STANDARD OPERATING PROCEDURE FOR CRYOSPHERE SERVICES DIVISION
(Revised Version 2.0)

National Center for Hydrology and Meteorology
Royal Government of Bhutan
2023

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1. Standard Operating Procedure

1.1. Title

Standard Operating Procedure (SOP) for Cryosphere Services Division (CSD) hereafter referred to as SOP 2023 for CSD.

1.2. Objective

To actively engage CSD officials in line with Division's mandate and functions.

1.3. Effective

The Revised SOP 2023 will be implemented with effect from 1st July 2023.

2. Mandate, Function and Structure of CSD

2.1. Mandate

The Cryosphere Services Division (CSD) is mandated to monitor, carryout out research and inventory on cryosphere (snow, glaciers, glacial lakes, and permafrost), and hazard assessment to generate science-based information for understanding of climate change, mitigation and adaptation planning

2.2. Functions of CSD

a) Prepare plans and programs related to cryosphere (snow, glaciers, glacier lakes) monitoring in Bhutan Himalayas;
b) Time series monitoring of glaciers and glacial lakes;
c) Operation and maintenance of cryosphere monitoring networks in coordination with other divisions of the Center;
d) Maintain Inventory and national Cryosphere Database (Cryosphere Information Hub);
e) Assess hazards and risks of glaciers and glacier lakes and threat of Glacial Lake Outburst Flood (GLOF) and melt contribution from glacier and snow to the river runoff;

f) Research and publish scientific papers on cryosphere and related studies.
g) Coordinate with national agencies related to snow and glacier monitoring and data collection;
h) Foster collaboration with regional and international institutions/agencies involved in the field of cryosphere research and data sharing through the Center;
i) Provide professional and technical services to the Center/other agencies on conceptual and methodological aspects of cryosphere monitoring and related studies.

2.3. Structure

Sections under Cryosphere Services Division:

a. Cryosphere Monitoring and Survey Section (CMSS)
b. Cryosphere Information & Management Section (CIMS)

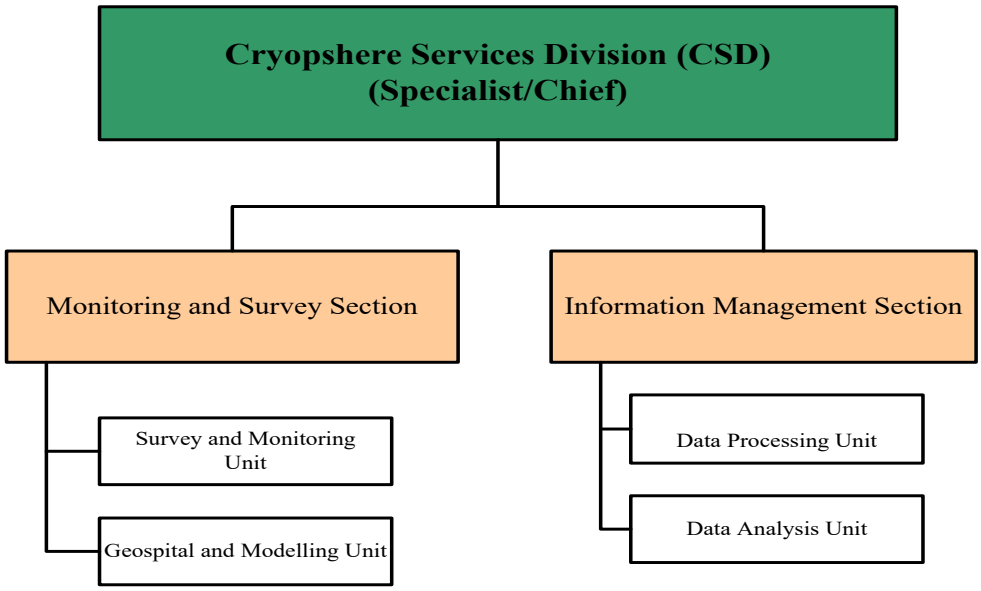

Figure 1: Organogram of CSD

3. SOP for Cryosphere Monitoring & Survey Section (CMSS)

Functions of CMSS:

a. Develop long term cryosphere monitoring program of Bhutan Himalayas;
b. Establish and operate long term benchmark glacier monitoring program to study status of the glaciers (mass balance, terminus activity, glacier surface activity, glacier dynamics including flow velocity and ice thickness), flow contribution and impact of climate change on water resources;
c. Establish and operate research based/time bound snow monitoring stations;
d. Preparing glaciers and glacier lakes inventory of Bhutan and updating;
e. Topographical and bathymetry survey of the glacier lakes for hazard assessment and modeling;
f. Conduct research activities on glaciers and snow melt and its contribution to surface runoff
g. Carry out Time Series Monitoring of glacial lakes, assess associated risk and implement appropriate mitigation/adaptation measures;
h. Coordinate with national stakeholders pertaining to snow, glacier and permafrost hazards and risk assessment;
i. Breach scenario modeling as input for hazard map preparation
j. Carryout research activities pertaining to GLOF and related hazards/risks;
k. Maintaining updated inventories on snow, glacier, and glacial lake and making timely publications;
l. Conduct research on permafrost

3.1 Annual Glacier Mass Balance measurements			
Actions of CMSS	**Time Frame**	**Operator**	**Output/Result**
a) Planning	1 Month	Field team	➢ Desk studies carried out. ➢ Logistics (route permit, ponies, and field equipment/instruments) arranged
b) Field work	2 Months	Field team	Data collected as per objectives
b) Data analysis	1 Month	Field team	Analyzed and processed
d) Report writing and submission.	2 Months	Officer in-charge	Standard/comprehensive scientific report generated and submitted.
3.2 Establishment of automatic climate & snow monitoring stations.			
Actions of CMSS	**Time Frame**	**Operator**	**Output/Result**
a) Prepare a technical comparative statement of technical	1-2 Month (depending on number of parameter/	Division focal	Technical specification prepared and submitted to the concerned Division.

specifications and present it to management for finalization.	sensor listed		
b) Prepare estimates and process technical sanction from Technical Standard and Research Division (TSRD)	1 Month	Division focal	The document comprising estimates of the work, technical specifications and implementation method should be presented to TSRD.
c) Assist Procurement Section for tendering process	1-3 Months	Division focal	Tender documents prepared, bids evaluated, tender awarded and goods received following due procedures.
d) Installation of station	2 Months	Division focal	Station established as per design and standards
e) Technical report writing/submission	1 Month from date of station establishment	Officer in-charge	Comprehensive report submitted

3.3 Conduct research on melt contribution to surface runoff from snow and glaciers using glacio-hydrological model.			
Actions of CMSS	**Time Frame**	**Operator**	**Output/Result**
a) Compilation of data.	1 Month	Focal team	Climatic data acquired
b) Processing and analyzing data	1 Month	Focal team	Required data sets processed and finalized
c) Set-up and run melt model	2 Months	Focal team	Results on contribution of glacier/snow melt to surface runoff estimated.
d) Report submission.	1 month	Focal team	Standard/comprehensive scientific report generated and submitted
3.4 Conduct research on melt contribution to surface runoff using isotope tracer method			
Actions of CMSS	**Time Frame**	**Operator**	**Output/Result**
a) Planning	1 Month	Focal team	➢ Desk studies carried out. ➢ Logistics (route permit, ponies, and field equipment/instruments) arranged.

b) Field work	As per objective of the work	Focal team	Samples collected as per requirement
c) Sample analysis	Depends on number of samples	Focal team	Data sets generated
d) Data analysis and report writing and submission	2 Months	Officer in-charge	Report submitted
3.5 Preparing glacier inventory			
Actions of CMSS	**Time Frame**	**Operator**	**Output/Result**
a) Data acquisition	1 Month	Focal team	Satellite imageries acquired/downloaded.
b) Processing of satellite and associated data sets	1 Month	Focal team	Refined imageries produced for further analysis.
c) Glacier mapping and data analysis	4 Months	Focal team	Final glacier boundaries produced as per set criteria
d) Report writing and submission.	1 Month	Focal officer	Glacier inventory produced
3.6 Time series monitoring of glacial lakes.			

Actions of CMSS	Time Frame	Operator	Result/Remarks
a) Planning	1 Month	Focal team	➢ Desk studies carried out. ➢ Logistics (route permit, ponies, and field equipment/instruments) arranged.
b) Field survey	2 Months	Focal team	Data collected as per objectives
c) Data analysis	1 Month	Focal team	Data analyzed
d) Report writing and submission	2 Months	Officer in-charge	Standard/comprehensive scientific report submitted.
3.7 Prepare Glacial lakes inventory & Potentially Dangerous Glacial Lakes.			
Actions of CMSS	**Time Frame**	**Operator**	**Output/Result**
a) Data acquisition	1 Month	Focal team	Satellite imageries acquired/downloaded.
b) Processing of satellite and associated data sets	1 Month	Focal team	Refined imageries produced for further analysis
c) Glacial lake	4	Focal team	Final glacier lake

mapping and analysis	Months		boundaries produced as per set criteria
d) Report writing and submission	1 Month	Focal officer	Glacial lake inventory produced
3.8Breach modeling for GLOF as an input for hazard mapping.			
Actions of CMS	**Time Frame**	**Operator**	**Output/Result**
a) Planning	1 Month	Focal team	➢ Desk studies carried out. Logistics (route permit, ponies, and field equipment/instruments) arranged.
c) Field work	2 Months	Focal team	Data sets collected as per objectives
d) Set up and run breach model	2 months	Focal team	Result on breach model produced
e) Report writing and submission	2 months	Officer in-charge	Standard/comprehensive scientific report generated and submitted

4. SOP for Cryosphere Information & Management Section (CIMS)

Functions of CIMS:

- ➢ Compile and archive up to date cryosphere data.
- ➢ Maintaining updated inventories on snow, glacier, and glacial Lake and making timely publication.
- ➢ Compilation and archiving of reports, data and publications related to the cryosphere.
- ➢ Data ingestion and operation of Cryosphere Information Hub-linked with NCHM web-server.
- ➢ Data processing and analysis to generate reliable information (long term goal).
- ➢ Provide cryosphere data and information for end users

4.1 Compile reports, data (field), satellite imageries in Cryosphere Information Hub and Maintain data repository systematically.			
Actions of CIMS	**Time Frame**	**Operator**	**Outcome/result**
a) Compilation of field data	1 Week (after the submission of scientific report)	Data focal	Archived all sets of data (Raw and analyzed)
b) Compilation of publications, articles, scientific paper and scientific reports related to cryosphere	1 Week (after the submission of scientific reports)	Data focal	All archived in soft and hard copy
c)Daily cryosphere	Daily	Data focal	Data from all

data archival			cryosphere stations archived
4.2 Provide cryosphere data and information for end users.			
Actions of CIMS	**Time Frame**	**Operator**	**Output/Result**
Render cryosphere data to user(s) upon instruction from Division head on Data request	1-3 days from date of data request	Data focal	Data provided based on Data sharing guidelines of the Center.

5. SOP for Common Services under the Division.

5.1 Planning, organizing meetings, submitting proposals for Divisional fiscal year Budget, Five Year Plan(s), APT, and update status on Budget.			
Actions of CSD	**Time Frame**	**Operator**	**Outcome/result**
a) Prepare annual budget, balance statement, submission of BRF, budget re-appropriation	As per deadline	Budget focal	Budget activities completed as per timeline given
c) Prepare APT of division in coordination with Centre's APT	As per deadline	APT focal	APT prepared and submitted

focal.			
d) Prepare FYP document of the division	As per deadline	FYP focal	FYP document prepared and submitted
5.2 Maintain stocks, scientific equipment and goods under the division			
Actions of CSD	**Time Frame**	**Operator**	**Output/Result**
b) Maintain inventory for CSD equipment, gear, survey tools and machineries.	Routine work	Division focal	Inventories maintained
c) Issue/return requested equipment with proper handing-taking upon approval	As and when required/requested	Division focal	Equipment issued with proper hand-taking.
d) Check and charge all rechargeable batteries, equipment and instruments	Regularly	Division focal	All batteries, equipment and instruments kept functional.
5.3 Ad-hoc services			
Actions of CIMS	**Time**	**Operator**	**Output/Result**

	Frame		
a) Bathymetry services	Based on the work nature	Assigned team	Report submitted *Note*: Result to be based on client's specific request.*
b) UAS services	Based on the work nature.	Assigned team	Report submitted *Note*: Result to be based on client's specific request.*

6. Amendment and Revision

TSRD in consultation with the division will review and update this SOP from time to time and submit to the management for approval.

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