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Flood Hazards and Livelihood Challenges in Lower Karnali River Basin: A Case from Sudur Paschim Province, Nepal

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Abstract:- The main aim of this paper is to point out the flood disaster prone locations and document preventive and post disaster risk management measures that have been practiced in lower Karnali River Basin. GIS database map and field observation through participatory method of investigations delineated flood hazard zones in the basin for showing spatial inundation scenarios and discussed with community to know whether and how the flood inundation and river bank cutting disasters impact on community livelihoods. Different aspects of flood vulnerabilities of the Karnali River basin have been analyzed with the help of satellite image and community experiences of disaster-prone areas. Safe shelter areas were mapped with reference to such inundation/hazard and risk reduction strategies in the corridor of the Karnali River from Chisapani station to Khakaraula Ghat near the India border. Findings of the study revealed that there is high risk of flood hazard in the downstream region of the Karnali River. The spatial extent of inundation of flood inundation scenarios has showed socio-economic risks with the losses account of life as well as farm land, food production, properties. Study emphasized on rational human activities for reducing the impact of natural disasters and river management plan in the lower Karnali River Basin. To reduce the increasing trends of flood hazard and its vulnerabilities in the basin community people need to prepare and implementing plan of flood disaster management with adequate financial and technical supports of local, province and federal level governments. The findings of the study suggested policy and development strategies and efforts for the resettlement of communities near the river and effective land-use planning in the basin.

Keywords:- *Karnali River Bain, Flood Hazard, Livelihood Challenges, Science to Policy and Words to Action.*

I. INTRODUCTION

Sudur Paschim Province has experienced high risk of multiple natural disasters where the socio-economic vulnerabilities of flood havoc are rising on due to low level of public awareness, poor infrastructure, insufficient preparedness and a lack of institutional capacity (1). All the river basins of the province along the Chure range the fragile Siwalik mountains are highly vulnerable to flooding during the monsoon period. Particularly, Karnali River Basin has become more sensitive zone of disaster and unpredictable incidents due to an increasing trend of unexpected rainfall patterns and climate extremes. The disaster risks of flood are also accelerated by unscientific construction works in the Chure range have significantly increased over the last few decades (2). The condition is further exacerbated by the ongoing unsustainable development activities and over extraction of river materials in geologically weak and young foothills. As Zurich (3) viewed the severity of floods has significantly increased that has linked to the rapid development activities both in upstream and downstream of the river basins. This has been proved by the unprecedented flood event affected more than ten thousand people in Karnali River basin in 2014, who lost their homes, and damaged their livelihoods resources. It is, therefore, an understanding of when and how changes in the river upstream cause floods in the downstream plains (the Tarai) is crucial for the safety of lower Karnali Basin and beyond.

Pointing out the local efforts and government level initiations for climate change adaptation practices and growing natural disasters management in Nepal, (4) noted that natural disasters such as flooding, droughts, landslides and extreme rain are faced the disaster incidents and dealt with for generations. Recently, climate change/variability has also accelerated the frequency, intensity and severity at which these natural disasters occur. Adaptation to climate change impacts is emerging as a key development agenda in Nepal. The national adaptation plan of action (NAPA) and subsequent local adaptation plan of action (LAPA) is designed to provide a guiding framework for the mitigation and adaptation to climate change specific to Nepal. However, there are missing links between the extent of climate change, level of impacts, and suitability of various adaptations strategies into mainstream development agenda in the context of Karnali lower basin due to the lacking to use bio-physical approach for the analysis of natural hazard related data and failed to incorporate community initiations.

Author (5) mentioned variety of natural hazards, such as landslides, flood/inundation, droughts, soil erosion, earthquakes, thunderstorm/lightening and bushfire in Nepal which are exacerbated by environmental deg¬radation processes. He further opined that there are location specific practices for resource conservation, utilization and disaster

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management for the well- being of local communities before, during and after disasters. He critically dealt some location specific practices which passed on from one generation to the next without being integrated into mainstream development strategies, disaster as science to policy. He Nicely stated that the experiences and location specific practices could be better to framing multidisciplinary tools as the dynamic and powerful measures to attempt words into actions and also breakdown the barriers of sustainability and build back better for disaster risk reduction. He further suggested an innovative frame for cross sectoral partnership which can establish better information and techniques for future sustainability and disaster risk reduction by coping knowledge of ecology, local skills and materials to mitigate the hazards and ensure the sustainability for community life style. For this, an action- oriented model i.e., political-ecological framework of the environmental resource conservation, disaster management and climate change adaptation practices require which are lacking in mostly vulnerable locations of Nepal.

Author (6) pointed out that the Karnali and Mahankali Rivers are more vulnerable in Tarai plains where floods damaged huge properties and warned further devastation by climate change induced hazards. National Action Plan (2018 - 2030), consistent with Sendai Framework for Disaster Risk Reduction (SFDRR) priori¬ties have paved out wider opportunities to work with three level governments system of governance which is a new roadmap for Nepal till 2030 as a second paradigm shift to set out various targets, priority actions and activities. How¬ever, the policy and strategies of National Disaster Risk Reduction focus to curative measures for post damaged as¬sessment and less emphasis on preventive measures and also failed to address the proper link up of local knowledge and indigenous practices with science and technology (7).

Emphasizing on local initiations with their location-specific knowledge for effective disaster risk reduction management UNESCAP (8) stressed to integrate local practices and ecology into science for identify knowledge that can be integrated with science, which could then be further disseminated for use by scientists, practitioners and policy-makers, and safeguard and valorize those that cannot be scientifically explained. This process can enable com¬munities to increase their resilience against the impacts of climate change and disasters. The study of Dekens (9) in Eastern Tarai on flood disaster preparedness also stressed on active involvement of local communities for flood disaster mitigation. However, (10) noticed that there is limited institutional and investment capacity in South Asian region at national and local levels to establish effective flood forecasting and early warning system (EWS) for minimizing flood risks and building community resilience. These studies show that for enhancing building community resilience can be possible through political- ecological approach where mass participation can be built participating by policy makers and scientists to protect human lives and their livelihoods. It is indicative that generating reliable database of climate change induced hazards for building an efficient flood risk resilience activity by involving non-scientists in the design and execution of flood disaster mitigation project (11), represents a potentially useful tool to make a flood risk reduction strategy, especially such remote and data-scarce areas.

Though the participation of local stakeholders and environmental scientists on disaster management since long; there is lack of comprehensive disaster management models and novel practice. Natural scientists themselves have thought and noted the importance of citizen science by incorporating indigenous knowledge for flood hazard management. This prefers collaboration between and among the scientists, policy makers, planners and local people who have past experiences to frame effective disaster reduction and building community resilience (12). Therefore, local level data base that need to be generated data to plan flood risk reduction strategies., However, the lack of disaster information network represents the main challenge in community-based flood disaster management.

Regarding the above-mentioned matter and issues on flood hazard and disaster in Karnali River Basin the main focus of the paper is to point out flood disaster prone locations through spatial inundation scenarios in the basin. To trace out the inundation and river bank cutting scenarios and impacts on community livelihoods with associated vulnerabilities are discussed . Evacuation maps and safe shelters have been planned with reference to such inundation/hazard and risk reduction strategies right from Chisapani station to Khakaraula Ghat near the India border.

II. STUDY AREA

Karnali, the antecedent snow fed river rises in the north west of Taklakot from the south of Mansarovar and Rakas lakh and enters in Nepal near the Khojornath flowing towards south-east, and forms a typical complicated threefold U bend before entering into the tarai. It drains Dhaulagiri to Nanda Devi mountain ranges covering nearly 41500 sq km of drainage area where the Humla Karnali (100 km), the Mugu Karnali (160 km), Seti (120km) and the Bheri (264 km) tributaries drain almost 80 per cent of the area in the basin. Likewise, Sinja, Tila, Lohare and Ramagad are also important tributaries of the river. Altogether there are 222 tributaries of this river system. The basin extends from 28˚2' north to 30˚4 northern latitudes and 80˚ 6'east to 83˚ 7' eastern longitude, covering a total area of 45,269sqkm and yielding an average annual discharge of 1441 m3/s (fig-1).

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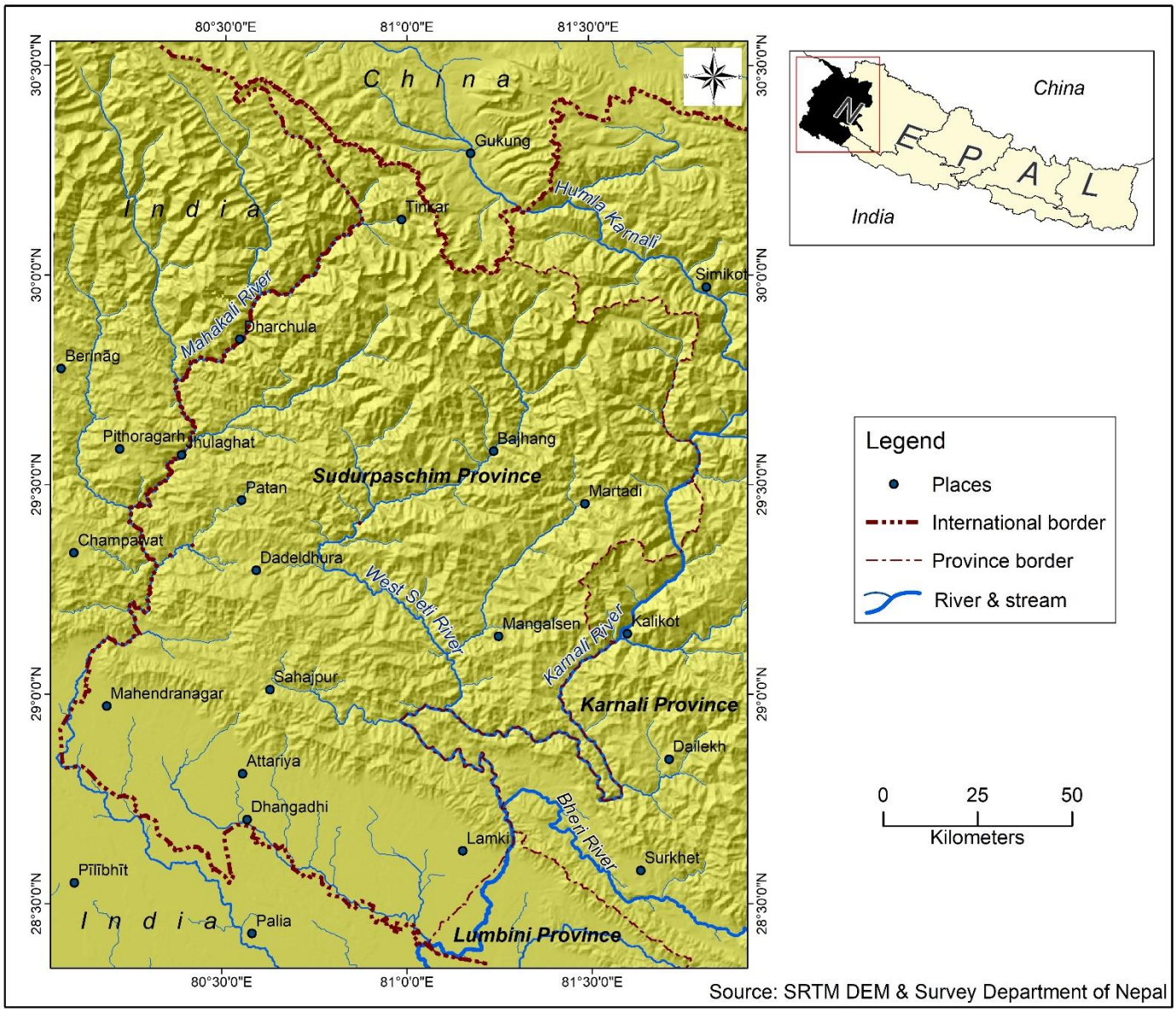

Fig-1: Location of Karnali River Basin

Actually, Karnali River starts in the High Mountains at an altitude covering 5500 m up to 7726 m, with the headwater lying at about 230 km North from Chisapani (mainstream Karnali River length). The lower Karnali River basin is one of the most densely populated and yet highly vulnerable regions of the province (13). Once the river reaches the floodplain area of Chisapani, it bifurcates into two major channels for ~50 km before converging into one channel again downstream near the India border. Both river channels are much wider and deeper (up to 15 m) and, as a result, the river velocity decreases. Still, there is a lack of reliable data. Only one hydrological station has been operated at Chisapani, representing the vast downstream region. This station measures changes the river water level at 15-min intervals using a radar-based water level sensor. However, it feeds information to a community-based flood EWS cannot predict every potential flood risk to the downstream plains, mainly due to the larger catchment area and frequently changing river channel in the downstream basin. There is also a manual staff gauge station alongside the radar station serving as a back-up measure should the system fail. A local gauge reader records the river water level three times a day and alerts local communities and relevant authorities (verbally) about any potential flooding. The study has covered approximately 38 km downstream from Chisapani(fig-2) in a region suffering from destructive flooding that causes significant loss of human life and extensive damage to agriculture, human settlements, and other physical infrastructures.

The Mohana River, lying in south of the Karnali Basin, descends from the Chure range, flows through the Tarai plain and meets with the Karnali River at the Nepal-India border. The watershed area of the Mohana delineated above the Nepal-India border is 3730.3 sqkm. The combined basin area of Karnali-Mohana (KarMo) above the Nepal-India border is 49,889 sqkm.

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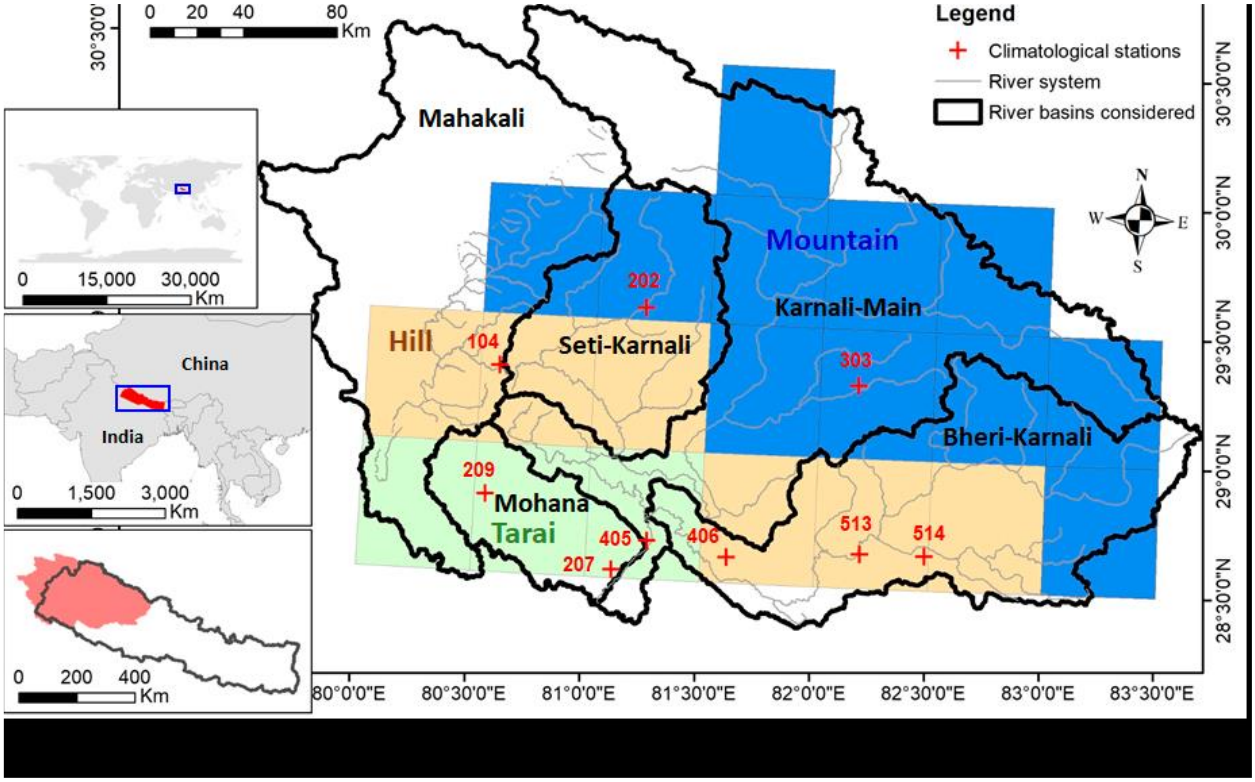

Fig 2. Karnal River Basin along with other Basins of Sudur Paschim province

III. METHODS

Political-ecological approach was adopted to assess flood disaster and peoples' vulnerability in the lower Karnali River Basin and -Mahana river basins. Adopted methods consist of identifying flood hazards across the basin through literature reviews, focus group discussions (FGDs) and key informant interviews (KIIs); designing and implementing questionnaire surveys for perception analysis; analysis of flood disasters and severity of risks.

Flood hazards prone area and settlements were identified through satellite image interpretation of the multi spectotral at which was taken in 5th March, 2021 and toposheet at the scale of 1: 25000 which was prepared in1996 through aerial photo. Information on flood hazards and peoples' vulnerability were collected using secondary sources and analyzed. Resource status and their analysis were made by applying participatory resource mapping (PRM) method during the field study period (20th March to 4th April, 2021). More than 130 households were surveyed to collect the socio-economic and environmental conditions of flood affected communities in and around the flood prone locations. Three FGDs were conducted in most vulnerable locations where participants were actively involved to point out the spatial characteristics and intensity of flood hazards. Elected representatives, government officials and municipal level stakeholders were interviewed as the key informants of the study. The number of key informants was altogether 20 who were interviewed by using semi – structure questionnaires in order to explore their views and opinions on flood hazard mitigation measures and novel practices for the long-term disaster risk management and sustainable livelihood improvement of affected communities.

Assembled information were processed in the composite band in the GIS environment, which were processed and categorized using the supervised classification to distinguish the region covered by the flood hazard prone areas and reclaimed land in the study area, this process was also applied to analyze objective one and two. Under the supervised classification polygons for features have been glued together and labelled to reflect the different features.

IV. RESULTS AND DISCUSSION

➢ *Flood hazards and impacts of Lower Karnali Basin*

The landscape of Karnali River basin (KRB) is highly vulnerable to an array of its upstream and downstream topographical characteristics which have contributed in increased frequency, duration and severity of the flood risks to many locations of right and left banks of Karnali River. The communities who live in the left bank of the river i.e., 5,6, 7, and 8 wards of Tikapur Municipality have experienced frequent flood risks and lost huge property and are living with uncertainty and insecurity since long. Field information further clicked the large number of communities living in these flood and inundation prone areas are low to middle income households, hereby having limited access to the necessary resources to equip them with relevant adaptation strategies. The increased risks to flash flood, drought and attract of wild animals on agriculture sectors have significant implications on community' lives. Affected communities heavily rely on natural resources. Household survey data shows that during the last four decades number of households were displaced from the area due to frequent flood hazards. Key informants reported that thousands of households were migrated to Nepalgunj Banke district, Gauriganga and Lamki

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Chuha municipalities of Kailali district from Sainpur, Daulatghat, Toligaun (Shrilanka i.e., Pathar Ghat of Tikapur Municipality) and Dhansinghpur. FGD participants also informed that due to the hazards like floods and droughts there is an increasing trend of youth drain due to unemployment because the agricultural production as well as productivity have declined. FGD participants mentioned the reason of heavy damaged of crop during long inundation and sedimentation on farmland that declined agricultural productivity and production entire the flood affected area. Physical infrastructures like rural roads, electricity pole, farmer's Kulo and cannel and buildings observed fully and partially damaged by the flood havoc (Fig-3).

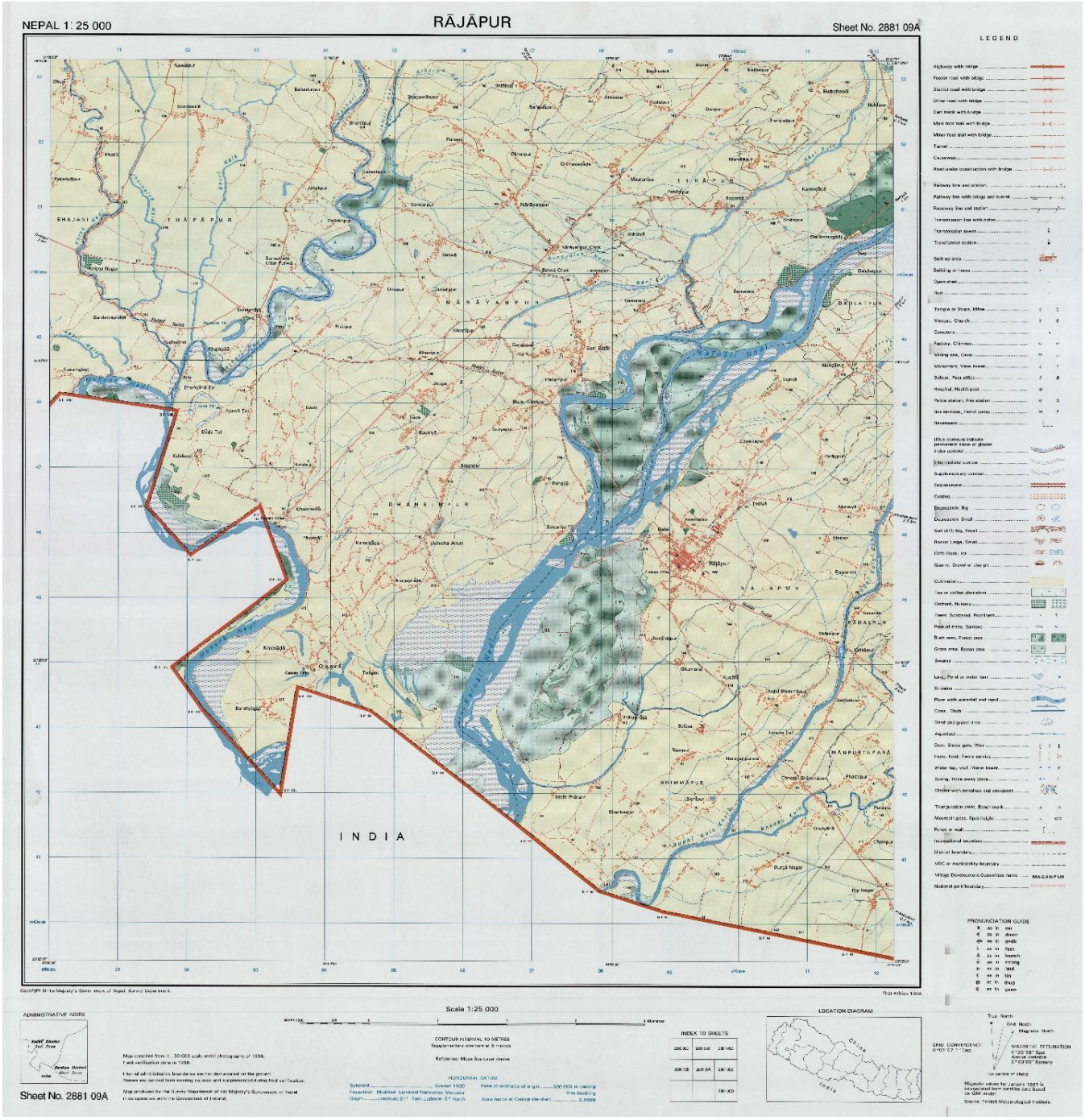

Fig-3: High flood risk prone area of lower Karnali River Basin

Regarding the safety measures that applied during the flooding time most the households reported that the left their houses and used readymade bag to bring the necessary goods with them. Some goods were hanging in roof of the house to safe from flood and inundation. They go far away for the shelter area which is constructed in relatively high land than the common settlement area. Respondents of all flood affected areas said that if heavy flood occurred, they not only lost their crops, stored food and cropland but also cattle flows and other domestic animals. Respondents of Toligaun expressed their views with deep pain and mentioned that flood occurs every post monsoon and lost their life and

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livelihoods. They have no alternation to bear this havoc in every year because they have no courage and property to shift relatively safer area. They no know and feel any support of governments to make them safe from disasters and improve their livelihoods since long. KIIs viewed that local government and social organizations had done some supportive works to the flood victim communities but the supports were neither sufficient nor effective to make safety net of communities due to the temporary nature of support like distribution of food materials, cloths and others. KIIs argued that all level governments have to adopt necessary long terms preventive measures i.e., construction of strong river embarkment right from Chisapani to Khakaraula Ghat for the safe of 50 km long corridor dense settlement. Some government officials viewed to relocate the flood affected settlement in safer and better area for their security and sustainable livelihood improvements. Elected representatives argued differently and said that there is an urgent need to adopt disaster preparedness strategies to better equip communities with the tools and knowledge to protect themselves against future hazards.

Lower Karnali basin and Mohana River basins have a significant potential to contribute to province level prosperity with a variety of comparative advantages in terms of livelihood improvement of rural communities and mobilization of available land, water and forest resources (14). However, the basin area is relatively vulnerable to climate change induced natural hazards and people are facing great vulnerabilities from floods droughts and inundation (fig-4). Karnali River channel has continuously changed it course every flooding period and cut river bank been in both sides. The toposheet which took in 1996 (fig-3) and recently captured satellite image and GIS database map (fig-4) are contrasting to each other in case of river channel and flood affected area in the basin.

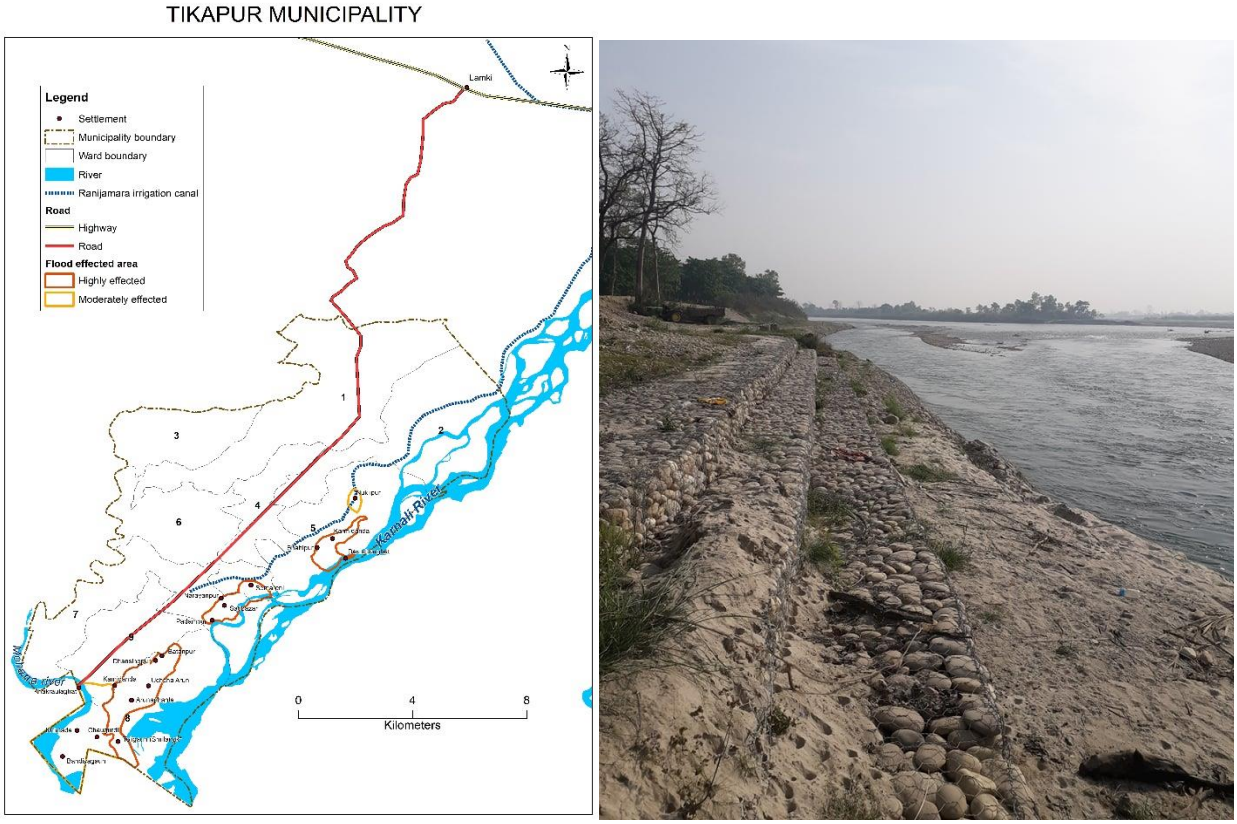

Fig-4: Flood disaster prone areas of Lower Karnali Basin

Residing in river bank the large number of people are affected when the water level rises. Because both buildings and agricultural land are closer to riverbanks for easier access to water for irrigation and other purposes that make them more susceptible to floods. The upper part of Karnali comprising of mountain, hills and Chure foothills experienced drought and landslides while the lower basin part lying entirely low land (Tarai) comprises of a parallel network of streams originating in the steep hill slopes and abruptly flattening into the plain and these streams characterized by peak flows and flash floods during the rainy seasons consequently, Lower Karnali Basin as well as Mahana River basin experience more flooding as well as serious damage to crops where a majority of agricultural activities rely on water resource(fig-5).

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Fig-5: Floods at Foothills streams in upper part of Lower Karnali Basin

➢ *Risk perception*

Perceived risks of flood hazards were also analyzed by undertaking the expressed views and opinions of respondents during the field visit. The highest proportion of households have perceived a medium risk of drought, extreme rain, crop damage, and market problems. More than half of the respondents have perceived high severity of the risks to flood and very few for hailstorm. Available facts and figures permit to say that the topography of the entire basin is more vulnerable to flooding and inundation. A large proportion of households in the basin depend on agriculture and rural livelihoods for their income and food security with the severity and uncertainty.

Despite the prevalence of natural hazards like floods and droughts in many parts of the basin, communities lack measures for post disaster recovery. Around 60 percent of the household heads said doing nothing on their response to hazards. However, 25 percent of respondents reported that affected people were forced to leave their houses with their productive assets in response to flooding. It is also more likely that these vulnerable communities do not have the required information to access available government or non-government- based assistances. As a result, more often than not, communities are unable to do anything in response to hazards risks. Few households, who potentially have access to information and resources, and have more flexibility in use of available resources, are responding in different ways such as selling livestock in case of animal disease, changing cropping patterns and using pesticides in case of pest damage to crops. Flood hazards continue to be a challenge for safe life and development without building the resilience of communities and ecosystems, affected communities will continue to lose assets including land, crops, housing, livestock and health.

Thus, the adaptation strategies and response mechanisms to deal hazards and associated impacts are therefore need to consider in order to empower communities across the basin with the necessary skill, tools and knowledge. It is therefore, focus to be improved access to resources, services, markets, technologies, and decision-making processes that are tailored to their needs and strengths (15).

➢ *Preventive measures*

An effort has been made to explore local peoples' best practices and their knowledge, ideas, skills and opinions on flood hazard mitigation during the events of flood hazard and to document their preventive as well as curative measures for future planning strategies in flood disaster prone area of Lower Karnali River basin. In response local people found to be aware about the flood events as a natural part and human interferences into the processes of flooding which caused dominant fatalities as an impact and huge effects on the people, environment and the economy. KIIs viewed that mass awareness program at community level could be best and location suit measure to be safe from ever occurring flood events in Lower Karnali basin. Whereas majority of household survey respondents reported to construct strong river embarkment along the Karnali corridor from Chisapani Station to Khakraula Ghat up to Indo-Nepal border with 5 to 8-meter height. They also mentioned to adopt transparency and norms of good governance in biding and granting river training, river embarkment and irrigation projects. FGD participants raised the issues to involve local communities in running development projects like irrigation, river embarkment and rural road construction to be safe from the malpractice of distance away contractor. Ward chairpersons of ward 7 and 8 argued to settle the border issue of Khakraula Ghat area where Indian Government has constructed Kailash Dam that disturbs the natural flow of Karnali River and every year residing community's nearby river bank lost their

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physical and economic properties as well as human causality. They suggested to take initiation by Federal Government of Nepal for the diplomatic solution to create a safe environment in Arunafanta, Bangaun and Toligaun and local and province level governments have to design specific preparedness plan to alert, rescue and safety measures at all levels through maintaining regular basic information and continuous ongoing training actions. They think that with appropriate and timely information, preparedness, everyone who may suffer from the consequences of flood events can be able to take his/her own precautions and thus seriously limit flood damages. Respondents suggested to address the voice of landless people of Karnali River bank area who are threatened annually by the flood disaster and livelihood challenges. Almost all KII and government officials viewed government has to prepare and implement the resettlement program for those communities who are usually affected from the flood disaster. Whereas the Mayer of the Tikapur Municipality emphasized to declare the Karnali corridor from Chisapani to Khakraula Ghat as *special flood risk zone* and federal government has to implement long term multi-sectoral development plans. Ward chairperson of ward no 5 stressed to improve livelihood of the flood disaster affected communities by shifting from traditional subsistence farming into commercial farming. The president of Nepal Red Cross Society Tikapur Brach differently viewed that flood of Karnali River has multi sector impacts and the vulnerability of the flood can only be reduced by involving multi sector stakeholders such as civil society, educational institutions, governmental and non-governmental organizations and people at large. He further emphasized on promotion of local knowledge, skills and techniques through life skill education curriculum, teaching text and techniques. Administrative Chief of Tikapur Municipality put his view on transnational efforts to restore rivers' natural flood zones in order to reactivate the ability of natural wetlands and floodplains to retain water and alleviate flood impacts. Household heads said that appropriate development activities can reduce the flood disaster risk. Since the last two years the vulnerability of the flood hazards in lower Karnali River Basin has drastically reduced due to the damp construction of Rani Jamara Irrigation Canal. They further reported that proper designed physical infrastructure development programs could be the effective measures for flood risk reduction in the basin. This argument directly corroborates by the studies (15 &16) of the Karnali watershed and basin.

In general, local people, local government authorities, government official and representatives of civil society including social and environment activists have similar preventive and curative measures for the mitigation of flood hazard in Karnali River Basin. It is indicative that preventive measures need to be taken to reduce possible adverse effects of floods on aquatic and terrestrial ecosystems, such as water and sedimentation and soil pollution in the Karnali River Basin.

V. CONCLUSION

It is evident from the above field base information and analysis that there is high risk of flood hazard in lower Karnali River Basin. The extending flood inundation scenarios in Karnali River Basin assess to draw a number of conclusions. Flood disaster has high socio-economic risks leading to loss of life and productive livelihood resources in every monsoon period. Most of the communities of flood hazard prone areas are poor in economic life standard and low level in education status with lack of adequate support of government and non-government organizations. Considering this critical condition of flood hazard affected communities, flood disaster reduction management in comprehensive way seems challenging task and need to empower affected communities by providing financial and technical supports from government side and capacity development activities lunch by social and educational organization for preparing and implementation of flood disaster response river management plan for the Karnali River. Ever extending flood hazard in the lower Karnali River Basin with increasing vulnerabilities can be addressed by the active involvement of local people, elected representatives, political parties, scientist and policy makers to prepare and implement plan for sustainable river management, community livelihood improvement and safety net of hazard prone areas 'lives. Further, this emphasizes on policy formulation for the resettlement of communities near the river and effective land-use planning in the basin.

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Conflicts of Interest: The authors declare no conflict of interest.

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