Terms of Reference for

ESTABLISHMENT OF "END-TO-END" FLOOD EARLY WARNING SYSTEM IN KOSHI AND WEST RAPTI RIVER BASINS TO SUPPORT AND STRENGTHEN DISASTER RISK MANAGEMENT

(Nepal: PPCR/DHM/S/QCBS-34)

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Kathmandu, Nepal

Department of Hydrology & Meteorology

1. Introduction

This Terms of Reference (ToR) is for a Consulting firm to establish a people-centered functional "End-to-End" Flood Forecasting and Early Warning System (FEWS)in two locations in Nepal, the Koshi and West Rapti river basins, to mitigate adverse impacts of flooding.

United Nations International Strategy for Disaster Reduction (UNISDR) defines Early Warning System as set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and act appropriately and in sufficient time to reduce the possibility of harm or loss. The expression "end-to-end early warning system" is used to emphasize that warning systems need to span all steps from hazard detection through to community response. The consulting firm will design and establish the early warning system and provide necessary training to enable the Department of Hydrology and Meteorology (DHM), the Ministry of Home Affairs (MoHA) and related sector agencies to provide impact based end-to-end flood early warning systems in the Koshi and West Rapti River basins.

2. Background

Of all the disasters reported in Nepal, floods and landslides are the most devastating in terms of the number of deaths that occur and the damage they cause. Between 1983 and 2013, floods and landslides killed 8,400 people with damages worth 1.5 billion Rupees (DWIDP, 2013).With climate change and variability, the frequency of extreme events such as floods and droughts is expected to increase. An analysis of 46 years (1961-2006) of precipitation data in Nepal shows an increasing trend in total and heavy precipitation events (Baidya, S.K., *et al*, 2008). This is expected to contribute to: increased likelihood of floods, landslides, avalanche, mudslide, soil and river erosion; increased flood runoff; increased forest fire; decreased ground water availability; decreased food production; and increase in damages and losses resulting from floods and drought.

Extreme rainfall events are on the increase in Nepal. The maximum recorded event was on 20 July, 1993 at Tistung meteorological station in Kulekhani watershed which amounted to a total of 540 mm of rainfall (Dhital,*et al*, 1993; Chalise and Khanal, 2001; Thapa, 2001). Other recorded events were i) 505 mm at Gumathang on 25 August 1968, and ii) 503 mm at Musikot on 29 July 1960 (DHM cited in Thapa, 2001). In September 2008, the Far Western region of Nepal witnessed the worst flooding in 25 years due to heavy late monsoon rains (229mm of rainfall within 24 hrs. and over 400mm of rainfall within 48 hrs.). In late September 2008, torrential monsoon rains swept across Nepal's Far Western Region, Kailali being the worst hit district. Within a week, over 160,000 people had been affected by these floods in 42 Village Development Committees. While hundreds were injured in the flooding, and over 25 people killed, the longer term effects of the natural disaster were of equal concern: much of the Fall 2008 rice harvest was lost; thousands of homes were damaged;

over 100,000 hectares of arable land were inundated with sand, permanently compromising soil quality and causing households to shift to alternative crops; and, many of the water sources were contaminated (Mercy Corps, Nepal, 2009).

The recent Jure landslide event of 2 August, 2014 is worth mentioning. In the early hours of 2 August 2014, a landslide occurred above Jure village. The massive landslide created a high dam across the Sun Koshi River. An inflow of about 160 m3/sec of water quickly created a large lake behind the dam. Within 13 hours the newly formed lake – which rapidly grew to a volume estimated at 7 million cubic meters – extended about 3 km upstream, completely submerging the 2.6 MW Sanima Hydropower Station (Shrestha,*et al*, 2014). This landslide dam caused 156 deaths and almost a billion Rupees in damages (Nepali Times, September 2, 2014).

In recent decades, global warming has brought some unprecedented changes in glaciers located in the Nepal Himalaya and the Tibetan part of the Himalaya in China, resulting in Glacier Lake Outburst Flood (GLOF) phenomenon. The impacts of a GLOF event are often devastating in downstream areas.

To address these issues, as part of the Building Resilience to Climate Related Hazards (BRCH) project, funded by the Pilot Program for Climate Resilience with support from the World Bank, DHM intends to establish an "End-to-End" Flood Early Warning System to help reduce the risk to people, property and livestock from flooding and subsequent impacts on health and livelihoods. At the initial stage, two river basins, the Koshi and West Rapti, have been selected for this purpose.

Building Resilience to Climate Related Hazards (BRCH) Project

Nepal is one of nine countries participating in the global Pilot Program for Climate Resilience (PPCR) financed by the Climate Investment Funds. This program provides financing for least-developed countries to pursue a climate-resilient development path that reinforces poverty reduction goals. The Ministry of Science, Technology and Environment (MoSTE) is the focal ministry in the Government of Nepal for the PPCR.

The multilateral development banks: the Asian Development Bank (ADB); the International Finance Corporation (IFC); and the World Bank, administer the funds on behalf of the Climate Investment Funds and supervise the projects in collaboration with MoSTE.

Nepal prepared the "Strategic Program for Climate Resilience" (SPCR) to outline its program to respond to priority climate risks. The SPCR complements the National Adaptation Program of Action (NAPA), Climate Change Policy, and Local Adaptation Plans of Action (LAPAs).

Among the five components identified under Nepal's SPCR, the following four components are currently being implemented:

Component 1: Building Climate Resilience of Watersheds in Mountain Eco-Regions;

Component 2: Building Resilience to Climate-Related Hazards;

Component3: Mainstreaming Climate Change Risk Management in Development;

Component 4: Building Climate Resilient Communities through Private Sector Participation.

BRCH project falls under Component 2. The main objective of the BRCH project is to enhance government's capacity to mitigate climate related hazards by improving accuracy and timeliness of weather and flood forecasts, and warnings, for climate vulnerable communities. It also aims to develop Agricultural Management Information System (AMIS) services to help farmers mitigate climate related production risks. The project comprises of four components:

A. Institutional strengthening, capacity building and implementation support of DHM;
B. Modernization of observation networks and forecasting;
C. Enhancement of the service delivery system of DHM; and
D. Development of an Agriculture Management Information System (AMIS).

Component A aims to develop and/or strengthen DHM's legal and regulatory framework, improve institutional performance as the main provider of weather, climate and hydrological information for the nation, build capacity of personnel and management, ensure operability of the future networks, and support project implementation.

Component B aims to modernize DHM observation networks, information and communications technology (ICT) systems, improve hydro-meteorological numerical prediction systems and refurbish DHM offices and facilities.

Component C aims to enhance the service delivery system of DHM by creating a public weather service that provides timely and accurate weather observations and forecasts, and information services for climate-vulnerable communities and the key weather dependent sectors.

Component D will provide critical and timely agro-climate and weather information, as well as agro-advisories, to farmers in order to increase productivity and reduce losses from meteorological and hydrological hazards.

For the implementation of the BRCH project, two Technical Committees have been established, one chaired by the Director-General(DG) of DHM focusing on Components A, B and C, and the other chaired by Ministry of Agriculture Development (MoAD) focusing on Component D. The two committees coordinate as needed.

A consultant System integrator (SI) is hired for four years to provide service to DHM. The main objective of SI team is to undertake detailed assessment, develop system design and plans, the development of technical documentation for the implementation of each of the project component, and effective technical support for project activities in order to achieve project goals.

The "End-to-End" Flood Early Warning System for the two river basins is one of the activities of Component C. For this purpose, two representative basins, namely Koshi in the east and West Rapti in the west of the country, have been selected on the basis of the following criteria:

i. **Physical Criteria:** Representativeness, accessibility, manageability, suitability, and presence of glacial lakes,

ii. **Facilities:** Existing telecom facilities, backup telecom facilities, history of station operation, quality of historic data, level of stakeholders involvement, optimality of network density, synergy with Pilot Project on Climate Resilience (PPCR), and level of security,

iii. **Development potentials of the basin:** Water Resources Development Potential, agricultural potential, industry potential, communication potential, Disaster Risk Reduction (DRR) potential, potential for bench-mark basin, potentiality for filling gaps, and tourism prospective,

iv. **Vulnerabilities:** Vulnerability to climate, watershed vulnerability, landslide/debris/sediment hazard, and water quality and epidemics

v. **Beneficiaries:** Downstream beneficiaries, beneficiaries at regional level, and technology transfer

The expected outcomes of the consultancy activities are:

- Re-assessment and monitoring of hydromet observation station networks for prescribed flood forecasting modeling, weather and flood forecasting, risk assessment and delivery of information for these two pilot river basins.
- Identification of the most effective and reliable weather and stream flow sensing equipment with data acquisition and communication system;
- Development of a mode of delegating DHM operational and forecasting activities to the regional and basin offices;
- Documentation of hotspot areas in each of the two river basins that require disaster management response;
- A well calibrated hydrological and hydrodynamic model and real time flood forecasting and early warning system;
- Development of a user-friendly interface as a decision support system (DSS) for the acquisition, management and dissemination of data, forecast and early warning information to concerned agencies and individuals including participating communities;

- A user friendly interface to access current and long-term hydro-climatic data for the research community, disaster management, and operative purposes for timely evaluation and updating of short and long term risks and impacts.
- A monitoring and evaluation method so that the decision support and end to end early warning system for floods can be periodically improved and upgraded.

3. Flooding Context in the Koshi and West Raptiriver basins

Basin maps of the West Rapti and Koshi river basins are shown in Figs 1 and 2 respectively. General descriptions of the two basins are given below.

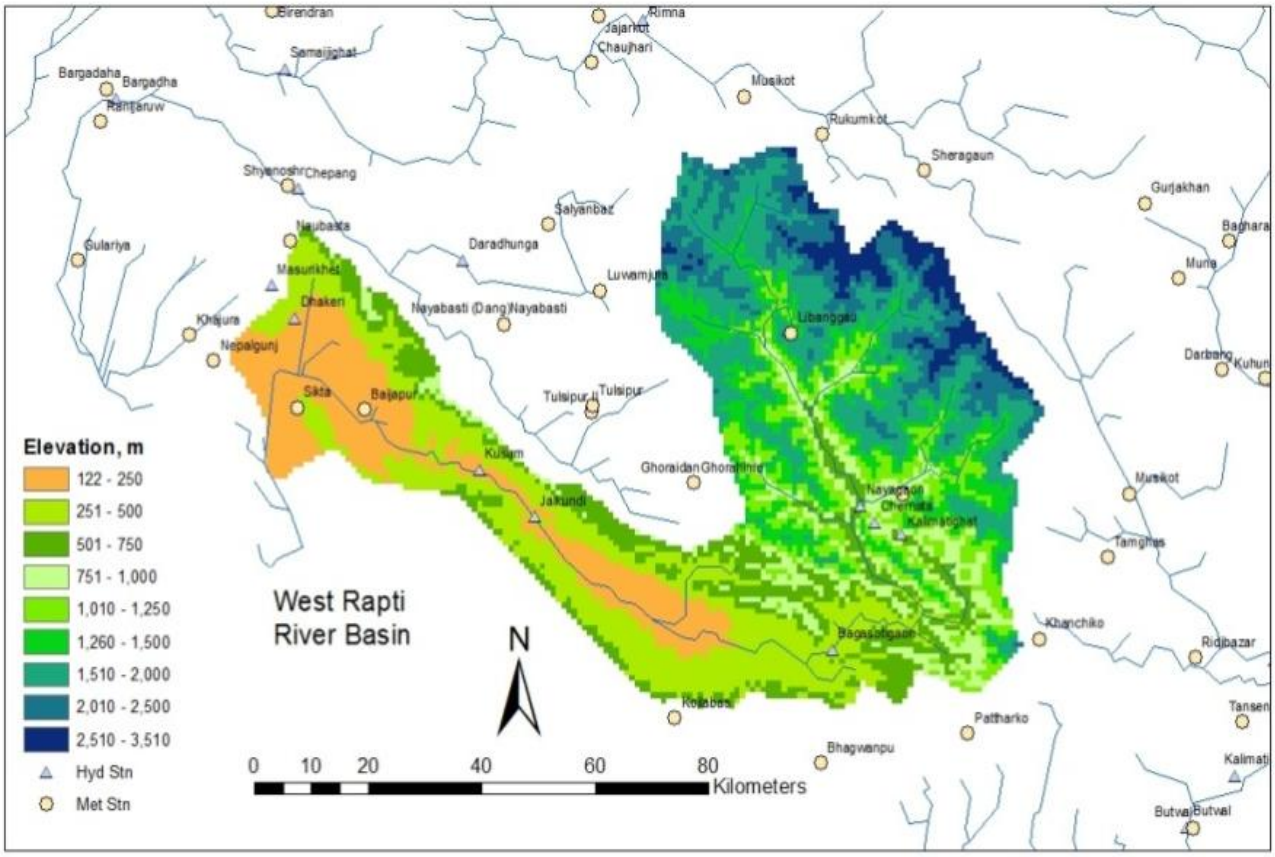

Figure 1. The West Rapti River basin

The West Rapti is one of the major rivers in the mid-western region of Nepal (Fig. 1). It has several tributaries such as Jhimruk , Mari, Arun, Lungri, Sit, Dunduwa, Sotiya and Gandheli rivers. Mari and Jhimruk rivers are the two largest tributaries. After the confluence of the Jhimruk and Mari rivers, the river is named as West Rapti river. The river originates from the middle mountains of Nepal, then enters the lowlands and finally drains to the Ghaghra (Karnali) river, a tributary of the Ganges in India. The catchment area of the study basin is 6500 km^2 with an average slope of 16.8% or 9.5 degrees. The length of main stream channel is 257 km.

The river has affected several Village Development Committees[1] (VDCs) along the river banks every year in the Banke district. Table 1 shows major flood disaster events recently reported from West Rapti basin. Many VDCs were affected from those flood events. The intensity of flood damage in terms of human casualty and physical damage was found to be higher in the years 1998 and 2008. The damage caused by river flooding is higher in the Banke district than in the Dang district.

Table 1. Flood incidents, and losses or damages, in the West Raptiriver basin

Impact/loss/damages	Year				
	1998	**2003**	**2006**	**2008**	**2011**
Location of damage	10 VDCs Banke	5 VDCs Dang	2 VDCs Dang	9 VDCs Banke	3 VDCs Banke
Human death	9	0	0	18	1
Injuries	630	265	180	853	196
Displacement (HH)	106	NA	NA	98	7
Property damage:					
Land (Bigha)	3690	642	465	2215	2660
Food grain (100kg)	4274	2500	1200	8310	1180
House (Nr)	393	740	54	203	101
Cattle (Nr)	164	31	0	62	9
Physical infrastructure:					
Roads (km)	21.5	5	1	6.5	4
Bridge	NA	1	0	NA	NA
Schools	3	0	0	2	1
Tubewells	0	0	0	0	0

Source: Emergency Flood Damage Rehabilitation Project, DWIDP, 2012

Flooding has been a serious problem for the communities of the West Rapti River basin for

[1]VDCs and municipalities are localities or sub-areas of the 75 districts of Nepal.

many years. Amongst the most affected villages are Betahani, Holiya, Binauna and Phatepur. The deposition of sands in the farmland by the river flooding originates from the Chure/Siwalik range. Inundation due to flooding, and bank erosion at various locations due to rapid geomorphologic changes, are the major problems affecting lives and livelihoods of the people living on the lower West Rapti river basin. The Nepalgunj municipality and other villages have been suffering from drainage congestion and inundation problems due to unplanned growth, faulty design of drainage systems and poor waste disposal practices.

The Koshi river originates from the High Himalayas (Fig.2). Mount Everest, the highest peak in the world, lies in the Koshi catchment. The upper catchment of the river system lies in Tibet. This river is also known as Sapta Koshi (seven rivers) as it is formed of seven rivers namely the Indrawati, Sun Koshi, Bhote Koshi, Tama Koshi, Dudh Koshi, Arun and Tamor. Three major rivers, Sun Koshi from the West, Arun from the North and Tamor from the East meet at Tribeni, 10 km upstream of Chatara.

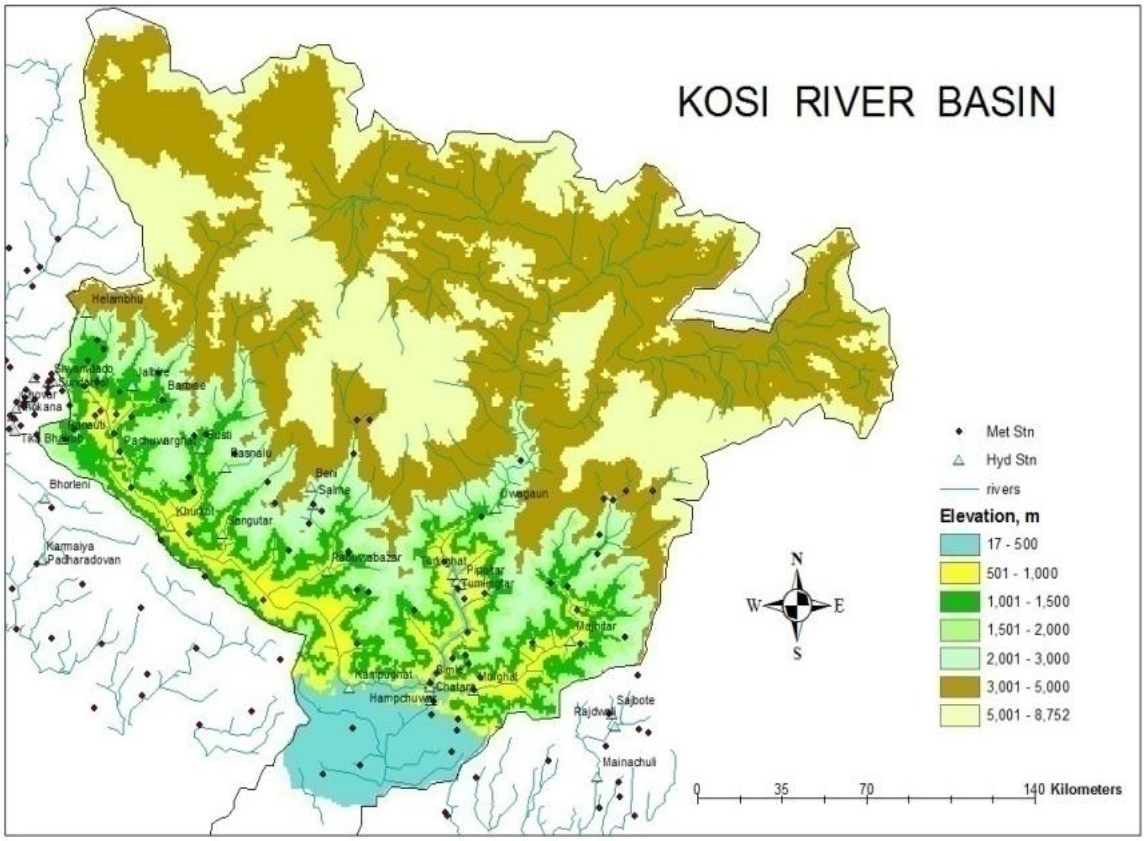

Figure 2. The Koshi River Basin

Below the confluence at Tribeni, the Koshi flows in a narrow gorge for a length of about 10 km, until it reaches the plains, near Chatara in Nepal. Further down, the river runs through the relatively flat plains of Terai consisting of sandy soil. The river flows through several districts in hill areas, but flows only through two Terai districts, namely Sunsari in the east

and Saptari in the west, before it enters into the State of Bihar in India near Hanuman Nagar.

The Koshi embankment breach in 2008 was a major disaster event that affected 48 wards of 17 VDCs of Sunsari district and destroyed habitats, aquatic lives, flora and fauna of the KoshiTappu Wildlife Reserve in Sunsari district (Table 2). About two thirds of houses, mostly one story huts made of mud, bamboo and thatch, were severely damaged. Moreover, the floods caused extensive damage to the optical fiber cable network laid along the main East-West highway disrupting communication networks in the eastern region of Nepal. About 15 kilometers of this highway were obstructed and 3 kilometers were destroyed.

In 1990 Koshi River flooding affected 7 wards (ward is a sub-area of VDC) of three VDCs of Saptari district where the flood remained for 3 to 13 days affecting three wards of Hanumanagar and Joginiya VDCs (Table 2). The flood water remained in different villages for a period of up to 16 days. Similarly, the flood events of 1991 and 2008 affected many families in Saptari and Sunsari districts (Table2).

Table 2.Flood incidents, and losses or damage, in the Koshi River basin[2]

Impact / loss / damages	Year of Flood Incidents		
	1990	**1991**	**2008**
Location of damage	Saptari (3 VDCs)	Saptari (2 VDCs)	Sunsari (48 wards of 17 VDCs)
Human death	NA	5	8
Injuries	167	95	9392
Displacement (HH)	230	151	1515
Property damage:			
Land (Bigha)	2000	5360	15646
Food grain (100Kg)	680	580	32900
House (Nr)	280	310	6910
Cattle (Nr)	220	60	5132
Physical infrastructure:			
Roads (km)	2	3.5	154
Bridge	1	0	53
Schools	0	0	28
Govt offices	0	1	8
Health offices	0	1	5
Tubewells	50	45	4554
Insecurity felt during flood	1 VDC	No	7 VDCS
Migration out (HH)	260	50	567

In general, most of the Terai has inundation and water logging problem during the monsoon.

[2]*Source: Emergency Flood Damage Rehabilitation Project, DWIDP, 2012*

4. Status of Early Warning Systems in Nepal

The Ministry of Home Affairs (MoHA) as the focal Ministry for disaster management of the Government of Nepal (GoN) formulated a national strategy for disaster risk management in 2009.

A National Emergency Operations Center (NEOC), under the organizational hierarchy of MoHA, was established in Kathmandu in early 2011 to strengthen communication among national centers and districts across the country. Regional Emergency Operation Centers (REOCs) and District EOCs are currently being planned to further strengthen communications, and facilitate dissemination of information for early warnings and emergency response to various sectors and communities.

The existing DHM flood warning system is limited to sharing general weather forecasts and disseminating flood water levels through a web site and through mobile alert systems to communities and stakeholders. In the West Rapti river basin there are altogether twelve near real-time hydrological and meteorological stations, out of which 8 and 4 are meteorological and river-gauge stations respectively. In Koshi river basin there are altogether twelve near real-time hydrological and meteorological stations, out of which 5 and 7are meteorological and river-gauge stations respectively.

At the local level, with support from Non-Governmental Organizations (NGOs), a number of community based disaster risk mitigation activities have been initiated in Nepal. The initiation of the Koshi River Basin community resilience project, funded by the International Federation of Red Cross and Red Crescent Societies (IFRC), has brought together different agencies working on community-based disaster risk reduction (CBDRR), water and sanitation and hygiene promotion (WatSan/HP), health, and livelihoods. These projects spread over different sub-basins reached over 4,000 people directly of which over 1,950 are women. The project has also installed flood information display boards in Sunsari and Saptari Districts, in July 2014, including SMS alerts. Practical Action-Nepal, an International Non-Governmental Organization (INGO), also initiated Community based Flood Early Warning Systems in seven river basins, namely the Kankai, Narayani, East Rapti, Seti (Kaski), Karnali, West Rapti and Babai. They developed an institutional arrangement for community based EWS with flow of information from central government (DHM-MoHA) to communities. Real time data measurement and collection utilizes automatic sensors, data logger and internet protocol that utilize the mobile communications network.

In the West Rapti Basin, there has been a continued involvement of DHM and Practical Action, with European Union's ECHO's support in establishing 'Community-based Flood Early Warning'. Selected communities in the flood prone VDCs have a relatively higher level of understanding of flood information including evacuation routes and communication of flood early warnings. The proposed consultancy should review and build upon these ongoing activities.

Topographical maps are being prepared for a contour interval of 0.5 meter for the West Rapti river basin including cross-section survey from an ongoing Asian Development Bank (ADB) project on hazards mapping. The implementing agency is DWIDP. DHM has already communicated with DWIDP requesting those data which are expected to be ready by September 2015.

The DHM shall provide a flood hazard map for Koshi downstream of Chatara with a contour interval of 0.5 meter. However these data will be required to be verified by the Consultant undertaking the assignment to which this ToR refers.

5. Objective of this Consultancy

The overall objective of the consultancy is to reduce the loss of lives and properties from flood hazard by improving the capacity of DHM in developing and implementing effective people-centered early warning system.

The specific objectives are:

- Development of a model for an effective End to End Early Warning System with robust methodological framework, review of the adequacy of the observation network for real time flood forecasting, delivery of information, monitoring and risk assessment.
- Establishment of a fully operational real time "End to End" Flood Forecasting and Early Warning System (FFEWS) while ensuring that flood warnings are disseminated to communities in at least four hotspot areas in each of the two pilot basins (Koshi and West Rapti). Early warning is expected to have a forecast period of at least 72 hours which will performed by flood forecasting. Flash flood forecasts will also be designed into the solution and utilize nowcasting techniques based on real-time hydrometeorological observations.

6. Specific scope of work

1. **Carrying out in-depth assessment of the Disaster Management Institutional Framework in Nepal and establishment of operational mechanisms with clear roles and responsibilities including the development of effective communication strategies.**

   Task 1.1 **Review of Legal and Regulatory Framework:** Review the existing legal and regulatory frameworks for Disaster Risk Reduction (DRR) and Multi Hazard Early Warning Systems (MHEWS), identify key gaps including availability and adequacy of standard operating procedures and assess whether the roles and responsibilities for key stakeholders are clearly defined.

   Task 1.2 Review good practice examples of the National Disaster Management Plans (NDMP). Review and identify gaps in the National Strategy for Disaster Risk Management in Nepal (2009) and other relevant documents and recommend improvements in developing an effective networking structure

and establishing strong operational linkages among the government Disaster Risk Management (DRM) agencies and other vital stakeholders from outside the government in Koshi and West Rapti basins.

Task 1.3 **Organizational Analysis at the National and Basin level:** Identify the key agencies and organizations at the national level and at the basin level that are responsible for carrying out different aspects of end to end FEWS. Provide this information in organizational maps one, for the Koshi basin and another for the West Rapti basin. Assess the technical and human resource capacities of key agencies for FEWS at the national, district and sub-district levels, and identify gaps.Specify and propose the technical and human resource capacity at a professional level especially for the flood early warning system (number of staff, roles, qualifications and competencies).

Task 1.4 Identify linkages among Disaster Risk Management (DRM) agencies and DHM within a disaster coordinating mechanism, and ensure that NDMP supports close coordination and communication among DHM and vulnerable communities, including Community-based Organizations (CBOs), Government Organizations (GOs), I/NGOs engaged in DRM. Assess (i) the existing horizontal coordination mechanisms between relevant national level agencies; and (ii) the vertical coordination mechanisms between national agencies, district, and sub-national agencies. Identify key gaps that need to be strengthened.

Task 1.5 Assess current status of Flood Early Warning Systems (FEWS) in the Koshi and West Rapti river basins; identify technical, organizational, institutional gaps, and challenges, in establishing a complete and effective flood early warning system; such a system to be comprised of the four interrelated elements in each of the two river basins, including (i) risk knowledge, (ii) monitoring and warning service, (iii) dissemination and communication, and (iv) response.

Task 1.6: **Summary and Recommendations:** Summarize key findings from Task 1 and propose recommendations for strengthening end to end FEWS in the Koshi and West Rapti basins. This should include recommendations for strengthening institutional capacity, human resource capacity and technical aspects of the system.

2. Comprehensive risk assessment of the threats caused by flood hazard in the two basins

Task 2.1 Carry out analysis of historical data including, but not limited to, return periods of flood hazards with varying lead times for the two basins. Identify historical observed highest flood discharge/level in Koshi and in West Rapti stations. Develop a catalog of important flood stages and the impact of

these flood stages with respect to both social and economic consequences for the target communities. This catalog will be useful in alerting the population of definitive consequences based on the flood forecast (e.g. 2.5 m water level at a certain area causes a given road to be inundated).

Task 2.2 Prepare and develop a digital library of geographical land use, topographic information, availability of digital elevation maps, and thematic information of the Koshi and West Rapti river basins such as: a)Topography and Terrain (Land Cover, Fluvial morphology, Digital Terrain Model (1m/ 0.5m), Buildings and infrastructures within 500m of High Flood Level (HFL); b) Flood levels (Flood water levels analyzed at return periods of 2, 5, 10, 20, 50, 100, 200, 500, 1000 years, at different river cross-sections; Flood inundation depth at return periods 2, 5, 10, 20, 50, 100, 200, 500, 1000 years Warning level flood inundation maps, Danger level flood inundation maps; c) Vulnerability, and Elements at Risk, at warning and danger levels, (Settlements, Buildings, Population, Agriculture land parcels, Other assets including cattle, Infrastructures and utilities).

Task 2.3 In each basin, identify areas/villages that are highly vulnerable toflood hazards and select at least 4 such areas/villages from each basin based on consultations with DHM, the System Integrator and other stakeholders. Carry out Flood Alert Rehearsals (mock drill) in these selected areas/villages. Analyze coping mechanisms, resources and capacities of communities in hotspot areas to respond to alerts and warnings. Ensure that appropriate actions are communicated to the public through awareness raising campaigns, prior to an emergency. Recommend a system to ensure that the communities in the hazard zone take action to minimize their exposure to the hazard and to reduce the consequences of flooding. Identify special recipients who are to be notified under various possible conditions of flood threat, determine the means of communications to be used in alerting each special recipient and adequately ensure affected persons receive timely warnings notwithstanding telephone and power failures.

3. Review of the SI Report on Observation network and assessment of network adequacy

Task 3.1 Review the assessment report, prepared by SI Observation Team 1, on present observation network of hydrological and meteorological stations, technical facilities, technology used for observation set-ups, data retrieval, data management and quality control/assurance mechanisms, specially the density of meteorological stations for FEWS purpose

Task 3.2 Based on site visits, survey and review of documents and information,

assess the adequacy of the hydro-meteorological network and data acquisition system required for flood forecasting and early warning in the two river basins and make recommendations for strengthening the observation network from a flood forecasting perspective. This should be done in close consultation with the SI Observation Team 1.

Task 3.3 Assess the current availability of information (both meteorological and hydrological) for the Koshi and West Rapti available at DHM. In support by the SI, NWP data from global models will be acquired, stored in the DHM data base and made routinely available for weather forecasting and flood forecasting purposes in the form of QPF. More localized QPF data will be made available by establishing the limited area model system based on the WRF model. A separate consulting firm will be acquired to test and tune the WRF model QPF data for operative use. The consultant will select and install necessary flood forecasting tools (hydrological and hydraulic models), while ensuring compatibility with available tools and data bases of DHM. The selected software should be applicable consistently in other river basins of the country. If commercial software is proposed, then indicate the number of licenses required, cost per license, annual subscription fees and other recurrent costs in financial proposal. It is also required to integrate forecasting tools with historical and real time data, communication and dissemination of forecast developed.

4. Integrated Flood Forecast Modelling System

Task 4.1 Develophydrological and hydraulic models calibrated and validated with historical data for Koshi and West Rapti basins. The hydraulic models will have a mapping feature to display model results spatially (inundation areas, flood levels etc.), and will also have embankment breach simulation capability. The forecast system will be linked to a real time data acquisition including all observation data, weather forecast data and other web-based data. The flood forecasting model should satisfy the following criteria:

(a) Provide reliable forecasts with sufficient warning time;

(b) Have a reasonable degree of accuracy;

(c) Meet data requirements within available data and financial means, both for calibration and for operational use;

(d) Feature easy-to-understand functions;

(e) Be simple enough to be operated by operational staff with moderate training.

- Establish relationship between rainfall and runoff separately for each basin considering the snowmelt equivalent water and develop expected hydrographs at different lead times. It is mentioned here that snowmelt equivalent water contributes a significant amount of runoff as stream flow and subsurface runoff as base flow, which may need to be addressed by incorporating the snow hydrology module when modelling both basins. The product should aim to establish critical thresholds for early warning of flood events.
- Develop a flood forecasting system for the two basins, with input of the meteorological and hydrological forecasts, in close collaboration with SI. The flood forecasting model should estimate the flood discharge, flood level, time to peak discharge and flood duration. The forecast of floods will be based on integrating hydrological precipitation–runoff models for the upstream and intermediate catchments with hydrodynamic models along the rivers channel and floodplains.
- Develop the system for Koshi and West Rapti river basins to automatically generate flood inundation maps showing the locations of severe flood advisories, warning and alerts for the 8 communities.

Task 4. 2 Integration of hydrological models with databases. A knowledgebase system consists of time series data (historical and real time) with analytical capabilities. Satellite and GIS data should be integrated in the modeling system. The knowledge base and databases should preferably be developed using freely available software tools.

5. Communication and Dissemination of Flood forecast and Early warning System

Task 5.1 Develop a web-based flood forecasting and early warning information system, so that the flood forecasts and warning messages are uploaded into the Web in freely understandable forms. The Web site should be designed in such a way that maps and flood warnings can be viewed with adequate resolution on mobile phones. The system should be able to generate RSS(Rich Site Summary)-feeds and E-mail alerts automatically.

Task 5.2 Develop an effective early warning dissemination system with selection of the most applicable communication systems taking the communication technology and methods used locally. The selection of communication technologies could include (but are not limited to) mobile apps, sirens, telephone, SMS etc.). The existing methods and communication networks, developed by disaster management stakeholders[3] should be benefited to avoid overlap and inconsistencies.

Task5.3 Develop an operational strategy for disseminating flood early warning at community level.

6. Design and development of an Operational Decision Support System (ODSS).

[3]DHM,MoSTE,MoHA,DWIDP, WECS, GOs,INGOs, CBOs and other stakeholders

The ODSS will consist of the centralized monitoring and forecasting facility located at the DHM Headquarters, the DHM regional Flood Forecasting& Warning centres at Nepalgunj for West Rapti and at Dharan for Koshi, and the network of appropriate Disaster Management Response Units (DMRU) at local communities. The ODSS will operate on a 24/7 basis guided by agreed Standard Operating Procedures (SOPs)to decide on the risks involved, and deliver the Flood Early Warnings with response advisory to local communities in the Koshi and West Rapti basins. The organization and management structure of the ODSS will be developed in close cooperation with the DHM and the SI and will include defining the roles and responsibilities of the different units, the posts of personnel and their qualifications and tasks. The tools and methods to be developed are broken into tasks as follows

Task 6.1 Prepare specifications for the software required for the internet-based workstations for Flood Forecasting and for Generating and dissemination Alerts and Early Warnings. The specifications of these workstations will be developed in close co-operation with the DHM meteorologists, hydrologists and the SI. An internet connection with adequate capacity will be enabled so that the workstations can be used at the regional flood warning centers. The required office space at these centers will be provided by the DHM.

Task 6.2 Contribute (in cooperation and support by DHM and SI) to prepare equipment specifications for establishing the above two workstations and equip the station with early warning user interface with adequate telecommunication capacity to access data and products from the DHM Headquarters, and with communication technology to deliver warning information to DMRUs at local communities. The consultant will specify the qualifications of the staff required for 24/7 operation, define roles and prepare a training plan for the staff.

Task6.3 Develop SOPs for communication and dissemination of flood early alerts, warnings, and advisories in consultation with key stakeholders (DHM, basin offices and Early Warning Centers) and community members. The flow of information will be achieved through a combination of approaches including the use of existing infrastructure, such as telephone and internet. Wherever possible, a mixture of technologies should be used, for communication effectiveness and redundancy: e.g. website, emails, SMS, remote controlled siren, radio, TV and cell broadcast, with backup such as HF-SSB transmission.

Task 6.4 Support local authorities and communities in identifying evacuation sites/places and plan the evacuation routes and processes.

Task 6.5 Conduct FEWS multi-stakeholder exercises and drills to test the systems and identify areas in need of improvement (one event in each basin).

Task 6.6 Conduct stakeholder interactions through pre-disaster workshops to evaluate, improve and document FEWS performance after the events (one event in each basin).

Task 6.7 Develop outreach activities in the target communities for the introduction of FEWS products and services to the stakeholders and community through information leaflets, workshops, publications.

7. Capacity Development

Task 7.1 Prepare System Operation Manual for the flood forecasting and early warning system, ODSS, modeling tools, knowledge base systems, dissemination strategy etc.

Task 7.2 Develop training plan and manuals, and conduct training courses for DHM staff for hydrological/hydraulic modeling, integrated system, ODSS, and numerical weather prediction.

Task 7.3 Conduct stakeholder workshops at national and river basin levels, to create awareness and familiarization with the EWS products and to obtain feedback for improvement.

Task 7.4 Prepare and recommend a system sustainability plan.

Task 7.5 Provide operational support on the developed ODSS/ FFEWS models. This operational support should be provided for one flood season in an intensive way so that DHM staff can take over the role. At the end of the first flood season, performance assessment of the forecast and EWS should be analyzed and reported. The Consultant should provide a remote technical and troubleshooting support for a period of 2 years after the acceptance of the final report.

7. Guidance, Supervision and Quality Assurance

Project Management Units (PMUs) have been established in each of the two implementing agencies (DHM and MoAD), and include technical, financial, procurement, environment, social, monitoring and evaluation specialists. The PMUs report to their respective Technical Committees, and the Technical Committees liaise with the Mainstreaming Climate Change Risk Management in Development Project of the Nepal PPCR to ensure knowledge management across the four SPCR Program Components.

General consultant/system integrator (SI) firm has been hired for four years (2014-2018) to provide service to DHM and MoAD.SI is also tasked to analyse the current situation at DHM based on own assessment and existing project documents, and develop detailed technical documents on the integrated modernization of DHM networks and system of services

provision to key sector users and public.

All key outputs/deliverables including designs and reports will be subjected to review at various levels. On technical matters, the Consulting firm will work in close consultation with National Project Director (NPD), PMU, SI and Project stakeholders.

The Consulting firm can get technical support and guidance from SI,as and when required during the period of implementation. In addition the Consulting firm will hold:

- Regular (monthly) consultations with DHM.
- Kick off meeting with key stakeholders (including sector representatives).
- A meeting every three months with key stakeholders (including sector representatives) to disseminate progress and receive feedback.
- Basin and community level consultations with local level GOs/NGOs and community representatives, to ensure Gender Equity and Social Inclusion (GESI).

8. Client's Commitments (Inputs)

The staff of DHM/PMU will provide basic organizational support to the Consultant.

At the request of the Consultant, DHM will provide the following documents:

- Information and data related to the project, including information on status of observation networks, precipitation and flow data for selected calibration events, monitoring/lab equipment, communication, computing resources, and data processing tools;
- Project Appraisal Document (PAD), reports of missions and other relevant publications;
- Administrative, financial, legal and regulatory documents in support of activities;
- Consultant's staff may work in the pilot basins and, if necessary, in any other location in Nepal, as per necessity of coordination in relation to the services.

9. General Requirements of the Consultant/Service provider

The Consultant/Consulting firm should have at least 5 years of working experience in designing, establishing and operating EWS for flood disaster risk management. This experience should be in basins of similar subtropical climate, preferably in South and Southeast Asia, in addition to other international experience.

The staffing requirements of key personnel for this assignment will include a minimum of the following positions.

9.1 International

1. Team Leader/FEWS Expert (9 Months):

The Team Leader will have at least 10 years and preferably over 15 years of experience working on developing and establishing flood forecasting early warning systems. S/he

must have at least 5 years and preferably over 10 years of experience in planning, designing and managing FFEWS in similar river basins, preferably in South Asia and in Southeast Asian region. S/he shall have knowledge in modeling, in web-based data portal for managing and disseminating hydro-meteorological information, forecasts and warnings. S/he will play the role of a coordinator in the implementation arrangements for DRM/DRR establishments. S/he will develop the framework of the FMIS (Flood Management Information System) cell with a suite of models for flood forecasting and warning system. S/he will be responsible for preparing Standard Operating Procedures and warning protocols in close consultation with stakeholders including communities. S/he is responsible for overall management including quality assurance, and timely delivery of outputs. The team leader is expected to reside in Nepal for a period of at least 9 months, of which at least5 months will be in the first year of the contract.

Qualifications:

- Master's degree in Water Resources Engineering or a closely related discipline. Relevant PhD degree/advanced degree will be an advantage;
- Proven experience in developing community-based early warning systems that relies on real-time hydro-meteorological data;
- Proven experience in developing successful design, implementation, and management of projects (including financial management) ensuring alignment with requirements of concerned institutions and development partners;
- Working knowledge of socio-economic and topographic surveys, hydrometry and hydro-meteorological database management;
- Working knowledge of appropriate technologies required for an Early Warning System including Response;
- Proven knowledge to work with flood forecasting and now-casting tools, using hydrologic/hydraulic modeling and GIS;
- Working knowledge in Human Resources Development;
- Strong grasp of computer applications and communications;
- Ability and willingness to travel in remote areas.

2. Numerical Data Analyst (2 Months)

The expert will be responsible for establishing the Quantitative Precipitation Estimate (QPE) and Quantitative Precipitation Forecasting (QPF) production system for the integrated to flood forecasting system using all observation data and the data from numerical weather prediction model(s). S/he should have good knowledge on data interpretation, interpolation and analysis. S/he will work with local meteorologist to compile adequate QPE and QPF data sets using the latest fine resolution data from

global and regional Numerical Weather Prediction models. S/he will compare results of different models to forecast high resolution climate data to increase the forecast lead time. S/he will conduct on-the-job training to the DHM and other concerned personnel. S/he will work with other respective experts to link the real time data collection stations and model with database and flood forecast information system (FFIS). The expert is expected to spend all of their allocated time in Nepal.

Qualification:

- Minimum of M.Sc.degree in Meteorology or Atmospheric sciences;
- Minimum 10 years and preferably over 15years of working experience in weather forecasting and nowcasting with minimum five years on QPF using numerical weather prediction model(s);
- Experience in statistical analysis, generation and verification of QPE and QPF;
- Experience on customizing meteorological now casting and forecasting models for hydrological forecasting purposes (e.g. nesting, bias correction, data assimilation).

3. Flood Forecasting Expert (6 Months)

The expert will be responsible for developing suitable hydrological precipitation – runoff models and hydrodynamic flood propagation models. The expert will establish appropriate flood forecasting models in each basin. Knowledge of preparation of flood bulletins and situation reports is required. S/he will transfer the technology to DHM personnel and the concerned departments, through on-the-job training in hydrological modeling, hydraulic modeling, flood forecasting, flood situation analysis, reporting, preparation of flood risk maps, and extraction of catchment characteristics. The flood forecasting expert will be expected to reside in Nepal during the entire work commitment period (6 months).

Qualification:

- Minimum of M.Sc. in Civil Engineering/Water Resources Engineering/Hydrology/Hydraulic Engineering/Hydro-informatics or any related discipline.
- The Expert will have at least 10 years' and preferably over15years of experience in flood forecasting using precipitation-runoff models and hydrodynamic models with GIS application.
- The experts must have experience of modeling snow and glacial melt water.
- The expert will have proven experience in statistical analyses of model performance and data quality control.

- S/he will have proven knowledge to conduct hands-on training on hydrological/hydraulic modeling, flood forecasting, and GIS application.

4. ICT System Expert (2 Months)

The ICT Systems Expert will be responsible in designing and implementing communication protocols integrating sensing devices, modeling systems and information dissemination systems. This includes surface meteorological and hydrological stations, radar networks, radiosonde, satellite pictures, and telecommunications for the delivery of weather products and early warnings. S/he will develop/upgrade the web-based data portal to disseminate flood warnings with a user friendly interface. The expert will also develop mobile applications to communicate flood forecasts and early warnings to those vulnerable, such as beneficiaries and stakeholders in both river basins. The ICT expert will be expected to reside in Nepal during the entire work commitment (2 months).

Qualifications:

- Minimum of a Master's degree in ICT, Engineering or Telecommunication or equivalent.
- Minimum of 10 years' and preferably over15 years of experience in designing, developing, and implementing communications systems to support information transfer including 5 years' experience in designing, developing, and implementing ICT Systems to support hydrological and meteorological services.
- The expert should have knowledge of computer programming and broad experience with numerous telecommunication mediums, especially those applicable to early warning information system and in preparing the hydrometeorological database.
- The expert should be willing to travel and work in remote areas.

5. Hydromet Database Management Expert (2Months)

The Hydromet Database Management Expert will integrate available data to form a FEWS system; this includes feeding data into required flood forecast systems as well as the handling and eventual data/alert dissemination and visualizations. The data sets include surface meteorological and hydrological stations, radar networks, radiosonde systems, remote sensing receiving stations, and telecommunications for the delivery of weather products and early warning to stakeholders. S/he will develop hydromet data interface for the management of flood forecasting for Disaster Risk Management (DRM). The expert will also develop and provide training to the staff of DHM and early warning centers. The Hydro-met Database Management expert will be expected to reside in Nepal during the entire work commitment period (2 months).

Qualifications:

- Minimum of M.Sc. in Computer Application/Hydrology/Applied Physics or Civil Engineering.
- Minimum of 5 years, preferable 10 years, experience in designing, developing, and implementing database management system including real time data received through different communication channels.

9.2 National Experts:

1. Flood Forecasting Expert/Deputy Team Leader (22 Months)

The expert will support the team leader in establishing EWS and overall management of the project. The expert will also support the international experts in developing appropriate flood forecast models in each basin and the transfer of technology to DHM personnel and the concerned departments through on-the-job training in hydrological modeling, flood forecasting, flood situation assessment, preparing flood risk maps and flood warning dissemination. Knowledge on preparation of flood bulletins and situation reports through a user friendly web-based interface is required

Qualification:

- Minimum of Master's degree in Civil Engineering/Water ResourcesEngineering/Hydrology/HydraulicEngineering/Hydro-informatics or a related discipline.
- Minimum 5yearsand preferably over10 Years of experience in managing similar type of projects.
- Minimum 5 years of experience in hydrological and hydraulic modeling with GIS application.
- Experience on web-based data portal to disseminate flood warnings.
- Experience in statistical analyses of model performance and data quality control.
- S/he will have proven knowledge to conduct the hands-on training on flood forecasting modeling, GIS application and data processing for EWS.
- Willing to travel and work in remote areas.

2. Meteorologist (National Expert 4 months)

The Meteorologist will be responsible for compiling and generating the nowcast and forecast products based on data made available from global models and localized WRF model at the basin scale to increase quality of the forecast for flood warning purposes. S/he will conduct on-the-job training to the DHM and other concerned personnel. S/he will work with the ICT System and Hydromet Database Management experts to link the

real time data collection stations and model with the database and the flood forecast information system (FFIS).

Qualifications:

- Minimum of M.Sc. degree in Meteorology or Atmospheric sciences.
- Minimum of 5 years' experience in designing, developing, and implementing Weather Forecasting Model using real time data received through communication channels. Preferable 10 years of experience. This includes, but is not limited to, surface meteorological and hydrological stations, radar networks, radiosonde systems, remote sensing receiving stations, and telecommunications for the delivery of weather products and early warning to stakeholders.

3. GIS Expert (3 Months)

The GIS Expert will be responsible to develop high resolution Digital Elevation Models; and extract catchment characteristics and geospatial information from satellite and radar images. S/he will also prepare inundation, flood risk and other geospatial maps and conduct hands-on training of GIS and remote sensing applications for DHM personnel and the concerned departments.

Qualifications:

- Master's Degree in Geo-informatics / Geography/Hydro-informatics or related field.
- Minimum of 10 years' and preferably over15years' experience in GIS and remote sensing application in hydrology/meteorology/water resources management.5 years of experience in flood mapping is preferred.

4. Survey Expert (4 Months)

The Surveyor will be responsible for carrying out topographic, bathymetric/hydrographic and cross-sectional surveys, producing information for spatial assessments, verifying maps and correcting digital elevation models.

Qualifications:

- Minimum B.Sc. with postgraduate courses in Surveying/Civil Engineering/Water Resources Engineering.
- Minimum of 10 years of experience in bathymetric, topographic and river channel surveying.
- Willing to travel and work in remote areas.

5. Community Mobilization and GESI Expert (16 Months)

The Community Mobilization Expert will mobilize the community to ensure their participation and will be responsible to assess gender & social inclusion (GESI) including specific needs of stakeholders, communities, policy-makers, decision makersand development partners. S/he will assist the Lead Expert to prepare national

Standard Operating Procedures (SOPs) and warning protocols in consultation with stakeholders including communities. S/he will ensure GESI aspect is followed while preparing the SOPs. S/he will develop community-based Decision Support System and response mechanism. S/he will assist the Lead Expert to coordinate the implementation arrangements for DRM/DRR establishments.

Qualifications:

- Master's degree in Social Science/Disaster Management/Community Development or similar discipline.
- Minimum of 10 years and preferably over15 Years of experiencein participatory disaster management and 5 year experience in developing community-based organizations for early warning system and in organizational arrangements for disaster risk management. Working experience in flood risk management will be preferable. Willing to travel and work in the rural and remote areas.

6. Training and HRD Specialist (6 Months)

The Training and HRD Specialist will be responsible for preparing an action plan for operational training and drills among executing agencies, stakeholders and communities. The training will include planning and drills for emergency preparedness and response, organized in close coordination with local, regional and national governments. S/he will also conduct training on the use of the Decision Support System and Response system. S/he will assess existing information exchange mechanisms, knowledge gaps and the response capability of different end users to follow Warning Protocol and Standard Operating Procedures (SOPs).

Qualifications:

- Master's degree in Management with specialization in HRD or Social Science/Disaster Management/Community or equivalent degree. Additional degree in Hydrology, Civil/Water resources engineering will be an advantage.
- Minimum 5year and preferably over10years' experience in training management, and development of training materials.
- Experience in organizing community-level training.
- Willing to travel and work in remote areas.

7. Non-key Experts

There will be three non-key experts. The non-key expert will assist the key expert in achieving the task obligations. Non-key experts will be:

a. ICT System Expert (4 months);

b. Hydromet Database Management Expert (6 months); and

c. Surveyor (6 months)

Qualifications:

- Minimum of Bachelors' degree in the relevant subject;
- Minimum of 5 years of experience in the relevant field;
- Willing to travel and work in remote areas extensively.

8. Supporting Staff:

Consultants are required to propose the supporting staffas per the their estimated needs to complete the assignment .

10. Reporting and timeline of deliverables

a. Reporting requirements shall be as follows:

All the reports are to be submitted in 3 hardcopies along with e-copies.

Report No.1 - Inception Report

The Consultant shall submit an Inception Report within 30 days. The report will be based on elaborated discussions with DHM, MoSTE, MoHA, DWIDP, WECS, GOs, INGOs, CBOs and other stakeholders. The Consultant shall propose a clear approach forcarrying out the tasks, methodologies required, deliverables and timeline. The Consultant shall review the existing information, identify gaps and make specifications of the surveys necessary for filling information gaps. The Consultant will also elaborate on: (i) additional tasks, (ii) work and staffing plans, and (iii) reporting modalities. The report must also clearly specify all risks and issues, which may negatively affect project deadlines and effective execution of project activities.

Report No.2 - Interim (Progress) Report

The Consultant shall submit an interim progress report within 6 months. It will include, among other topics, workshops/consultation with experts, stakeholders including GOs, INGOs and civil society.

Report No.3 Second Progress Report

The Consultant shall submit a second progress report within 9 months. It will include all the activities carried out within this 9 month period.

Report No.4 Mid-term Report

The Consultant will submit Mid-term Report within 12 months. The report shall consist of development of flood forecasting system, flood forecasting models, decision support system among others.

Report No.5 Operation and Commissioning Report

Report on operation and commissioning of the system submitted within 18 month

Report No.6 Third Progress Report

The consultant will submit a third progress report within 22 months. It will include all the activities carried out within this 22 month period.

Report No.7 Draft Final Report

Draft Final Report within 23 months.

Report No.8 Final Report

Final Report (within 24 months).

b. Timeline of deliverables shall be as follows

The contents of the deliverables shall fully comply with the Specific Scope of Work detailed in Section6.

Task No	Task Title	Description of Deliverable	Period in months (From the signing of the contract date)
Inception	Inception Report	Details of task execution modality together with a work schedule including capacity needs assessment Elaborate on: (i) additional tasks, (ii) work and staffing plans, (iii) reporting modalities, and all risks and issues, which may negatively affect project deadlines and effective execution of project activities	1
1	Assessment of the disaster management institutional framework in Nepal and establishment of operational mechanisms with clear roles and responsibilities including the	Review the existing legal and regulatory frameworks for Disaster Risk Reduction (DRR) and Multi-Hazard Early Warning Systems (MHEWS) in Nepal and in other countries	3
		Identify gaps in the National Strategy for Disaster Risk Management in Nepal (2009) and recommend improvements for establishing strong operational links between DRR agencies in each basin	
		Prepare organizational maps for each basin showing key agencies involved in different	

Task No	Task Title	Description of Deliverable	Period in months (From the signing of the contract date)
	development of effective communication strategies	aspects of end to end FEWS	
		Assess technical and human resource capacities of key agencies for FEWS, and identify gaps	
		Technical and human resource capacity at professional level for FEWS	
		Identify linkages among Disaster Risk Management (DRM) agencies and DHM, with a disaster coordinating mechanism, and assess both vertical and horizontal links	
		Assess current status of FEWS in the two basins, including risk knowledge, monitoring and warning service, dissemination and communication, and response	
		Overall recommendations for strengthening end to end FEWS in the two basins, including human resource capacity and technical aspects of the system.	
2	Comprehensive risk assessment of the threats caused by flood hazard in the two basins	Analysis of historical flood events in each basin	6
		A catalog of important flood stages and their impact with respect to social and economic consequences in each basin	
		Digital library for each basin showing topography and terrain, flood levels, and vulnerability of existing assets	
		In each basin select at least 4 villages which are highly vulnerable to flood hazards and conduct Flood Alert Rehearsals in these 4 villages	
3	Review of the SI report on observation network and assessment of network adequacy	Review of the SI Observation Team assessment report on present observation network and processes of the hydrological and meteorological stations	7
		In each basin assess the adequacy of the	

Task No	Task Title	Description of Deliverable	Period in months (From the signing of the contract date)
		present hydro-meteorological network and data acquisition system required for flood forecasting, and recommend improvements	
		Assess the adequacy of current meteorological and hydrological information in each basin available from DHM	
		Install hydrological and hydraulic models for flood forecasting	
4	Integrated flood forecast modeling system	Detailed design of flood modeling & early warning and Inundation Modeling system including inputs and outputs, Internal and external interfaces, data flow schedules for dynamic updating of model, and Input-output data formats	12
		Installation of hydrological and hydraulic models for flood forecasting	
		Calibrate and validate hydrological and hydraulic models with historical data from the two basins	
		Link the forecast models to a real time data acquisition system including radar, weather forecast, and other web-based data	
		Establish relationship between rainfall and runoff, incorporating the snowmelt equivalent water, for the two basins	
		In each basin automatically generate flood inundation maps from the flood forecasting models	
		Integrate the hydrological models with a knowledge-based system of databases	

Task No	Task Title	Description of Deliverable	Period in months (From the signing of the contract date)
5	Communication and dissemination of flood forecast and early warning system	A web-based flood forecasting and early warning dissemination system	15
		Mobile apps to provide SMS alerts	
		An operational strategy for disseminating flood early warning at community level	
6	Design and development of an Operational Decision Support System (ODSS)	Two workstations for FFEWS at Nepalgunj and Dharan	18
		Equipment specifications for these two workstations	
		Equip the two workstations with an early warning user interface	
		Specify qualifications, define roles, and prepare training plan for those DHM staff proposed for manning the two workstations	
		Standard Operating Procedures (SOPs) for communication and dissemination of flood warnings, alerts, and advisories	
		Identify evacuation sites and routes	
		One FEWS multi-stakeholder drill in each basin	
		One Pre-disaster workshop in each basin	
		Introduce FEWS products and services to stakeholders and community	
7	Capacity development	System Operation Manual	22
		Training plan, manuals, and training courses for DHM staff	
		Stakeholder workshops, to create awareness of EWS products	

Task No	Task Title	Description of Deliverable	Period in months (From the signing of the contract date)
		System sustainability plan	
		System performance assessment and system improvement plan	
		Operational support on the developed ODSS/FFEWS models for one flood season	
		Remote technical and troubleshooting support on the developed ODSS/FFEWS models for 2 years after final report	
Reports	Draft final report		23
	Final Report		24

For all deliverables, 10 paper-copies and 5 copies on DVD should be provided

11. Payment Schedule

10 percent on signing of contract as advance against a bank guarantee,

10 percent on submission and approval of Inception Report,

10 percent after submission and approval of Interim Progress Report,

20 percent after approval of Mid Term Report,

20percent after submission and approval of (1) Report on Training plan, with manuals, and training courses for DHM staffand (2) the Operation and Commissioning Report,

20 percent after submission and approval of Draft Final Report on well-functioning system,

10 percent after submission and acceptance of Final report and after confirming the well-functioning of the system.

12. Duration of Consultancy

24 months.

13. Consultant's Selection Method

The selection method will be Quality Cost Based Selection (QCBS).

14. References

Baidya,Saraju K., Shrestha, Madan L. and Sheikh Muhammad, M. 2008. Trends in Daily Climatic Extremes of Temperature and Precipitation in Nepal, Journal of Hydrology and Meteorology, Society ofHydrologists and Meteorologists-Nepal, Volume 5 Number 1, pp 44-48

Chalise, S. R. and Khanal, N. R. 2001. Rainfall and Related Natural Disasters in Nepal. In: Li Tianchi, S. R. Chalise and B. N. Upreti (eds) Landslide Hazard Mitigation in the Hindu Kush-Himalayas. Kathmandu: ICIMOD. pp 71-78

Dhital, M, Khanal, N., Thapa, K. B. 1993. The Role of Extreme Weather Events, Mass Movements, and Land Use Changes in Increasing Natural Hazards: A Report of the Preliminary Field Assessment and Workshop on Causes of the Recent Damage Incurred in South-central Nepal (July 19-20, 1993). Kathmandu: ICIMOD.

DWIDP [Department of Water Induced Disaster Prevention). 2013. Annual Disaster Review. Kathmandu: DWIDP

Thapa, K. B. 2001. Water-Induced Disasters in the Himalaya: Case Study of an Extreme Weather Event in Central Nepal. In: Li Tianchi, S. R. Chalise and B. N. Upreti (eds) Landslide Hazard Mitigation in the Hindu Kush-Himalayas. Kathmandu: ICIMOD. pp 63-70

Marahatta, S. and Bhusal, J.K. 2009. Relating Hydrological Extremes with Area – A Case on Extreme Floods in South Central Nepal. Journal of Hydrology and Meteorology, Society of Hydrologists and Meteorologists-Nepal, Volume 6 Number 1, pp 44-48

Mercy Corps, Nepal, 2009. Natural Resource and Disaster Risk Management, Response to the 2008 Kailali Flood.

Nepali Times, September 2, 2014

Shrestha, A. B., Khanal, N. R., Shrestha, M., Nibanupudi, H. K., Molden, D. J., 2014. Eye on the Sun Koshi Landslide: Monitoring and Infrastructure Planning Key to Minimizing Scale of Disaster (http://www.icimod.org/?q=14356)