SYSTEM REQUIREMENTS SPECIFICATION

FOR

CENTRALIZED HYDROMET DATABASE MANAGEMENT SYSTEM

Revision History

Name	Date	Reason for Changes	Version
SRS v1.0	27/08/2020	Initial version	1.0
SRS v2.0	18/09/2020	Content update	2.0
SRS v3.0	28/10/2020	Content update	3.0
SRS v4.0	02/11/2020	Final version	4.0

Table of Contents

1. Introduction

1.1 Purpose

The purpose of the Software Requirements Specification (SRS) document is to provide a clear and precise description of the functionality of the Hydro-Met Data Management System (HDMS). This SRS serves as a document between the NCHM and the software vendor regarding the requirements of the HDMS. Throughout the HDMS implementation process for commercial off-the-shelve (COTS) or custom application development, this SRS is intended to provide a clear reference for product design, implementation, testing, and maintenance.

The requirements are separated into two parts: functional and non-functional requirements. The functional requirements describe the interactions between the system and users, as well as define the system's inputs, outputs, and processing of data. The non-functional requirements relate to the attributes of the system.

This document describes the scope, objectives and goal of the enhanced HDMS. In addition, this document also describes the IT infrastructure requirements for NCHM.

1.2 Product Scope

The main purpose of upgrading the existing system to a centralized HDMS to improve their capability and capacity of NCHM to:

- (i) help improve the dissemination of and response to warnings for public safety and economic security.
- (ii) inform planning and decision making for cost-effective investments in national climate-resilient development.
- (iii) produce, manage, translate, and communicate hydro-met data and information to stakeholders and end-users;
- (iv) assist stakeholders and end-users in accessing, interpreting, and utilizing the generated data and information;

1.3 Overview

The SRS is divided into four major sections: Introduction (Section 1), General Description (Section 2), and Specific Requirements (Section 3). Section 1 presents the purpose and intended audience of the document, the scope of the product, organization of the document, and references.

Section 2 describes the product perspective, functions, user classes and characteristics, operating environment, design and implementation constraints, documentations, assumptions and dependencies. The product perspective will describe the product functionalities. Product functions highlight the main features of the system and user classes and characteristics will highlight the type of system users. General constraints will list the factors that will impede the implementation process such as organizational factors, hardware limitations or safety and security considerations. Assumptions and dependencies will list the factors that, if changed, will affect the requirements of the SRS of the system, assumptions made, and any dependencies of the system.

Section 3 presents the specific requirements, which are divided into: external interface requirements, functional requirements, non-functional requirements. Section 4 describes the hardware and infrastructure requirements such as database, Data Centre, LAN, WAN, operations and site adaptation requirements.

2. General Description

2.1 Product Perspective

The purpose of centralizing the existing HDMS is to meet the increased demand for high-quality data and services on weather, hydrological and climate to enhance community resilience, contribute to economic growth and protect life and property from extreme weather, climate and water events. The Conceptual architecture of HDMS is shown in Figure 1.

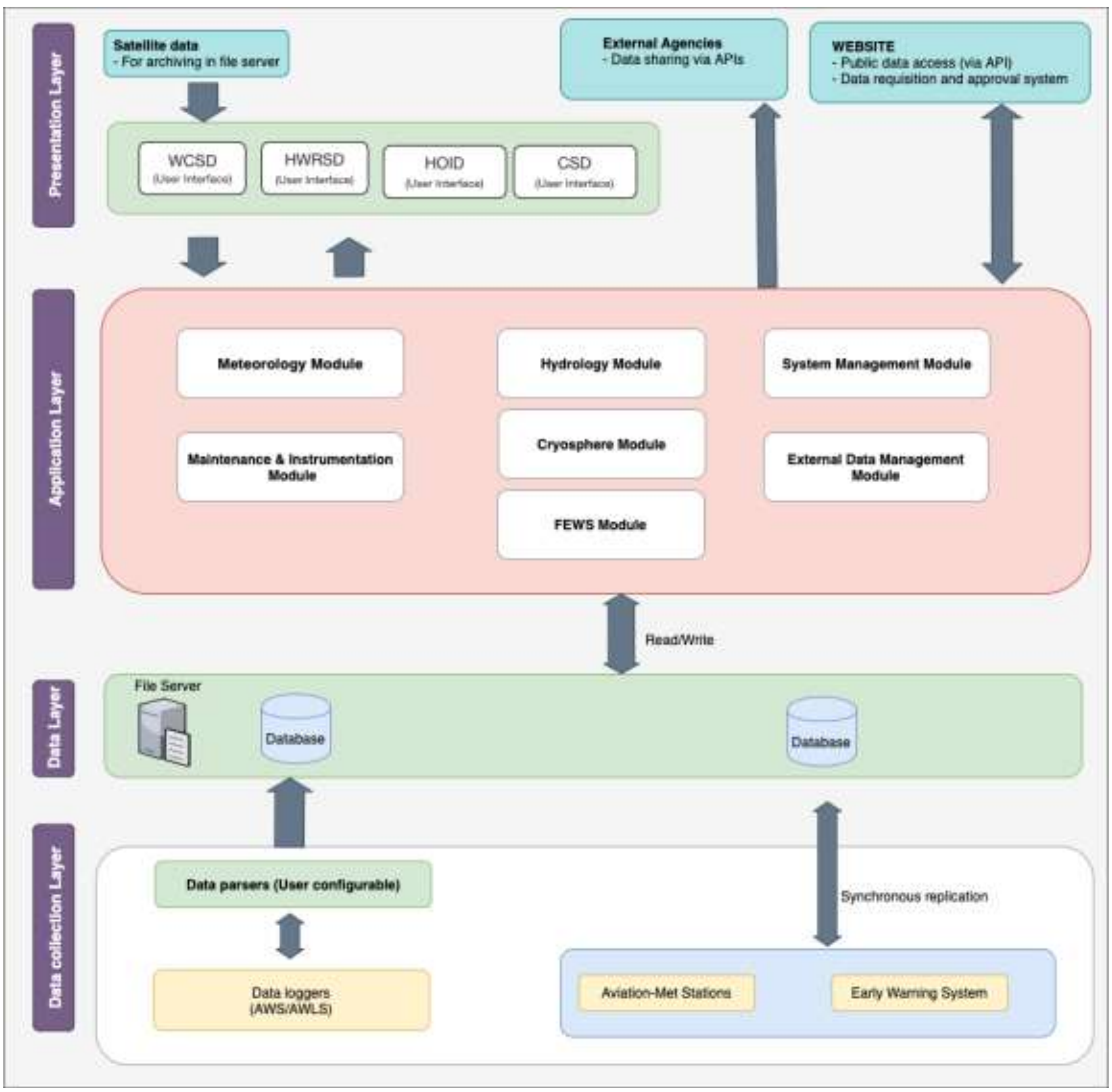

Figure 1: Conceptual Architecture of HDMS

The upgradation is expected to improve a result-based decision support service for weather incidents and events that threaten lives and livelihood and build competence to provide sector-relevant information for socio-economic development, and support development of integrated environmental services to foster healthy communities and ecosystems and also enhance the capabilities of NCHM to:

1. deliver and improve access to high-quality weather, climate, hydrological and related environmental predictions, information, warnings and services in response to users' needs and to enable their use in decision-making by relevant sectors.
2. reduce risks and potential impacts of hazards caused by weather, climate, water and related environmental elements.
3. produce better weather, climate, water and related environmental information, predictions and warnings to support, in particular, reduced disaster risk and climate impact and adaptation strategies.
4. access, develop, implement and use integrated and interoperable Earth- and space-based observation systems for weather, climate and hydrological observations, as well as related environmental and space weather observations, based on world standards set by WMO.

2.2 Product Functions Summary

The enhanced HDMS should function as a one-stop software platform that will allow the employees of NCHM at the head office and those stationed at different stations across the country to perform their daily work functions. The main modules of the system are listed in Table 1.

Table 1: Summary of System Modules

Sl.#	Module	Description
1	Meteorology Module	Data entry, visualisation and reports for WCSD
2	Hydrology Module	Data, entry, visualisation and reports for HWRD
3	Cryosphere Module	Data entry, visualisation and reports for CSD
4	Maintenance and Instrumentation Module	System maintenance (hardware) screen and reports for all the stations
5	System Management Module	Control panel for super user (Data Manager)
6	Data Management Module	Data Correction, Data back-up and recovery interface. Data sharing and to fetch data from external sources using APIs.

7	Aviation Met Interface	Interface for airport forecasts and observations and generate custom airport forecast and observations from the data stored at hourly rate in the HDMS
8	Data acquisition (Parser)	The data acquisition layer is user configurable (open), so that the NCHM staff can add data loggers from any vendor.

The component diagram of the HDMS is shown in Figure 2.

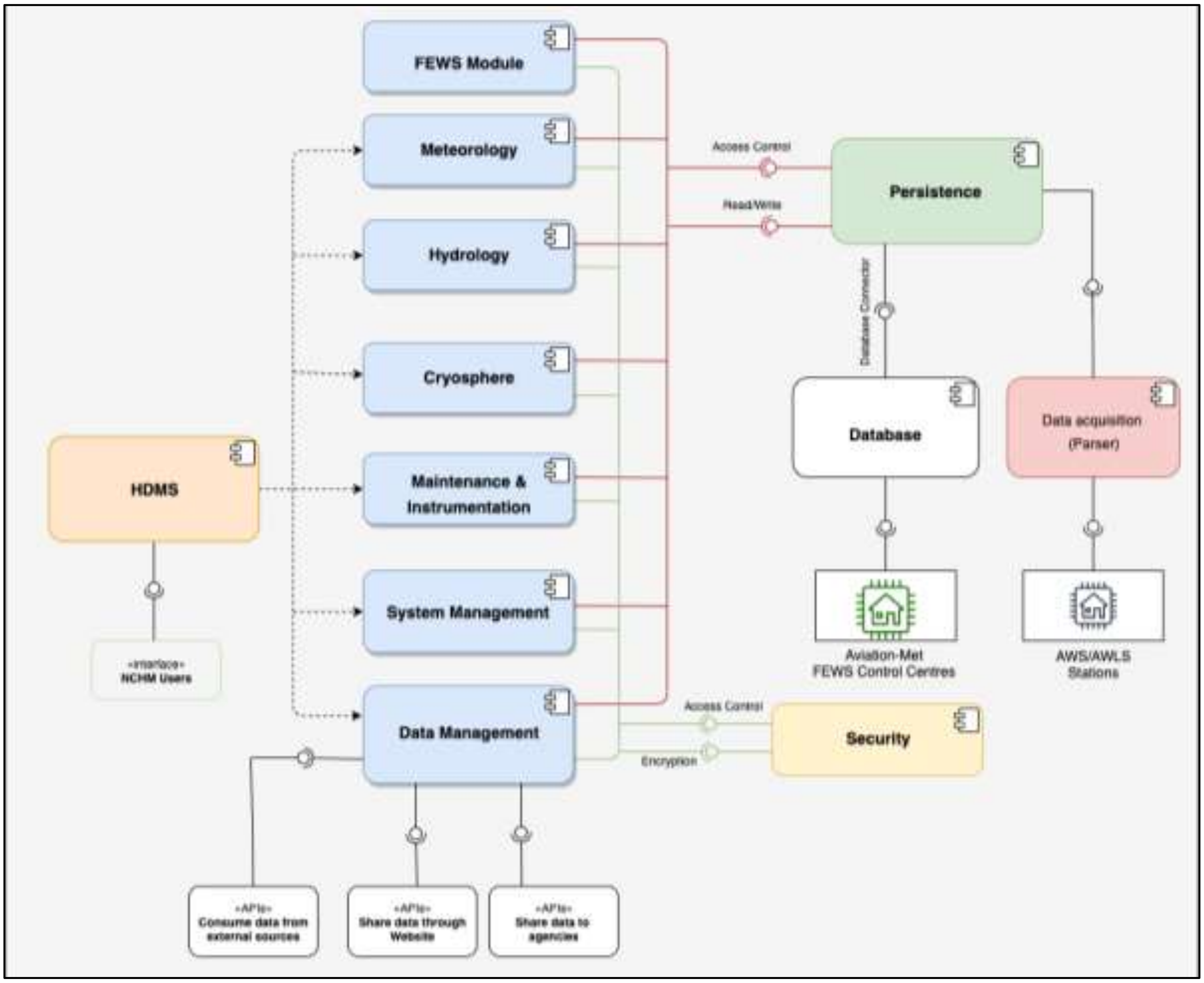

Figure 2: Component Diagram.

HDMS should implement a role-based access control mechanism that can manage user access right based on roles and permissions and manage users by group (division). It should only allow the users to add, edit and delete the data belonging to their division and grant view rights for viewing data belonging to other divisions.

The specific product functions are listed in section 3.

2.3 User Classes and Characteristics

There are five categories of users of the system as shown in Table 2.

Table 2: User class and characteristics

User Class	Roles	Description	Who
System Management	All	Overall system administrator, including creating or deleting users.	IT Officer/s
Engineers	Maintenance and Instrumentation module	Station Creation/ Deletion, Station Details, Maintenance functions, sensors change, raw data access, access to all systems. But cannot create or del users.	HOID Team
WCSD	Meteorology module	Meteorological data and functions, data input for met data, analysis, report generation. Write access to Met Stations/data only. Storage and visualization of satellite images.	WCSD Engineers and Data team
HWRD	Hydrology Module	Hydrological data and functions, data input for hydro data, analysis, report generation. Write access to Hydro stations/data only.	HWRD Engineers and Data team
CSD	Cryosphere Module	Cryosphere data and functions, data input for Cryosphere data, analysis, report generation. View access to selected stations/data only.	CSD Engineers and Data team
Management	View rights to all the modules	View the status of all stations, view issues, maintenance records, view/download all data but no write access.	Chiefs, Specialists, Researchers, and Director

2.4 Operating Environment

The server-side components of the HDMS will operate on a web-server hosted at NCHM server room while the client-side components of the software system must operate within common web browser environments using Secure Hypertext Transfer Protocol (HTTPS) with mapped private ports. The requirements are as follows:

Table 3: Software Requirements

Platform	Description
Operating System	
Database	MySQL/MariaDB The database management system (DMBS) for the application should have following features: Scalability: ability of a system to handle an increased load without redesign of the system. Availability: ability of a system to be operational for a large percentage of the time Manageability: ability to detect faults (or the absence of faults) and the ability to automatically react to them
Web Server	Apache/ Nginx
Browser Support	Google Chrome, Mozilla Firefox, Apple Safari, Microsoft browser e.g. Edge

The hardware requirements are listed in section 5.

2.5 Design and Implementation Constraints

During the implementation of the system, the selected vendor should be aware that portability, scalability, maintainability, reliability, testability, interoperability and security are important features of the system. Therefore, common libraries and tools should be used.

2.6 User Documentation

The users of the HDMS are the target audience for user documentation about the software system. Different types of documents such as guidelines, tutorials, and frequently asked questions) in printed (hard copy) or Portable Document Format (PDF) format must describe the use of the software system. The “help” and “about” sections of the system should contain useful information in HTML format.

2.7 Assumptions and Dependencies

The assumptions and dependencies that may affect the requirements specified in this SRS are:

- The communication between remote observation centres and the stations
- The new centralised HDMS will support open configuration option in the control panel for addition of new stations and devices.

3. Specific Requirements

The Specific Requirements section is divided into three main categories: The External interface, Functional, and Non-Functional requirements. The hardware and infrastructure requirements are listed separately section 5.

3.1 External Interface Requirements

3.1.1 User Interfaces

The user interface of the system should provide an organised method that separates each section of the application for easy access. The user should be able to intuitively find the sections of the system using visual cues such as appropriate icons. It should also include pop-ups displaying notifications, error messages, or warnings should use the same theme and template as the rest of the application. The interfaces required are listed in Table 4.

Table 4: user Interfaces

User Interfaces	Description
Administrator User Interface	The user interface for administrative tasks must include a Dashboard with the ability to manage: ● Users and user groups, ● Role and Permissions, ● Data templates and Master records. ● Parameter Setting
General user interface	The user interface for division users must include a Dashboard with functions specific to their division with following features: ● Data Summary displayed by charts and graphs ● Summary of data in table format ● Add and Update relevant information ● Generate and export
Remote station user interface	The remote user interface should allow the users at remote station across the country to add, review and submit data to the HDMS
Maintenance user interface	The maintenance user interface should have following features:

	• Station management: The interface should also provide an easy way to add stations and devices. • Metadata management: The interface for adding and viewing metadata.
Researchers/Management	View the status of all stations, view issues, maintenance records, view/download all data but no write access.

Details on system interface are available in the functional requirements section of this document. The system will be simple with a friendly user interface.

3.1.2 Communications Interfaces

The communication interface required are listed in Table below.

Table 5: Communication Interfaces

Communication Type	Interface Required
File Transfer	FTP/https/text/
Data submission Notification	Notification via HDMS – Message icon highlighted by red colour with message count
System Notification	Message icon highlighted by red colour with message count
Alerts	Notification with sound

3.2 Functional Requirements

3.2.1 Hydrology and Water Resources Services (HWRS)

Requirement ID	REQ – 1.0
Functions name	Manual data entry interface for data sent from field (date and water level)
Input	• Provision for Manual data entry sent from field (date, time, location and water level) • Provision for uploading data manually from non-real time data loggers or stations that are gone off-line • Provision for updating and storing cross sections to generate rating curves, rating table and flow with validity date. • Storage of processed data from global sources. (file server, linked with HDMS)
Output Screen	• Quality checks – limits, trends with email notification on errors, correction mechanism and audit trails. • Auto filling/ missing interpolation data • Water levels • Discharge using rating curve • Basic Statistics; 5-no summary (max, min, 3Qs) • Advanced Statistics: Standard deviation- coefficient of variation- monthly, daily, annual, hourly • Data for a particular time, 9am and 2pm every day for date X-Y • Viewer- graphical and tabular result- both options required. • Data download and sharing system

Requirement ID	REQ – 2.0
Function name	Manual Sediment data entry
Input	Sediment data entry manually with date and locations
Output Screen	• Quality checks – limits, trends with email notification on errors, correction mechanism and audit trails. • Basic Sediment Statistics; 5-no summary (max, min, 3Qs) • Ppm report for sediment data by basin or stations • Data download and sharing system

Requirement ID	REQ – 3.0
Function name	AWLS- water level and discharge, automatic systems
Inputs	• AWLS- water level and discharge from data loggers of automatically sensed data • Automatic data input from field device – using mobile/telemetry devices of manually read data (e.g., through a tablet/ mobile phone App) • Provision for updating and storing cross section to generate rating curves.
Output Screen	As detailed above for Screen A

Requirement ID	REQ – 4.0
Functions name	Early Warning System (EWS)
Input	• EWS network systems • Historical data update from old EWS • Hydraulic information of the stations to set limits

Output Screen	● Quality checks – limits, trends with email notification on errors, correction mechanism and audit trails. ● Water levels ● Discharge using rating curve ● Wind Rose and extreme weather data ● Basic Statistics; 5-no summary (max, min, 3Qs) ● Advanced Statistics: Standard deviation- coefficient of variation- monthly, daily, annual, hourly ● Viewer- graphical and tabular result- both options required. ● Data for a particular time, 9am/2pm every day for date X-Y ● Auto filling/ missing interpolation data ● Decision support system – Alarms and Alerts and Warnings for all parameters (discharge, water level, temperature, rainfall per hour, wind speed etc)

Requirement ID	REQ – 5.0
Function name	Flood Hazard mapping and Forecasts
Input	● Insertion of GIS maps and geospatial data ● Provision to put in flood risk details based on studies/ surveys ● Receive/ accept outputs from hydrological models
Output Screen	● Quality checks – limits, trends with email notification on errors, correction mechanism and audit trails. ● Flood hazard maps for different flood risks – historical/ analysis ● Flood warnings and Forecasts by stations/ rivers/ basins ● Flood hazard mapping – dynamic for Flood decision support system-link result from hydrological model (results from the hydrological models are shown on this system automatically with pre-assigned levels). ● Sharing of flood forecasts/ warnings to other agencies/ users automatically. ● Data download and sharing system

Requirement ID	REQ – 6.0
Function name	Water Quality
Input	● Automatic Water quality parameters ● Manual Water quality parameters
Output Screen	● Quality checks – limits, trends with email notification on errors, correction mechanism and audit trails. ● Water Quality Reports ● Basic Statistics; 5-no summary (max, min, 3Qs) ● Viewer- graphical and tabular result- both options required. ● Download and email options

Requirement ID	REQ – 7.0
Function name	Ground Water Data
Inputs	Automatic and manual Ground water data with location
Output Screen	● Quality checks – limits, trends with email notification on errors, correction mechanism and audit trails. ● Basic Statistics; 5-no summary (max, min, 3Qs) ● Advanced Statistics: Standard deviation- coefficient of variation- monthly, daily, annual ● Viewer- graphical and tabular result- both options required. ● Data download and sharing system

Requirement ID	REQ – 8.0
Function name	Historical Data Sharing Mechanism / Online data disbursement format
Input. **Online form**	● Link to all historical hydrology, meteorology and cryosphere data

	● Online web form for data request with dropdown menu options of stations, time and parameters ● Verification and approval of data request by supervisor ● Notice to concerned data manager for data request with list of data requested ● Compilation, checking, preparation of the data and invoice by concerned data manager ● Payment receipt and verification or waiver approval by supervisor/ accounts
Output – Email Report	Emailing of data by the data manager to the applicant.

3.2.2 Weather and Climate Services (WCS)

Requirement ID	REQ – 9.0
Functions name	Manual data entry sent from field (date, time and weather parameters)
Input	● Provision for Manual data entry sent from field (date, time, location and weather parameters) ● Provision for uploading data manually from non-real time data loggers or stations that are gone off-line ● Provision of mobile application/ web-interface data transfer from field to the HDMS
Output Screen	● Quality checks – limits, trends with email notification on errors, correction mechanism and audit trails. ● Auto filling/ missing interpolation data ● Weather parameters ● Basic Statistics; 5-no summary (max, min, 3Qs) ● Advanced Statistics reports/summary for all the available meteorological parameters: Standard deviation, max, min, coefficient of variation on an annual, monthly, daily basis. ● Station view with details such as location (lat and lon), type (manual or automatic), status (parameter reporting)

	• Wind rose • Extreme weather event records (historical and present) • Viewer- graphical and tabular result- both options required. • Provide data for SmartMet from AWS/Manual stations • Format for customized daily net data provision (historical data) on different time scales, and different basic statistics. • Details on Climate indices • Data download and sharing system • Customized data inventory (report/data present based on station or parameter /count on missing data/auto filling/ missing interpolation data. Both graphical and tabular result options required.

Requirement ID	REQ – 10
Function name	AWS- Weather Data, automatic systems
Inputs	• AWS- Weather from data loggers of automatically sensed data • Automatic weather observation data input from field device – using mobile/telemetry devices of manually read data (e.g., through a tablet/ mobile phone App)
Output Screen	As detailed above for REQ- 9 • Data frequency counts

Requirement ID	REQ – 11
Function name	Air Quality
Input	• Quality checks – limits, trends with email notification on errors, correction mechanism and audit trails. • Automatic Air quality parameters • Manual Air quality parameters

Output Screen	• Quality checks – limits, trends with email notification on errors, correction mechanism and audit trails. • Air Quality Reports • Basic Statistics; 5-no summary (max, min, 3Qs) • Viewer- graphical and tabular result- both options required. • Download and email options • Advanced Statistics reports/summary for all the available meteorological parameters: Standard deviation, coefficient of variation on an annual, monthly, daily basis.

Requirement ID	REQ – 12
Function	• AgroMet Service
Input	• Historical data • Weather forecast (daily, three days, medium and extended range forecast) and seasonal forecast (monthly and seasonal outlook)
Output	• API- AgroMet (DSS)- data sharing to AgroMet directly

Requirement ID	REQ – 13
Functions name	• Aviation Met service
Input	• Quality checks – limits, trends with email notification on errors, correction mechanism and audit trails. • Integration for airports-pull from airport forecasts and observations • Store all airport forecast in HDMS • Store airport forecast and observations at hourly rate to HDMS
Output	• Aviation Weather forecast summary of all airports • Historical observed data at airports • Provision to share data for aviation services as per international standards – ICAO/ WMO norms

Requirement ID	REQ – 14
Functions name	Weather Forecasts
Input	• Output from Smart-met Weather Forecast to go into HDMS for comparison study and accuracy of forecast. • Seasonal forecasts • Pull WRF, Satellite, other GFS/ ECMWF data into the system for storage and sharing
Output	• Quality checks – limits, trends with email notification on errors, correction mechanism and audit trails. • Weather Forecasts by locations and time • Graphs, tables, plots, histogram • Seasonal forecast reports- CPT format, NetCDF, trends • Route forecasts (tourism, road, helicopter) • Provision to do comparison study and accuracy of forecast from SmartMet and observed data. • Sharing of weather and seasonal forecasts or warnings to other agencies/users automatically.

3.2.3 Cryosphere Services

Requirement ID	REQ – 15
Function name	• Snow monitoring Data
Input	• Quality checks – limits, trends with email notification on errors, correction mechanism and audit trails. • Snow depth and SWE from AWS/ Manual stations • Snow incident reporting with pictures (Where, when, how much, picture) • Snow camera • AWS/ Manual stations with snow data • Temperature, Precipitation and Solar Radiation data for high altitude stations
Output	• Snow depth + SWE data for different locations with time- basic statistics

	• Net-geo meter- to generate – energy mass balance with precipitation and temperature data • Snow incident report; name of observer, location, date and time of observation. Basic statistics. • Snow report for different stations and times. – Table and graphical.

3.2.4 Maintenance and Instrumentation Services

Requirement ID	REQ – 16
Functions Name	Maintenance and Instrumentation Services (MIS) Module
Input	• Station details with location, status, observers • Equipment/sensor info-parameters – date of installation, make, model, repair and calibration • Maintenance record – GPS with time steps, history, what was done time, and activities performed • Connection to the data coming from site • New station/upgradation add/delete/edit functions • cross section details (hydro) with date
Output	• Quality checks – limits, trends with email notification on errors, correction mechanism and audit trails. • Quick View: Site details with observer, location, data, status • Sensor details with make, model and date of repair/ calibration • Raw data info • Manual data-verification/endorsement system check after transmission • Station map updated with status • Last reporting time • Daily QC checked SMS/ email notification

Requirement ID	REQ – 17
Function name	Glacier (GI), and Glacier Lake (GL) Monitoring
Input	● Glacier mass balance records ● Glacier lake level monitoring ● Glacier lake study reports (potentially dangerous lakes, techniques used, and results.) ● Satellite image analysis and reporting with dates (GI. Lakes in tables with all Information/graphical)
Output	● PGDL details info- image, technique ● Image download with date and locations (DB access to image) ● Glacier surface change report ● GL+ GI. Lake metadata on map with recent survey, observation, picture, download with recent source ● Glacier mass balance: Glacio-hydrological year, glacier mass balance, method adopted (direct/geodetic), location, specific mass balance, cumulative mass balance, hypsometry (graph) ● Glacier inventory: report, glacier list (ID, Latitude/longitude/elevation, area, year of publication), map-based location, pop-out graph (y-axis: surface area, x-axis: year) ● Glacier cumulative front variation (map based). Pop out graph with y axis: frontal variation (m), x-axis: year, raw csv, table, shapefile. ● Potentially dangerous glacial lakes (PGDL): map-based location, pop out (location, volume, depth, surface area, imageries, latitude/longitude/elevation, surrounding geomorphology (list out), date and year of update.

3.2.5 Events and Publications Library

Requirement ID	REQ – 18
Function name	Events and Publications Library
Input	● Manual input of extreme weather events such as hailstorm, snow events, floods etc with basic information, pictures and dates. ● Publication details, authors and metadata along with the publication
Output	● Historical extreme weather events with dates and details searchable by date or event or location. ● publications by NCHM searchable by topics, dates or authors

3.3 Non-functional Requirements

3.3.1 Performance Requirements

One of the main advantages of this system is, users can interact with this system without Internet connectivity. So, the system should be able to function its full cycle without Internet connectivity.

- Alerts should be accurate and trigger in real-time.

3.3.2 Safety Requirements

The system should not trigger false alerts or reports, the verification process should be followed before sending alerts. Unauthorized users should not be able to send alerts or tamper with the system.

3.3.3 Security Requirements

- Access to HDMS should be allowed only for authorized system users.
- The server-side data should be secure and not be accessible by unauthorized persons.

3.3.4 Software Quality Attributes

Availability

HDMS should be active and ready to use at any given time whereby the users should be able to access the systems from anywhere at any time. Given that HDMS is a distributed system with observation centres and stations located at remote places, there are shortcomings in using it as an effective alerting tool during a major disaster when telephone networks are known to get congested. Therefore, the implementation of HDMS system should take those into consideration.

The data-centres for hosting the HDMS servers should have backup power and other infrastructure to offer uninterrupted business continuity.

Correctness

The alert messages cannot be ambiguous because ambiguity may result in the execution of inappropriate emergency response plans.

3.3.5 Business Rules

User Class	Business Rules
Administrators	The administrator will have full right view, add, edit and delete data for the entire system.
Approvers	The users under this class will have only approving right for the data submitted by other users.
Division users	The general users can view, add, update or delete data specific to their own division only. This class of users are restricted to view, add, update or delete data belonging to other divisions.
Guest users	The class of users will have right to view specific division only
System Auditors	The system auditors will have only view rights for the whole system.

4. Infrastructure Requirements

4.1 System Architecture

The proposed system architecture is as shown in following diagram.

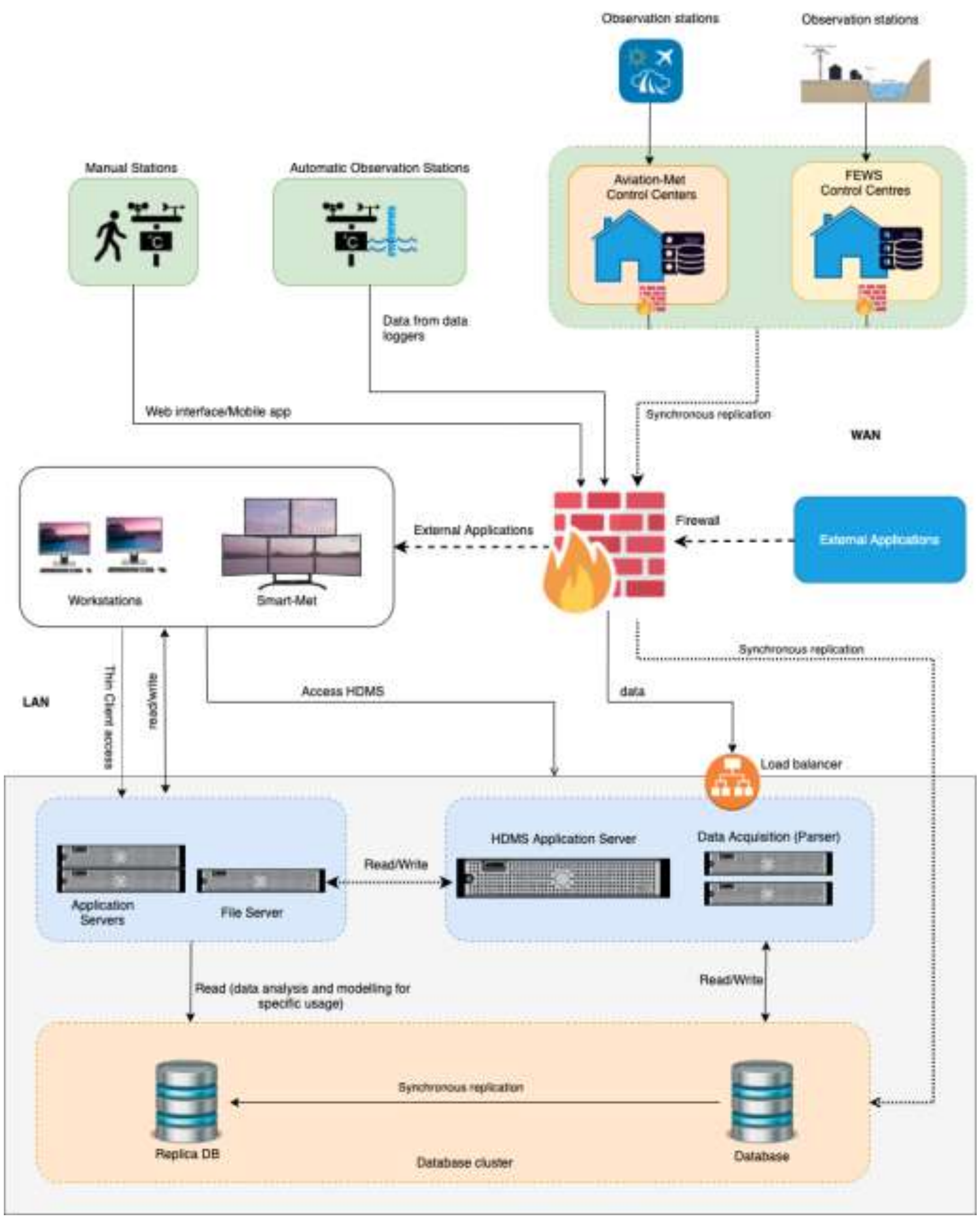

Figure 3*: System Architecture*

4.2 LAN Architecture

The propose LAN architecture for the NCHM is as below.

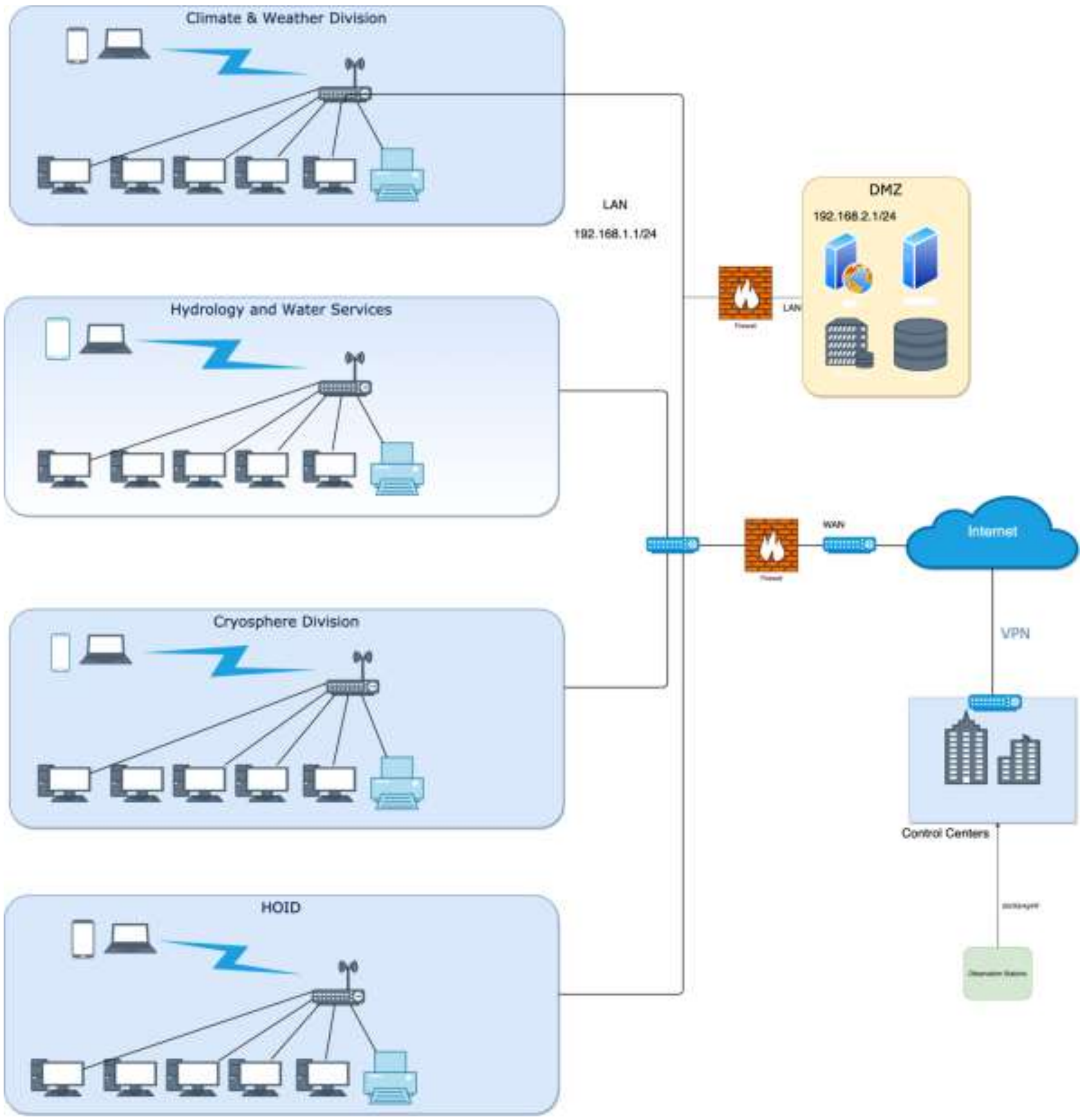

Figure 4*:* LAN Diagram

4.3 WAN Diagram

A Wide Area Network (WAN) is also proposed as shown in Figure 5.

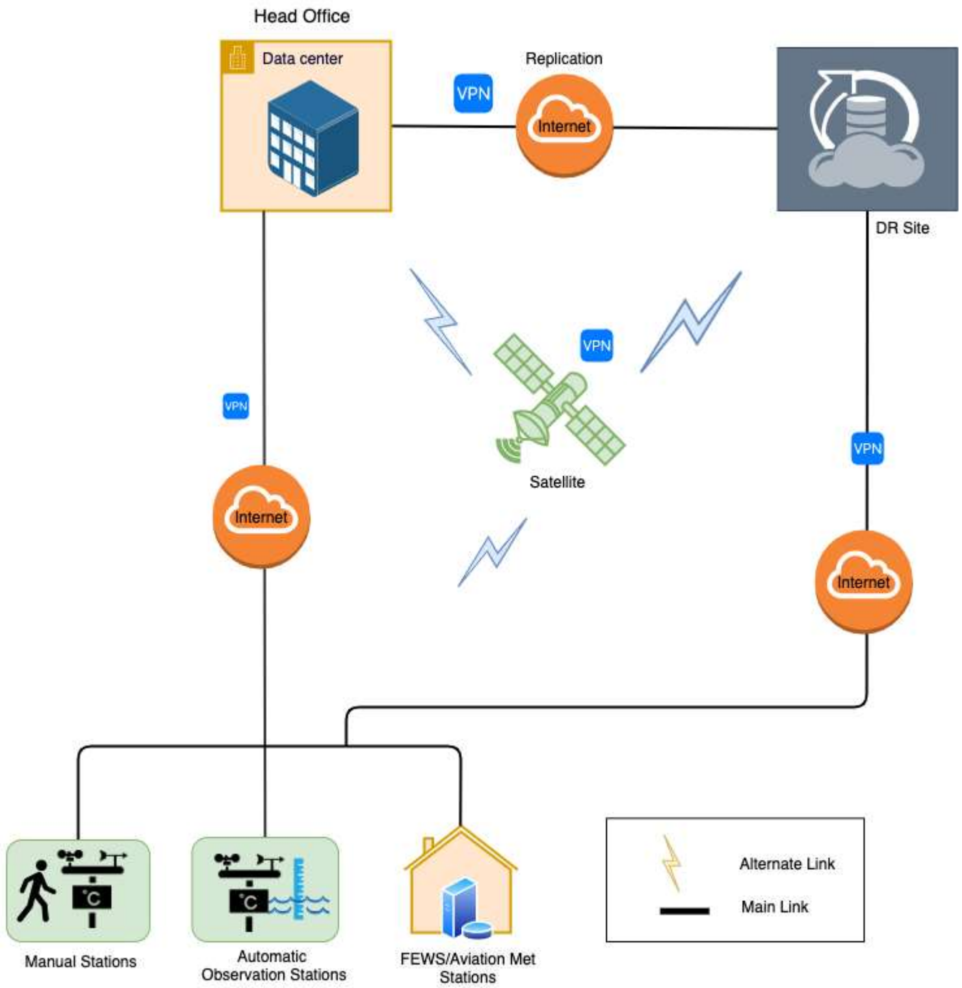

Figure 5: WAN Diagram

4.4 Disaster Recovery Site Architecture

Disaster recovery (DR) site is a location that aims to protect an organization from the effects of significant negative events that come in all shapes and sizes. It's not just catastrophic events such as hurricanes, earthquakes and tornadoes, but also incidents such as cyber-attacks, equipment failures and even terrorism that can be classified as disasters.

Having a disaster recovery strategy in place enables an organization to maintain or quickly resume mission-critical functions following a disruption with the goal of continuing the operations as close to normal as possible.

The proposed network diagram for production site and disaster recover site is shown in Figure 6. It shows the production site (data centre) located at the head office.

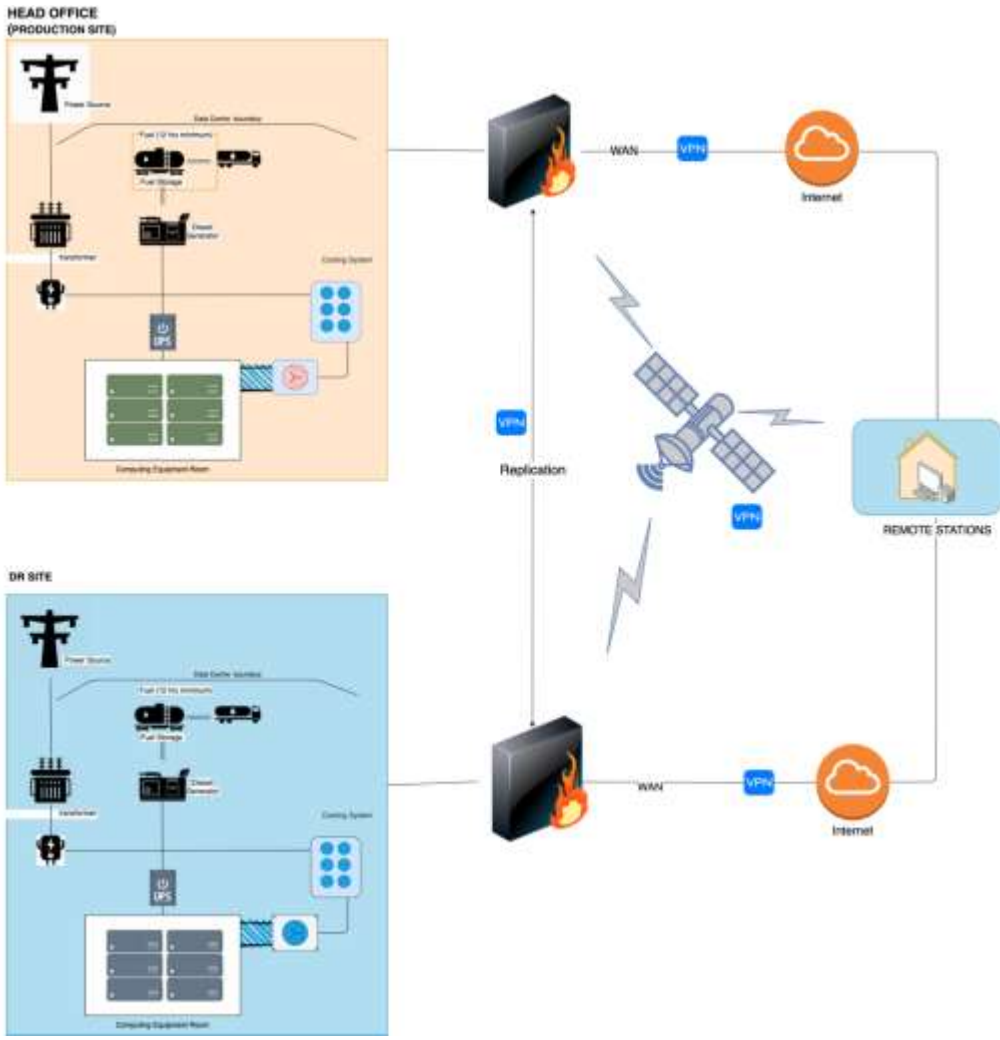

Figure 6: Disaster Recovery Site

4.5 Data Centre Requirements

The Uptime Institute defines Data Centre is a dedicated space used to house IT infrastructure such as; networked computers, data storage, switches and other components that make up a large IT network. A data centre must also remain operational within strict parameters for electrical supply, temperature and humidity, all without interruption.

The Uptime Institute – Data centre Tier Classification Standard has classified the Data Centre into Four Tiers.

4.5.1 Tier I: Basic Site Infrastructure

The fundamental requirement:

1. A Tier I basic data centre has non-redundant capacity components and a single, non-redundant distribution path serving the critical environment. Tier I infrastructure includes: a dedicated space for IT Systems; a UPS to filter power spikes, sags, and momentary outages; dedicated cooling equipment; and on-site power production (e.g., engine generator, fuel cell) to protect IT functions from extended power outages.
2. Twelve hours of on-site fuel storage for on-site power production (e.g., engine generator, fuel cell).

4.5.2 Tier II: Redundant Site Infrastructure Capacity Components

The fundamental requirement:

1. A Tier II data centre has redundant capacity components and a single, non-redundant distribution path serving the critical environment. The redundant components are extra on-site power production (e.g., engine generator, fuel cell), UPS modules and energy storage, chillers, heat rejection equipment, pumps, cooling units, and fuel tanks.
3. Twelve hours of on-site fuel storage for 'N' capacity.

4.5.3 Tier III: Concurrently Maintainable Site Infrastructure

The fundamental requirements:

1. A Concurrently Maintainable data centre has redundant capacity components and multiple independent distribution paths serving the critical environment. For the electrical power backbone and mechanical distribution path, only one distribution path is required to serve the critical environment at any time.

2. The electrical power backbone is defined as the electrical power distribution path from the output of the on-site power production system (e.g., engine generator, fuel cell) to the input of the IT UPS and the power distribution path that serves the critical mechanical equipment. The mechanical distribution path is the distribution path for moving heat from the critical space to the outdoor environment. For example, chilled water piping, condenser water piping, refrigerant piping, etc.
3. All IT equipment is dual powered and installed properly to be compatible with the topology of the site's architecture. Transfer devices, such as point-of-use switches, must be incorporated for critical environment that does not meet this requirement.
4. Twelve hours of on-site fuel storage for 'N' capacity.

4.5.4 Tier IV: Fault Tolerant Site Infrastructure

The fundamental requirements:

1. A Fault Tolerant data centre has multiple, independent, physically isolated systems that provide redundant capacity components and multiple, independent, diverse, active distribution paths simultaneously serving the critical environment. The redundant capacity components and diverse distribution paths shall be configured such that 'N' capacity is providing power and cooling to the critical environment after any infrastructure failure.
2. All IT equipment is dual powered with a Fault Tolerant power design internal to the unit and installed properly to be compatible with the topology of the site's architecture. Transfer devices, such as point-of-use switches, must be incorporated for critical environments that do not meet this specification.
3. Complementary systems and distribution paths must be physically isolated from one another (Compartmentalized) to prevent any single event from simultaneously impacting both systems or distribution paths.
4. Continuous Cooling is required. Continuous Cooling provides a stable environment for all critical spaces within the ASHRAE maximum temperature change for IT equipment as defined in Thermal Guidelines for Data Processing Environments, Third Edition. Additionally, the Continuous Cooling duration should be such that it provides cooling until the mechanical system is providing rated cooling at the extreme ambient conditions.
5. Twelve hours of on-site fuel storage for 'N' capacity.

4.5.5 Recommendation for Server Room Upgrade

After assessing the current Server Room infrastructure of NCHM and also considering other factors such as:

1. Lack of permanent office for the head office based in Thimphu.
2. Budget constraints
3. Investment on current server room

The assessment team in consultation with NCHM has found that upgrading the current server room to Tier I Data Centre is the most viable option for the current situation. The architecture of the Tier I Data Centre is shown in Figure 7.

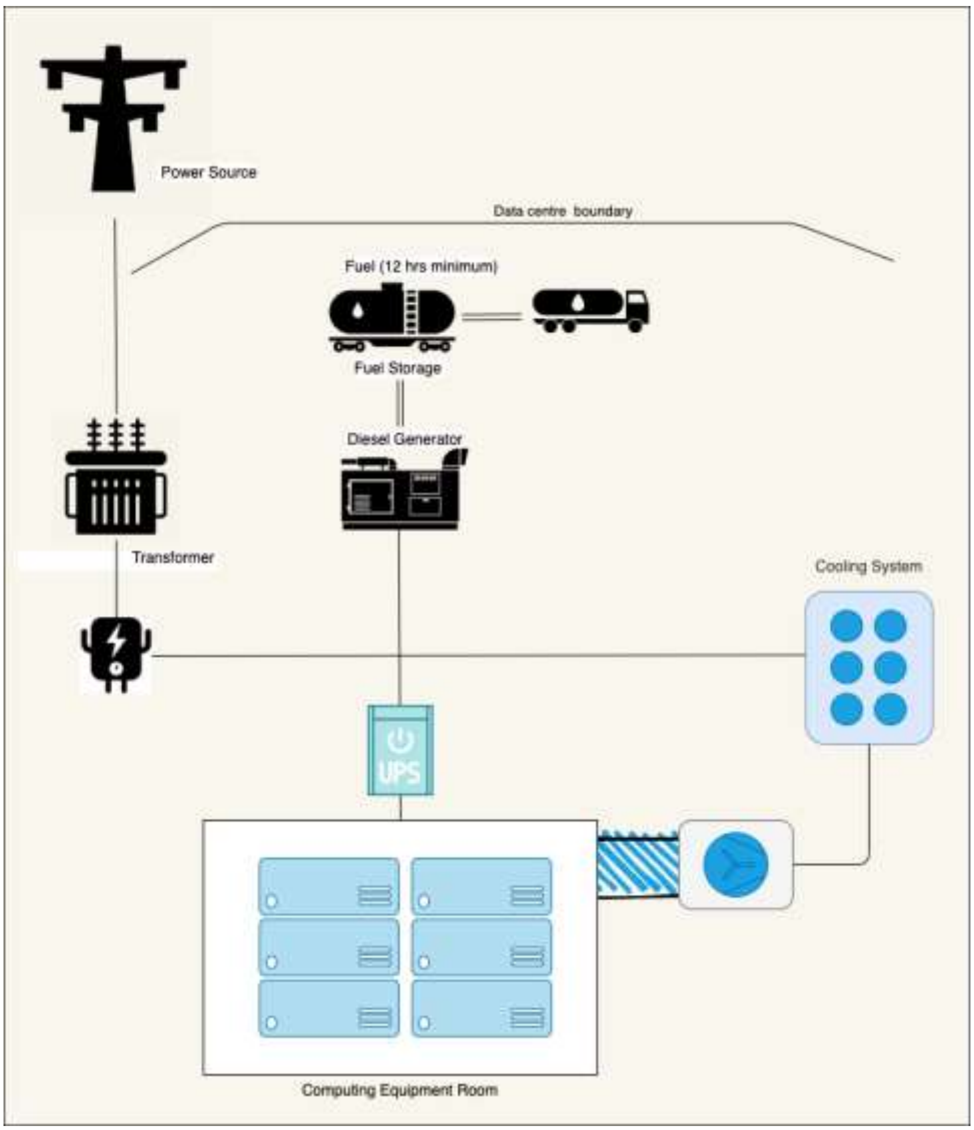

Figure 7: Tier 1 Data Centre

5. Data dissemination via website

The data approved by the centre for public access should be made available through NCHM website and should be integrated using APIs.

5.1 Functional Requirements

ID	Function Name	Description
1	**Weather Watch**	• Current weather • Weather Forecast
2	**River Watch**	• Flood Warning • EWS
3	**Reports**	• Hydro-met Report for public access. • Domain type (climate, hydro, cryosphere) • report generation with predefined parameters • data range • duration range
4	**Others**	• Weather advisories • Bulletins
5	**Satellite live Map**	• Map with live satellite data
6	**Data Request and approval system**	Online data request and approval system with payment integration.

5.2 Flow Chart (Data Request)

The flowchart for online data request and approval system in Figure 8 which should be incorporated in the website. The processes (steps) are described in the next section.

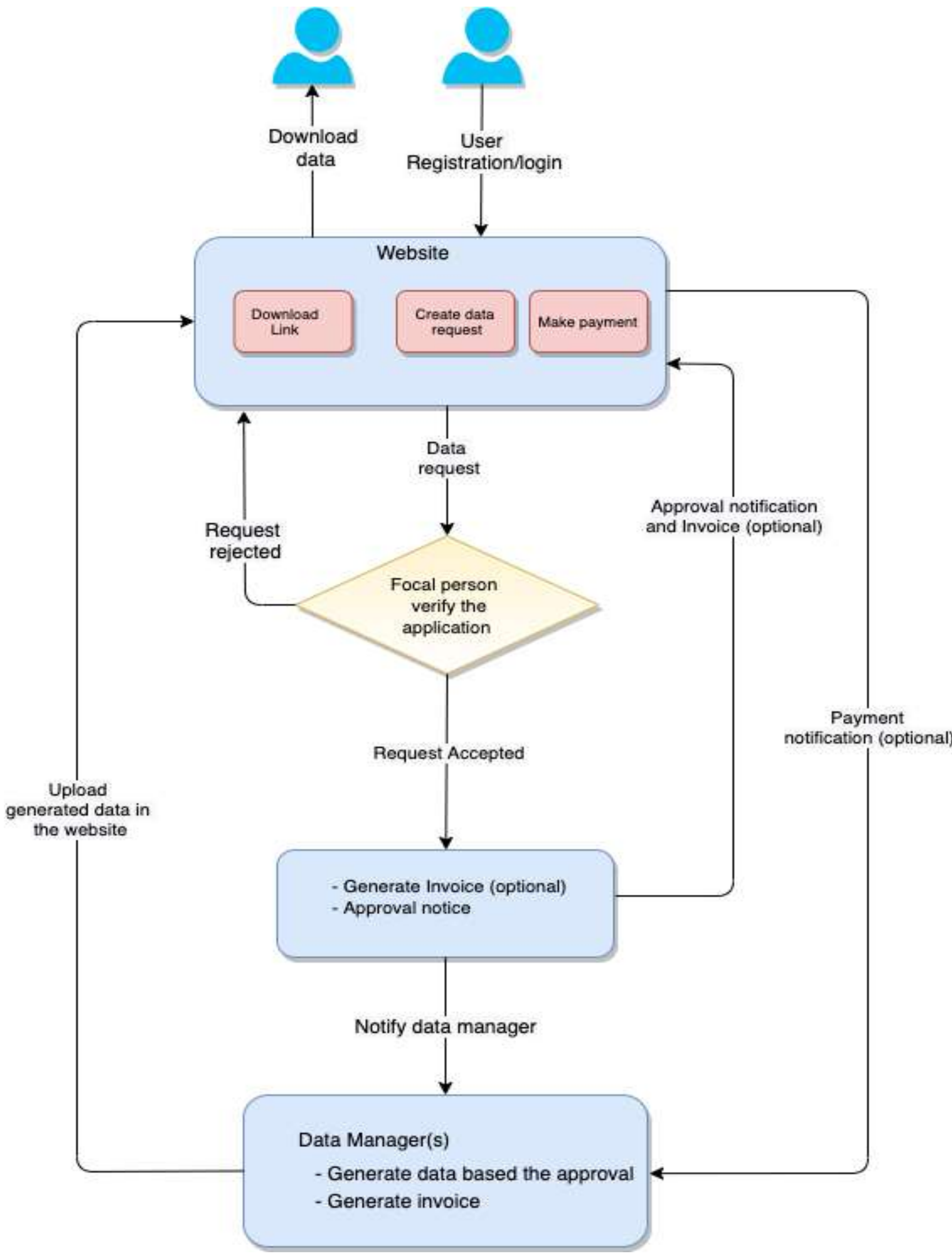

Figure 8: Data request flow chart

5.3 Date request process

Step 1	Description
1	Register by filling up a simple form Returning users can directly login by providing email and password.
2	Activate the account by simple email verification, where the user will receive an email from the website and asked to click on the link to verify the email
3	Create a date request by selecting the relevant parameters and submit
4	After submitting the request, the user can then track the status of the application
5	The focal person at NCHM will review the request and will approve or reject the application
6	If approved, the focal will then notify the data requester via system notification about the application status and an email/SMS will also be sent automatically by the system to the user, along with an invoice if applicable. If rejected, a rejection notification will be sent.
7	After receiving the notification, the data requester can pay the amount online through the website.
8	Once the payment is done, the data manager will prepare the requested data and upload the data under the data requester's profile page with a download link.
9	Download the data from the website.