Basin-based flood forecasting and warning: Nepal experience

Dr. Rishi Ram Sharma
Director General
Department of Hydrology and Meteorology, Nepal

9th Meeting of the RIMES Council
23-24 August 2017
Port Moresby, Papua New Guinea

Flood 11-14 August 2017

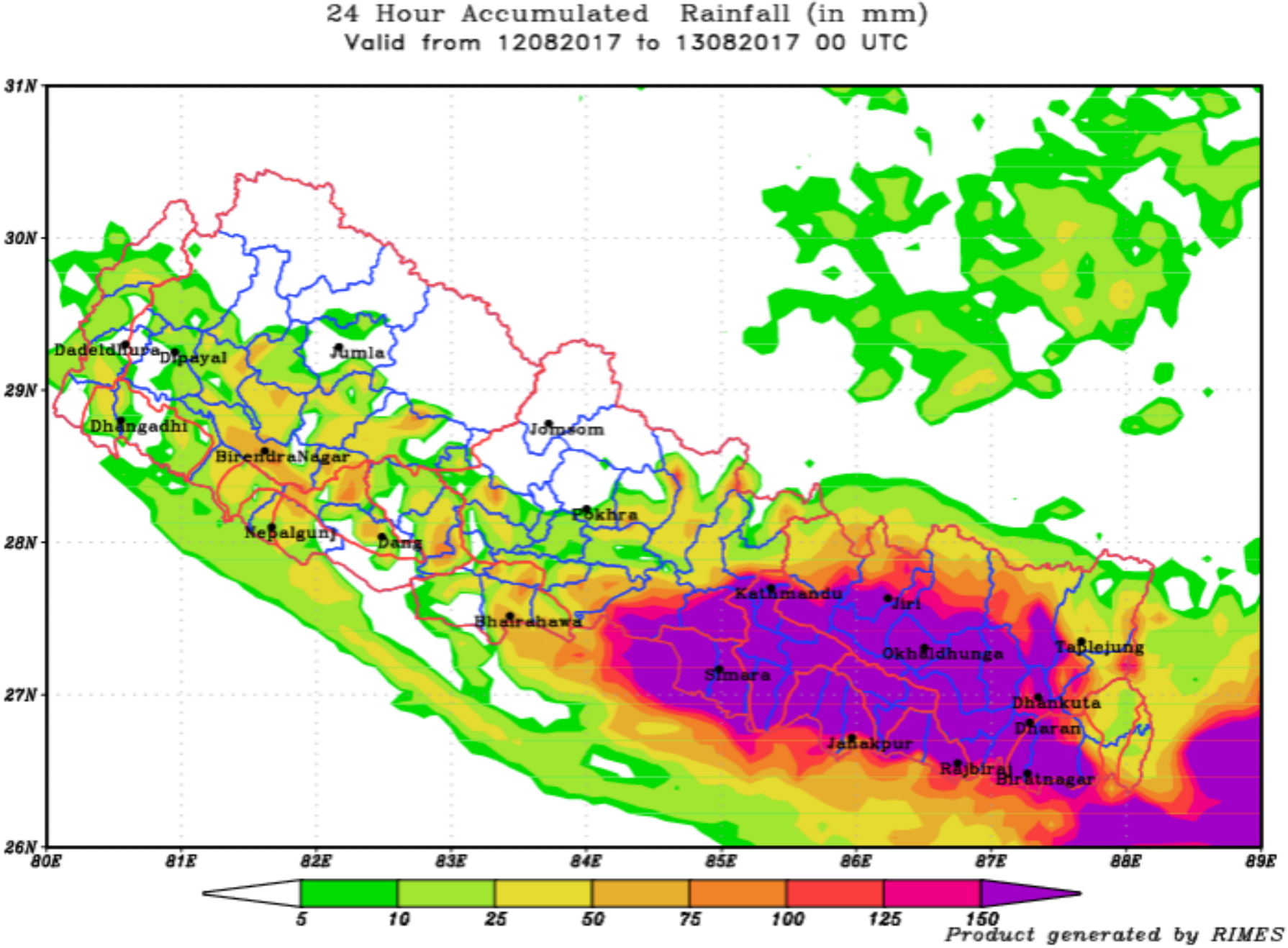
Dead (flood & landslide)	141
Missing	35
Injured	133
Displaced Families	88,596
Affected Families	342,198
Houses Destroyed	
Completely	66,057
Partially	132,176

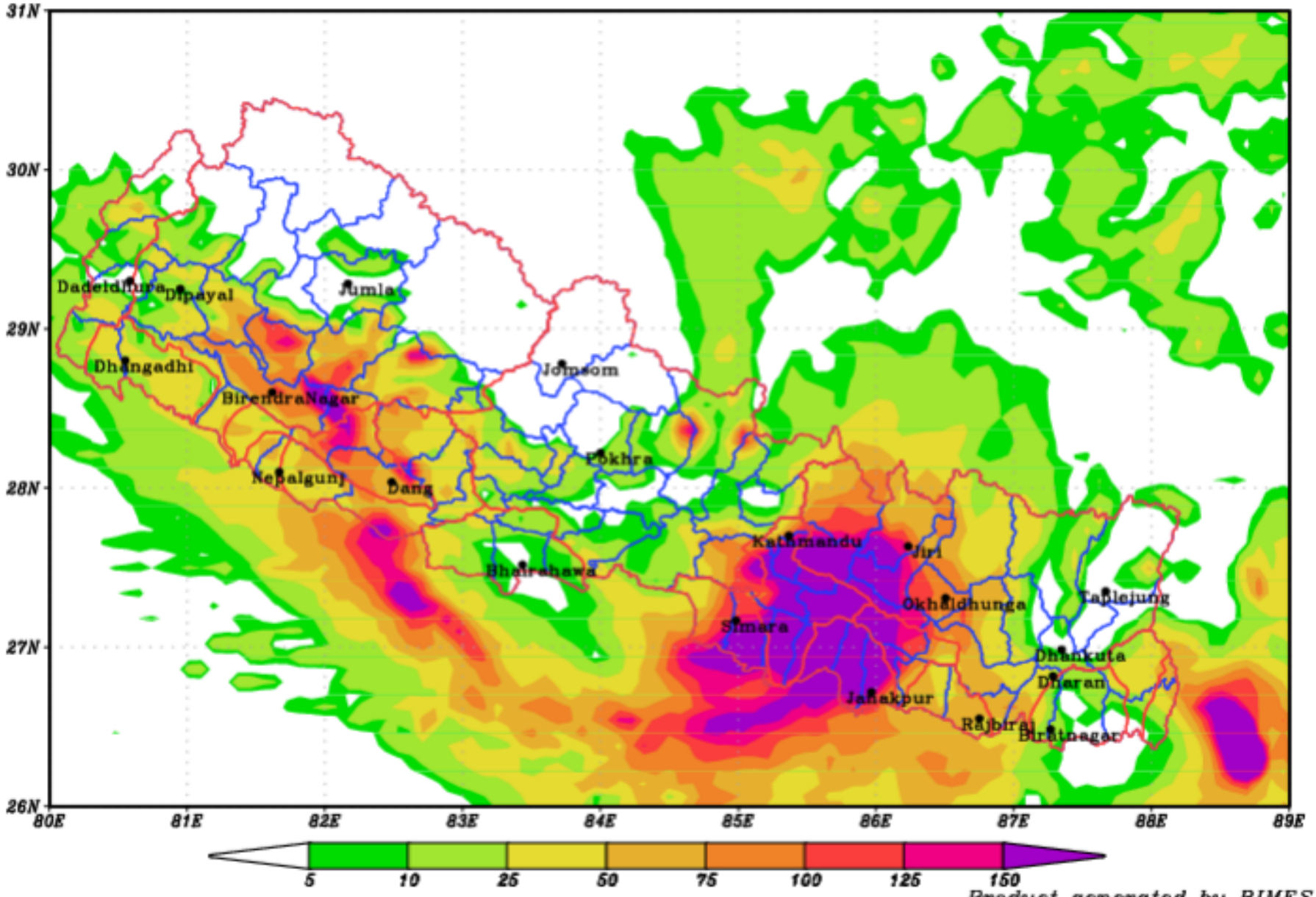
- Prevailing monsoon trough in the mid hills.
- Record Breaking Rainfall in 24 hour
- Hetauda: 516 mm, Rajaiya: 496 mm
- Kusum: 435 mm

- Highest intensity (after system automation) 99.8 mm/hour)

- Recorded Highest Water Level at Kusum West Rapti River: 9:05 m
- (Danger Level 5.4 m)

- Inundated area: yet to confirm (approx. >7% of national territory)
- Wider and persistent coverage of the weather system:
- Those river basin with Early Warning System: Almost no casualty


24 Hour Accumulated Rainfall (in mm)
Valid from 12082017 to 13082017 00 UTC
31N
30N
29N
28N
27N
26N
80E
81E
82E
83E
84E
85E
86E
87E
88E
89E
Dadeldhura
Dipayal
Jumla
Dhangadhi
Jomsom
BirendraNagar
Pokhra
Nepalgunj
Dang
Kathmandu
Jiri
Bharahawa
Okhaldhunga
Taplejung
Simara
Dhankuta
Dharan
Janakpur
Rajbiraj
Biratnagar
5
10
25
50
75
100
125
150
Product generated by RIMES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Dadeldhura
Dipayal
Jumla
Dhangadhi
Jomsom
BirendraNagar
Pokhra
Nepalgunj
Dang
Kathmandu
Jiri
Bharatpur
Okhaldhunga
Taplejung
Simara
Dhankuta
Dharan
Janakpur
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5
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75
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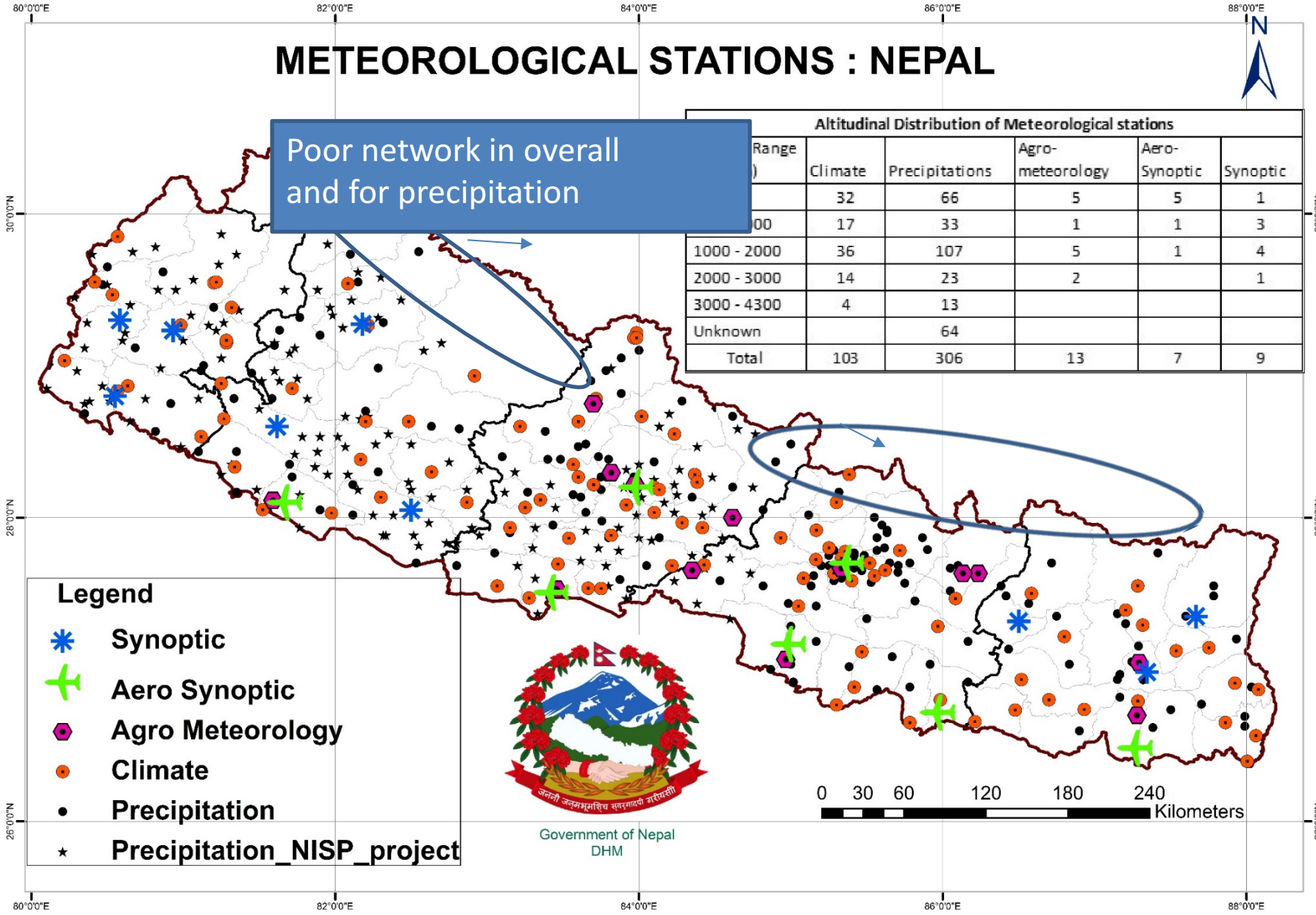
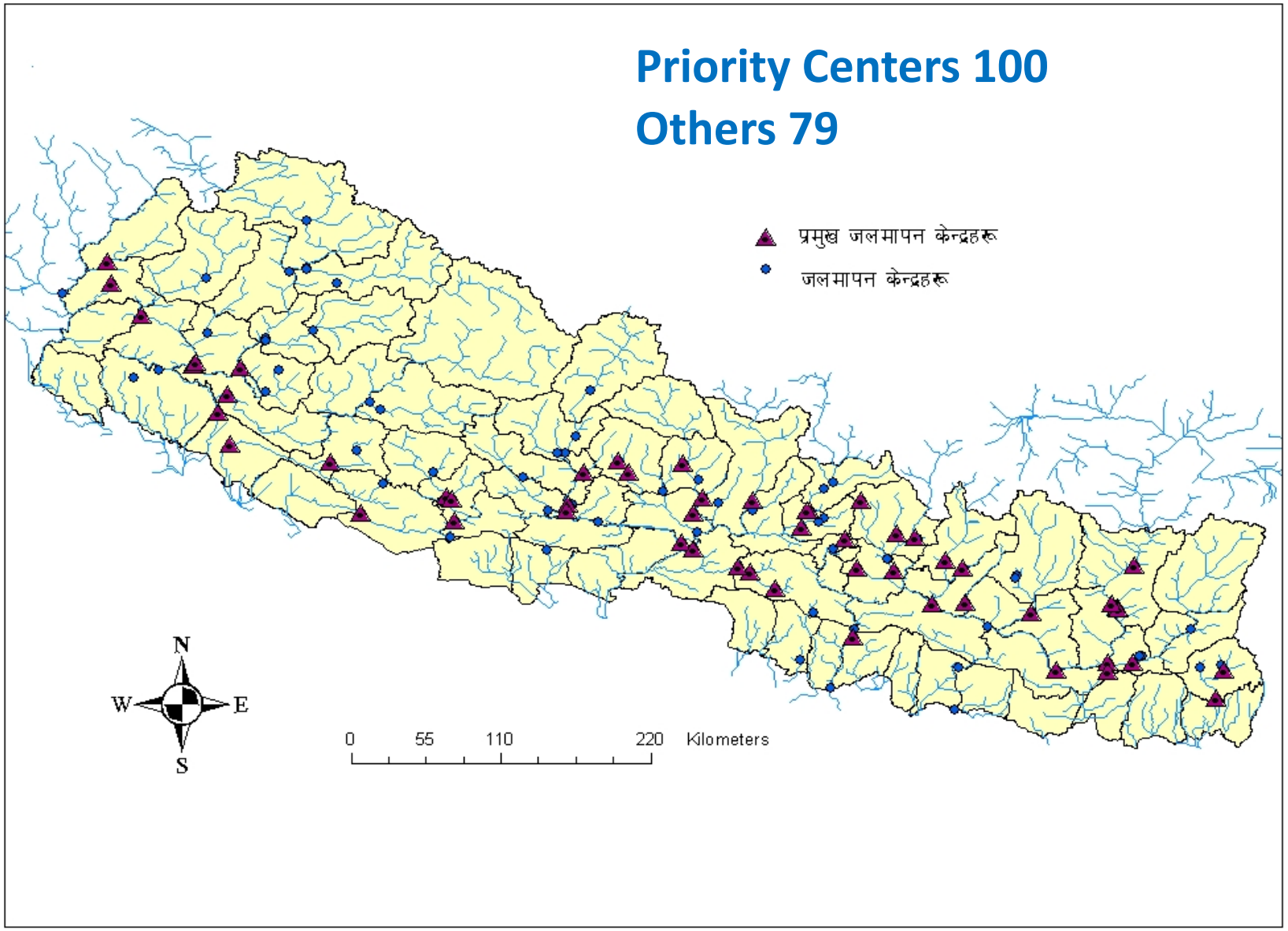
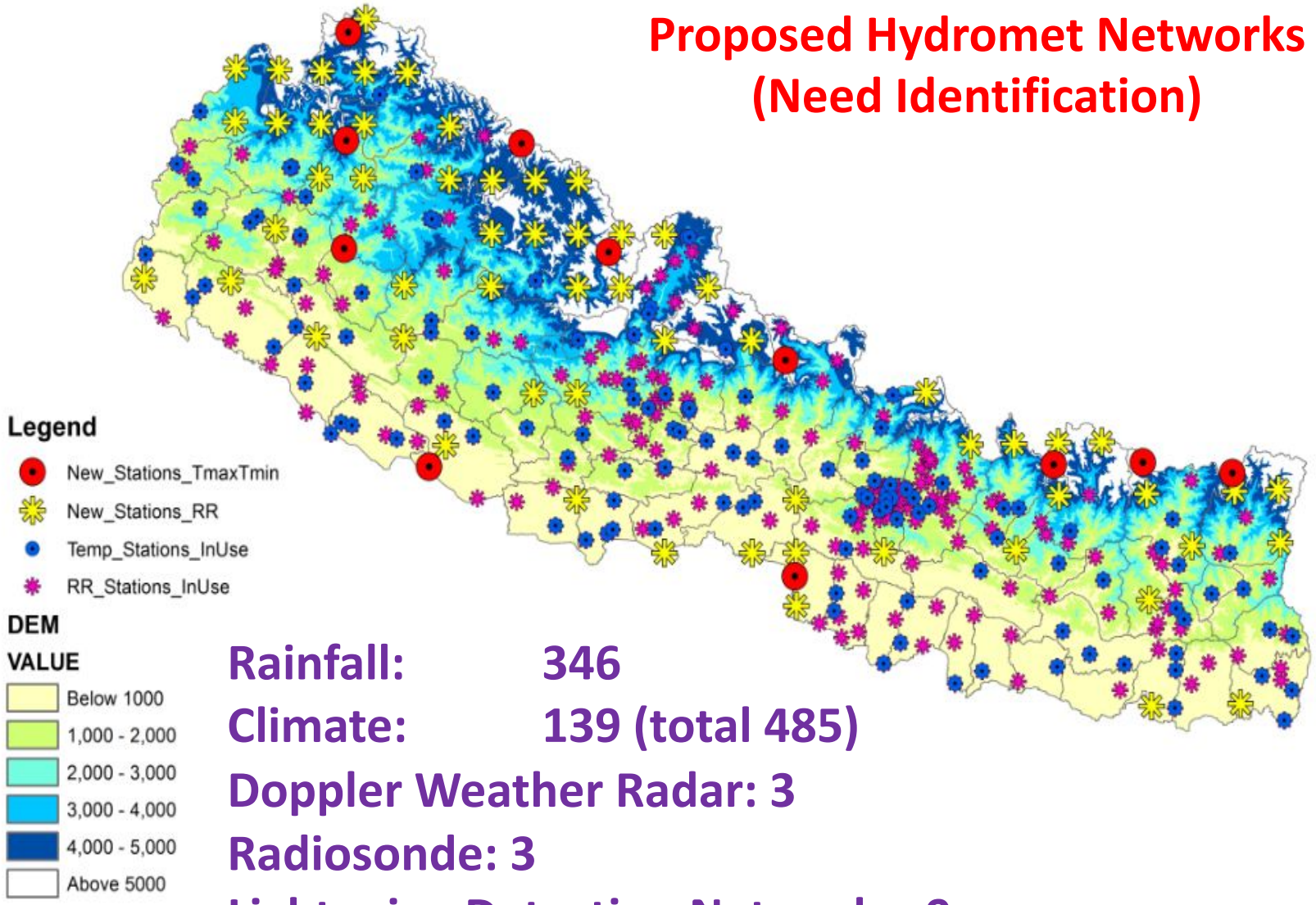
Product generated by RIMES


METEOROLOGICAL STATIONS : NEPAL
Poor network in overall and for precipitation
Altitudinal Distribution of Meteorological stations
Range)
Climate
Precipitations
Agro-meteorology
Aero-Synoptic
Synoptic
32 66 5 5 1
00 17 33 1 1 3
1000 - 2000 36 107 5 1 4
2000 - 3000 14 23 2 1
3000 - 4300 4 13
Unknown 64
Total 103 306 13 7 9
Legend
Synoptic
Aero Synoptic
Agro Meteorology
Climate
Precipitation
Precipitation_NISP_project
Government of Nepal
DHM
0 30 60 120 180 240
Kilometers
N
80°0'0"E
82°0'0"E
84°0'0"E
86°0'0"E
88°0'0"E
30°0'0"N
28°0'0"N
26°0'0"N

Hydrological Observation Centers



Proposed Hydromet Networks (Need Identification)



Rainfall: 346

Climate: 139 (total 485)

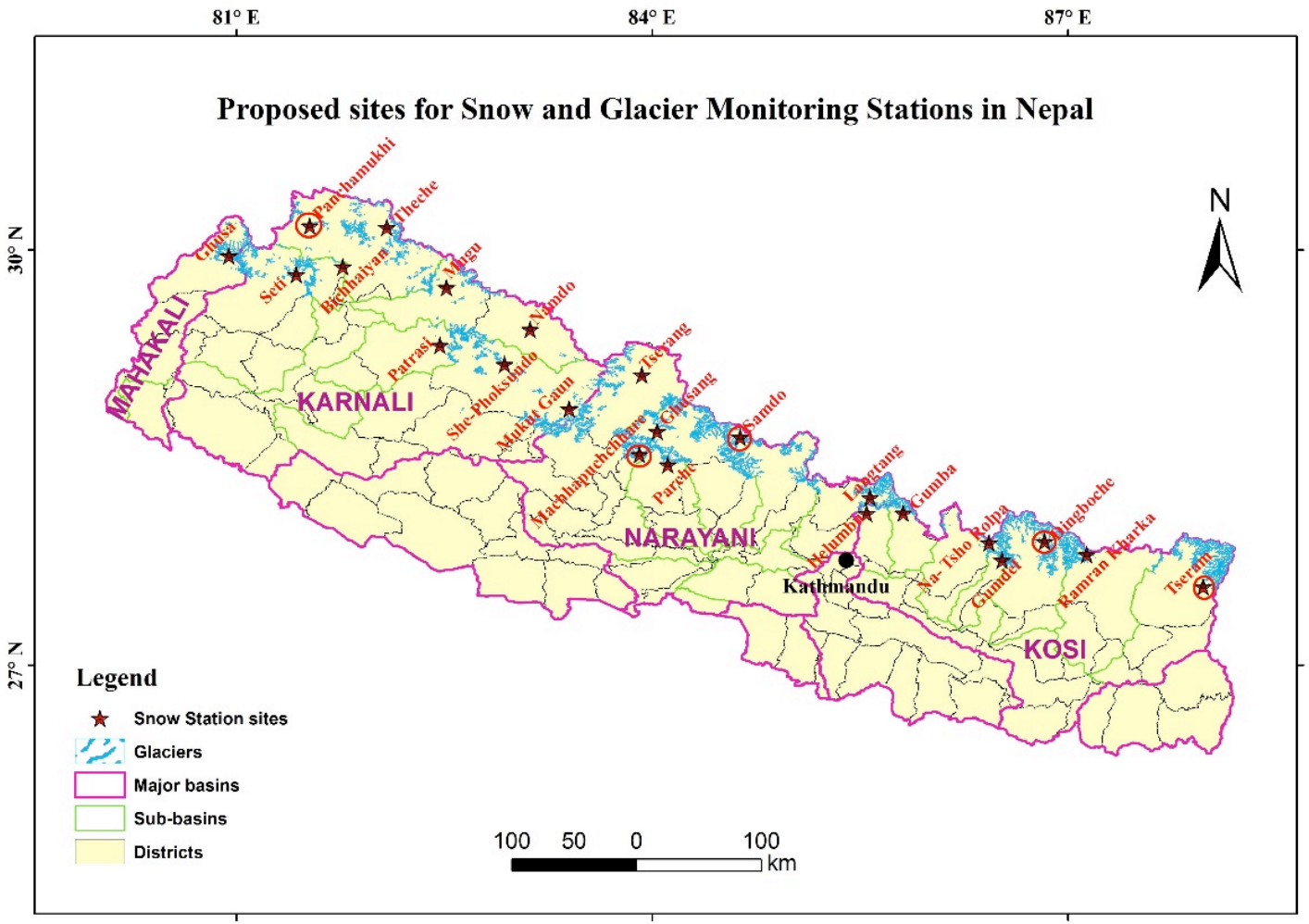
Doppler Weather Radar: 3

Radiosonde: 3

Lightening Detection Networks: 9

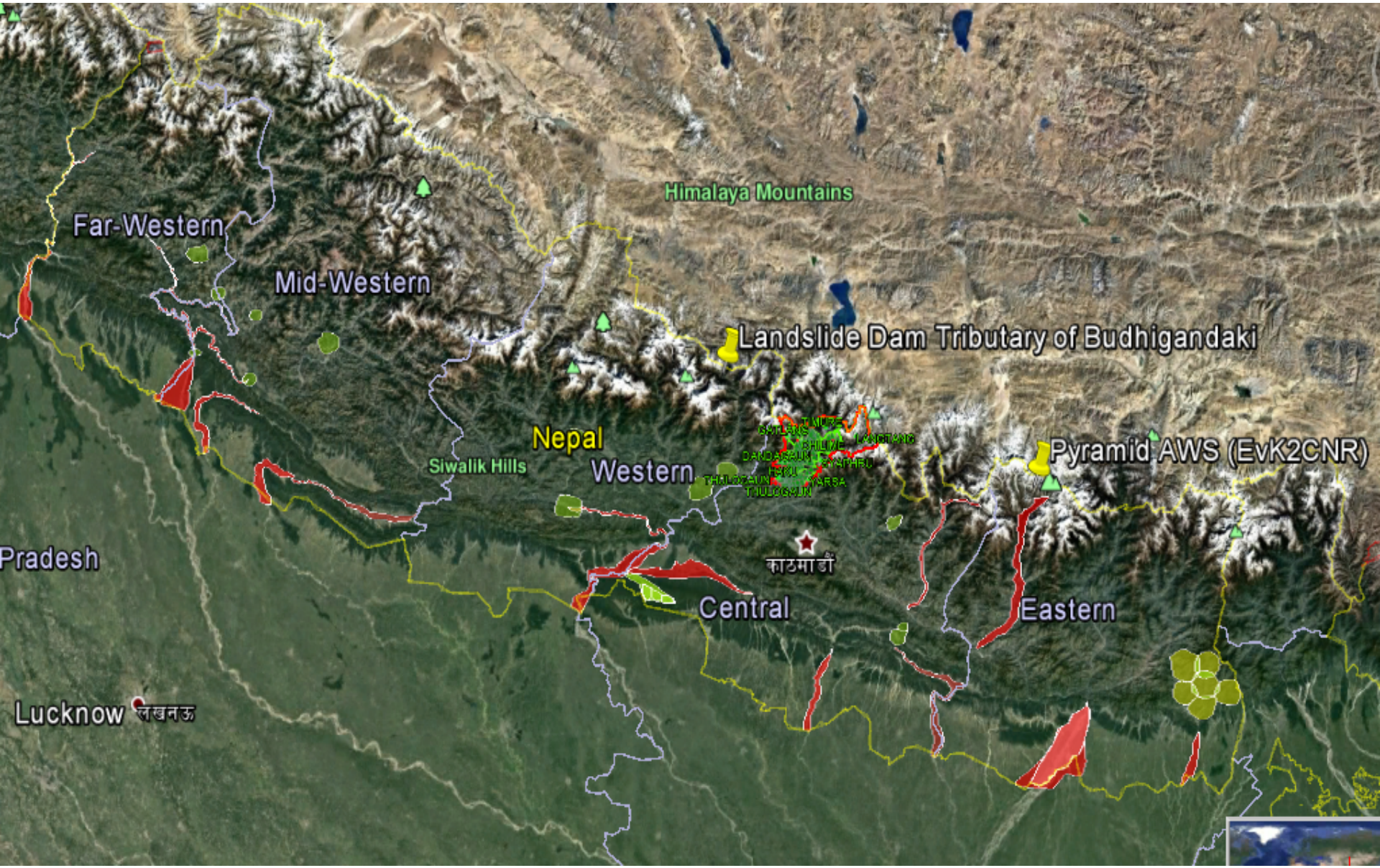
Water level and Discharge Measurement: 183

Glacier Mass Balance: 23



Optimal network for snow and glacier monitoring sites in Nepal (23 stations)

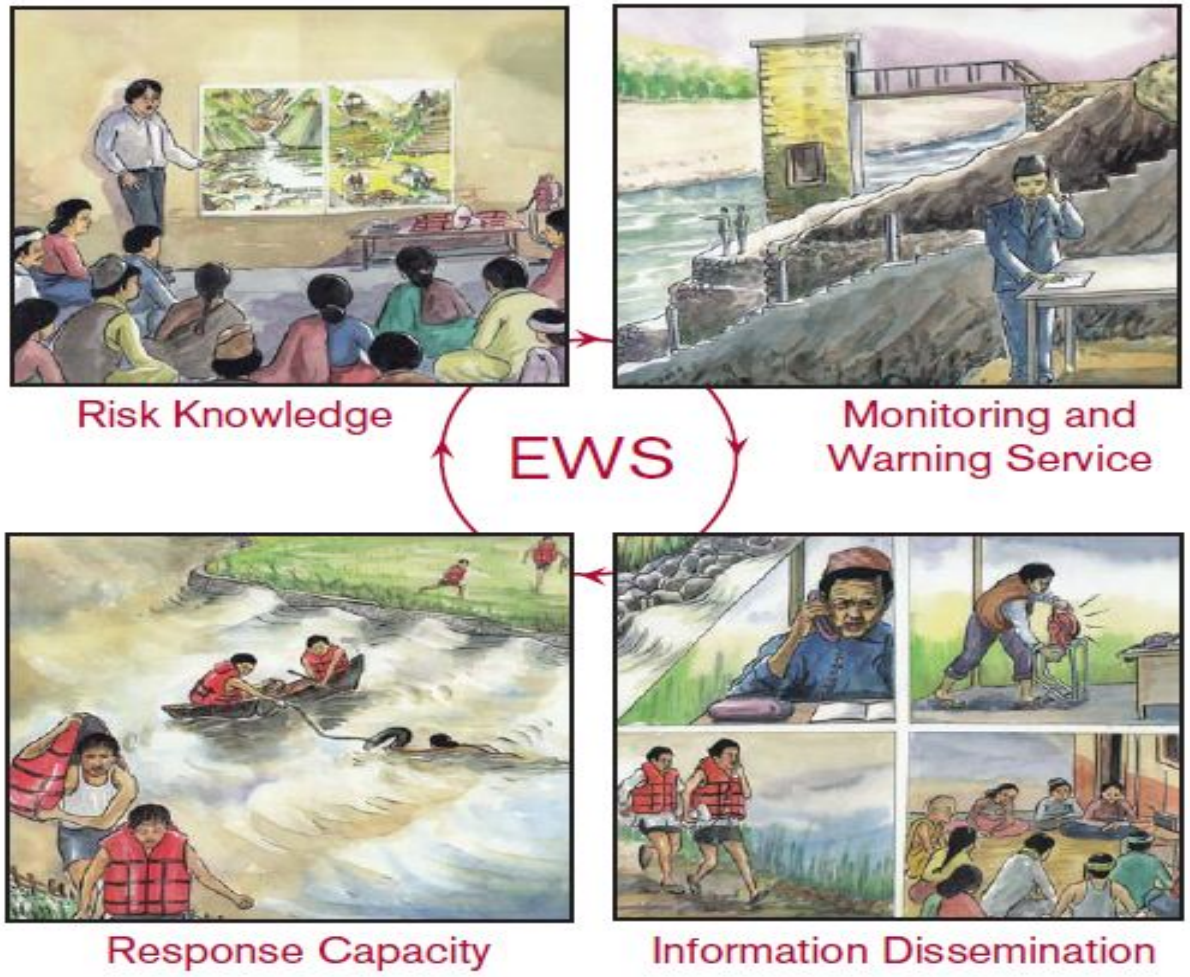
Flood and Landslide Early Warning System Sites



Total 43 Polygons / River Basins

Early Warning System (EWS)

"A system of data collection and analysis to monitor people's well-being (including security), in order to provide timely notice when an emergency threatens, and thus to elicit an appropriate response."



Early Warning System

Specific Objective

- Increase time for response mobilization before disasters strike
- Increase Coordination & Mobilization of Human and Non-human emergency resources, including neighboring Communities/ VDCs/ Districts, with respect to previous years
- Increase real-time information to improve decision making process during the disaster

Information Dissemination through Dedicated Web- based

Government of Nepal
Ministry of Population and Environment
Department of Hydrology and Meteorology
Hydrology Division
Flood Forecasting Section

Home | Real Time Data | Manually Observed Data | Current Forecast | Community Outreach | Projects | Publications | River Watch | Rainfall Watch

Notice Board

Flood Forecast Bulletin (22Aug2017, 6 PM- NPT)
पच्चिम राप्ती,बबई लगायतमा जलसतह बिस्तारै बढ्ने अनुमान ..

Flood Forecast Bulletin (21 August 2017, 6 PM)
महाकाली, बबई लागयतमा रातिदेखि जलसतह बिस्तारै बढ्ने अनुमान।..

Flood Forecast Bulletin (20 August 2017, 6PM)
No High Flood Risk in the country!..

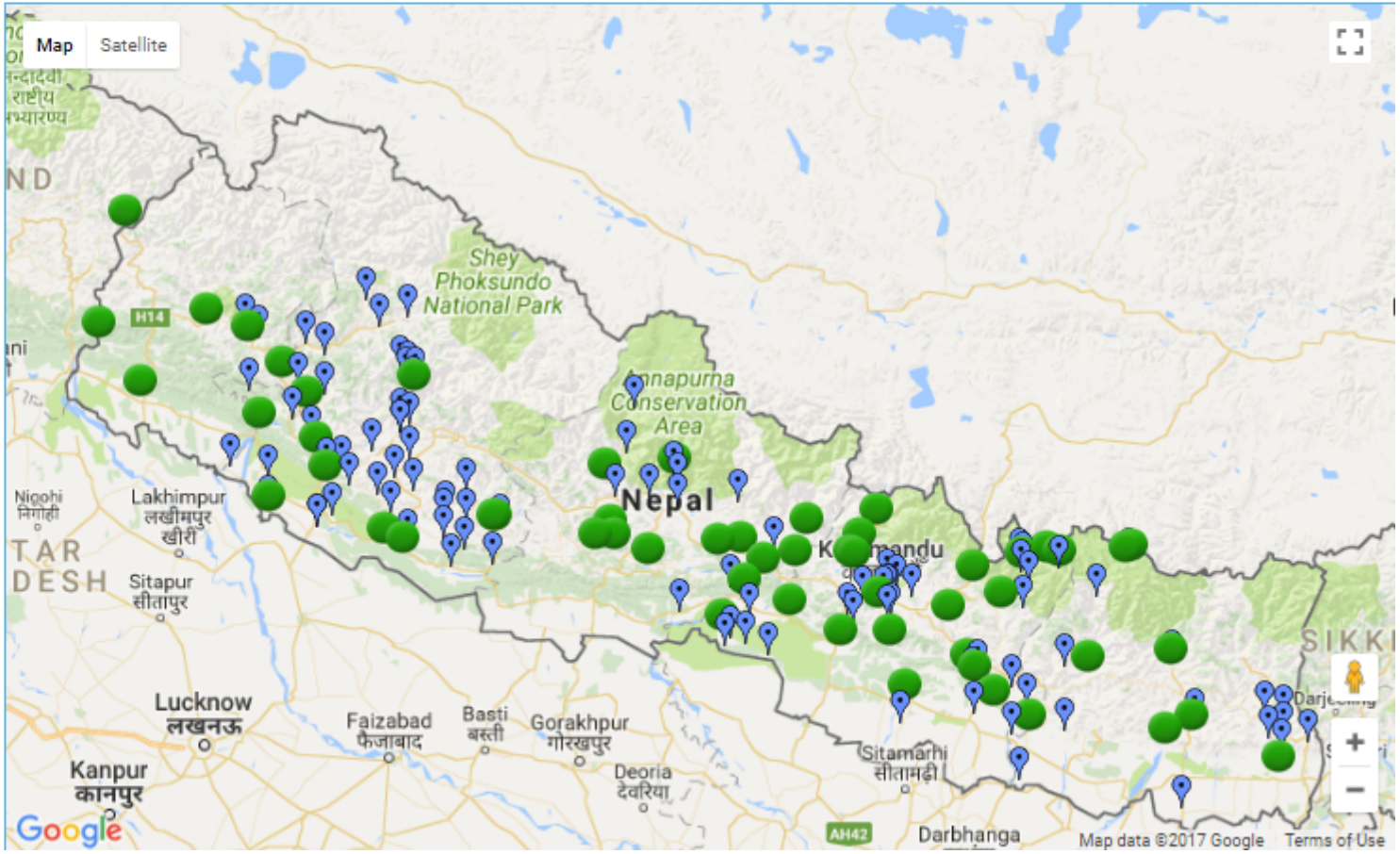
Flood Forecast Bulletin (19 Aug 2017, 6 PM- NPT)
No Flood Risk in Major rivers!..

Flood Forecast Bulletin (18 August 2017, 6 PM)
बाढिको जोखिम न्युन ..

News and Events

Flood Forecast and Warning Bulletin (16 August 2017 at 6 AM NPT)
बबईमा र मध्य देखी पश्चिमी तराई सम्मका अन्य सबै चुरिया नदीहरुमा मध्यम जोखिम ..

चितवनको माडीक्षेत्रको लागि विशेष



Government of Nepal
Ministry of Population and Environment
Department of Hydrology and Meteorology
Flood Forecasting Section

RAINFALL WATCH

Last updated on 2017-08-23 00:39:0

S.N	Basin Name	Station Index	Station Name	RAINFALL IN mm					Status ***
				1 hour (23-00)	3 hour (21-00)	6 hour (18-00)	12 hour (12-00)	24 hour (00-00)	
1	Kamala	1108	Bahun Tiplung	N/A	N/A	N/A	0.80	0.80	Below Warning Level
2	Karnali	240	Karnali at Asaraghat	N/A	N/A	N/A	0.00	41.80	Below Warning Level
3	Karnali	241	Lohare Khola at Tallo Dungeshwor	0.00	0.00	0.00	0.00	22.80	Below Warning Level
4	Karnali	259.5	West Seti at Dipayal	0.00	0.00	0.00	0.00	0.00	Below Warning Level
5	Karnali	280	Karnali at Chisapani	0.00	0.00	0.00	0.20	8.20	Below Warning Level
6	Karnali	329	Manma	0.00	0.00	0.60	1.60	2.20	Below Warning Level
7	Karnali	404	Jajarkot	0.00	0.20	1.60	1.60	46.60	Below Warning Level
8	Karnali	426	Kunathari - Surkhet	0.00	0.00	0.00	3.40	3.80	Below Warning Level

Total 76 real-time rain gauge telemetric stations.

Government of Nepal
Ministry of Population and Environment
Department of Hydrology and Meteorology
Flood Forecasting Section

RIVER WATCH

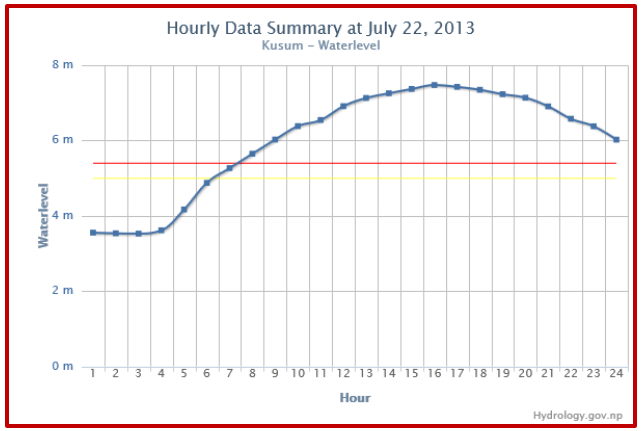
S.N	Station Index	Station Name	Water Level (m)	Flow (m^3/sec)	Warning Level (m)	Danger Level (m)	Trend	Status
1	105	Mahakali at Dattu 2017-08-23 00:15:00	3.88	-	5.8	6.5	Steady	Below Warning Level
2	178	Mahakali at Parigaon 2017-08-23 00:30:00	4.92	-	5.80	7.00	Rising	Below Warning Level
3	240	Karnali at Asaraghat 2017-08-22 18:30:00	5.57	1915.80	6.6	8	Falling	-
4	241	Lohare Khola at Tallo Dungeshwor 2017-08-23 00:30:00	3.26	130.37	5	5.5	Falling	Below Warning Level
5	259.5	West Seti at Dipayal 2017-08-23 00:30:00	2.56	-	8.6	9	Rising	Below Warning Level
6	280	Karnali at Chisapani 2017-08-23 00:30:00	7.69	4213.10	10.00	10.80	Falling	Below Warning Level
7	289.95	Babai at Chepang 2017-08-22 05:50:00	3.32	-	5.50	6.10	Falling	-
8	291	Babai at Bhada Bridge 2017-08-23 00:30:00	4.69	153.15	7	8	Falling	Below Warning Level
9	339.3	Jhimruk at Cherneta 2017-08-23 00:30:00	1.67	-	5.3	5.8	Steady	Below Warning Level
10	375	West Rapti at Kusum 2017-08-23 00:25:00	2.59	121.90	5	5.4	Falling	Below Warning Level
11	417	Badigad at Rudrabeni 2017-08-23 23:10:00	2.88	331.80	4.6	-	Rising	-

Total 36 real-time water level telemetric stations from 9 basins.

Early warning system: Case study of Banke District

22 July, 2013

Display board at DAO, Banke showing water level of Rapti River at Kusum (above danger level)



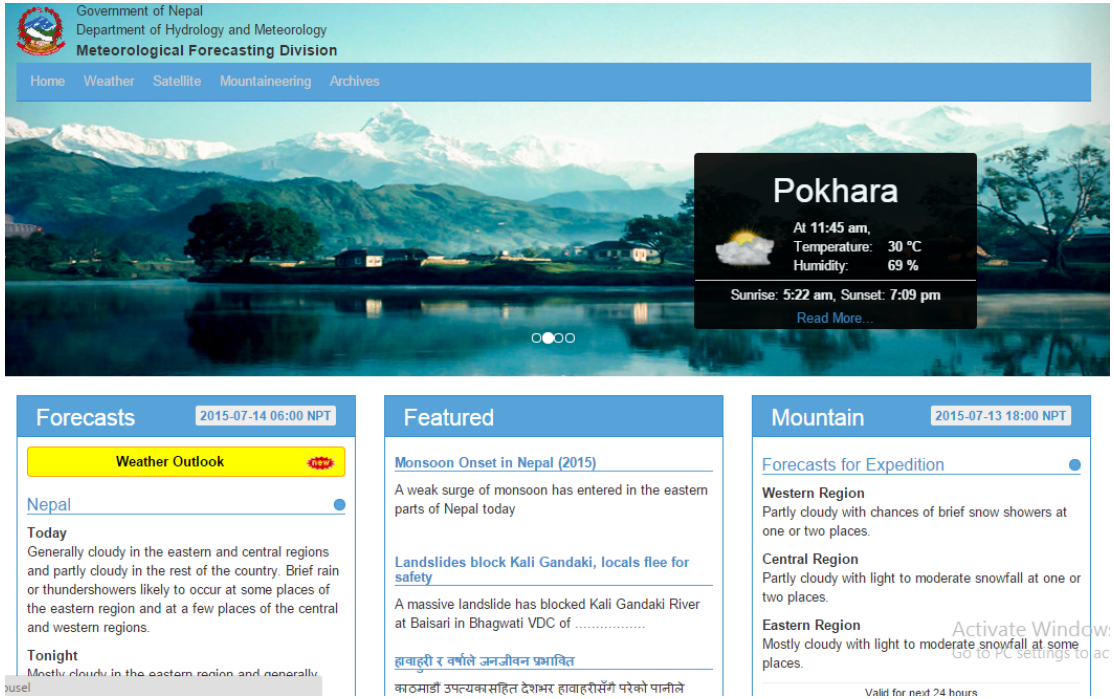
Source:
www.hydrology.gov.np

CDO, Banke taking flood level information

Photo: Community people shifting their belongings to safe place

Information Dissemination

www.mfd.gov.np
www.hydrology.gov.np
www.dhm.gov.np



Localized Bulk SMS

Operational service 24/7

Tel: 977-1-4486869, 4113191

Notice Board Service: 1618-0707-33333

Toll Free Service 1155

Capacity Development

A. Trainings

- **ToT** on GLOF risk management was conducted to train 20 **Local Resource Persons (LRPs).**
- LRPs have been mobilized to **educate and aware** local communities on GLOF risk preparedness.
- A **ToT manual** on GLOF risk management has been **developed.**

Capacity Development

Three trainings on **First Aid, Light Search** and **Rescue,** and **CBEWS** conducted for capacity building of **taskforce members, LRPs and local youth.**

Capacity Development

B. GLOF Mock Drills

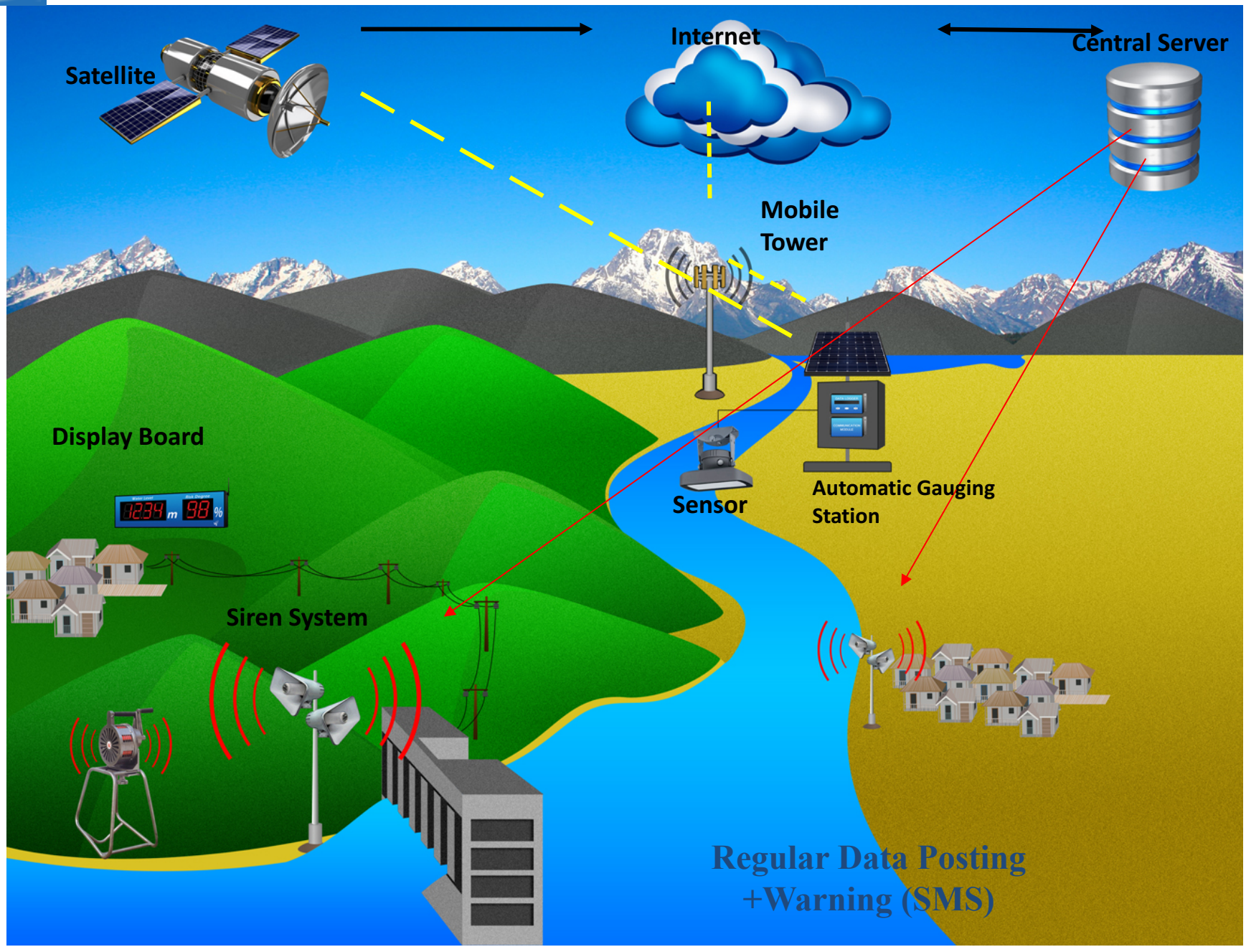
- **Nine Mock drill events** encompassing the **12 high risk settlements** have been conducted involving community members including Taskforce members and LRPs.
- This aims to train vulnerable communities, LRPs and Taskforce members to better respond the GLOF events.

Capacity Development

C. Equipment Support

Taskforces have been **equipped** with LSAR, FA and CBEWS equipment.

Communication



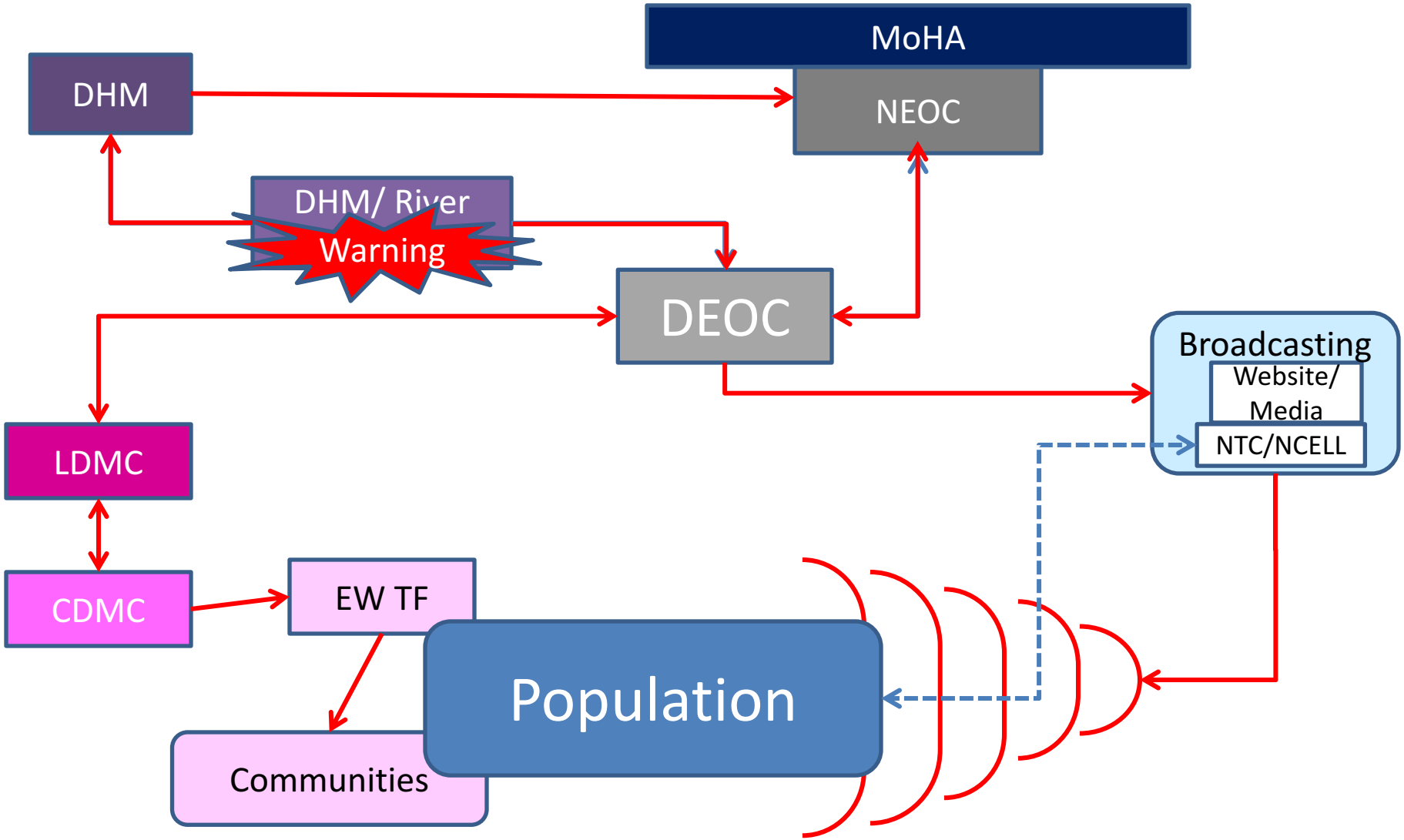
GLOF Early Warning System

National Masters Training : Flood EWS (Feb 27- March 4, 2014)

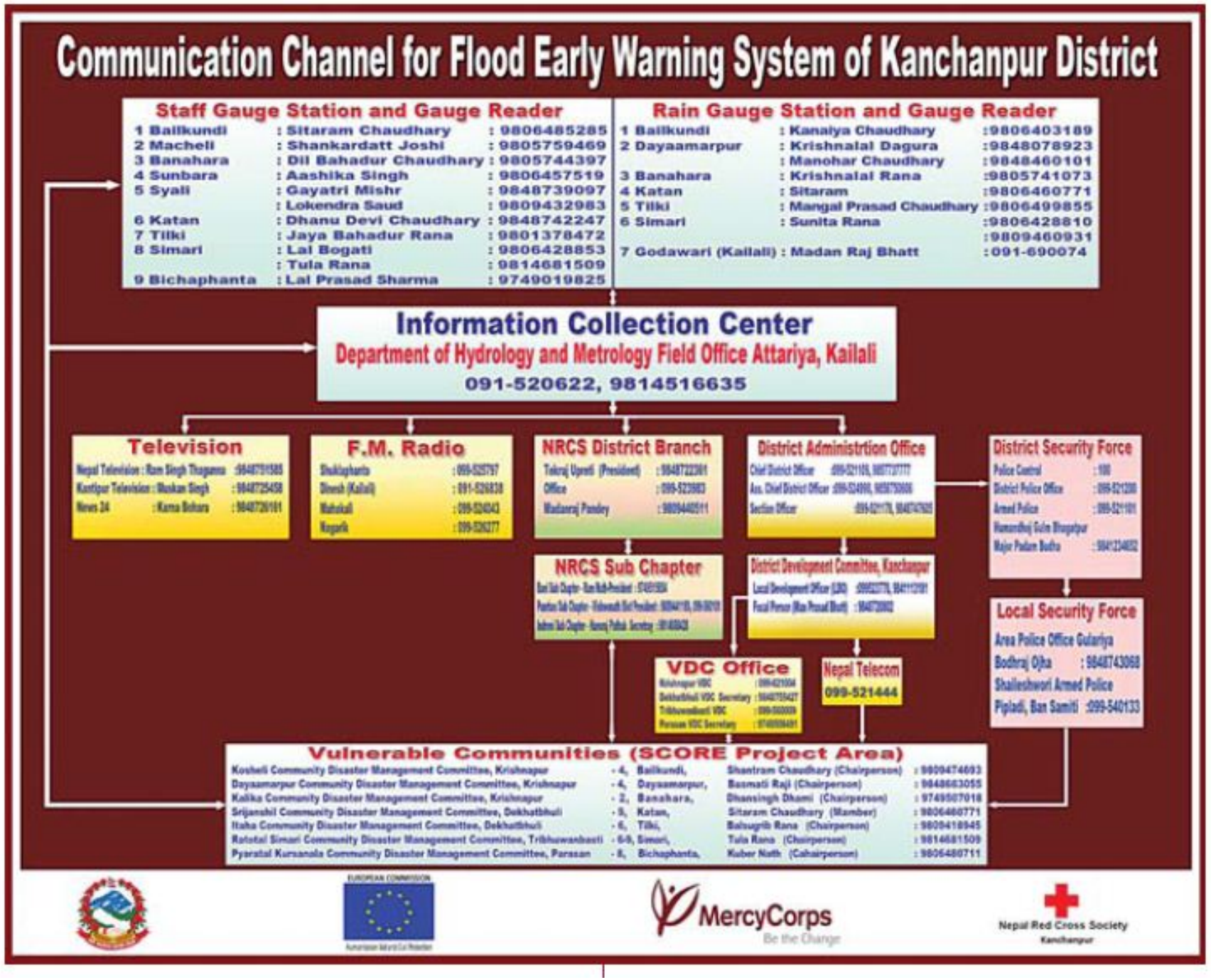
- DHM, MOHA and MOFALD organized the training
- 6 days Training
- 29 persons trained

Flood Early Warning Dissemination

MoHA: Ministry of Home Affairs (गृह मन्त्रालय)
NEOC: National Emergency Operation Centre (केन्द्रीय आपतकालिन कार्यसञ्चालन केन्द्र)
DHM: Department of Hydrology and Meteorology (जल तथा मौसम विज्ञान विभाग)
DEOC: District Emergency operation Centre (जिल्ला आपतकालिन कार्यसञ्चालन केन्द्र)
LDMC: Local Disaster Management Committee (स्थानिय विपद् व्यवस्थापन समिति)
CDMC: Community Disaster Management Committee (समुदाय स्तरीय विपद् व्यवस्थापन समिति)
EW TF: Early Warning Task Force (पूर्वसूचना कार्य दल)



Communication Channel for Flood Early Warning System of Kanchanpur District



Ncell To Send SMS Alert For Flood And Landslides

On **Jul 24, 2016**

Share

Ncell, the private telecom operator of Nepal has signed a MOU with Department of hydrology and meteorology (DHM) to send an early warning or SMS alert to people residing in the place where the risk of flood and landslide is high. With the alert, it can help people to move towards safe place and prevent loss of property there.

Development of Flood Forecasting Model for Narayani River Basin, Nepal

Technical Workshop
Development and Implementation of User- Relevant Flood Forecast Generation and Application System for Nepal

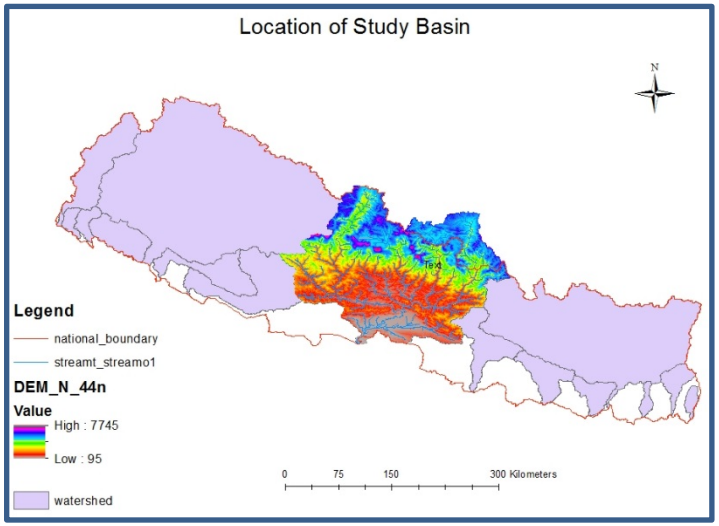
17 to 21st April, 2017

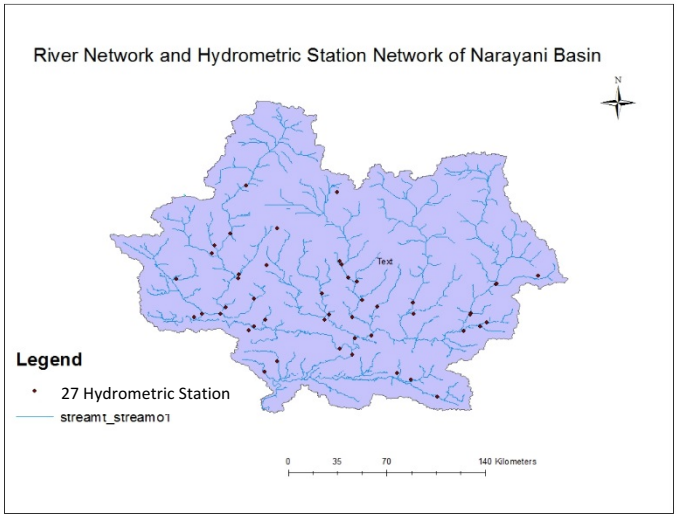
Binod Parajuli
bp_gorkhali@hotmail.com

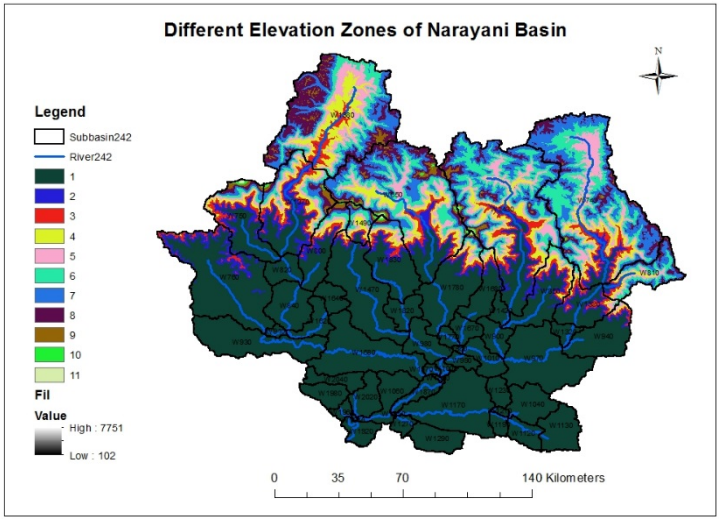
Study Area

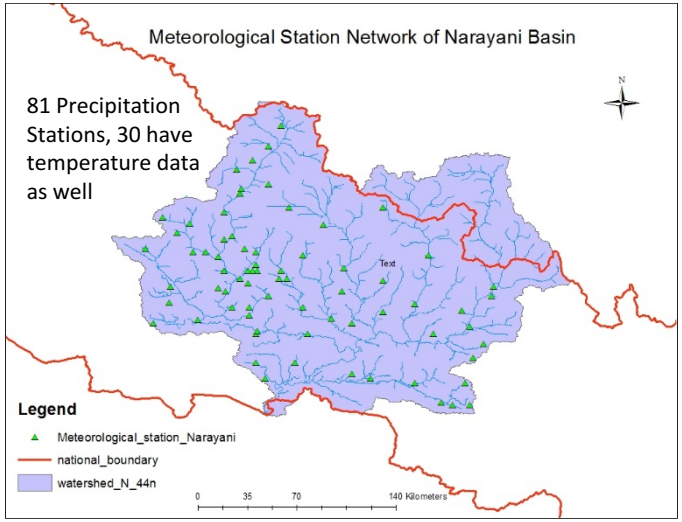
- Nepal, with an area of 147,181 sq. km. and mean width 193 km, has major three river systems: *Koshi, Narayani and Karnali.*
- Narayani River originates in Tibet and has total of *36,300 km²*.
- *89%* of the catchment lies in Nepal and the rest is in Tibet.
- The vertical elevation of watershed ranges between 102m to 8,147 m above the mean sea level.
- The *Kali Gandaki, Trishuli, Daraudi, Seti, Madi, Marsyangdi, BudhiGandaki and East rapti* are the Eight major tributaries of Gandaki River

Value	Elv Zone (m)	Area (%)
1	100-2500	52.67%
2	2500-3000	4.95%
3	3000-3500	4.54%
4	3500-4000	5.40%
5	4000-4500	7.02%
6	4500-5000	8.83%
7	5000-5500	9.31%
8	5500-6000	5.57%
9	6000-6500	1.35%
10	6500-7000	0.25%
11	7000-7800	0.09%







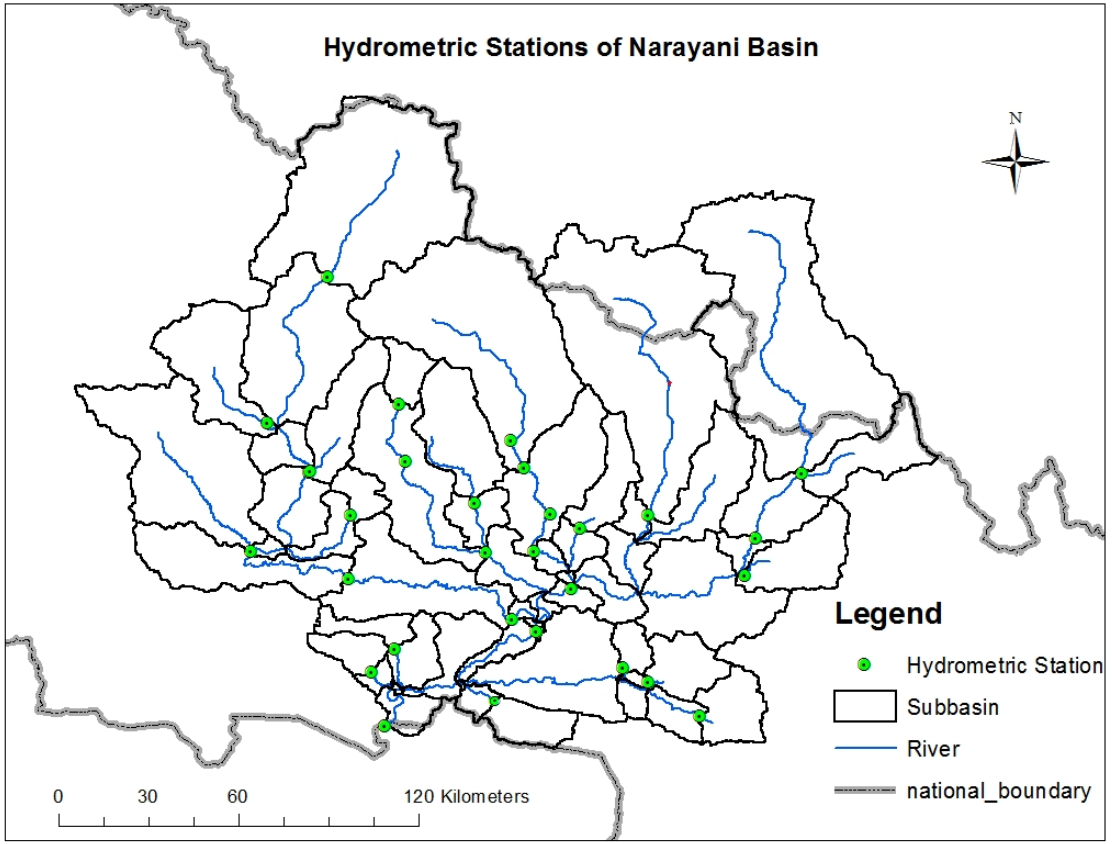


Basin Model

Development of Hydrological Model

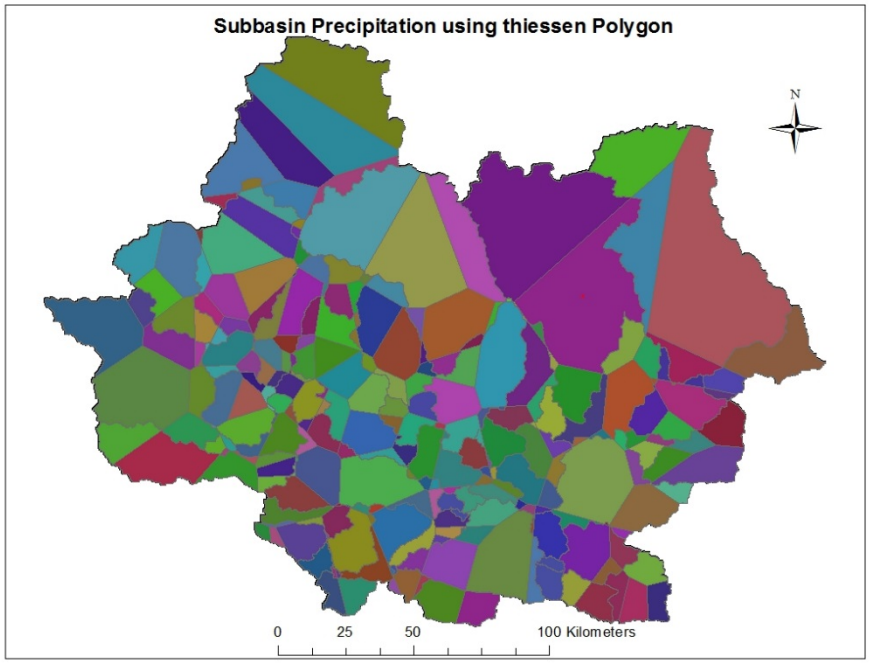
HEC-GeoHMS results

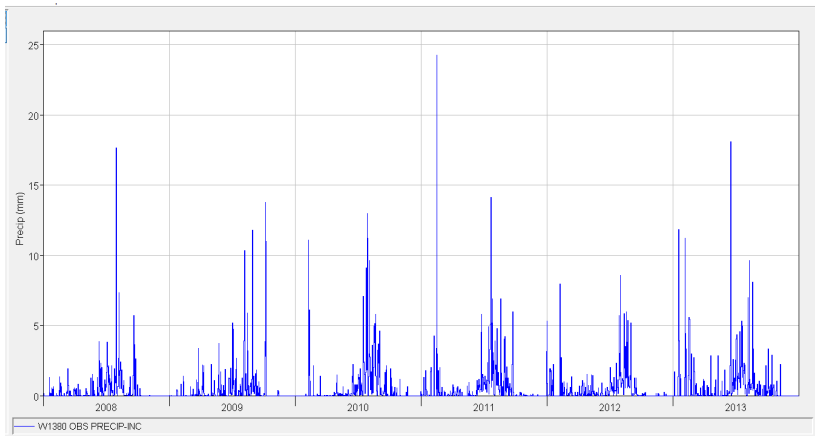
- 56 sub-basins
- Sub-basin created based on hydrometric stations (Forecasting Station).

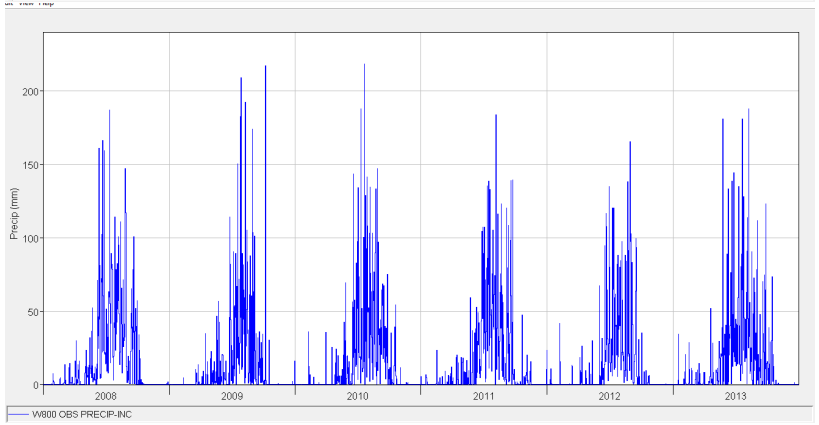


Data Preparation and Processing

Data Preparation: Sub-Basin Average Rainfall calculation



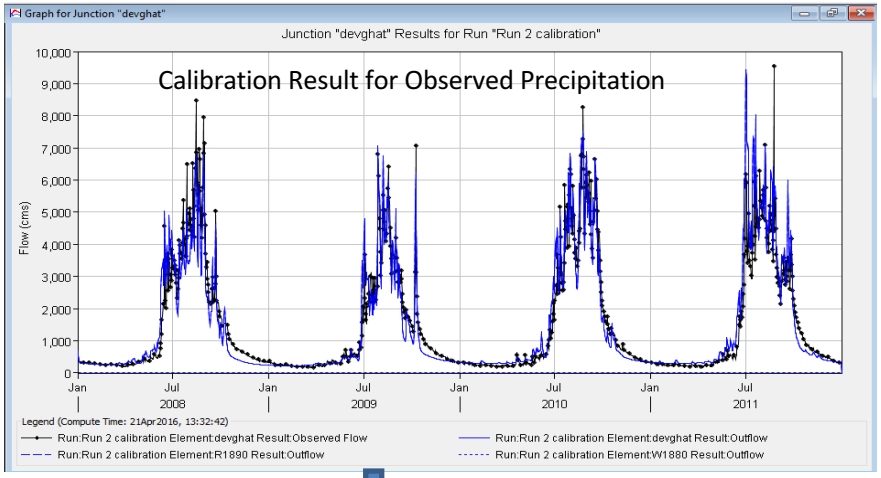


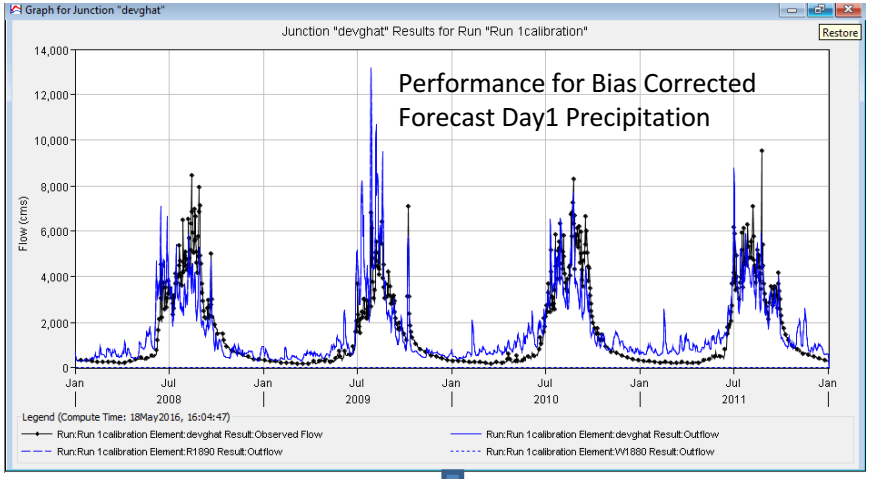


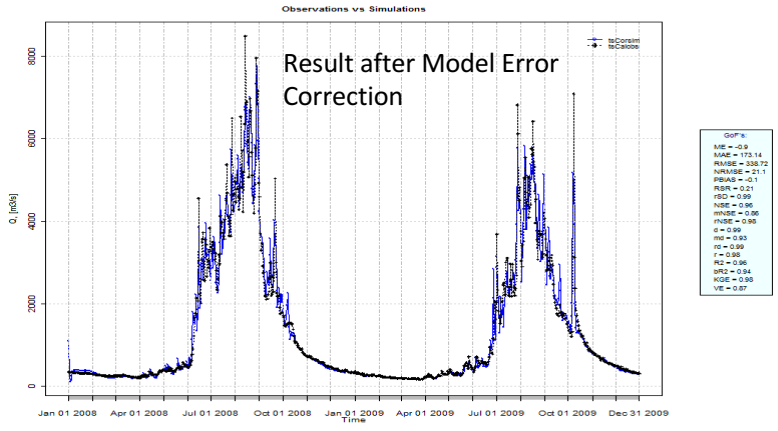
The Sub-basin Precipitation are calculated using Thiessen Polygon Method

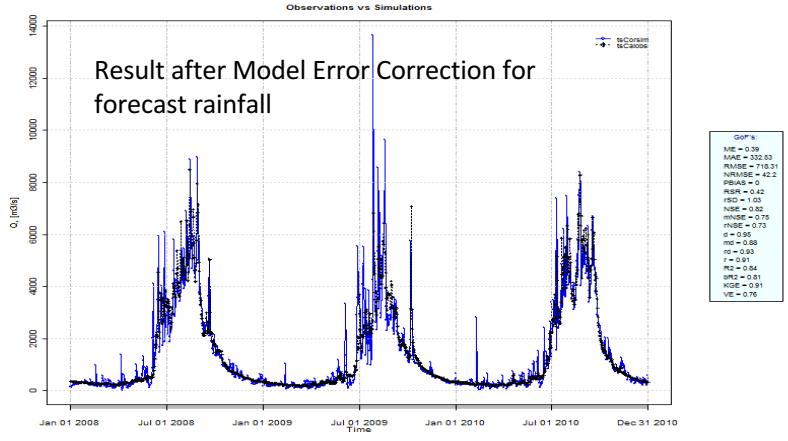
Calibration Result at Devghat Flood Forecasting Station

Calibration Period: 2008 to 2011

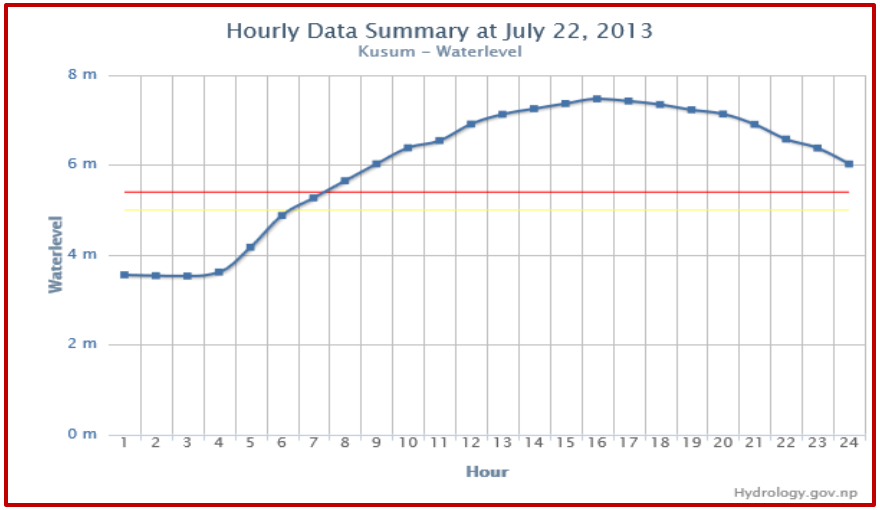


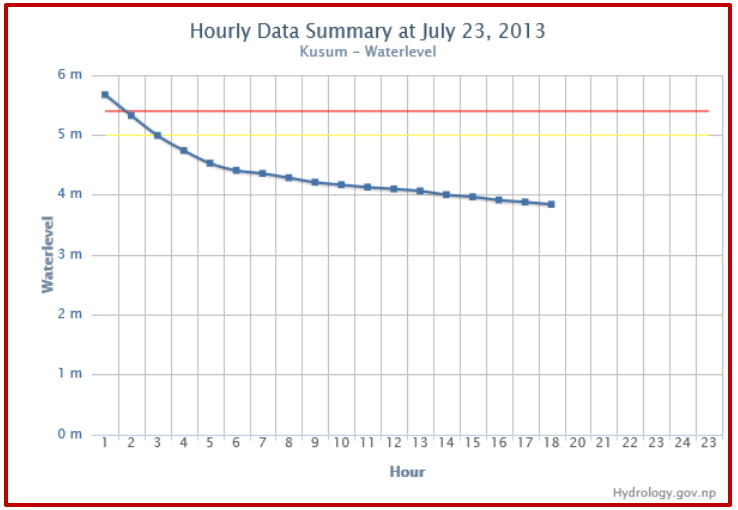


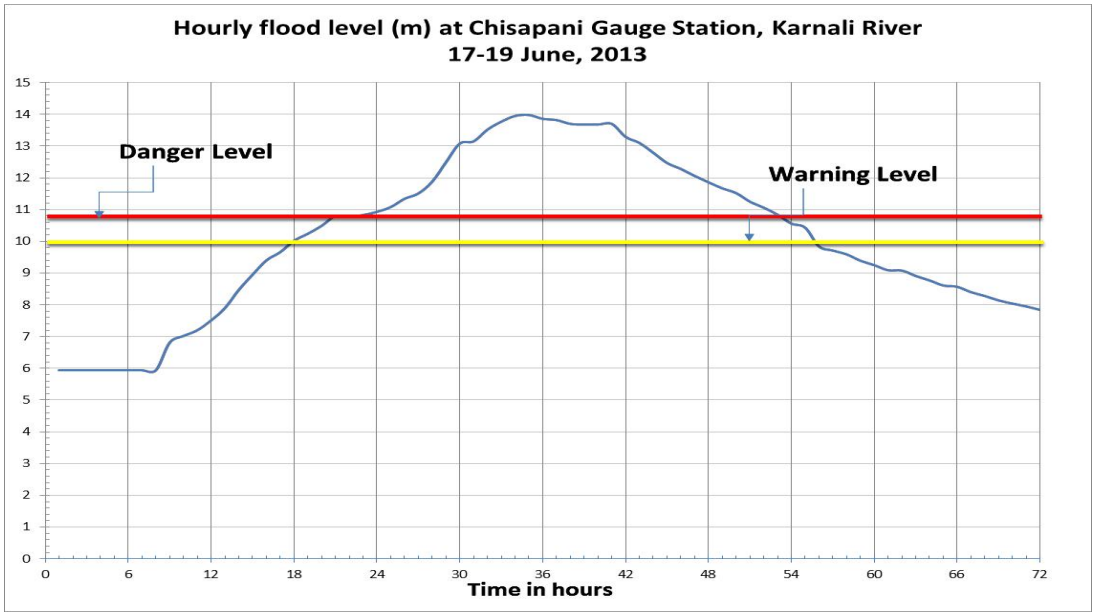




Web Based Telemetry

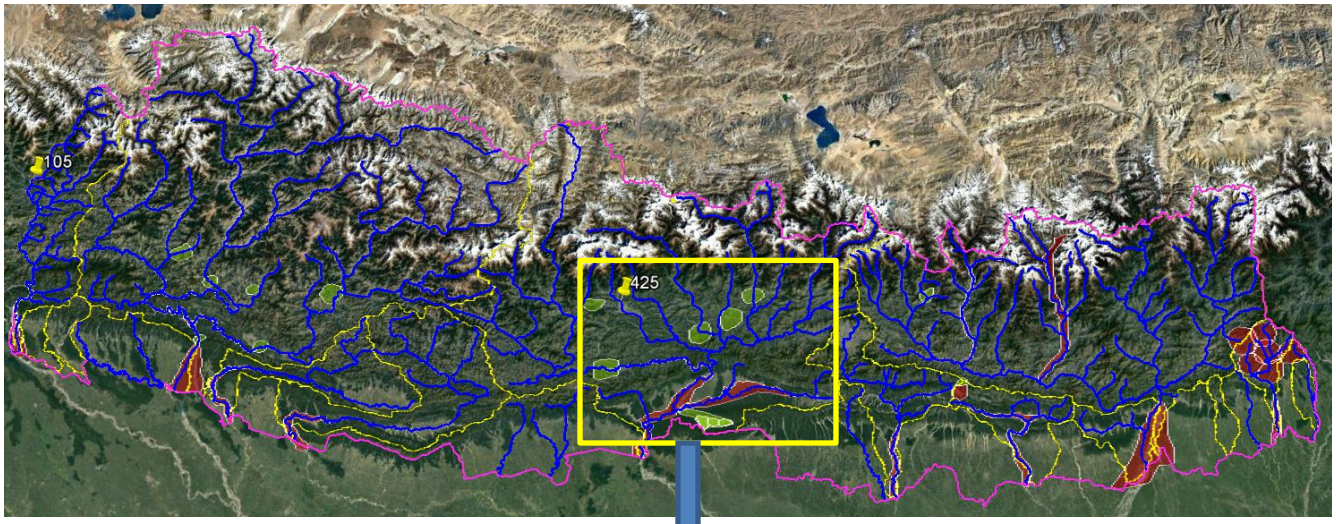


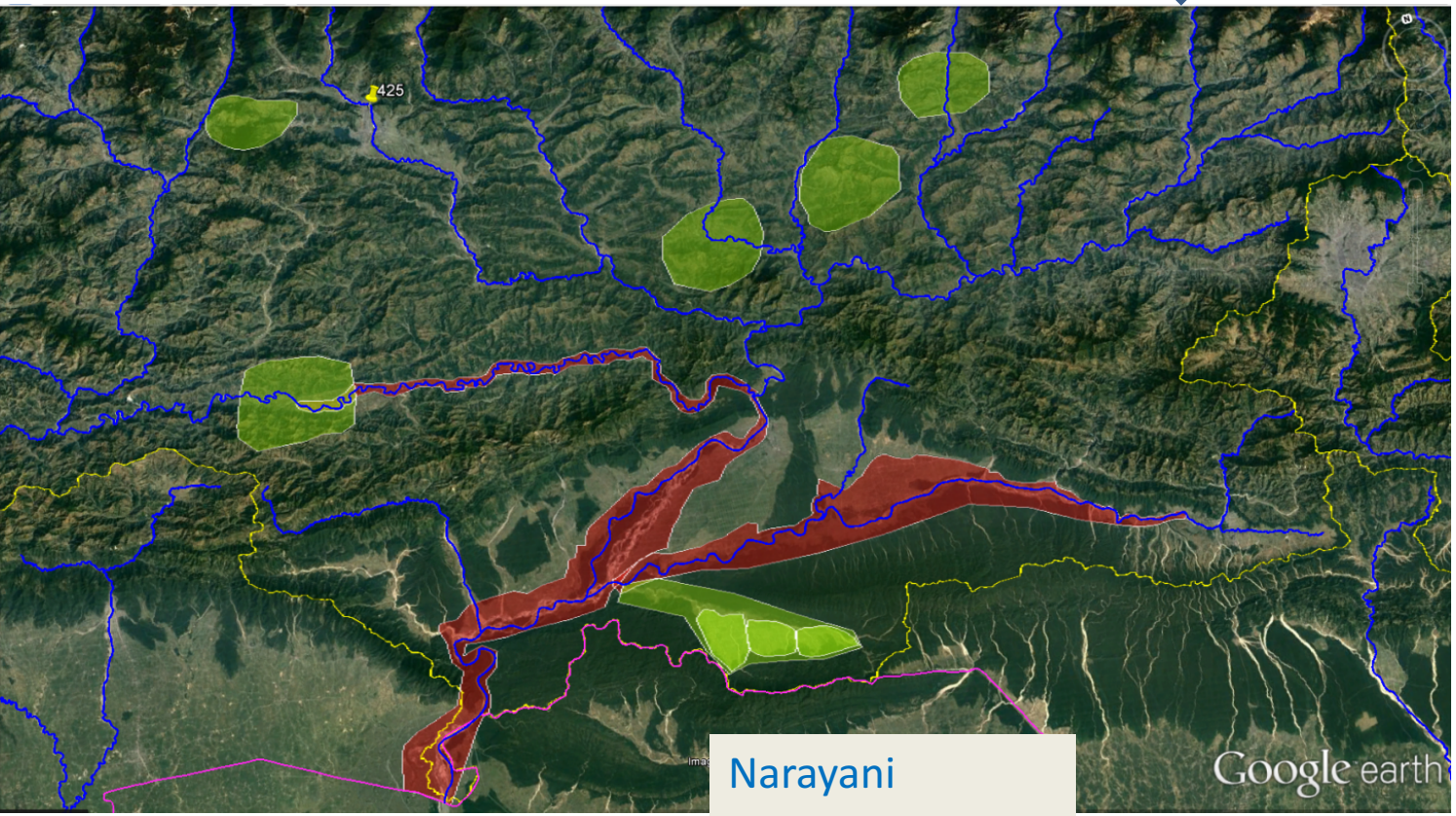




http://www.hydrology.gov.np

Mass SMS To vulnerable communities





Narayani

43 polygons in 9 river basins

Targeted particularly for flood and landslide

Mass SMS using mobile phones
DHM-NCELL and
DHM-NTC Collaboration for Mass SMS
MoU signed on 20 and 28th July 2016

	* Please add "-DHM" at the end of SMS content while sending	SMS Messaging			
SN	Polygon Name (File Name in FTP location)	Rising water level: near warning level	above warning level	above danger level	falling water level: below warning
1	WestRapti_Basin_Hydro_West Rapti_Kusum	Westrapti Kusumko jalamapan kendrama jalsataha chetawani taha najik pugekole sajag rahanuhuna anurodh chha	jalamapan kendrama jalsataha le chetawani taha par garekole sajag rahanuhuna anurodh chha	Westrapti Kusumko jalamapan kendrama jalsataha le khatara ko taha par garekole surakchhit sthan ma rahanuhuna anurodh chha	Westrapti Kusumko jalamapan kendrama jalsataha samanya awasthama farkiyekole tatkal kunai khatara chhaina
2	Kankai_Basin_Hydro_kankai_d/s	Kankai Mainachuliko jalamapan kendrama jalsataha chetawani taha najik pugekole sajag rahanuhuna anurodh chha	jalamapan kendrama jalsataha le chetawani taha par garekole sajag rahanuhuna anurodh chha	Kankai Mainachuliko jalamapan kendrama jalsataha le khatara ko taha par garekole surakchhit sthan ma rahanuhuna anurodh chha	jalamapan kendrama jalsataha samanya awasthama farkiyekole tatkal kunai khatara chhaina
3	Kankai_Basin_Rain_IlamTeaState	Tapain raheko wa aaspasko chhetra ma bhari barsa bhayeko chha viralo jaminma pahiro ra najikaiko khola nalama badhi aauna sakchha sachet bhaie surakchhit sthan ma rahanuhola!			
4	Kankai_Basin_Rain_KanyamTeaState	Tapain raheko wa aaspasko chhetra ma bhari barsa bhayeko chha viralo jaminma pahiro ra najikaiko khola nalama badhi aauna sakchha sachet bhaie surakchhit sthan ma rahanuhola!			
5	Kankai_Basin_Rain_MaiPokhari	Tapain raheko wa aaspasko chhetra ma bhari barsa bhayeko chha viralo jaminma pahiro ra najikaiko khola nalama badhi aauna sakchha sachet bhaie surakchhit sthan ma rahanuhola!			
6	Kankai_Basin_Rain_Rake	Tapain raheko wa aaspasko chhetra ma bhari barsa bhayeko chha viralo jaminma pahiro ra najikaiko khola nalama badhi aauna sakchha sachet bhaie surakchhit sthan ma rahanuhola!			
7	Kankai_Basin_Rain_SoktimTeaState	Tapain raheko wa aaspasko chhetra ma bhari barsa bhayeko chha viralo jaminma pahiro ra najikaiko khola nalama badhi aauna sakchha sachet bhaie surakchhit sthan ma rahanuhola!			
8	Kankai_Basin_Rain_Jeetpur	Tapain raheko wa aaspasko chhetra ma bhari barsa bhayeko chha viralo jaminma pahiro ra najikaiko khola nalama badhi aauna sakchha sachet bhaie surakchhit sthan ma rahanuhola!			

Status o Kankai River, Jhapa

26 July 2016

- Kanyam Tea State
- Ilam Tea State
- Mai Pokhari
- Rake
- Soktim Tea State
- Zeetpur
- Mahakali
- Others

Flood Alerts

Water Level of **Karnali at Chisapani** at **2016-07-26 22:15:00** is **rising** [8.09 m] and Below Warning Level

Water Level of **Babai River at Chepang** at **2016-07-26 22:00:00** is **falling** [4.64 m] and Below Warning Level

Water Level of **Rapti River at Kusum** at **2035-06-05 21:45:00** is N/A [N/A m] and N/A

Water Level of **Narayani River at Devghat** at **2016-07-26 16:20:00** is **rising** [10.24 m] and Higher Than Danger Level

Water Level of **East Rapti at Rajaiya** at **2016-07-26 22:15:00** is N/A [N/A m] and N/A

Water Level of **Bagmati River at Karmaiya** at N/A is N/A [N/A m] and N/A

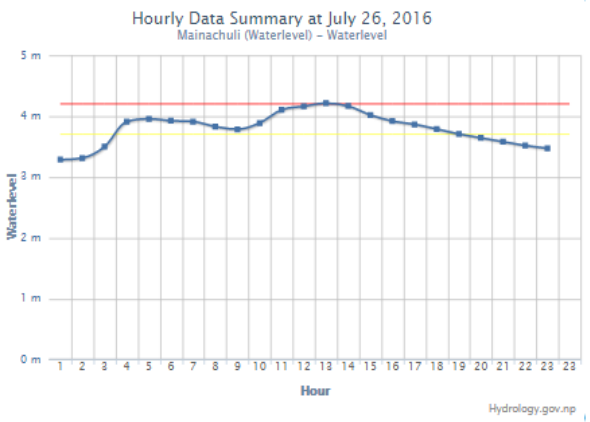
Water Level of **Koshi River at Chatara** at **2016-07-26 08:20:00** is **rising** [5.21 m] and Below Warning Level

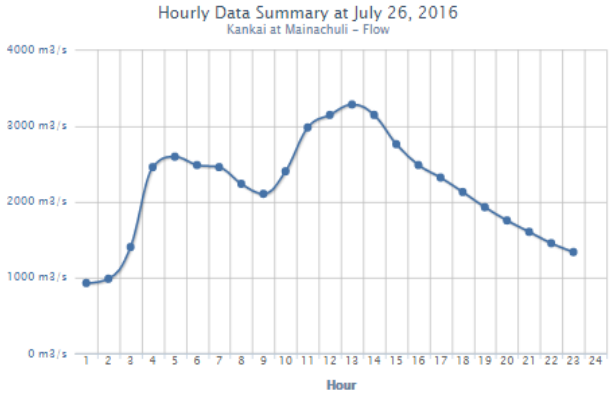
Water Level of **Kankai River at Mainachuli** at **2016-07-26 22:15:00** is **falling** [3.47 m] and Below Warning Level

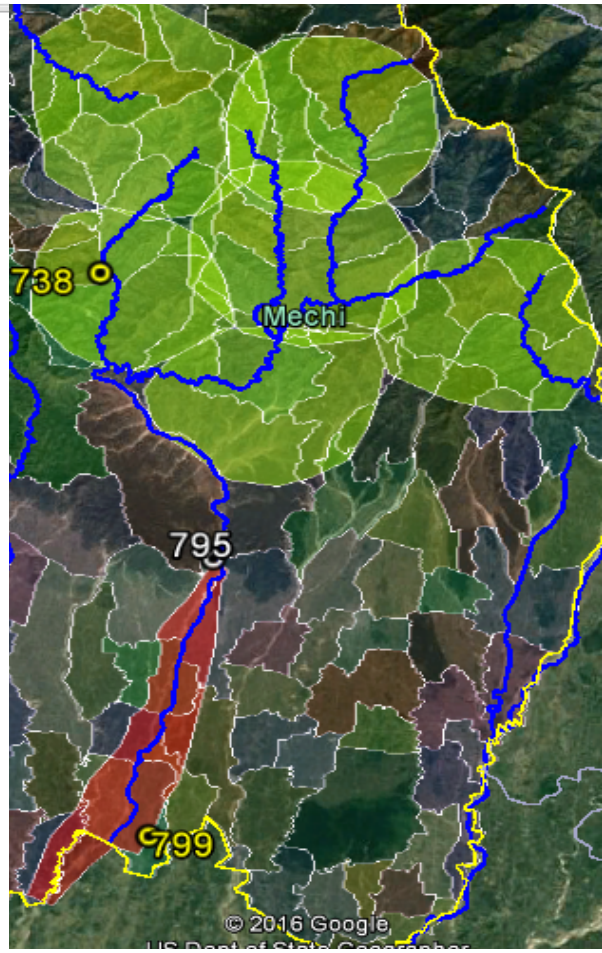
Weather Forecast

Select Date 2016-07-26 View Type Hourly View

Hour	Value (m)	Flow (m^3/s)
1	3.28	926.00
2	3.31	982.00
3	3.50	1400.00
4	3.91	2452.50
5	3.96	2590.00
6	3.92	2480.00
7	3.91	2452.50
8	3.83	2232.50
9	3.78	2100.00
10	3.89	2397.50
11	4.10	2975.00
12	4.16	3140.00
13	4.21	3277.50
14	4.16	3140.00
15	4.02	2755.00
16	3.92	2480.00
17	3.86	2315.00
18	3.79	2125.00
19	3.71	1925.00
20	3.64	1750.00
21	3.58	1600.00
22	3.52	1450.00
23	3.47	1334.00
24	-	-



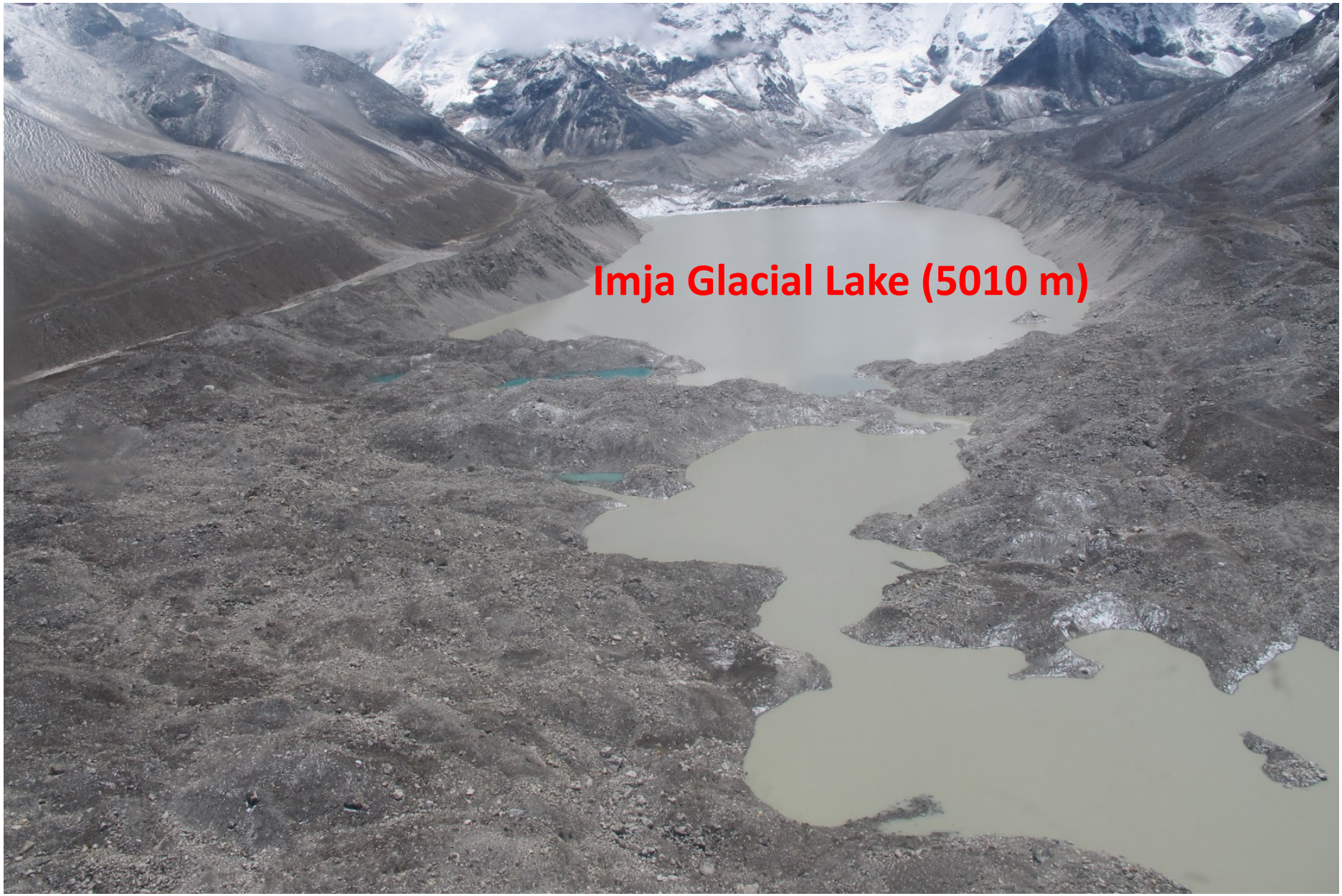




Rising water level: near warning level	above warning level	above danger level	falling water level: below warning
Kankai Mainachuliko jalamapan kendrama jalsataha chetawani taha najik pugekole sajag rahanuhuna anurodh chha	jalamapan kendrama jalsataha le chetawani taha par garekole sajag rahanuhuna anurodh chha	Kankai Mainachuliko jalamapan kendrama jalsataha le khatara ko taha par garekole surakchhit sthan ma rahanuhuna anurodh chha	jalamapan kendrama jalsataha samanya awasthama farkiyekole tatkal kunai khatara chhaina

Total Number of Message Sent: 32429
Total Number of Successful Message: 31240
Total Number of Failed Message: 1189

Tcho Rolpa Glacier Lake Level Reduction by 3 m (4500 m)


Imja Glacial Lake (5010 m)

Imja Glacier Lake Lowering (5010 m) by 3.4 m in 2016

Components and Stakeholders

- **DHM (Department of Hydrology and Meteorology)**
  - ***Monitoring and Observation of Hydrological and Meteorological Information***
  - ***Communication and Dissemination***
- **MoHA (Ministry of Home Affairs)**
  - ***Response and Coordination***
  - ***Rapid Assessment***
  - ***Communication and Dissemination of Information***
- **MoFALD (Ministry of Federal and Local Development)**
  - ***Preparedness and Capacity Building***
  - ***Community support to response and assessment***
- **Media and Private Sector**
  - ***Communication and Dissemination***

DHM-RIMES collaboration:

MOU was signed in : 29 Dec, 2014

Project Name

Technical Assistance for Development of Flood Forecast Generation and Application System for Disaster Mitigation in Nepal

Project Goal

User-relevant end-to-end flood forecast generation and application system developed and demonstrated over Narayani, Babai and Karnali sub-basins of Ganges Basin in Nepal

Project Objectives

- **Enhancing meteorological and hydrological monitoring capacities for the generation of long-lead location-specific flood forecasts**
- **Customization of flood forecast models for Narayani, Babai and Karnali basin**
- **Development of Decision Support System (DSS) to communicate relevant, long-lead, location-specific flood risk information.**

12 Stations upgraded by RIMES

Narayani Basin

Station no. 404.7	- Magdi khola at Magal ghat.
Station no. 415.1	-Adhikhola at Burlangtar
Station no. 417	- Badigad khola at Rudrabeni.
Station no. 449.91	-Trisuli River at Kali khola.
Station no. 460	- E. Rapati river at Rajaiya.
Station no. 439.7	- Marshyandi River at Bimalnagar
Station no. 847	-metrological at Khudi Bazar (AWS)

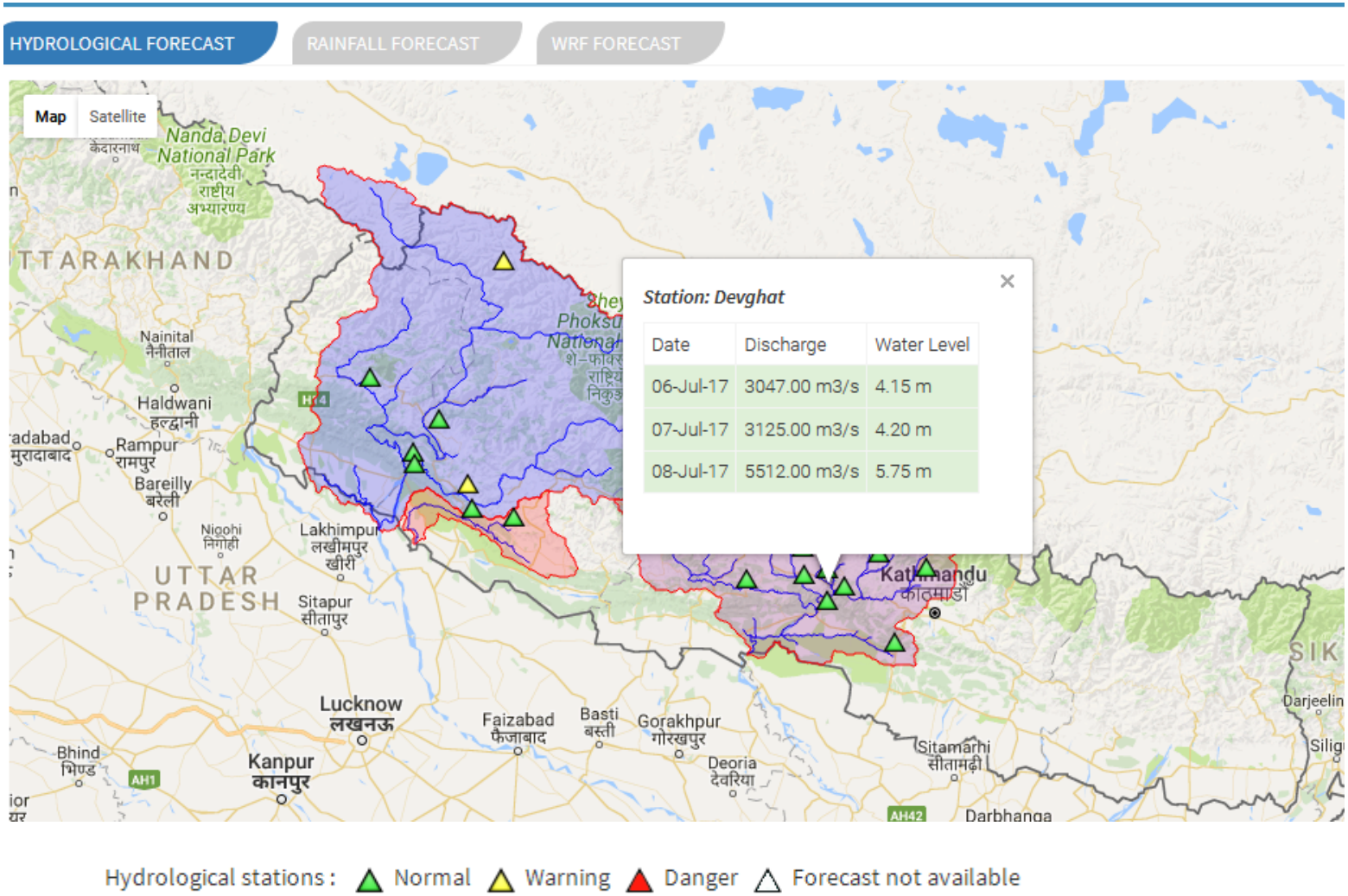
Karnali Basin

Station no. 265.	-Thuli Bheri at Rimna
Station no. 241	- Lohare khola atTallo dugesore
Station no. 256.5	-Budhi ganga at Chitreghat
Station no. 0513	-metrological station at Chourjhahari (AWS)

Babai Basin

1. Station no. 289.95 - Babai River at Chepang

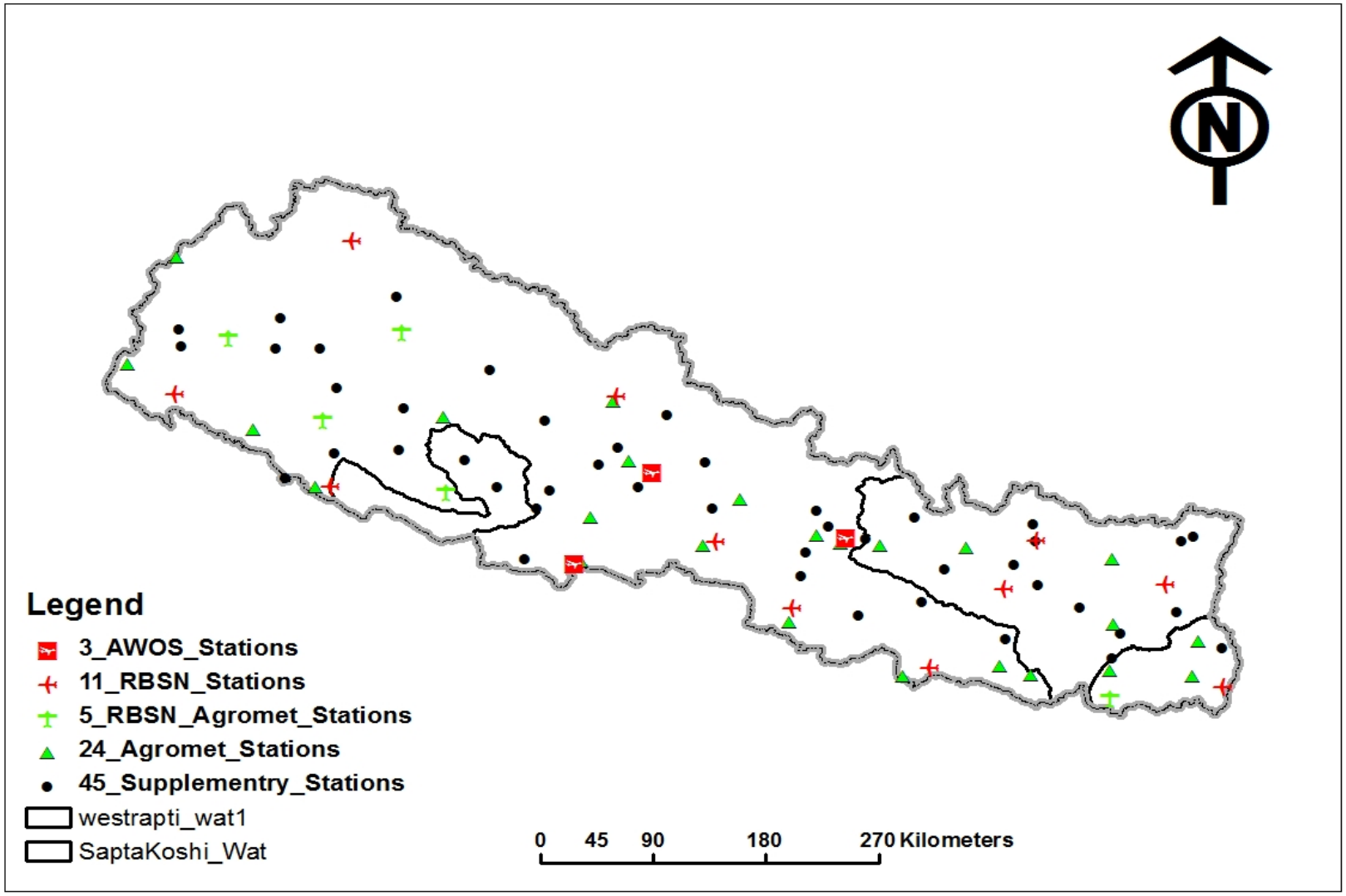
3-Day Flood Forecast Using 3 day Weather Forecast DHM-RIMES Collaboration



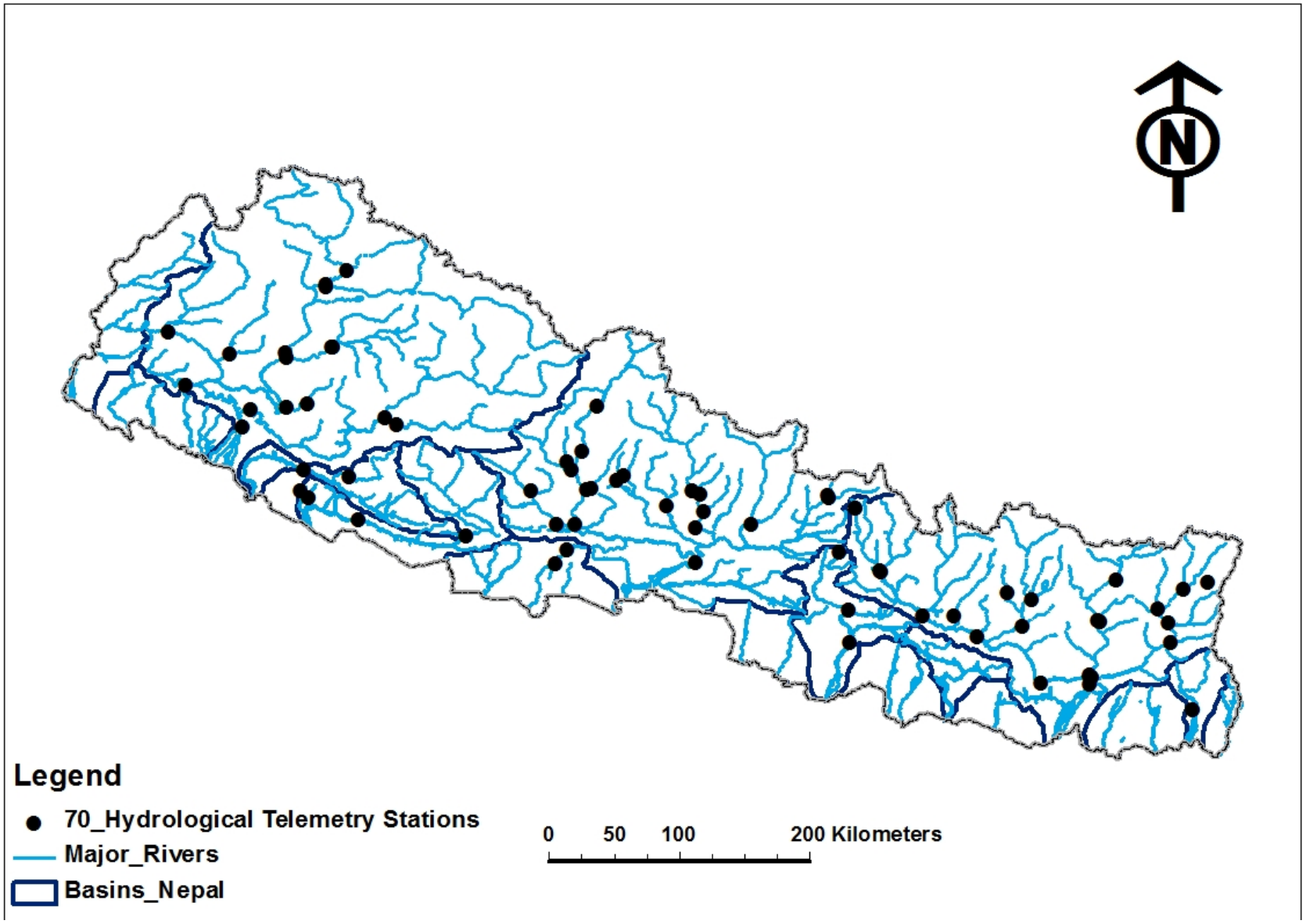
DHM-RIMES Technical Workshop on- Development and Implementation of User Relevant Flood Forecast Generation & Application System for Nepal

Future Plan and Activities

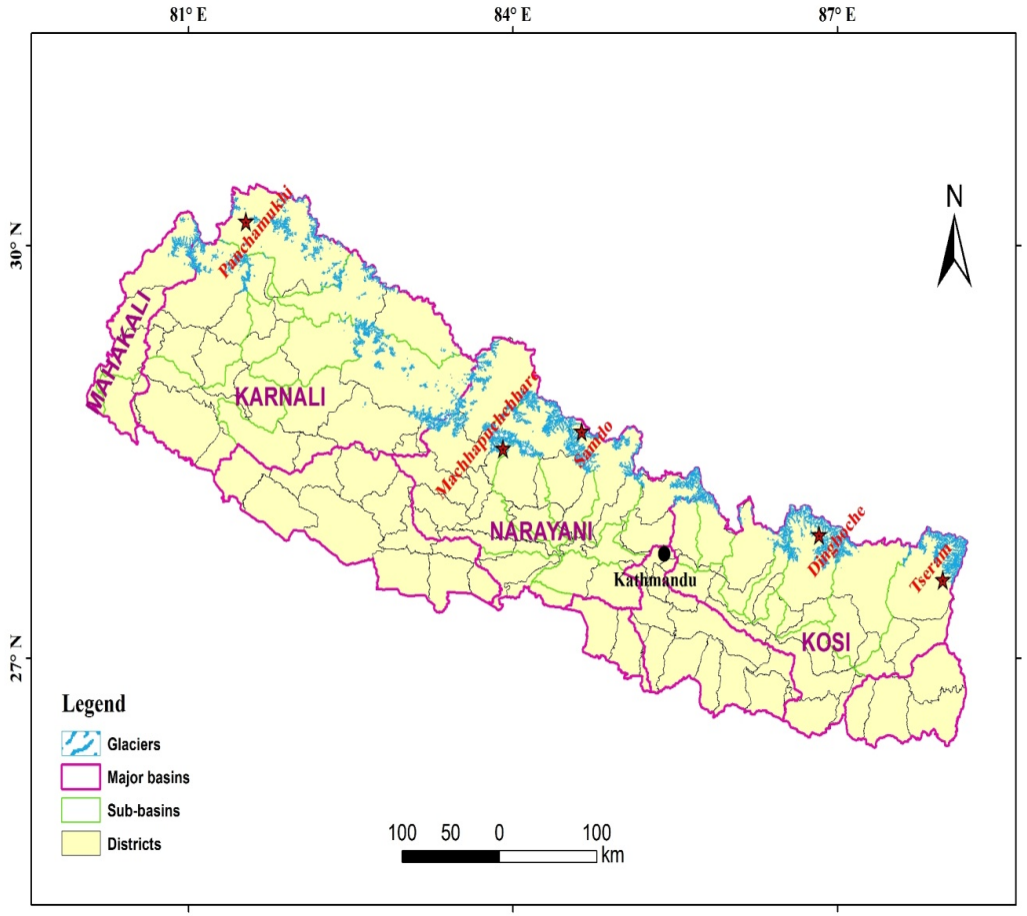
88 Automatic Weather Stations (AWS, within 12 months)



70 Automatic Hydrological Stations (within 12 months)

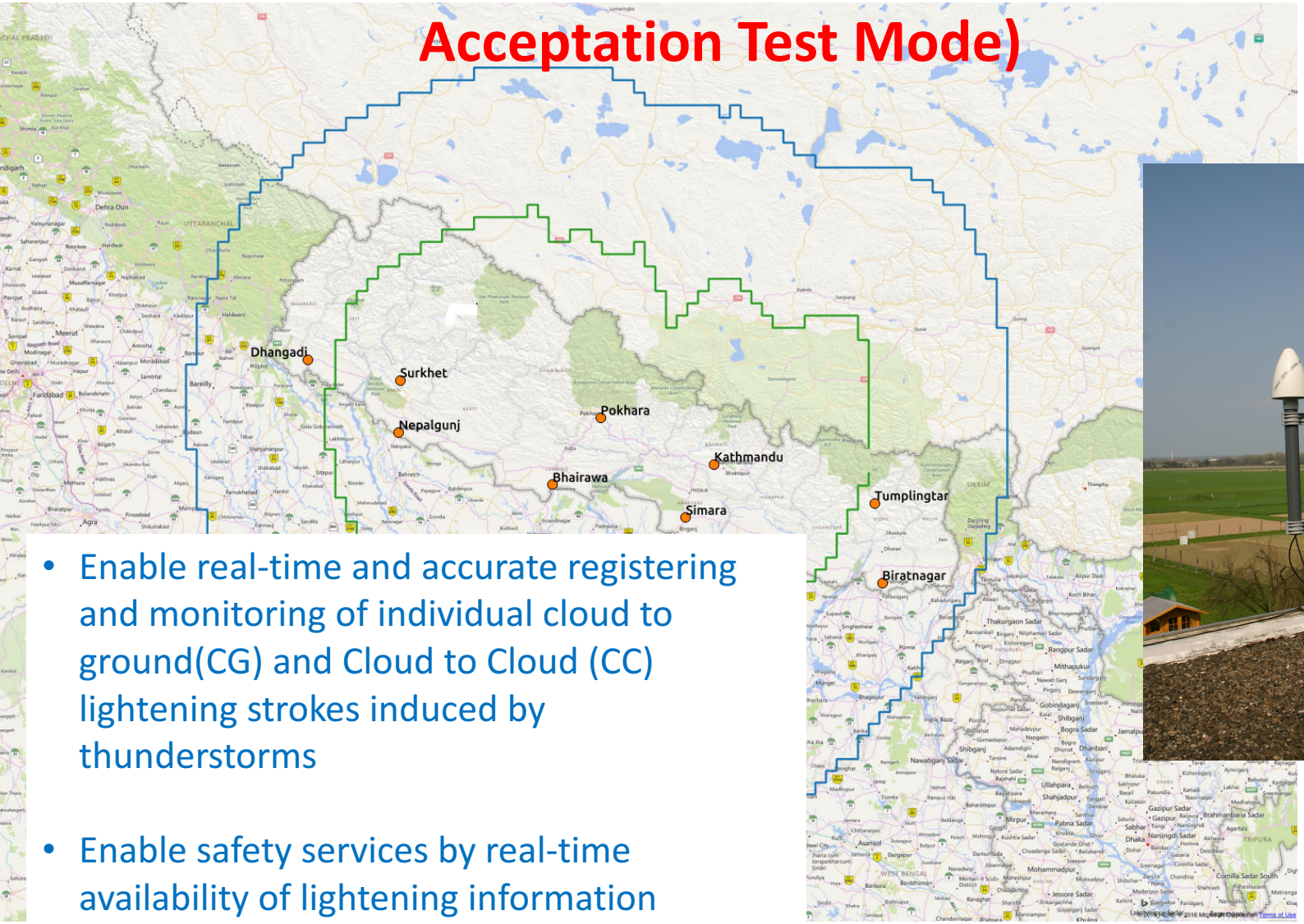


Upgrade of Snow & Glacier Monitoring Network (by Nov. 2018)



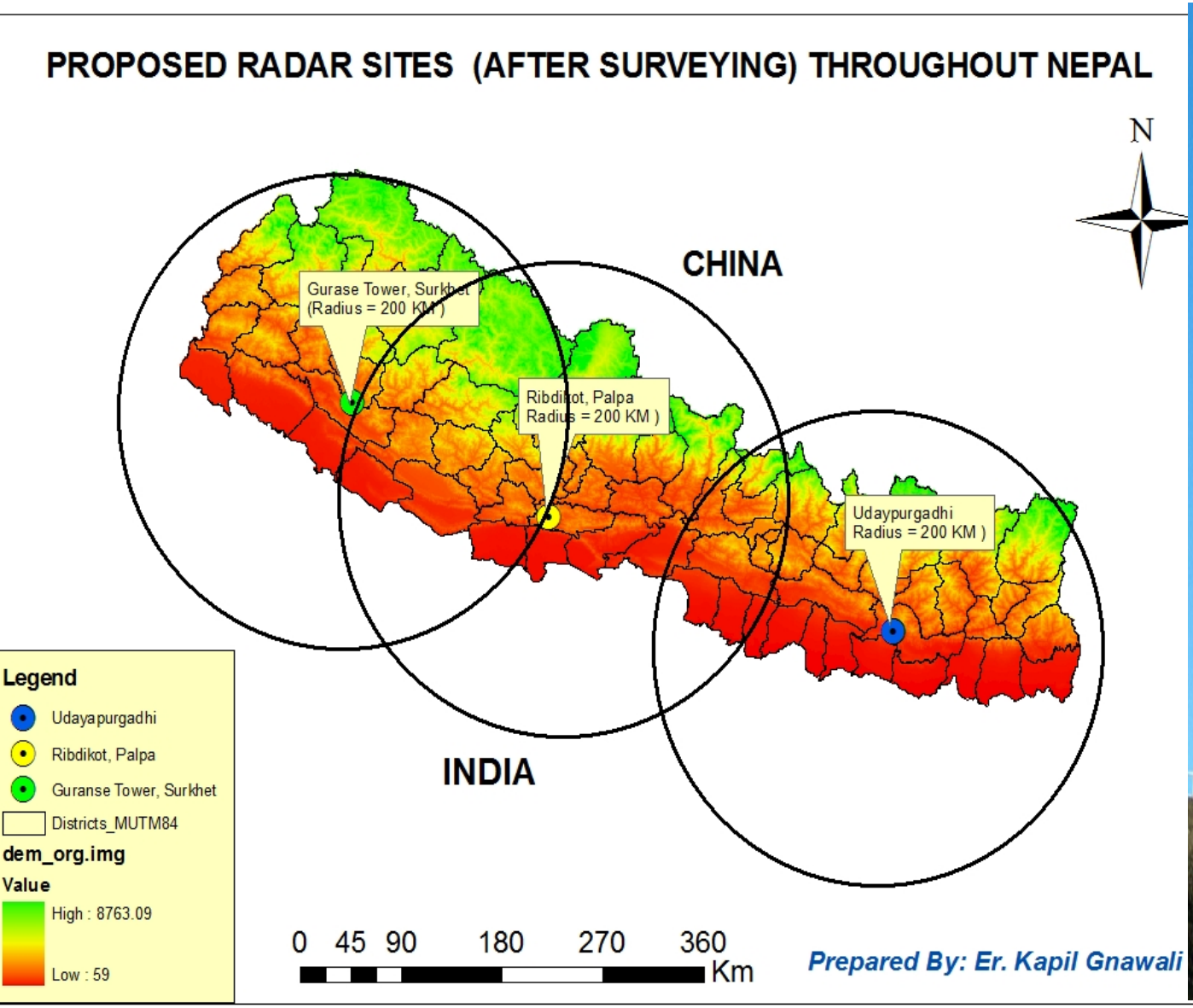
Station name	Elevation (m)
Tseram	3892
Dingboche	4411
Samdo	3830
Machhapuchchhre	3677
Panchamukhi	4155

Lightening detection network (completed, now in Site Acceptation Test Mode)



- Enable real-time and accurate registering and monitoring of individual cloud to ground(CG) and Cloud to Cloud (CC) lightening strokes induced by thunderstorms
- Enable safety services by real-time availability of lightening information
- Enable scientific research and risk analysis using archived lightening information.

3 Doppler Weather Radar (within 2 years)



3 Upper air station (1 from PPCR-BRCH project and 2 from SAARC Storm Project (within one year)

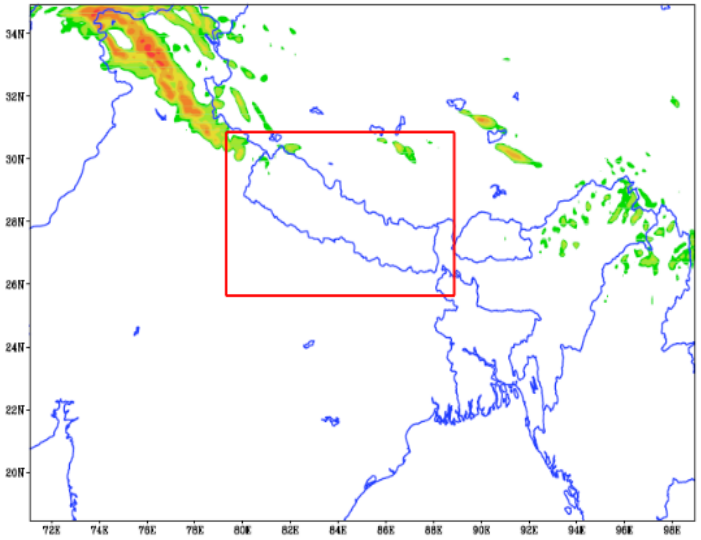
- Upper Air Station
- Measures wind, humidity, pressure, temperature, at different atmospheric layers
- Helps to increase accuracy of Meso-scale forecast
- Enhance safety services by realtime availability of upper air information

High Power Computer (HPC) for Numerical Weather Prediction

- Minimum 512 core
- RAM 128 GB
- Storage system 32 TB expandable up to 64 TB

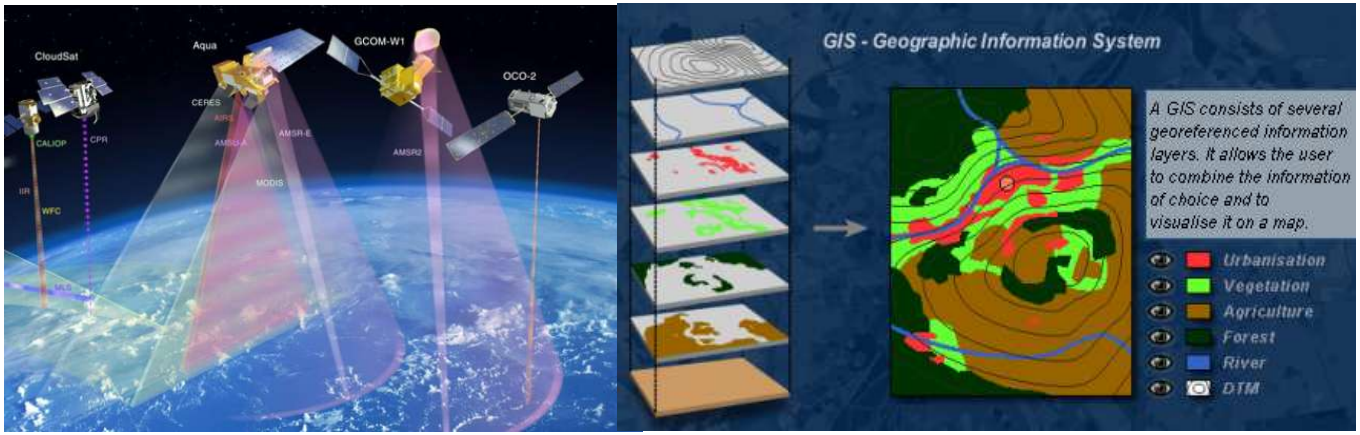
High Resolution Local Area Numerical Weather Prediction System

- To provide short term weather forecast by establishing an operational High Resolution NWP system
- To provide quantitative precipitation forecast (QPF) for flood forecasting thereby Increasing lead time for flood warning.



Remote sensing and GIS laboratory

- Established
- ERDAS Pro 2015- image processing
- Intergraph GeoMedia Pro 2015 – GIS software



Calibration laboratory

- To calibrate meteorological instruments such as temperature, humidity, pressure etc.

TV presentation system at DHM

- Weather Broadcast
- Meteorologists will present the weather forecast
- Timely information on risk involved with extreme hydro-Meteorological phenomena which will help for preparedness

DHM New Office Building (18 months from now)

Challenges and way forward

- Expansion of EWS
- Lack of legal framework (legal framework drafted)
- Human resource (new organogram proposed)
- Operational cost after the DHM modernization (cost recovery model proposed in legal framework)
- Lack of clear role and responsibility on EWS (EWS policy is drafted but need wider consultation and consensus).
- Community empowerment and involving of local government.
- Increase of lead-time (rainfall-runoff modelling)
- Switch to Multi—hazard EWS with strong foundation.

Thank you very much for your kind attention !