COUNTRY HYDROMET DIAGNOSTICS

Informing policy and investment decisions for high-quality weather forecasts, early warning systems, and climate information in developing countries.

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Department of Hydrology and Meteorology Nepal (DHM) Peer Review Report

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METEOROLOGISKA INSTITUTET
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UN environment programme

SOFF Systematic Observations Financing Facility — Weather and climate data for resilience

WORLD METEOROLOGICAL ORGANIZATION

Alliance for Hydromet Development

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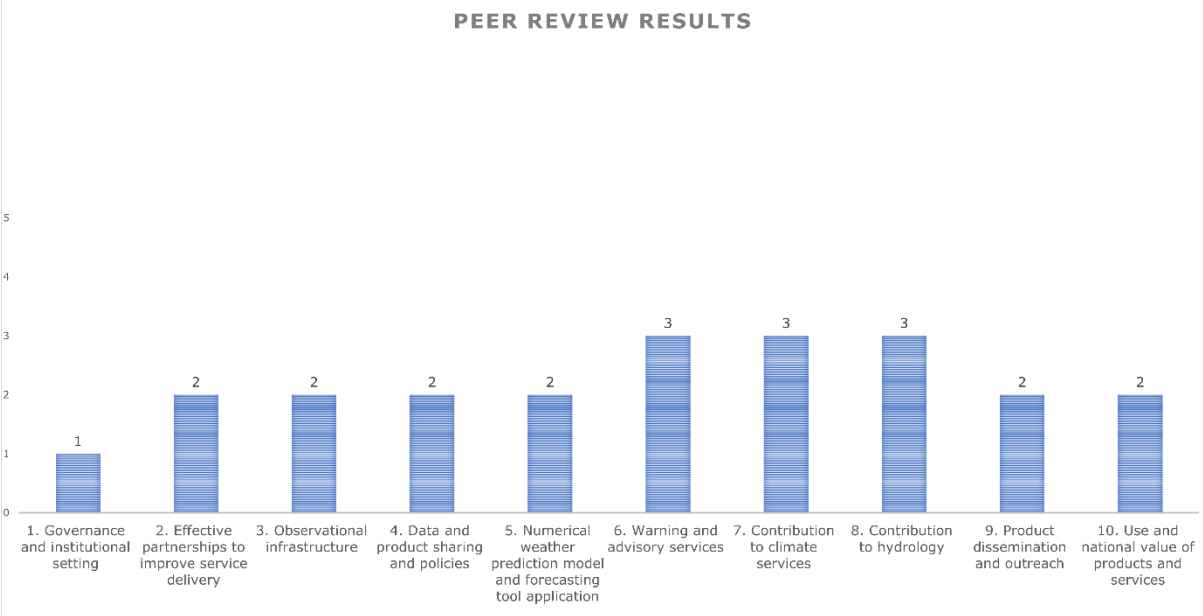
Table of Contents

List of Abbreviations

AARCC	Asia Regional Resilience to a Changing Climate
AWS	Automatic Weather Station
BRCH	Building Resilience to Climate-Related Hazards project funded by WB
CAAN	Civil Aviation Authority of Nepal
CAP	Common Alerting Protocol
CARE	Climate Adaptation and Resilience for South Asia
CHD	Country Hydromet Diagnostics
CMA	Model by China Meteorological Administration
DHM	Department of Hydrology and Meteorology
DMS	Data Management System
DRR	Disaster Risk Reduction
ECMWF	European Centre for Medium-Range Weather Forecast
EWS	Early Warning System
FMI	Finnish Meteorological Institute
FNEP	Finnish-Nepalese Project for Improving Capability of the Government of Nepal to respond to the increased risks related to weather related natural disasters caused by climate change
GBON	Global Basic Observing Network
GFS	Global Forecast System
GTS	Global Telecommunication System
IBF	Impact-Based Forecasts
ICIMOD	International Centre for Integrated Mountain Development
ICT	Information and Communication Technology
JICA	Japan International Cooperation Agency
MHEWS	Multi-Hazard Early Warning System
MoEWRI	Ministry of Energy, Water Resources and Irrigation
MoU	Memorandum of Understanding
NARC	*Nepal* Agricultural Research Council
NCOF	National Climate Outlook Forum
NDRRMA	National Disaster Risk Reduction and Management Authority
NGO	*Non-Governmental Organization*
NWP	Numerical Weather Prediction
O&M	Operation and Maintenance
QC	Quality Control
RC	Red Cross
SMS	Short Message Service
SOFF	Systematic Observations Financing Facility
SOP	Standard Operating Procedures
USAID	United States Agency for International Development
WAFS	World Area Forecast System
WB	World Bank
WIS	WMO Information System
WMC	World Meteorological Centre
WMO	World Meteorological Organization
WRF	Weather Research and Forecasting Model

Executive Summary

Full infrastructural modernization of the Department of Hydrology and Meteorology (DHM) was implemented in 2013–2021 as part of the Building Resilience to Climate-Related Hazards (BRCH) project funded by the World Bank (WB). Nevertheless, DHM has critical challenges in establishing and maintaining the whole value chain due to a lack of human and financial resources. This is shown on its relatively low maturity level scores (average 2 out of 5) of the CHD elements. DHM has the potential to rapidly develop towards higher maturity levels, but it requires intensive external support, especially for capacity building, technical assistance, and operation and maintenance (O&M) funding.



Element	Maturity level score
1. Governance and institutional setting	1
2. Effective partnerships to improve service delivery	2
3. Observational infrastructure	2
4. Data and product sharing and policies	2
5. Numerical weather prediction model and forecasting tool application	2
6. Warning and advisory services	3
7. Contribution to climate services	3
8. Contribution to hydrology	3
9. Product dissemination and outreach	2
10. Use and national value of products and services	2

The main gaps identified by the Country Hydromet Diagnostics are as follows:

- *Legislation:* Currently there is lack of Hydromet act and regulation in Nepal but DHM has prepared and submitted the draft Hydromet Policy to its line ministry, Ministry of Energy, Water Resources and Irrigation for the Policy review and approval process among stakeholders and relevant ministries. It is especially important to enter the Policy into legal force, as it would specify DHM's responsibilities and would be the basis for establishing cost-recovery systems for services in the future. Currently, weather, climate and hydrology-related actions are mentioned in several regulations, but DHM is not mentioned as the responsible body in many cases.

- *Insufficient operational funding and critical shortage of staff:* Insufficient governmental budget lack of commercial services and cost-recovery mechanism, strict national procurement rules and the lack of availability of services have limited the implementation of planned procurement and outsourced services. A relatively high share of DHM's program (observation, ICT) is outsourced due to a lack of internal human resources. DHM does not have enough qualified personnel to deliver various services as per customer/public demand including 24/7 weather/aviation services. The modernization of DHM requires a variety of human skills (especially ICT and technical expertise, but as governmental authority the DHM is not allowed to create/recruit required post. DHM doesn't have separate Hydromet ICT post and thus, ICT experts might be transferred to other departments.

- *Observational Infrastructure:* Infrastructure exists but network is not expanded to high altitudes areas. Major gap is that sustainable O&M is missing due to the lack of sufficient funding, procurement and human resources, and thus causing serious gaps in data (especially radar and lightning). The quality of the existing infrastructure should be ensured. Availability of high-resolution satellite data and all features of the Data Management System (DMS) should be implemented, like near real-time Quality Control (QC).

- *Warning and Advisory Services:* the DHM is disseminating flood warnings directly to the public and concerned authorities including NDRRMA via SMS. Weather-related warnings are issued in separate advisories on the DHM website, and on social media and in daily news broadcasts (TV, radio), while the NDRRMA is responsible for the further dissemination of advisories to provincial districts and local stakeholders. The content of the weather and flood advisories should be harmonized and simplified to ensure consistent understanding of the situation, thresholds for the major hazards should be researched and established, and communication to the community level should be encouraged, e.g. with the support of NGOs.

- *Weather forecasting and tools:* There are gaps in the utilization of available data for weather monitoring, nowcasting and forecasting (e.g. expanding of lead-time by global data, use of ensemble forecast) due to a lack of human resources and technical capability. An operational verification system for NWP should be established to support daily weather services and model development purposes. Finally, no research or development (e.g. data assimilation) is currently taking place in weather forecasting, climate and NWP related works.

- *Climate and Agrometeorological Services:* Continuation of the National Climate Outlook Forum (NCOF) should be ensured with appropriate funding, and the National Framework for Climate Services (NFCS) should be implemented. The expansion of climate and agrometeorological services requires upgrade of the existing DMS with reliable QC, allowing for the automatization of production processes and further development of tailored services for different sectors.

- *Hydrological Services:* Flood warnings are mostly based on observations and hydrological model should be implemented. Cooperation between the hydrological

and meteorological divisions should be encouraged, for example through the use of weather observations and NWP as input to hydrological modelling, verification of numerical weather and hydrological models, daily briefings, efficient coordination in cases of severe hydro-met events.

- *Effective partnerships:* For all service provision and collaboration the official agreement (MoU) and regular communication with stakeholder should be established. The development of tailored services for customers is limited due to a lack of human resources and capability to utilize the existing infrastructure. No customer management process nor regular customer satisfaction survey are in place.
- Development funding is highly competitive in Nepal and projects should be coordinated to avoid overlapping. Long-term partnerships with operational support are recommended to ensure the sustainable development of DHM.

Chapter 1: General information

Introduction

Nepal is a landlocked country in the Himalayan region, covering 147 181 km^2 (193 x 885 km). The landscape is one of the world's most mountainous, varying from near sea-level (59 m) to the world's highest mountain (88484.86m). Altitude is increasing rapidly from south to north causing a variety of climate zones (Figure 1), from tropical to polar climates.

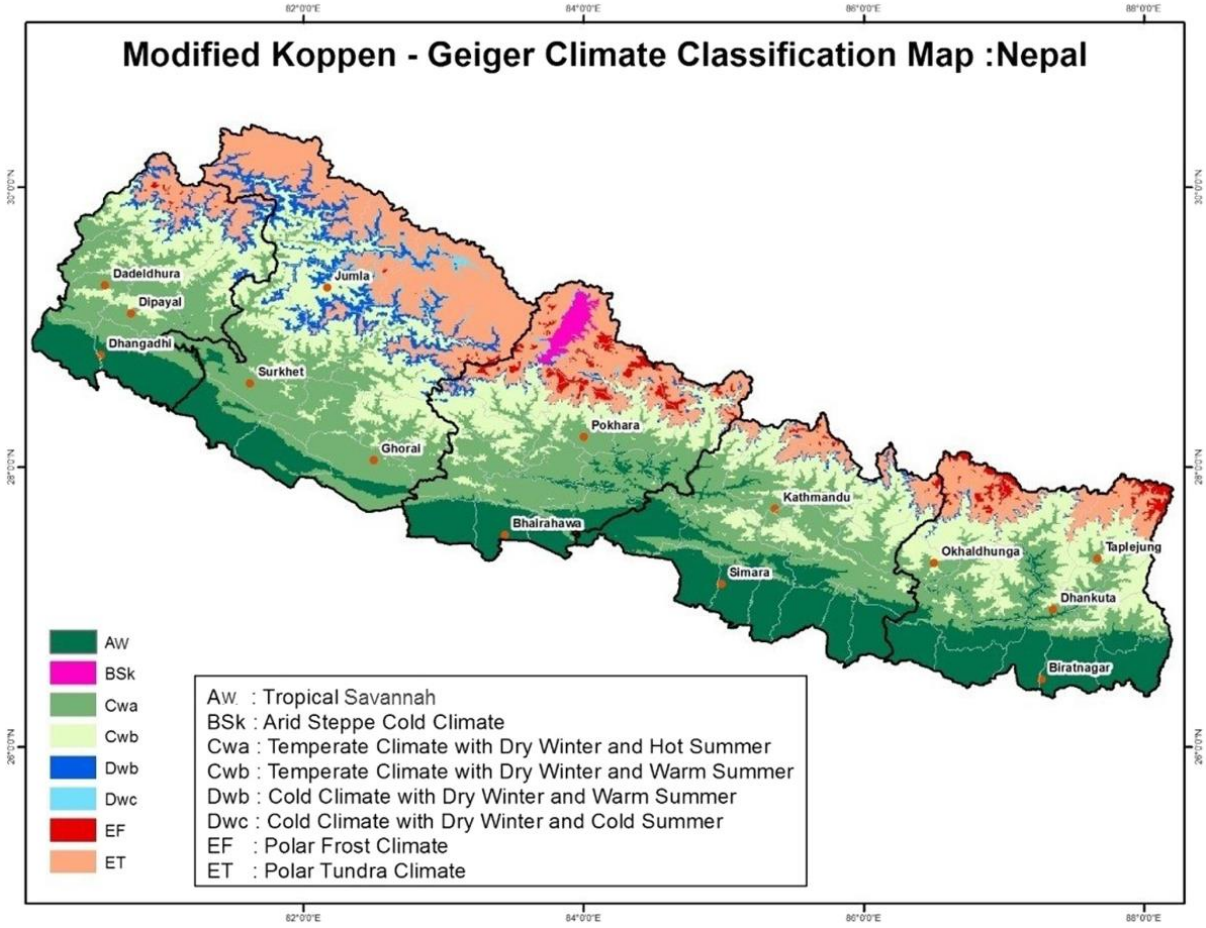


Figure 1. Climatic map of Nepal based on altitude corrected Köppen-Geiger classification method[1]

Nepal is affected by the South Asian monsoon causing high seasonal variation in rainfall and occurrence of weather-related hazards (fig.2). About 80% of annual precipitation falls during the monsoon season, causing floods and landslides which are the most common weather-related hazards in Nepal. On the other hand, drought, lightning, hails, windstorms, avalanches, cold wave and heatwaves also cause loss of life and property annually. In addition, a total of 15 glacial lakes have been identified as dangerous related to glacial lake outburst floods[2].

[1] Karki, Ramchandra & Talchabhadel, Rocky & Aalto, Juha & Baidya, Saraju. (2015). New climatic classification of Nepal. Theoretical and Applied Climatology. 10.1007/s00704-015-1549-0.
[2] Government of Nepal. Nepal Disaster Risk Reduction Portal. Nepal Risk Information. http://drrportal.gov.np/risk-profile-of-nepal

According to the Long-term Climate Risk Index (2000–2019), Nepal is the 10th most vulnerable country to impacts of weather-related hazards.[3] Climate scenarios are predicting an increase in temperatures and higher frequency of extreme events. These natural hazards pose a great threat to the human lives and economy. In Nepal, the loss and damage due to climate change is increasing. Climate-induced disasters cause around 65% of all disaster-related annual deaths. The average annual economic loss from climate-induced disasters is about 0.08 per cent of the GDP (2018/19 figures at the current price). In extreme years like the 2017 Terai floods, the economic loss and damage from the single disaster event was around 2.08 per cent of the GDP (2017/18 figures at the current price). Multiple studies have predicted an increase in L&D caused by climate-induced disasters in the future.[4] Poor and rural populations, as well as the climate sensitive agricultural sector, tend to be the most vulnerable to such risks.

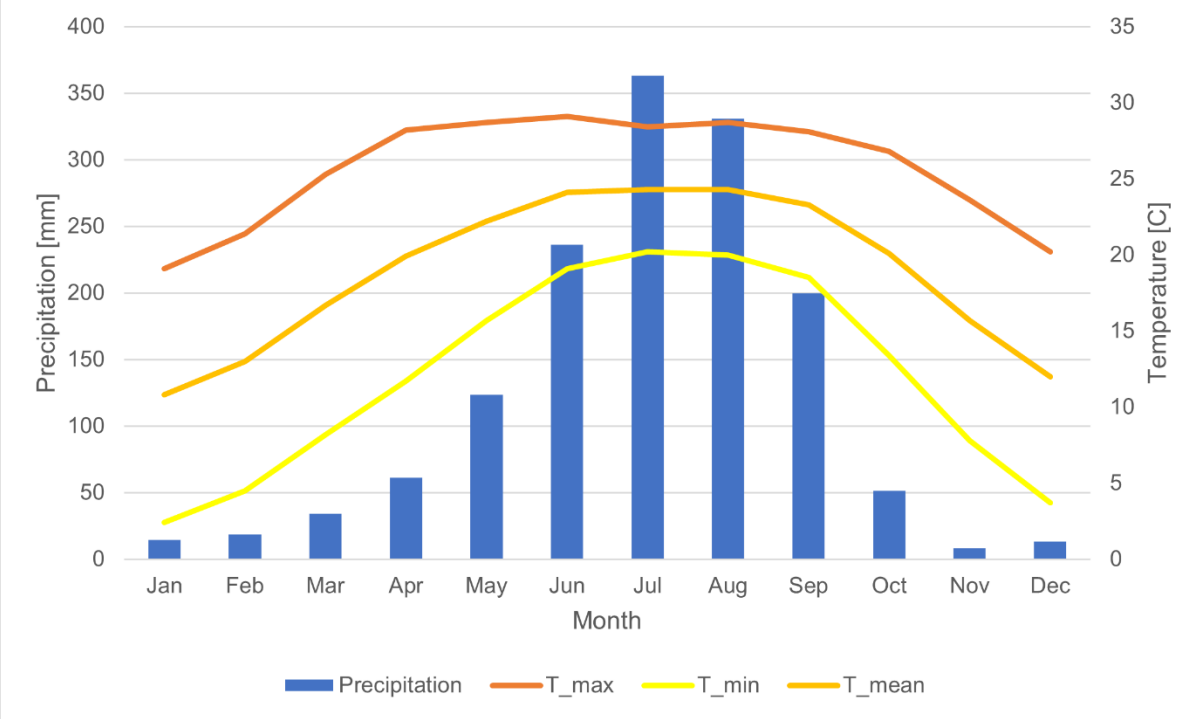


Figure 2. Monthly precipitation and temperature in 1980-2020 in Kathmandu, Nepal[5].

DHM is a governmental organization under the Ministry of Energy, Water Resources and Irrigation (MoEWRI). DHM has mandate to provide services in fields of hydrology meteorology by providing the data, forecasts and advisories/warnings services to public and various economic sectors, such as water resources, agriculture, energy, aviation, disaster risk management. For this purpose, DHM is implementing meteorological and

[3]Germanwatch, 2021. Global Climate Risk Index 2021. https://www.germanwatch.org/sites/default/files/Global%20Climate%20Risk%20Index%202021_2.pdf

[4] MoFE. (2021). National Framework on Climate Change Induced Loss and Damage (L&D). Ministry of Forests and Environment, Government of Nepal. Kathmandu, Nepal. https://www.mofe.gov.np/uploads/documents/national-framework-on-loss-and-damage-approved-document-20211653988842pdf-0805-652-1658826902.pdf

Mahfuz, A. and Suphachol, S, 2014. Assessing the Costs of Climate Change and Adaptation in South Asia. https://www.adb.org/sites/default/files/publication/42811/assessing-costs-climate-change-and-adaptation-south-asia.pdf

[5] DHM. Monthly Climate Normal for 20 Different Stations in Nepal 1980-2010. https://opendatanepal.com/dataset/monthly-climate-normal-for-20-different-stations-in-nepal-1980-2010

hydrological activities, such as observations and data distribution, forecast and warnings, climate services and agromet advisories, snow, glacier, sediment, water and air quality monitoring, as well as coordination with national and international agencies, including the World Meteorological Organization (WMO).

CHD methodology

The Country Hydromet Diagnostics (CHD) is implemented as part of the SOFF (Systematic Observations Financing Facility) readiness phase funded by the Alliance for Hydromet Development. The initial CHD data provided by WMO was reviewed and references were confirmed based on DHM's input collected in:

- CHD workshop on 21st August 2023, which involved around 10 participants from DHM representing all sections (Annex 1);
- SOFF readiness phase missions organized in May and August 2023;
- Remote meetings between SOFF respondents at the DHM and FMI;
- Cooperation between DHM and FMI since 2009.

Figure 3. CHD workshop organized on 21st August 2023 at the DHM.

Chapter 2: Country Hydromet Diagnostics

Element 1: Governance and institutional setting

1.1 Existence of Act or Policy describing the NMHS legal mandate and its scope

DHM has mandate from Government of Nepal to provide hydro-meteorological services, but documentation is not available. Weather, climate and hydrology-related activities are recognized in several regulations. Only few of them recognize DHM as the responsible authority. For example, the Working Division Regulation of the Government of Nepal[6] has provided the mandate to provide national meteorological and hydrological service under the Ministry of Energy, Water Resources and Irrigation (MoEWRI). The MoEWRI is the regulatory body and the service provision is address to the DHM. DHM has prepared a Hydromet Policy with the support of the World Bank. The Policy is submitted to the MoEWRI for review and approval process among stakeholders and relevant ministries. The Policy would define the DHM as the sole authority related to weather, climate and hydrological information provision.

According to the Disaster Risk Reduction National Strategic Action Plan 2018-2030 DHM is responsible e.g. real-time weather observations[7]. One objective of the National Disaster Risk Reduction and Management Regulation (2019)[8] is to develop mechanisms to reduce disaster risks at local communities based upon weather and flood forecasts and early warnings. DHM engage in all the national, provincial and local level disaster committee as the invitee member. DHM has also assigned a dedicated disaster focal person to coordinate with disaster related agencies.

Civil Aviation Requirements for Meteorological Services for International Air Navigation, CAR-3[9], states that the Civil Aviation Authority of Nepal (CAAN) shall designate the DHM to provide or to arrange for the provision of meteorological services for international air navigation on its behalf.

The National Climate Change Policy (2019)[10] includes sectoral working policies which are directly linked to the DHM actions, e.g. dissemination of weather information for agriculture, water management and tourism to increase safety and sustainability. Based on the Second Nationally Determined Contribution (NDC)[11], climate services should be strengthened, including climate monitoring, climate forecasts and early warnings to enhance sustainable development and long-term adaptation to climate change.

Short-term actions are described in the National Adaptation Plan[12] (NAP). The objective of the NAP is to strengthen socio-economic development by building a climate-resilient society and reducing possible climate change impacts on the people and ecosystem of Nepal. DHM is the main agency to analyse and interpret climate change and to put forward

[6] GoN, Working division Regulation
[7] GoN, 2018. National DRR Strategic Plan of Action 2018–2030. https://dpnet.org.np/resource-detail/26
[8] Ministry of Home Affairs, 2019. Disaster Risk Reduction and Management Regulation, 2076. https://moha.gov.np/en/post/disaster-risk-reduction-and-management-regulation-2076
[9] Civil Aviation Authority of Nepal, 2017. Civil Aviation Requirements for Meteorological Service for International Air Navigation, CAR-3, https://caanepal.gov.np/storage/app/media/CAR-3.pdf
[10] National Climate Change Policy, 2076 (2019). https://www.icimod.org/wp-content/uploads/2021/07/National-Climate-Change-Policy_english_2019_compressed.pdf
[11] Government of Nepal, Second Nationally Determined Contribution (NDC), 2020. https://climate.mohp.gov.np/attachments/article/167/Second%20Nationally%20Determined%20Contribution%20(NDC)%20-%202020.pdf
[12] Government of Nepal, National Adaptation Plan (NAP) 2021–2050. Summary for policymakers. 2021. https://www.preventionweb.net/publication/national-adaption-plan-nap-2021-2050-nepal

impact analysis. According to the Environmental Protection Regulation (2019)[13], climate and river flow projections should be provided for climate change adaptation and risk management actions.

1.2 Existence of Strategic, Operational and Risk Management plans and their reporting as part of oversight and management.

The Fifteenth Plan[14] (Fiscal Year 2019/20–2023/24) of the National Planning Commission states development objectives related to hydrology and meteorology in line with national strategies, including:

- formulating policies as per WMO standards and expanding services on a cost-recovery basis;
- upgrading manual stations to automatic stations, and establishing new stations in high altitudes;
- undertaking reliable forecasting by utilizing radar and sounding observations;
- developing early warning system (EWS) with other national authorities as per the Sendai Framework for Disaster Risk Reduction (DRR); and
- collaborating with global and intergovernmental bodies.

DHM is implementing main activities of the Fifteenth Plan and implementation is monitored by the MoEWRI and National Planning Commission. DHM does not have risk management plan.

The MoEWRI has developed a draft plan for the whole Ministry, which include near, mid-term and long-term development plans, if approved. Multiple DHM-specific plans have been drafted as part of development projects; e.g. currently the World Bank is drafting a "Hydromet Master Plan", a development plan and a roadmap of the full value chain prepared through the WB-funded *Building Resilience to Climate Related Hazards* (BRCH) project. Several development plans were drafted as part of the "*Finnish-Nepalese Project for Improving Capability of the Government of Nepal to respond to the increased risks related to weather related natural disasters caused by climate change*" phases 1 to 3 (FNEP1–3). In addition, the national disaster management plan and climate change policy include development goals for hydro-meteorological services.

1.3 Government budget allocation consistently covers the needs of the NMHS in terms of its national, regional, and global responsibilities and based, among others, on cost-benefit analysis of the service. Evidence of sufficient staffing to cover core functions

Total costs of DHM's services were NRP 270 305 000 (capital expenses due to BRCH were 50 % meaning total costs of NRP 540 479 000) in fiscal year 2021–2022: The salaries covered 37 %, O&M only around 4 % due to outsourced observation and 47 % for station maintenance and ICT support including investment to equipment and consulting services [15].

[13] Environmental Protection regulation, 2019. https://lawcommission.gov.np/en/wp-content/uploads/2021/03/The-Environment-Protection-Act-2019-2076.pdf
[14] Government of Nepal, National Planning Commission. The Fifteenth Plan (Fiscal Year 2019/20–2023/24). https://www.npc.gov.np/images/category/15th_plan_English_Version.pdf
[15] World Bank, 2023. Strengthening Hydromet and multi-hazard early warning service in Nepal. An Hydromet Master Plan. Draft 26.9.2023.

If excluding capital expenditure, the governmental budget for operation and development has increased in 2020-2023. In reality, there have been budget cuts during fiscal year 2022-23 and the allocated budget has not been in sufficient level for sustainable operational service. E.g. radar have generators for power shortages but no budget for diesel, daily allowance is very limited and does not cover necessary costs during station visits, salaries have not paid for all months and travel expenses are not in suitable level to implement several station repairing visits.

In addition to the available budget, the main challenge has been usage of the budget in last years. Only around 50–60 % of the planned budget has been used. This is because of budget cut down later in the fiscal year and unused budget left especially in consultancy and capital expenses. Thus, the available budget has not reached the necessary level for sustainable operational service and DHM has reduced its' activities. Another challenge has been hiring of educated staff and some consultancies could not be implemented due to inadequate budget, strict national procurement rules or availability of requested services.

Fiscal year of Nepal changes in mid-July. Procurement planning can be started after the change of fiscal year. After getting the approval of the fiscal year's budget and procurement plan the DHM could begin procurement. In case of failed tendering the retendering is possible according to the procurement act and regulations of Nepal. Operation of the DHM is funded by the central government. Budget is allocated by the Ministry of Finance based on the DHM proposal via the line ministry (MoEWRI). Fiscal year is changing in mid-July. Procurement of infrastructure and services could be started only after the budget of ongoing fiscal year is approved. Procurement process is time-consuming and in case of failed tendering the process might be postponed to the following fiscal year. DHM is allowed to charge on historical data deliveries, but the revenue is collected by the central governmental system. CAAN supports DHM by providing a space at some of the airports including international airports for aviation weather services and also contributes for the allowances for additional airport operation hours of duty forecaster/observer.

A socio-economic study was implemented in 2011 under FNEP1, before BRCH, estimated that benefit-cost ratio would be around 9 in 2013–2030[16]. At the beginning of BRCH (2013) the ratio was estimated to be 6–7. After successful implementation and sustainable operation, the ratio is expected to be almost 11 in 2030. Based on the Hydromet Master Plan (2023) drafted by the World Bank, the benefit-cost ratio would be 4,5–5,7 under a minimal scenario where all BRCH infrastructure would operate sustainably. This expects GBON compliance, including regular maintenance and calibration of instruments and quality control of data, which are included under SOFF. Under the optimal scenario, the DHM would be an effective and modern hydro-meteorological service provider, increasing the ratio up to 13,1–15,5.

1.4 Proportion of staff (availability of in-house, seconded, contracted- out) with adequate training in relevant disciplines, including scientific, technical, and information and communication technologies (ICT). Institutional and policy arrangements in-country to support training needs of NMHS.

DHM has a serious shortage of staff to be able to operate climate, 24/7 weather and flood services. In June 2023 DHM had around 277 permanent employees, excluding part-time observers (Table 1). Technical staff (meteorologist, hydrologist, ICT experts and

[16] Perrels, A., 2011: Social economic benefits of enhanced weather services in Nepal. FMI FNEP Reports 2011

technician) are engaged to both, operational service and administrative work including procurement. In BRCH, the proposed number of staff was 308[17]. There is especially a lack of duty forecasters and (ICT) engineers. Combination of limited man-power and workload of the current employees limits research and development activities at the DHM.

Table 1. Proportion of staff

Total Staff number	277
Management	5
Meteorologist (including senior divisional meteorologist and climate and agromet service)	44
Meteorological Technician (assistant meteorologist)	94
Hydrologist	33
Hydrological Technician	43
Senior Divisional Engineer/ Electronic Engineer	3
Communication Asst.	8
Senior Divisional Chemist/ Chemist	2
Assistant Chemist	1
Other (account, administration)	44

Currently, a minimum of bachelor's degree in meteorology is mandatory to become a meteorologist. For hydrologist a minimum of a master's degree in hydrology or related, or a bachelor's in civil engineering is required. These permanent staff are nominated by the Public Service Commission and assigned to the post by the line ministry. The challenge is that many graduates move abroad due to studies or are assigned to other responsibilities. DHM can propose annual contract-based employees (like ICT) only by approval of the line ministry. Tribhuvana University offers a master's degree in meteorology which covers the WMO BIP-M competence requirements.

1.5 Experience and track record in implementing internationally funded hydromet projects as well as research and development projects in general.

DHM has extensive experience with internationally funded hydrometeorological development projects. Below are ongoing and major projects in the last years:

- WB BRCH (2013–2021) was a huge infrastructure modernization project including the installation of around 90 automatic weather and 70 hydrological stations, one radar and sounding station, lightning location system, calibration laboratory, upgrading of data management system, establishment of two river based EWS, installation of NWP with data assimilation and necessary hardware for systems, hydrometeorological workstation, tv presentation system, new websites. An institutional framework was also proposed, and very basic system level training was organized.
- FNEP (2010–2024) consists of total 4 capacity building projects between DHM and the Finnish Meteorological Institute (FMI). FNEP is funded by the Ministry of Foreign Affairs of Finland. FNEP1: development plans, piloting of real-time data

[17] BRCH Project report. BRCH Phase 1, Technical Summary report, appendix 4a: PLAN FOR TRAINING AND PROFESSIONAL DEVELOPMENT OF THE STAFF OF DEPARTMENT OF HYDROLOGY AND METEOROLOGY OF NEPAL

management system (DMS), FNEP2: further development of DMS, installation of WRF, development of new climate products, FNEP3: support to utilize systems installed in BRCH, FNEP3 Exit: finalization of the FNEP3.

- AARCC (2018–2022) with the UK Met Office: Piloting of IBF with rainfall as an hazard and landslide as an impact in four districts of Nepal viz: Sindhupalchowk, Rasuwa, Myagdi and Baglung.
- Japan International Co-operation System (JICS) project (ongoing): upgrading of 12 existing stations to fully AWS and addition of 1 new AWS.
- Priority River Basin Flood Risk Management Project (PRBFRMP, 2021-2027, ADB funded): One of the component of the project will support in flood-prone areas to improve early flood warning systems through (i) installing about 43 rain gauges and 31 hydro meteorological stations, (ii) developing about 5 flood forecasting and early warning system (FFEWS), and upgrading 1 FFEWS (iii) improving maintenance of FFEWS.

Summary score and recommendations for Element 1

The CHD Element 1 score is 1, reflecting "Weakly defined mandate; serious funding challenges; essential skills lacking; little formalized governance and future planning." The main recommendations to strengthen DHM's institutional setting are:

- Efforts are ongoing to develop an act defining DHM's roles and responsibilities. It is especially important to ensure that the act enters into legal force. This would need strong political support nationally. The act would be the base for cost-recovery in the future, which is important for DHM's development. DHM as responsible body or MoU on service provision is missing in several cases.
- Insufficient operational budget and unable to use the budget: The governmental budget for a 24/7 operational service should be increased to a sustainable level. Existing national barriers to implementing planned investment and services should be studied. In project-based investments operational support should be ensured.
- Critical shortage of staff: DHM has critical shortage of staff to run a 24/7 weather, aviation and climate service. Modernization requires a variety of human skills, especially investment in ICT and technical know-how. Long-term partnerships are particularly important to enhance weather-specific knowledge of individuals. When possible, automatization of the production process should be implemented to release staff workload from manual tasks. Development of the personnel policy is recommended to ensure long-term employment and easier recruiting.
- Development funding is highly competitive in Nepal and thus long-term partnerships with operational support are recommended to ensure the sustainable development of the DHM.

Element 2: Effective partnerships to improve service delivery

2.1. Effective partnerships for service delivery in place with other government institutions.

DHM cooperates with several governmental authorities but only some MoUs on service provision and collaboration are in place. For example, DHM has MoUs with the Nepal Agricultural Research Council (NARC) on agrometeorological data sharing and preparation of national agro-advisory bulleting, with the Department of Health on climate data sharing and with Nepal Electricity Authority on sharing of real-time data. DHM has regular cooperation with CAAN related to aviation weather service and with the National Disaster Risk Reduction and Management Authority (NDRRMA). National Climate Outlook Forums are organized annually.

2.2. Effective partnerships in place at the national and international level with the private sector, research centres and academia, including joint research and innovation projects.

Public-private partnerships is existing in Nepal. There is no open data policy, but private telecommunications companies (MoUs) are supporting disaster risk reduction by sharing flood early warnings to the public without costs. Due to the lack of sufficient number of staff, DHM has outsourced some regular programme to the private sector. Main support from private partner in operations are technical maintenance of the hydrological and meteorological networks, and the upgrade and maintenance of data management system.

DHM is the main agency in several multi-sectoral national forums, like the regular meetings with disaster management authorities, different sectors and NGOs (e.g. Red Cross), the monsoon forum and technical meetings with NARC on agrometeorological services. DHM is participating annually in international events like Regional Climate Outlook Forum (RCOF) and Hydromet forum. In addition, project-based multi-sectoral meetings are organized when needed.

2.3. Effective partnerships in place with international climate and development finance partners.

No long-term partnerships are in place, but project-based partnerships with the main international climate funders like the World Bank, Asian Development Fund, UN Development Programme, UN Environment Programme, USAID, Finland, Norway, JICA and ICIMOD exist.

2.4. New or enhanced products, services or dissemination techniques or new uses or applications of existing products and services that culminated from these relationships.

In recent years, the main projects which have included a component on service provision are:

- BRCH: Modernized the production system and enhanced DHM's forecasting capability in general. Dedicated new services: EWS for two river basins on floods, upgraded DHM's website and mobile application for the public, and developed an agrometeorological portal for weather and climate information (NAMIS).
- FNEP: focus in capacity building but also some service development over the years. Climate products: operational monsoon monitoring, climate normal for period, fine resolution elevation corrected monthly temperature and precipitation maps, new climatic classification of Nepal. Piloted weather services: cold wave forecast in co-operation with the Red Cross, low level temperature and wind maps, significant

weather charts for domestic aviation. Community level event on dissemination of DHM's services organized in co-operation with Red Cross.

- AARCC (2018–2022) with the UK Met Office: Piloting of IBF with Rainfall as an hazard and landslide as an impact in four districts of Nepal viz: Sindhupalchowk, Rasuwa, Myagdi and Baglung.

Summary score, recommendations, and comments for Element 2

The CHD Element 2 score is 2, reflecting "Limited partnerships and mostly excluded from relevant finance opportunities". Recommendations to enhance partnerships:

- Regular and active multi-sectoral cooperation is essential for functional disaster-risk management, health and safety for the public, strengthening of the economy (agriculture, tourism, aviation, hydro power).
- Official agreements or MoUs on service provision and cooperation.
- Long-term international partnerships to ensure sustainable development of the DHM.

Element 3: Observational infrastructure

3.1. Average horizontal resolution in km of both synoptic surface and upper-air observations, including compliance with the Global Basic Observing Network (GBON) regulations.

Currently DHM has 88 operational AWS (fig 4). In additional, number of AWS have installed for specific purposes such as tourism and total number of AWS is over 133 and some of these stations are located at the existing manual stations. DHM has also several manual station networks, but exact number of stations varies due to ongoing automatization (17 aero-synoptic, 194 precipitation, 79 climate and 6 agro-met stations). Only 17 aero-synoptic stations are reporting to the GTS and average horizontal coverage of one surface station is ~8 700 km^2 in one of the most challenging terrains. None of the stations are GBON compliant due to limited time resolution and lack of real-time quality control. According to WMO GBON Global Gap Analysis, 4 stations would fulfil the standard density network requirements. In the National Gap Analysis, a total of 15 stations were proposed to be upgraded by SOFF support to reach denser GBON network as an easy-fix possibility.

DHM is running upper-air sounding once a day, or less, due to budgetary reasons. Sounding data is not disseminated to the GTS due to technical problems. One sounding station would practically fulfil the horizontal resolution requirements of GBON but its location near Kathmandu would cause lack of coverage of western Nepal and thus, a second sounding station is recommended.

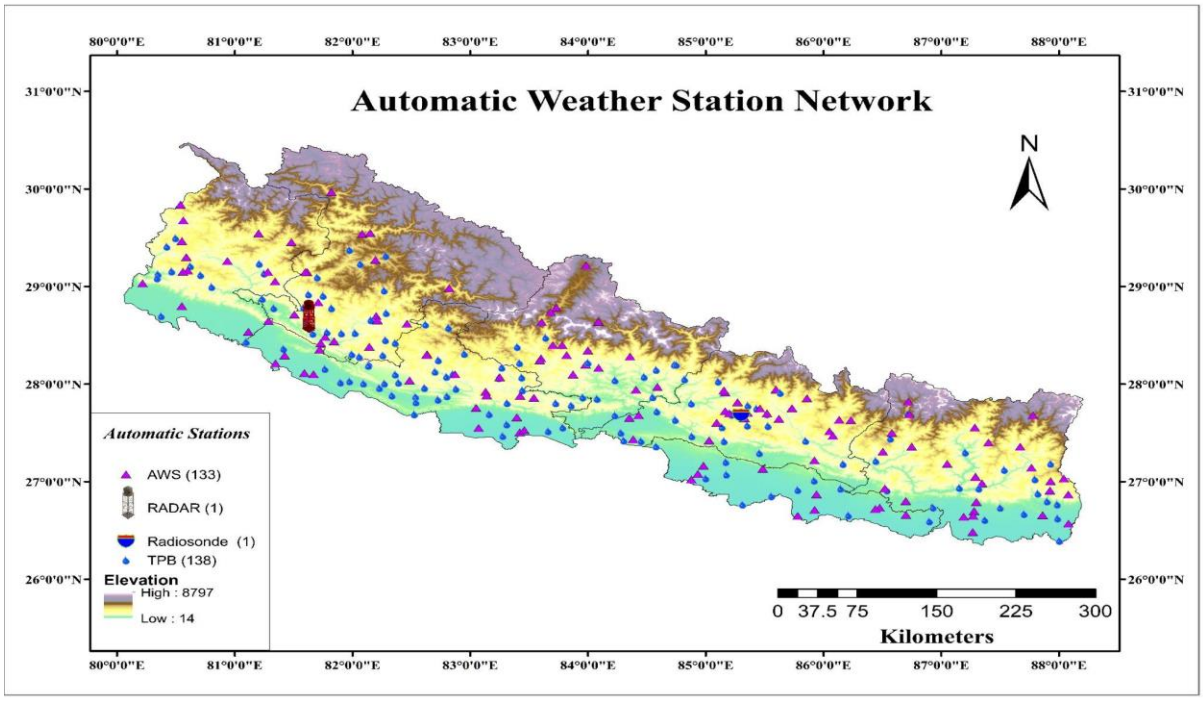


Figure 4. Meteorological station network (automatic) in Nepal.

3.2. Additional observations used for nowcasting and specialized purposes.

In total, 3 radars have been installed between 2018 and 2023. Radars have significant problems in operation and could not operate properly especially during severe weather. The lightning detection network, including 9 sensors, was installed in 2017 but is not currently operational due to technical problems (data transmission, high noise). Thus, freely available lightning observations are used for nowcasting purpose and aviation weather service. . Himawari (Japan) satellite data is available at the workstation and freely

available satellite pictures are used for forecasting purposes. A satellite reception station exists but has not been fully utilized.

3.3. Standard Operating Practices in place for the deployment, maintenance, calibrations and quality assurance of the observational network.

Currently maintenance of hydrological stations is outsourced to a private company. The maintenance contract of automatic meteorological stations of the BRCH ended at the beginning of 2022 and currently all stations are without maintenance due to procurement reasons. Standard Operating Procedures (SOP) for AWS maintenance have been drafted but not implemented fully because DHM has no human capacity to maintain its station networks by itself.

Calibration laboratory facilities for temperature, humidity, pressure and rainfall have been established under the BRCH project but are not in operation due to a lack of man-power and training. Manual for operation of calibration facilities have been submitted by the system provider, but SOP for full calibration process is missing. Co-operation with Regional Instrument Centre should be considered.

There are no records on staff trained according to the WMO Information System (WIS) for the WMO Global Observing System (OSCAR/Surface). There is regular communication with the WMO Information System Data Quality Monitoring System (WDQMS) on quality problem information.

3.4 Implementation of sustainable newer approaches to observations.

Sustainability of the observation network operations and maintenance is a major challenge. Calibration lab is already established under BRCH project but not in operation. All the instruments deployed are without calibration. Three RADARs have been already installed but not in full operation. The operation cost is high and the technicians to maintain RADAR is a matter of higher level of competence. There is also lacking of required human resources to handle RADAR. There are also technical issues with LINET to be in operation.

3.5. Percentage of the surface observations that depend on automatic techniques.

At the end of 2023, about 60% of surface meteorological observation has been automated and 75 % of hydrological stations. DHM is upgrading existing manual station into automatic station every year.

Summary score, recommendations, and comments for Element 3

The CHD Element 3 score is 2, reflecting "Basic network, large gaps, mostly manual observations with severe challenges and data quality issues". The most urgent recommendations to improve the observation infrastructure are:

- Sustainable O&M is missing due to insufficient resources and funding causing serious lack in data (AWS, sounding, lightning, radar). Regular maintenance and calibration of instruments should be carried out to reach GBON requirements. High resolution satellite data flow should be restored.
- Radar is the most valuable observation technique in the nowcasting of severe rain patterns. It is especially crucial to have all 3 radars in reliable operation. In addition to technical assistance for system maintenance and operation, development of radar products and training on radar data interpretation in severe weather is needed.

Element 4: Data and product sharing and policies

4.1. Percentage of GBON compliance – for how many prescribed surface and upper-air stations are observations exchanged internationally. Usage of regional WIGOS centres.

17 (aero-)synop stations have less than 30% data availability due to manual observations, only one station operates 24/7. Sounding data (max 1 sounding per day) is not shared to the GTS due to technical reasons. Currently, observations are transmitted to the GTS; WIS 2.0 implementation is planned under SOFF.

Potential quality control exists in the real-time data management system but has technical problems (slowness, hardware). Thus, quality control is not currently fully operational.

4.2. A formal policy and practice for the free and open sharing of observational data.

No open data policy exists in Nepal. DHM is selling the data as per government decision and the revenue is collected in the centralized governmental system.

4.3. Main data and products received from external sources in a national, regional and global context, such as model and satellite data.

Freely available satellite data on clouds, rain and lightning and other meteorological parameters from international sources is in daily use in forecasting and other services. Global model data, like ECMWF, GFS and CMA are freely available from websites, and only limited data is available for meteorological workstations. Further training on utilization of different satellite products and model data is needed.

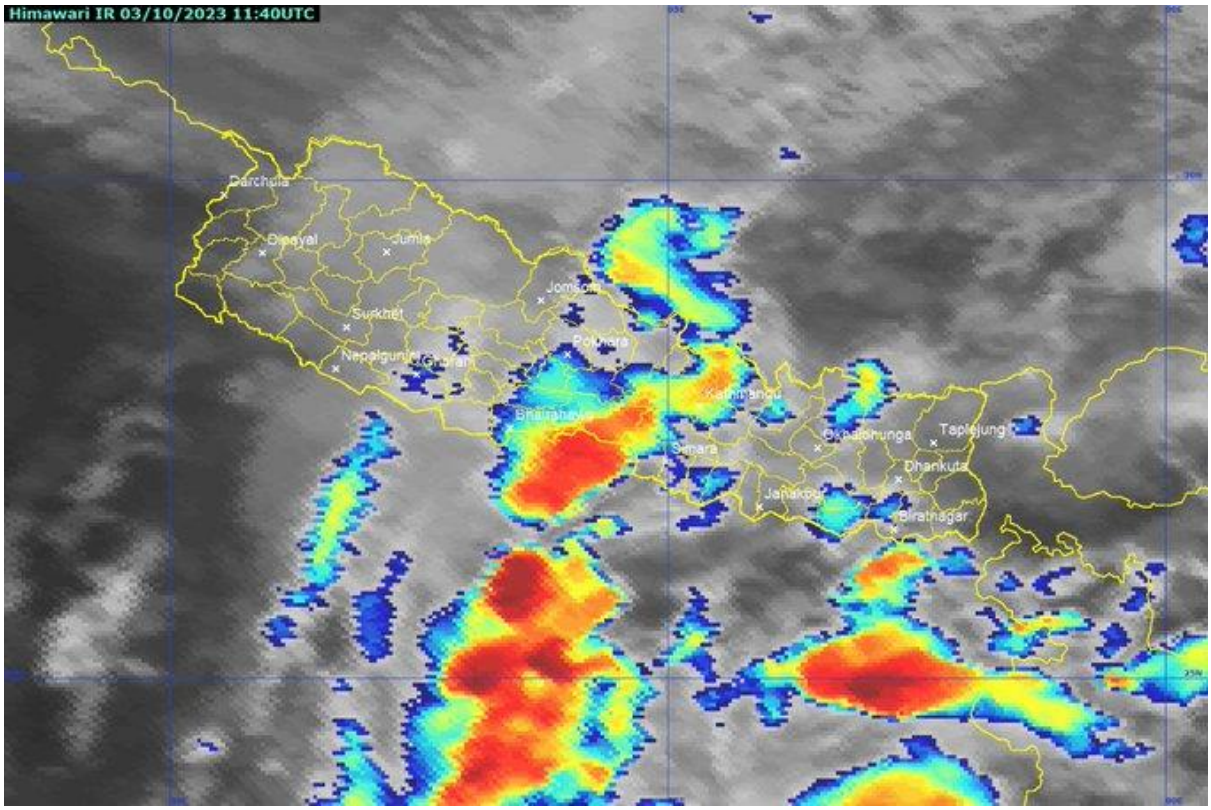


Figure 5. Himawari infrared channel satellite picture used for identifying rain patterns.

Summary score, recommendations, and comments for Element 4

The CHD Element 4 score is 2, reflecting "A limited amount of GBON compliant data is shared internationally. The existing data sharing policies or practices or the existing infrastructure severely hamper two-way data sharing". Recommendations to improve data policy and sharing:

- Stability and speed of available internet bandwidth should be strengthened to ensure fluent production process of services.
- Troubleshooting of technical problems of the data management and develop new features. Upgrade of the existing DMS is planned in SOFF
- Ensure regular maintenance and calibration practices to strengthen sustainability and quality of the observation network. GBON compliance is planned to be enhanced under SOFF.
- Ensure that all relevant data is available for forecasting and other services, and provide training how to utilize the data.

Element 5: Numerical model and forecasting tool application

5.1. Model and remote sensed products form the primary source for products across the different forecasting timescales.

NWP products available in the internet are widely used in daily forecasting process. GFS gridded data, WRF run by DHM and WAFS products for aviation are all available in SynergieWeb workstation. Data is used in the production of 3-day weather forecasts and advisories (manually). Boundary conditions and initial data of the GFS are used in limited-area model WRF. SynergieWeb workstation was installed by the BRCH. The workstation has several features e.g. viewing of different observations (ground, satellite) and model data, expert corrections to model data, manual and automatic product production. DHM would need advanced training on utilization of Synergie and available WMC products further. Beside of possibility of automatic production process the city forecasts are generated manually to the DHM website.

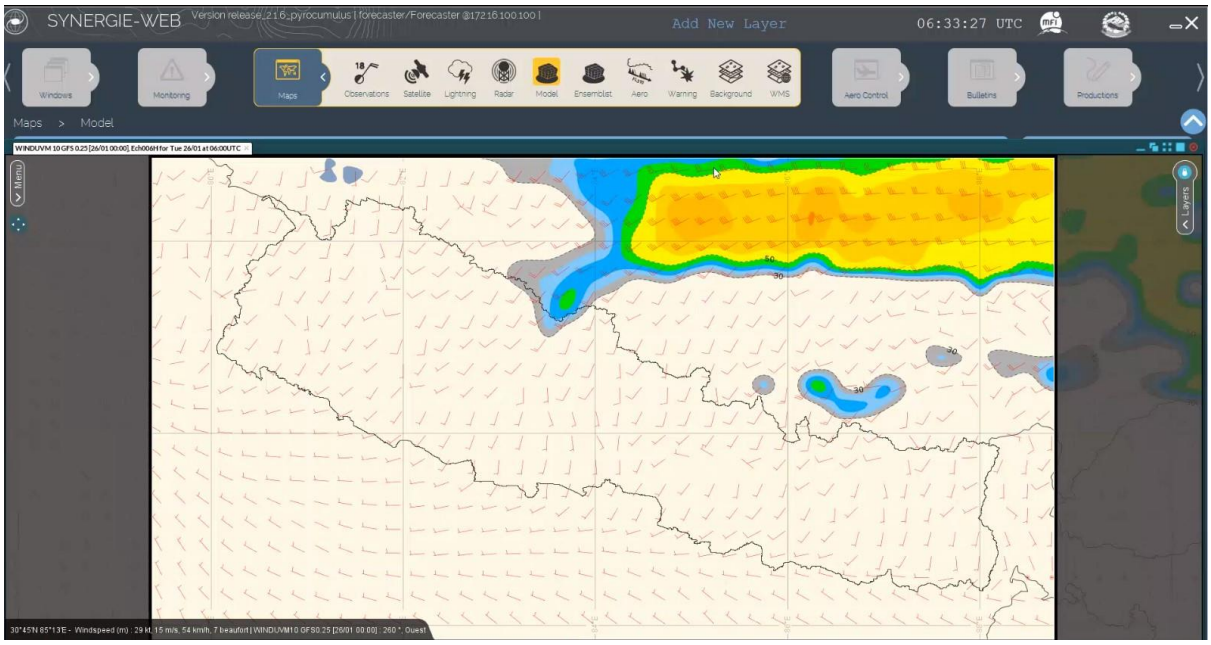


Figure 6. Synergie-web workstation

5.2. a) Models run internally (and sustainably), b) Data assimilation and verification performed, c) appropriateness of horizontal and vertical resolution.

DHM is running WRF in 2 domains with resolution of 9 km and 3 km. WRF is updated every 6 hours based on boundary conditions and initial data of the latest GFS. Lead time of the forecast is 72 hours.

Verification has been done only for limited periods. DHM has two model set-ups: with and without data assimilation (only ground observations in use). Based on preliminary verification results, the set-up without data assimilation is slightly more accurate. Due to challenging terrain, a higher resolution model and/or advanced post-processing techniques are required.

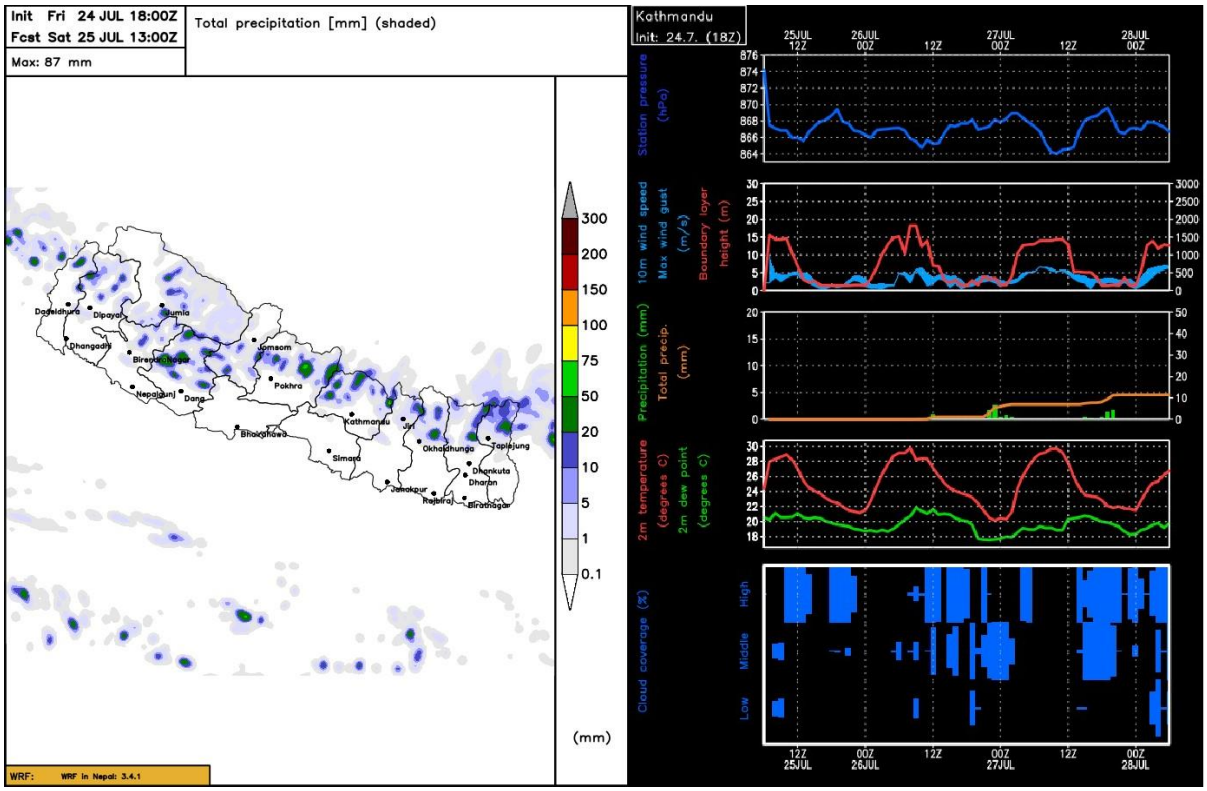


Figure 7. Example on WRF outputs at internal website. Precipitation, temperature and wind gust map are available at the DHM website

5.3. Probabilistic forecasts produced and, if so, based on ensemble predictions.

None.

Summary score, recommendations, and comments for Element 5

The CHD Element 5 score is 2, reflecting "Basic use of external model output and remote sensed products in the form of maps and figures, covering only a limited forecast time range". Recommendations to improve NWP and forecasting tool applications:

- Basic training on weather forecasting in different time frames and use of ensemble forecasts. Support to utilize real-time observations for nowcasting purposes and expanding lead time by global model data.
- Establishment of operational NWP verification system is important for model development and forecasting purposes.
- Advanced utilization of SYNERGIE workstation to produce more reliable forecasts effectively (e.g. model comparison, expert modification, product automatization).
- Establish research cooperation on NWP development, including data assimilation, AI and mountain meteorology.

Element 6: Warning and advisory services

6.1. Warning and alert service cover 24/7.

Public and aviation weather service works 24/7, while flood forecasting is performed 24/7 only during monsoon season. Weather and flood forecast can cover a maximum of 72 hours, and once a week DHM publishes agrometeorological outlooks covering 7 days. Leadtime for weather warnings is 2-12 hours, for floods in major river basin around 6-12 hours. For flash floods lead-time is very limited.

National disaster risk management is under the responsibility of the NDRRMA. Currently, Nepal does not have MHEWS, and neither is the Common Alerting Protocol (CAP) format in use. Warnings are published at the DHM website and shared via social media for the public. For floods, a mass SMS system exists. Based on a study conducted by NGOs, about 40% of the population has access to warnings disseminated via TV, radio, SMS and website. In the southern part of Nepal, 60-70% of the population have access to SMS flood forecasts. Warnings are actively shared via social media. The number of Flood forecasting social media account followers is around 23 000–30 000 (X, formerly Twitter): @DHM_FloodEWS, also present on Facebook), and for the Meteorological Division 8 500–18 000 (X, formerly Twitter): DHM_Weather, and Facebook).

6.2. Hydrometeorological hazards for which forecasting and warning capacity is available and whether feedback and lessons learned are included to improve warnings.

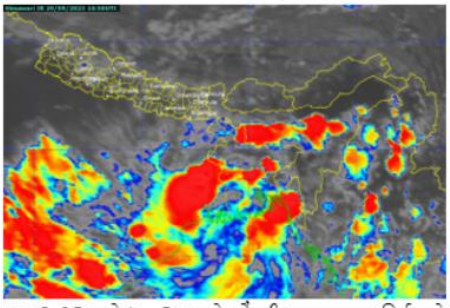
Currently DHM prepares a special weather bulletin (heavy rain, heat wave/cold wave) and a flood bulletin, which are linked to each other. Flood forecasting systems have been installed in 24 river basins. South Asian Flash Flood Guidance System (FFGS) is in use for flood warnings.

General forecasts include information on the probability of thunderstorms. High-altitude forecasts cover the risk of avalanches (5 provinces, 4 altitude levels). Cold wave / fog monitoring is observation-based but includes also a 2-day forecast. A pilot warning on cold waves was implemented in the FNEP project. Heatwave monitoring was developed in 2023: it is also observation-based and includes a 5-day forecast. A pilot warning on landslide was implemented in the AARCC project. The DHM publish warning map on its website (warning on rainfall, temperature, wind snowfall). Advisories (weather and flood) are published in pdf format on DHM website and archived.

DHM's performance and role are evaluated only event-specifically, if required, and feedback mechanisms from users are informal. Flood forecast is verified 24 hours after events. Also, NDRRMA is monitoring flood and rain observations (fig 14) and record false alarms. NDRRMA or local authorities might request to revise the threshold levels based on impacts. SMS flood warning process is tested once a year at 1-2 regions by local governments, the Red Cross, security forces and official ministries.

नेपाल सरकार
ऊर्जा, जलस्रोत तथा सिंचाई मन्त्रालय
जल तथा मौसम विज्ञान विभाग
मौसम पूर्वानुमान महाशाखा
विशेष मौसम बुलेटिन - ५ (Special Weather Bulletin - 5)
(जारी मिति २०८०-०६-१२, साँझ ६:०० बजे, सन् २०२३ सेप्टेम्बर २९)

नेपालमा मनसुनको बहिर्गमन (Monsoon Withdrawal) को औसत मिति अक्टोबर २ रहेतापनि यस वर्षको मनसुन औसत मिति भन्दा केहि दिन ढिलो बाहिरिने सम्भावना देखिन्छ। हाल बंगालको खाडीको उत्तर-पश्चिम भागमा विकास भैरहेको न्यून चापीय क्षेत्र (Low Pressure Area) उत्तर-पश्चिम दिशा तर्फ सर्ने संभावना देखिएकोले आगामी ३ / ४ दिनसम्म देशका धेरै स्थानहरुमा आंशिक देखि सामान्य बदली भई केही स्थानहरुमा मेघगर्जन/चट्याङ्ग सहित हल्का देखि मध्यम वर्षा तथा कोशी, मधेश, गण्डकी र लुम्बिनी प्रदेशका एक वा दुई स्थानमा भारी वर्षाको समेत सम्भावना रहेको देखिन्छ।



२०८०-०६-१२ गते ४०:३० बजे मौसमी भूउपग्रहबाट लिईएको तस्वीर

यस अवस्थामा, पहाडी भू-भागमा पहिरोको जोखिम रहेको, ठूला तथा साना नदी नाला र खोलाहरूमा पानीको सतह केही बढ्न सक्ने, दैनिक जन-जीवन तथा सडक, हवाई यातायात समेत केही प्रभावित हुन सक्ने सम्भावना भएको तथा बाली भित्र्याउने बेला पनि भएकोले आवश्यक सतर्कता तथा पूर्व तयारी अपनाउन सर्वसाधारण तथा सबै सरोकारवाला निकायहरूमा अनुरोध छ।

मौसम पूर्वानुमान महाशाखाले नियमित रुपमा मनसुन बहिर्गमन प्रक्रियालाई अनुगमन गरिरहेको छ र यस सम्बन्धी थप जानकारी अद्यावधिक गर्दै जानेछ।

मौसम सम्बन्धी थप जानकारीका लागि सम्पर्क राख्नुहोला:
मौसम पूर्वानुमान महाशाखा, जल तथा मौसम विज्ञान विभाग,
त्रिभुवन अन्तरराष्ट्रिय विमानस्थल (TIA), गौचर, काठमाडौं
फोन: ०१-४११३१९१, ०१-४११३३४५
Facebook: www.facebook.com/dhmweather
Twitter: www.twitter.com/dhm_weather

Figure 8. Special weather bulletin on heavy rain published at the DHM website.

Figure 9. Warning map available at the DHM website and mobile app.

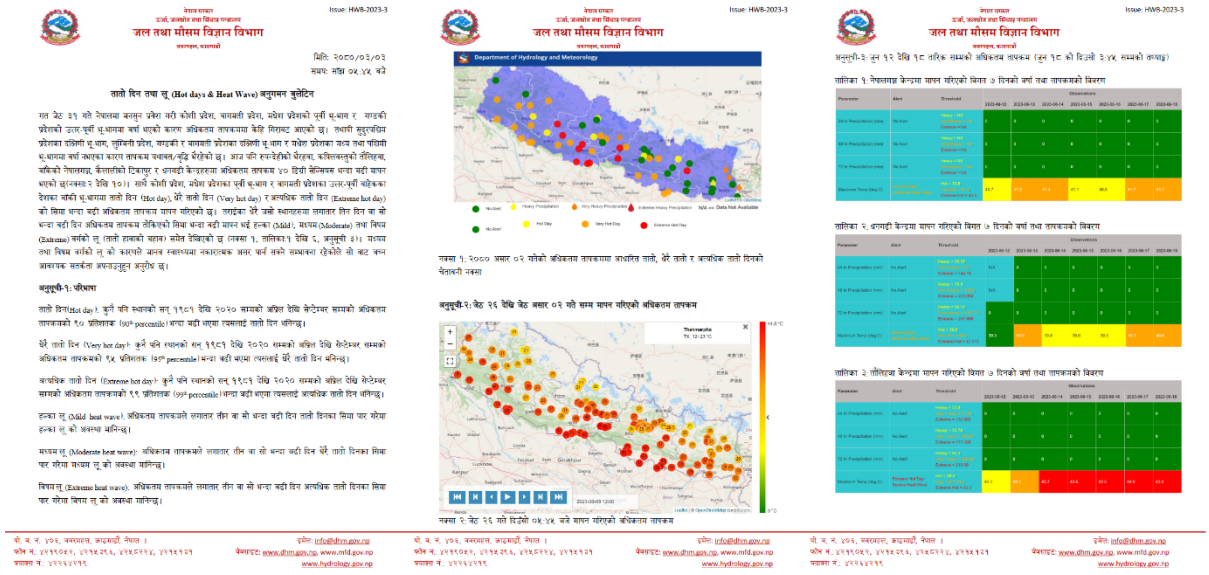


Figure 10. Example on heat wave bulletin at the DHM website

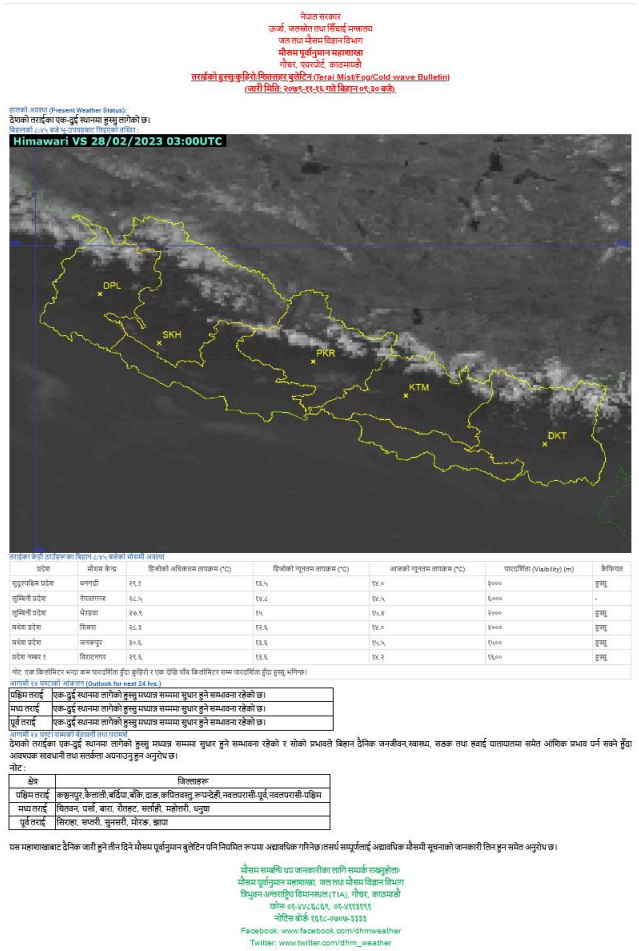


Figure 11. Fog / Cold wave bulletin at the DHM website

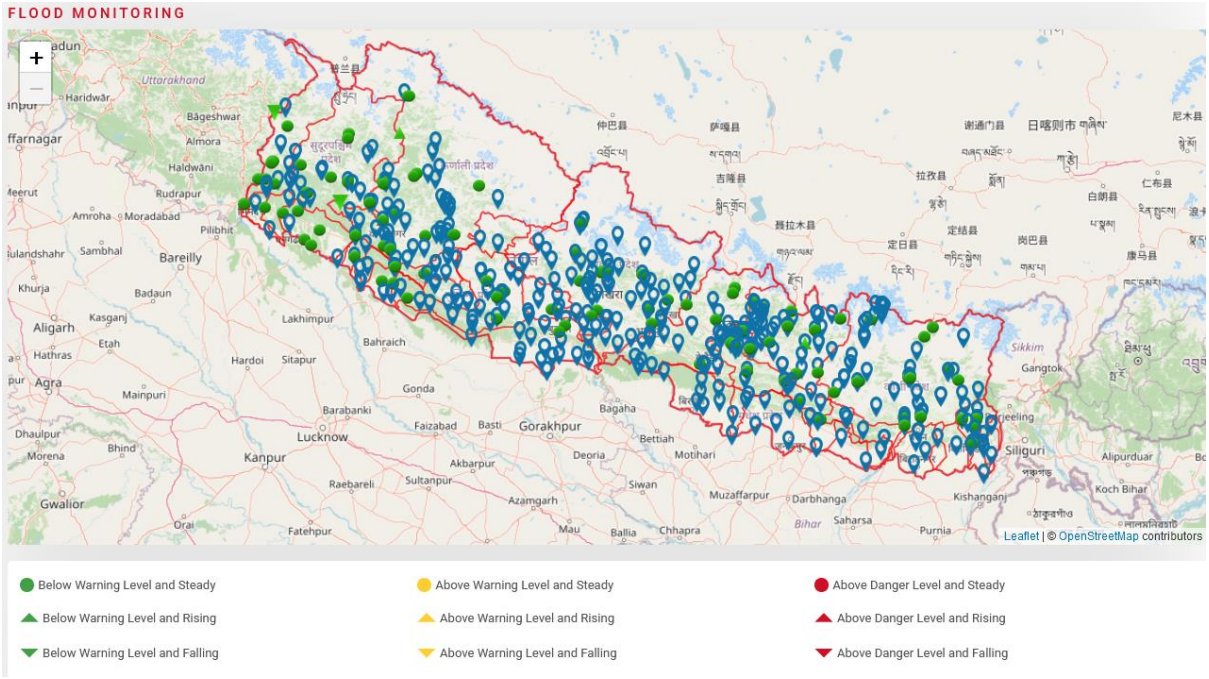
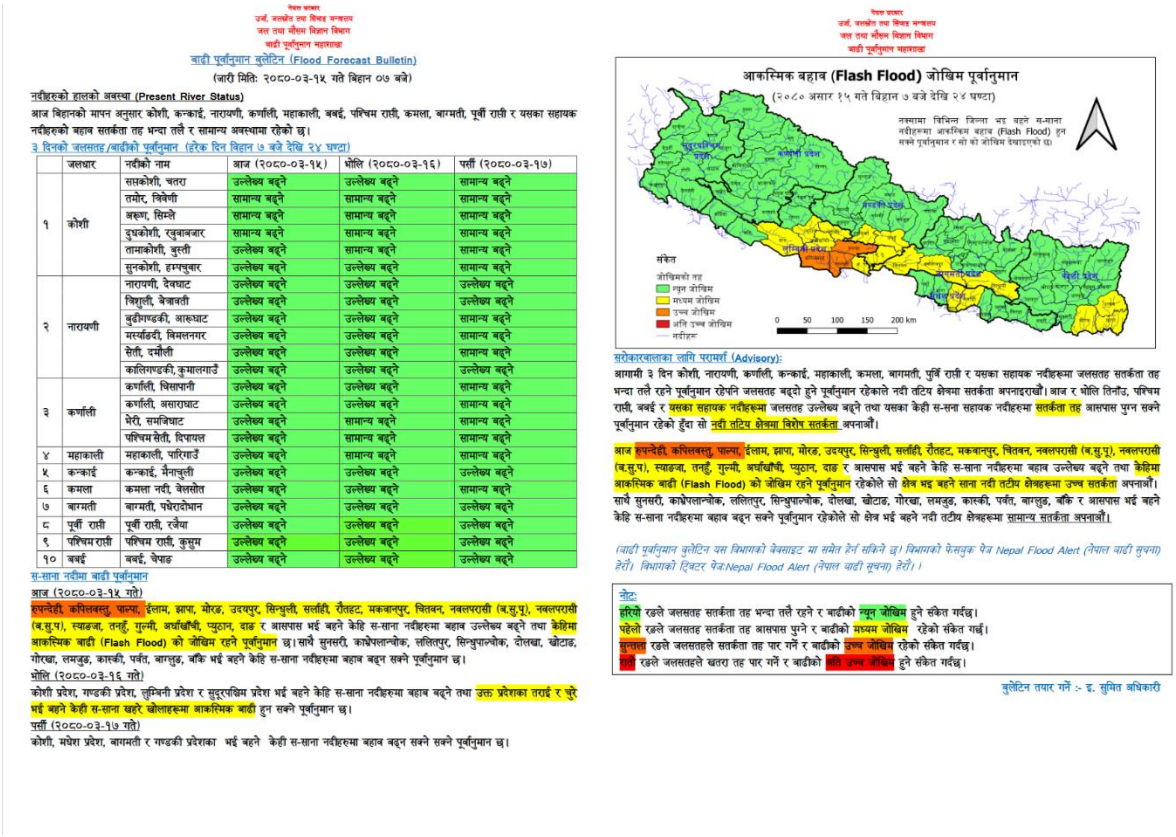


Figure 12. Flood monitoring at the DHM website



बाढी पूर्वानुमान बुलेटिन (Flood Forecast Bulletin)

(जारी मिति: २०८०-०३-१५ गते बिहान ०७ बजे)

नदीहरुको हालको अवस्था (Present River Status)

आज बिहानको मापन अनुसार कोशी, कन्काई, नारायणी, कर्णाली, महाकाली, बबई, पश्चिम राप्ती, कमला, बागमती, पूर्वी राप्ती र यसका सहायक नदीहरुको बहाव सतर्कता तह भन्दा तलै र सामान्य अवस्थामा रहेको छ।

३ दिनको जलसतह /बाढीको पूर्वानुमान (हरेक दिन बिहान ७ बजे देखि २४ घण्टा)

	जलधार	नदीको नाम	आज (२०८०-०३-१५)	भोलि (२०८०-०३-१६)	पर्सी (२०८०-०३-१७)
१	कोशी	सप्तकोशी, चतरा	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने	सामान्य बढ्ने
		तमोर, विवेणी	सामान्य बढ्ने	सामान्य बढ्ने	सामान्य बढ्ने
		अरुण, सिम्ले	सामान्य बढ्ने	सामान्य बढ्ने	सामान्य बढ्ने
		दुधकोशी, खुवाबजार	सामान्य बढ्ने	सामान्य बढ्ने	सामान्य बढ्ने
		तामाकोशी, बुत्ती	उल्लेख्य बढ्ने	सामान्य बढ्ने	सामान्य बढ्ने
		सुनकोशी, हम्पचुवार	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने	सामान्य बढ्ने
२	नारायणी	नारायणी, देवघाट	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने
		त्रिशुली, बेत्रावती	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने
		बुढीगण्डकी, आरुघाट	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने	सामान्य बढ्ने
		मर्स्याङदी, बिमलनगर	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने	सामान्य बढ्ने
		सेती, दमौली	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने	सामान्य बढ्ने
		कालिगण्डकी, कुमालगाउँ	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने
३	कर्णाली	कर्णाली, चिसापानी	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने	सामान्य बढ्ने
		कर्णाली, असाराघाट	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने	सामान्य बढ्ने
		भेरी, समबिघाट	उल्लेख्य बढ्ने	सामान्य बढ्ने	सामान्य बढ्ने
		पश्चिम सेती, दिपायल	उल्लेख्य बढ्ने	सामान्य बढ्ने	सामान्य बढ्ने
४	महाकाली	महाकाली, परिगाउँ	उल्लेख्य बढ्ने	सामान्य बढ्ने	सामान्य बढ्ने
५	कन्काई	कन्काई, मैनाचुली	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने
६	कमला	कमला नदी, बेलसोत	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने	सामान्य बढ्ने
७	बागमती	बागमती, पथेरादोभान	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने
८	पूर्वी राप्ती	पूर्वी राप्ती, रजैया	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने
९	पश्चिम राप्ती	पश्चिम राप्ती, कुसुम	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने
१०	बबई	बबई, चेपाङ	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने	उल्लेख्य बढ्ने

स-साना नदीमा बाढी पूर्वानुमान

आज (२०८०-०३-१५ गते)

हप्नदेही, कपिलवस्तु, पाल्पा, ईलाम, झापा, मोरङ, उदयपुर, सिन्धुली, सर्लाही, रौतहट, मकवानपुर, चितवन, नवलपरासी (ब.सु.पू), नवलपरासी (ब.सु.प), स्याङजा, तनहुँ, गुल्मी, अर्घाखाँची, प्युठान, दाङ र आसपास भई बहने केहि स-साना नदीहरुमा बहाव उल्लेख्य बढ्ने तथा केहिमा आकस्मिक बाढी (Flash Flood) को जोखिम रहने पूर्वानुमान छ। साथै सुनसरी, काभ्रेपलान्चोक, ललितपुर, सिन्धुपाल्चोक, दोलखा, खोटाङ, गोरखा, लमजुङ, कास्की, पर्वत, बाग्लुङ, बाँकि भई बहने केहि स-साना नदीहरुमा बहाव बढ्न सक्ने पूर्वानुमान छ।

भोलि (२०८०-०३-१६ गते)

कोशी प्रदेश, गण्डकी प्रदेश, लुम्बिनी प्रदेश र सुदूरपश्चिम प्रदेश भई बहने केहि स-साना नदीहरुमा बहाव बढ्ने तथा उक्त प्रदेशका तराई र चुरे भई बहने केही स-साना खहरे खोलाहरुमा आकस्मिक बाढी हुन सक्ने पूर्वानुमान छ।

पर्सी (२०८०-०३-१७ गते)

कोशी, मधेश प्रदेश, बागमती र गण्डकी प्रदेशका भई बहने केही स-साना नदीहरुमा बहाव बढ्न सक्ने सक्ने पूर्वानुमान छ।

आकस्मिक बहाव (Flash Flood) जोखिम पूर्वानुमान

(२०८० असार १५ गते बिहान ७ बजे देखि २४ घण्टा)

सरोकारवालाका लागि परामर्श (Advisory):

आगामी ३ दिन कोशी, नारायणी, कर्णाली, कन्काई, महाकाली, कमला, बागमती, पुर्वि राप्ती र यसका सहायक नदीहरुमा जलसतह सतर्कता तह भन्दा तलै रहने पूर्वानुमान रहेपनि जलसतह बढ्दो हुने पूर्वानुमान रहेकाले नदी तटिय क्षेत्रमा सतर्कता अपनाइराखौं। आज र भोलि तिनाँउ, पश्चिम राप्ती, बबई र यसका सहायक नदीहरुमा जलसतह उल्लेख्य बढ्ने तथा यसका केही स-साना सहायक नदीहरुमा सतर्कता तह आसपास पुग्न सक्ने पूर्वानुमान रहेको हुँदा सो नदी तटिय क्षेत्रमा विशेष सतर्कता अपनाऔं।

आज हप्नदेही, कपिलवस्तु, पाल्पा, ईलाम, झापा, मोरङ, उदयपुर, सिन्धुली, सर्लाही, रौतहट, मकवानपुर, चितवन, नवलपरासी (ब.सु.पू), नवलपरासी (ब.सु.प), स्याङजा, तनहुँ, गुल्मी, अर्घाखाँची, प्युठान, दाङ र आसपास भई बहने केहि स-साना नदीहरुमा बहाव उल्लेख्य बढ्ने तथा केहिमा आकस्मिक बाढी (Flash Flood) को जोखिम रहने पूर्वानुमान रहेकोले सो क्षेत्र भइ बहने साना नदी तटीय क्षेत्रहरुमा उच्च सतर्कता अपनाऔं। साथै सुनसरी, काभ्रेपलान्चोक, ललितपुर, सिन्धुपाल्चोक, दोलखा, खोटाङ, गोरखा, लमजुङ, बाँकि र आसपास भई बहने केहि स-साना नदीहरुमा बहाव बढ्न सक्ने पूर्वानुमान रहेकोले सो क्षेत्र भई बहने नदी तटीय क्षेत्रहरुमा सामान्य सतर्कता अपनाऔं।

(बाढी पूर्वानुमान बुलेटिन यस विभागको वेबसाइट मा समेत हेर्न सकिने छ। विभागको फेसबुक पेज Nepal Flood Alert (नेपाल बाढी सूचना) हेर्नु। विभागको ट्विटर पेज:Nepal Flood Alert (नेपाल बाढी सूचना) हेर्नु।)

नोट:

हरियो रङले जलसतह सतर्कता तह भन्दा तलै रहने र बाढीको न्यून जोखिम हुने संकेत गर्दछ।

पहेलो रङले जलसतह सतर्कता तह आसपास पुग्ने र बाढीको मध्यम जोखिम रहेको संकेत गर्छ।

सुन्तला रङले जलसतहले सतर्कता तह पार गर्ने र बाढीको उच्च जोखिम रहेको संकेत गर्दछ।

रातो रङले जलसतहले खतरा तह पार गर्ने र बाढीको अति उच्च जोखिम हुने संकेत गर्दछ।

बुलेटिन तयार गर्ने :- इ. सुमित अधिकारी

Figure 13. Flood bulletin at the website of hydrological division

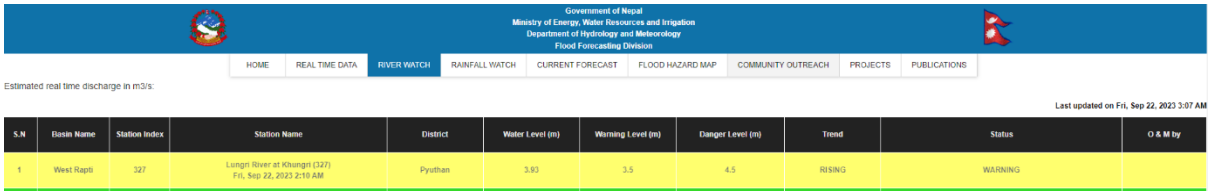


Figure 14. River watch at the website of hydrological division

6.3. Common alerting procedures in place based on impact-based services and scenarios taking hazard, exposure and vulnerability information into account and with registered alerting authorities.

Currently, Nepal does not use the CAP format in issuing warnings. Only limited forecasters have got the basics training on impact-based forecast (IBF) under AARCC and South Asian Hydrometeorological Forum. Pilot IBF have been implemented only in projects, e.g. the AARCC project piloted IBF on heavy rain for 4 districts and cold wave warnings have been piloted for 2 districts.

DHM updates the flood hazard map regularly. Statistics on disasters are collected on the national disaster risk portal[18]. The latter includes information on the number of injured, dead, missing, affected families and estimated capital losses. A more detailed description on the impacts of floods is only provided by 2 district-level pilot groups and tourism for its' operation. Also, internet is used as an information source.

Summary score, recommendations, and comments for Element 6

The CHD Element 6 score is 3, reflecting "Weather-related warning service with modest public reach and informal engagement with relevant institutions, including disaster management agencies". Recommendations to strengthen warning services and to achieve the objectives of the Early Warning for All Initiative by 2030:

- Availability and utilization of existing technical facilities should be strengthened strongly to establish more reliable and effective warning service. Technical assistance and capacity building are necessary to achieve these. General capability of forecasting should be enhanced e.g. increase the lead time of the forecast from three days to at least a week, establish research unit in the field of weather and meteorology,
- DHM should promote MHEWS e.g. by harmonizing dissemination of weather and flood warnings (warnings issued in common portal, SMS dissemination also for weather warnings, simplifying warning messages) including awareness activities to the public with the forecast mechanism, forecast terminologies and forecast uncertainty.
- Encourage piloting of new warnings and developing threshold levels in collaboration with stakeholders and in research cooperation. DHM is recommended to continue the IBF forecast service, upscale the forecast, and plan for the sustainability of the IBF projects.
- Strengthening regular cooperation with authorities (regular meetings and testing of full value chain of disaster management, wrap-up discussion after severe events).

[18] Government of Nepal. Nepal Disaster Risk Reduction Portal. http://drrportal.gov.np/

Element 7: Contribution to Climate Services

7.1. Where relevant, contribution to climate services according to the established capacity for the provision of climate services.

DHM's role in national adaptation planning needs to be prioritized which will enhance coordination, resilience that contributes significantly to addressing climate change impacts. The National Adaptation Plan and Environmental Protection Plan state DHM's responsibilities to provide certain climate services (more information in Element 1: Governance and institutional setting). A draft National Framework for Climate Services was prepared under the CARE project in 2020 but is not implemented yet. National Climate Outlook Forums for stakeholders have been organized yearly during monsoon season, but there is lack of the budget allocation for the event in 2023.

The currently available data management system (more information in Element 4: data and product sharing and policies) is supporting climate service production but requires tools and technologies for enhancing products and services from available data which includes observations from 1947. DMS has internal tools for climate monitoring, which enable production of climate products. Quality control of observations requires automatization which will improve quality of data without manual intervention and also saves time and solves problem related with human resources. Currently, the climate and agrometeorological sections practice manual quality control of observations prior to service production.

The Climate and Agrometeorological sections are providing various services for the Nepalese society and decision-making, e.g. daily and monthly weather reports on rainfall and temperature, seasonal outlooks for monsoon and winter, monsoon monitoring, 7-day weather monitoring and outlook (one/week), and specific products for agriculture. Elevation corrected kriging method and long-term climatological data is used in production. The latest climate normal period covers 1991–2020. It includes annual and monthly precipitation and temperature. Many of these services have developed under different projects, like FNEP.

Climate products are available on the DHM website in separate pdf files and are disseminated via Facebook (Climate Section) and X (@ClimDhm). The Nepal Agriculture Management Information System (NAMIS) portal for agriculture decision-making was established in co-operation with the NARC under the BRCH project[19]. The portal is not currently active. Some agrometeorological products are published on Facebook (Agromet Dhm Nepal) and X (@DHM_Agromet). Economic benefits of the DHM's service for the agricultural sector were studied under FNEP1.

[19] namis.gov.np/index.php

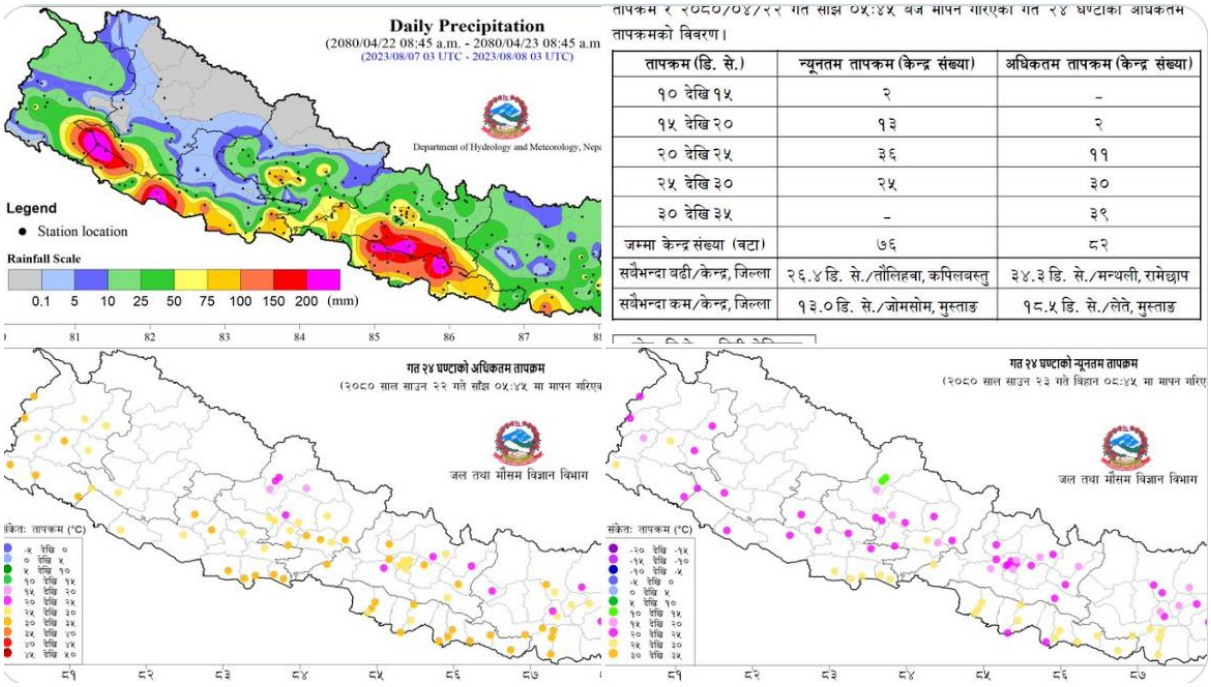
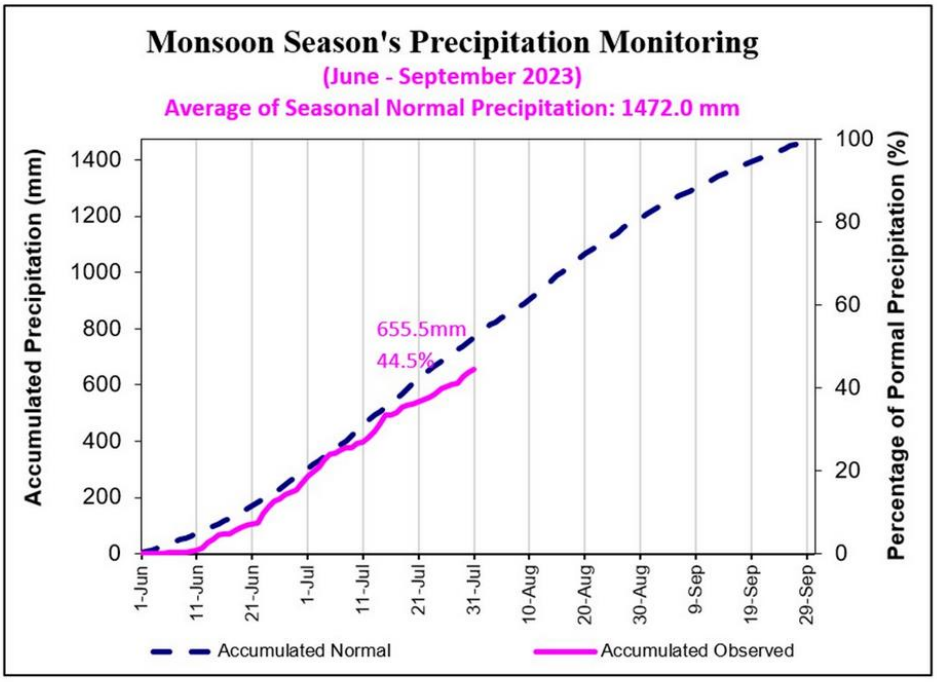


Figure 15. Example of a daily precipitation report published by the Climate Section's account in X (formerly Twitter).

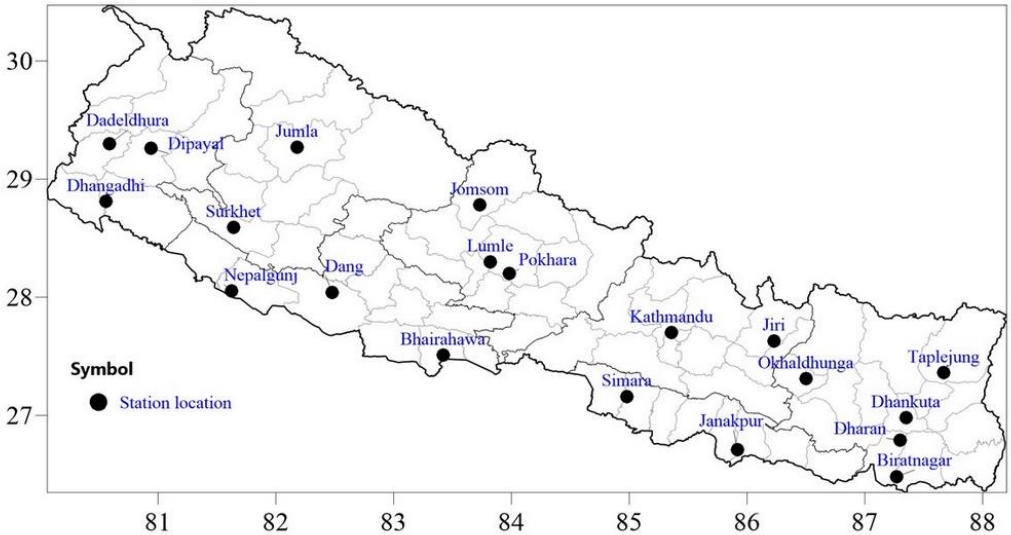
Summary score, recommendations, and comments for Element 7

The CHD Element 7 score is 3, reflecting "Essential Capacity for Climate Services Provision". Recommendations to strengthen climate service and to achieve the objectives of the Climate Service Implementation recommended by WMO:

- Enhancing quality control in the DMS is necessary for automatization and more efficient climate and agrometeorological service provision for different sectors, and for increasing the availability of climate information on the DHM website. Capacity building and cooperation with stakeholders is needed in automatization and development of new products.
- DHM's role in national adaptation planning needs to be prioritized which will enhance coordination, resilience that contributes significantly to addressing climate change impacts. Responsibilities between DHM and the Ministry of Forests and Environment (MoFE) related to climate information provision should be clarified and the NFCS implemented according to its draft.
- Continuation of current services and NCOF should be ensured by stable budget and capable staff. NAMIS portal should be activated in collaboration with NARC.



Graph 1: Blue dashed (----) line indicates the average of daily accumulated normal precipitation of 20 stations (Map 1) during monsoon season (June - September) and pink solid line (——) indicates the average of daily accumulated precipitation of this monsoon season.



ALT Map 1: Location of 20 Meteorological Station

Figure 16. Monsoon season monitoring

Element 8: Contribution to hydrology

8.1. Where relevant, standard products such as quantitative precipitation estimation and forecasts are produced on a routine basis according to the requirements of the hydrological community.

The DHM is operating over 200 hydrological stations and 11 cryosphere stations covering all over the country including the smaller catchments also. Water level is primary parameter and some stations are also measuring precipitation and discharge. 75% of the stations are automatic and under a regular maintenance contract. Sediment section is responsible for 24 sediment and some water quality stations; other sections are responsible for glacial lake outburst floods (GLOF) and snow monitoring.

Flood forecasting systems have been installed in 24 river basins according to the South Asian Flash Flood Guidance System for flood warnings. Lead time of the forecasting system is maximum 72 hours. Rainfall and water level watch based on automatic observations are shown on the DHM website. In addition to websites, the warnings are disseminated via SMS and social media. See more in Element 6: Warning and advisory services.

8.2. SOPs in place to formalize the relation between Met Service and Hydrology Agency, showing evidence that the whole value chain is addressed.

DHM is responsible for meteorological, hydrological and cryosphere monitoring, forecasts and warnings. DHM has a common database for meteorological and hydrological observations, and weather forecasting model output is used as input to hydrological modelling. Warning of heavy precipitation is linked to flood warning. All the warnings are published on the DHM website and social media. NDRRMA also disseminate those warning to local, provincial and central authorities through own network. Water resources assessment and flood management plans are responsible of other authorities.

8.3. Data sharing agreements (between local and national agencies, and across international borders as required) on hydrological data in place or under development.

Only the real time data up to few days is made public via DHM website and shared with some local governments. Data is shared to the South Asia Flash Flood Guidance System (SAsiaFFGS).

8.4 Joint projects/initiatives with hydrological community designed to build hydrometeorological cooperation.

Currently ongoing projects:

- Priority River Basin Flood Risk Management Project PRBFRMP: EWS for small river basins.
- Bagmati River Basin Improvement Project: training on EWS at the Bagmati flood prone.

Summary score, recommendations, and comments for Element 8

The CHD Element 8 score is 3, reflecting "There is a moderately well-functioning relationship between the meteorological, hydrological and water resources communities but considerable room for formalizing the relationship and SOPs". Recommendations to strengthen the hydrological service:

- Modernisation and adaptation of new technologies should be continued and ensure current service level (O&M)
- information dissemination, awareness and interpretation of hydro-met advisories to different stakeholders up to the community level should be strengthened in co-operation with stakeholders
- Cooperation between the hydrological and meteorological divisions should be encouraged, e.g. all weather observations and NWP to be used as input in hydrological modelling, verification of numerical weather and hydrological models, daily briefings, deep commitment in severe weather cases, common portal and practices in warning dissemination.
- Capacity building and development of hydrological modelling and forecasting in research cooperation and/or with external support.

Element 9: Product dissemination and outreach

9.1. Channels used for user-centred communication and ability to support those channels (for example, does the NMHS operate its own television, video or audio production facilities? Does it effectively use cutting-edge techniques?).

DHM's services for the public are available on the DHM website developed in 2022[20]. It presents most of the observations, products and forecasts from all sections. The mobile application is a duplicate of the DHM website with limited content.

Each services have separate social media accounts in Facebook and X (e.g. @DHM_FloodEWS, @DHM_Weather, @ClimDhm, @DHM_Agromet). Social media is actively used in the dissemination of daily information and advisories, and the number of followers is up-to 30 000. Detailed numbers are shown in Element 6: Warning and advisory services.

Public media such as National radio, TV channels are announcing daily weather forecasts in the mornings and evenings in addition to weather and flood advisories/warnings to the public. Printed media also publish weather reports. In addition, advisories are sent to the authorities via email, and flood warnings via mass SMS for the public. TV studio was installed under BRCH but has not been in operation due to a lack of training.

9.2. Education and awareness initiatives in place.

Educational and awareness initiatives are organised for stakeholders, such as radio programs for the public, awareness lectures for school, college level student and also for the public with the coordination of government agencies and NGOs. Many awareness activities are project-specific, like in AARCC, FNEP or BRCH.

9.3. Special measures in place to reach marginalized communities and indigenous people.

Currently there are no special measures to reach marginalized communities. Some promotion of DMH's services has been carried out in co-operation with NGOs such as Red Cross, Practical action, WWF, Care Nepal etc to enhance the availability of services at the community level.

Summary score, recommendations, and comments for Element 9

The CHD Element 9 score is 2, reflecting "Traditional communication channels and a basic dedicated website is used to disseminate forecasts and basic information." Recommendations to strengthen information dissemination:

- Dissemination of weather, climate and flood information should be harmonized to ensure easy access to services to every public. Automatic products generation system should be carried out in full operation to ensure accurate and timely service for the public including marginalized communities and indigenous people.
- Awareness of DHM's services should be strengthened. Cooperation with local governments and NGO's would improve the availability of services, especially in rural communities.

[20] www.dhm.gov.np

Element 10: Use and national value of products and services

10.1. Formalized platform to engage with users in order to co-design improved services.

DHM participates in regular platforms, e.g. related to disaster risk management during monsoon season by NDRRMA, agrometeorological services and technical meetings by NARC, aviation weather service provision with CAAN, and climate data dissemination with Department of Health services. The annual NCOF meeting was not organized in 2023 due to budgetary reasons.

Cooperation with stakeholders is mainly ad-hoc or project-based. Tailored services are available for agriculture and for aviation, which are one of the most weather-dependent sectors, in addition to disaster risk management and electricity. Agriculture services are disseminated via NAMIS. For aviation, DHM is providing METAR's and SPECI for 17 airports, TAF for international airports (3), SIGMET for convective events, briefings for pilot and airline personnels, flight folder based on SADIS data including in-route forecasts (METAR & TAF), low level charts and Significant Weather Charts. Currently Nepal has 3 international airports, 5 regional airports with regular operation and over 30 domestic airports with seasonal operation. All domestic flights are operating via regional airports.

The first socio-economic study was implemented in 2011 under FNEP1[21], before BRCH implementation. Cost-benefit analysis included the agriculture, electric power supply, public health and safety, civil aviation and tourism, and road transport sectors. In 2023 the World Bank evaluated the socio-economic benefits of proposed improved services[22], but a study of the socio-economic benefits of the current service level is missing.

10.2. Independent user satisfaction surveys are conducted, and the results used to inform service improvement.

A comprehensive user satisfaction survey was done in 2019 under BRCH, and included the agriculture, aviation, hydropower, irrigation, media, tourism, and water supply sectors, as well as universities, research community and NGOs. This survey was an extension of a previous baseline survey implemented in 2015. DHM has a survey platform on their website. The baseline survey was repeated for the aviation sector in 2019 under FNEP3 as part of the piloting of a customer management process. Currently DHM has no SOP for customer management process nor a service delivery plan.

10.3. Quality management processes that satisfy key user needs and support continuous improvement.

DHM has several SOPs related to the production of observations and weather service, but full quality management system (QMS) is missing. DHM has planned to implement QMS for aviation weather services. The ToR for the development of the QMS Roadmap were drafted in 2022, but implementation is missing. Climate services are provided based on DHM's expertise.

[21] Perrels, A., 2011: Social economic benefits of enhanced weather services in Nepal. FMI FNEP Reports 2011

[22] World Bank, 2023. Strengthening Hydromet and multi-hazard early warning service in Nepal. An Hydromet Master Plan. Draft 26.9.2023.

Summary score, recommendations, and comments for Element 10

The CHD Element 10 score is 2, reflecting "Service development draws on informal stakeholder input and feedback". Recommendations to strengthen service delivery:

- Enhance service level by developing customer management process including regular stakeholder meetings, user satisfaction surveys for main sectors and development of new services based on feedback.
- Improve aviation weather service by developing service processes according to ICAO requirements (products, QMS, cost-recovery) and development of new services for domestic aviation. Development of aviation services requires more human resources and external support.
- Implementation of QMS roadmap and enlarge of QMS to cover full value chain would need external training and support.
- Development of sector specific weather forecast mainly for agriculture, tourism and aviation. New services should be automized to ensure more efficient service production.
- Number of awareness activities to the public with the DHM services, forecast mechanism, forecast terminologies and forecast uncertainty.

Annex 1 Consultations (including experts and stakeholder consultations)

DHM participants in the SOFF workshop in 21st Aug 2023.

SOFF Meeting

Venue: DHM, NEPAL **Date:** August 21, 2023

Attendence Sheet

S.N	Mr/Ms.	Name	Designation	Section	Signature
1.	Mr.	Suman K. Regmi	S.D. Meteorologist	Climate Data & Network	
2.	Mr.	Shiva pd. Nepal	" "	Agromet Section.	
3		Ram P. Awasthi	" Hydrologist	Sediment and Limnology	
4	Mr.	Saket Kumar Karn	" "	Saketkarn@gmail.com	
5		Nirajan Saprkota	" SDM		
6	Mr	Sunil Pd Kharel	SDM		
7	Mr.	Sudarshan Humagain	Meteorologist	Climate Analysis Section	
8.	Mrs	Indira Kadel	SDM		
9.	Mr.	Niraj S. Pradhananga	Meteorologist	Snow Survey & Glacial Lake	
10.	Mr.	Govind Kumar Jha	"	NWP Section	

Annex 2 Urgent needs reported

The most urgent need to ensure the current service level is sufficient funding and human resources. Without successful financing, procurements and staffing service level of the DHM will drop dramatically in the following years. The main and most urgent gaps, as listed in the Executive Summary, are:

- Insufficient operational funding and problems to implement planned procurement: insufficient governmental budget, lack of commercial services and cost-recovery system, national procurement rules or availability of procured services have limited the implementation of outsourced services as well as the procurement of required properties. A relatively high share of DHM's operations is outsourced due to a lack of human resources (e.g. O&M of observation stations). Originally planned governmental budget has cut during fiscal year meaning DHM has to reduce from its' activities.
- Critical shortage of staff: DHM does not have adequate qualified personnel to run 24/7 service even for the public as well as aviation and the demands of forecast are increasing day by day. Operational staff have a high share of managerial tasks in addition to their duty responsibilities. High modernization of the value chain would require variety of human skills, especially ICT and technical expertise.
- Adequate operation and maintenance of observations is missing due to the lack of sufficient funding and human resources, causing a serious lack of data. Operation of radars is unreliable, and the lightning system is inactive. The quality and number of weather and hydrological observations are expected to decrease in the near future due to a lack of appropriate maintenance. Lack of weather stations in high hills and Himalayas and plan for wide coverage of those stations.
- Quality control in the data management system (DMS) should be fully implemented to support the quality of observations and automatization of DHM production process (e.g. climate and agrometeorological services, tailored weather services for different sectors). The automatization of basic production processes would release human resources for other tasks.
- Warning and advisory services should be enhanced by making use of all technical capabilities in forecasting and monitoring hazards, establishing thresholds for major hazards, standardizing the content and dissemination of weather and flood advisories, and strengthening regular cooperation with authorities and NGOs.
- Long-term partnerships covering capacity building, outsourcing of services, R&D cooperation with operational support are especially crucial for the development of DHM

Annex 3 Information supplied through WMO

- CHD EW4All WMO Data Inventory and Review Sheet
- WMO Global GBON gap Analysis
- WMO Monitoring System Data
- WMO EW4All Rapid Assessment for Pillar-2
- WMO Hydrology Survey
- Data from Checklist for Climate Services Implementation

Annex 4 List of materials used

In addition to WMO guidelines, the following material was utilized:

- Online material included as reference to this document
- The DHM, MFD, HD websites
- Social media accounts by DHM's sections
- Project documents produced in FNEP and BRHC
- DHM internal documents and drafts, e.g. Hydromet Master Plan (WB, 2023)