshop

between NCHM and the agriculture stakeholders. To aid this process, the NCHM will formally seek the assistance of WMO both financially and technically.

The NCHM should plan the works in close coordination with WMO to ensure that the data rescue and establishment of CMDS is completed successfully and delivered before the end of March 2018.

## **ii. Customization of Climate Services Toolkit**

WMO has already developed a web portal for Climate Services Toolkit (CST) under GFCS activities. However, for practical use of CST in Bhutan, there is a need to customize some of the toolkits for Bhutan. For instance, a seasonal climate prediction toolkit is customized for Bhutan, which allows NCHM to upload the local data and compare with global data in a single window. This customization of CST will enable NCHM to generate sector-specific climate products and services. To speed up the process of customization of climate services toolkit for Bhutan, NCHM should immediately seek the financial and technical assistance from WMO. Both NCHM and WMO should ensure that the customization of CST should be sustainable over the long run.

## **iii. Capacity development of NCHM and DoA**

Limited knowledge and skill in the generation of climate services and analysis and efficient use of climate services are one of the drawbacks of both NCHM and DoA respectively. Workshops are being organized by NCHM to build the capacity of the agriculture sector, and this should continue. It is seen that WMO could support the capacity development training workshops and seminars for both NCHM and DoA in Bhutan or outside Bhutan within the phase of WMO Canada Project on GFCS.

## **iv. Data and product sharing by IMD and RIMES**

Climate products and services available with IMD were presented, and their use in Bhutan was discussed at length during the workshop. While IMD share some of the climate information services on the website, it is not sufficient for Bhutan. Therefore, NCHM should prepare a list of immediate data and products/services requirement from IMD and should route the request through WMO. WMO shall assist in expediting data and product sharing from IMD.

NCHM will also request the sharing of ECMWF data available with RIMES to Bhutan. To aid this process, NCHM will formally write to RIMES on this matter.

### **Other medium-term and long-term actions**

#### **i. Establish the medium and extended range forecasting**

Through the discussions during the workshop and consultation with individual participants, there is a high demand for medium and extended range forecast products. The availability of such products will help DoA in more effective planning and decision making. NCHM should explore with IMD and Regional Climate Centers of WMO for possible assistance in the development of medium and extended range weather forecasting for Bhutan. Plans are already in place for NCHM to start extended range weather forecasting. Extended range forecasting should be fully operational with trained staffs and necessary infrastructures.

#### **ii. Strengthen the capacity of NCHM in delivering climate services**

Delivering climate services to agriculture has become an important mandate for NCHM. As NCHM is a relatively new agency and lacks human resource and infrastructures in providing climate services, it should focus on the development of human resources capacity in weather and climate science through short-term and long-term training. Over the long run, NCHM should further carry out analytical work and consultation to assess the strengthening of institutional capacity for climate services both regarding human capacity and infrastructures.

#### **iii. Strengthen the capacity of DoA in the utilization of climate information services**

One of the critical issues that were raised and discussed was the lack of capacity of DoA to discern the climate information services that are disseminated by NCHM. For efficient utilization of climate information services and converting them into useful information for decision making, the capacity of DoA needs to be developed. The proposal of establishment of Agro-met Unit under DoA may aid in filling some of the gaps in utilization and understanding of climate services.

#### **iv. Use of mobile apps and other social media to disseminate climate information services**

How climate information services are reached out to the farmers and the general public was discussed. Through presentations by some participants and discussions in the group, accessibility of available climate information services was crucial. The climate information services are best reached through the use of mobile apps; social media such as Facebook and Wechat and mass media such as newspapers and television. NCHM and DoA should work in collaboration in future for the development of mobile apps so that climate information services are easily accessible by the users.

#### **v. Installation of agro-met stations in the vicinity of farming areas**

Through analysis in this report, it was found that most of the existing agro-met stations with NCHM are located in semi-urban areas or away from the farming lands. The stakeholders from agriculture have expressed the need to install agro-met station within the vicinity of farming areas. NCHM and DoA should work in coordination to install stations based on the need for agriculture. Both agencies need to decide over the long run, how the installation of agro-met stations in required sites can be sustainable.

#### **vi. Training of community representatives in understanding and utilization of climate services**

Through the analysis of this report, it was learnt that even though users have access to climate services, there is a lack of skill in the communities to understand and communicate the climate information services. DoA in collaboration with NCHM should look at ways to train community representatives in understanding the climate information services and relate this to their locality to use for their decision making.

#### **vii. Climate projection data for long term planning and research**

Through the analysis of this report, the requirement of climate projection data in the agriculture sector was discussed. The availability of information on climate variability and climate change will help the agriculture sector in their long term plans and research works. To aid this process, NCHM has to build capacities to deliver climate projection data.

#### **viii. Strengthen the institutional linkages**

Through this report, it is found that institutional linkage between NCHM and DoA should be strengthened. A Strong institutional linkage between NCHM and DoA will enable proper network planning for agro-meteorological stations; utilization and dissemination of climate information services more effectively and efficiently.

**Table 1 Road map and sequencing of activities**

<b>Sequencing of activities in Number of Months</b>	<b>4</b>	<b>12</b>	<b>18</b>	<b>24</b>	<b>30</b>	<b>36</b>	<b>42</b>	<b>48</b>	<b>54</b>	<b>60</b>
<b>Short-term actions (Deliverable within Phase of WMO Canada Project on GFCS)</b>										
Data Recuse and Assessment of Climate Data Management systems (CDMS)										
Customization of Climate Services Toolkit										
Capacity development of NCHM and DoA										
Data and product sharing by IMD and RIMES										
<b>Other medium-term and long-term actions</b>										
Establish the medium and Extended Range Forecasting										
Strengthen the capacity of NHCM in delivering climate services										
Strengthen the capacity of DoA in utilization of climate information services										
Use of mobile apps and other social media to disseminate climate information services										
Installation of agro-met stations in the vicinity of farming areas										
Training of community representatives in understanding and utilization of climate services										
Climate projection data for long term planning and research										
Strengthen the institutional linkages										

## Annex 1: Stakeholders Consulted

### Agriculture

Sl No.	Name	Designation/Organization
1	Ms. Kinley Tshering	Director, DoA
2	Wangda Dukpa	Chief, ARED, DoA
3	Tashi Wangdi	Chief, APD, DoA
4	Sangay Dorji	Sr. AO, NPPC, Simtokha Thimphu
5	Tshering Penjor	PAO, ARDC, Wengkhar, Mongar
6	Chokey Nima	AS, ARDC, Wengkhar, Mongar
7	Tashi Phuntsho	HO, ARDC, Samtenling, Sarpang
8	Ratu Kinley	AS, ARDC, Samtenling, Sarpang
9	Cheku Dorji	AO, ARDC, Bajo, Wangdiphodrang
10	Ugyen Dorji	AO, ARDC, Bajo, Wangdiphodrang
11	Kailash Pradhan	Specialist, ARDC, Yusipang, Thimphu
12	Karma Pelden	ARDC, Yusipang, Thimphu
13	Sonam Norbu	AS, Lhuentse
14	Chimi Tshewang	AS, Mongar
15	Phuntsho Wangdi	AS, S/Jongkhar
16	Tshering Lhamo	AS, Trashigang
17	Pema Chorten	AS, Pemagatshel
18	Buddha Kumar Rai	AS, Trashiyangtse
19	Yeshe Dorji	AS, Paro
20	Tandin Tshewang	AS, Paro
21	Thinley Gyelmo	AS, Sarpang
22	Tshering Dema	AS, Punakha
23	Gembo Dorji	AS, Wangdiphodrang
24	Ngawang	AO, ARED, DoA
25	Sagar Acharya	AO, ARED, DoA

### National Center for Hydrology and Meteorology

Sl no.	Name	Designation/Organization
1	Singay Dorji	Chief Meteorology Officer, NCHM
2	Tshering Wangchuk	Engineer, NCHM
3	Tshencho Dorji	Sr. Hydro-met Officer, NCHM
4	Tayba Buddha Tamang	Dy. Chief hydro-met Officer, NCHM
5	Sonam Rabten	Hydro-met officer, NCHM
6	Ugyen Chhophel	Sr. Hydro-met officer, NCHM
7	Pema Syldon	Hydro-met Officer, NCHM
8	Monju Subba	Hydro-met Officer, NCHM
9	Sonam Tashi	WCSD, NCHM
10	Tshering Wangchuk	WCSD, NCHM



### Stakeholders from other agencies

Sl no.	Name	Organization/Agency
1	Tshering Wangchuk	Department of Disaster Management
2	Rinchen Zangmo	Kuensel Corporation (print media)
3	Yeshe Dema	
4	Samten Dolkar	Bhutan Broadcasting Service (BBS)
5	Nawaraj Chettri	UNDP
6	Tshering Penjor	
7	Dechen Tshering	World Bank
8	Tulsi Gurung	College of Natural Resources
9	Chogyel Wangmo	