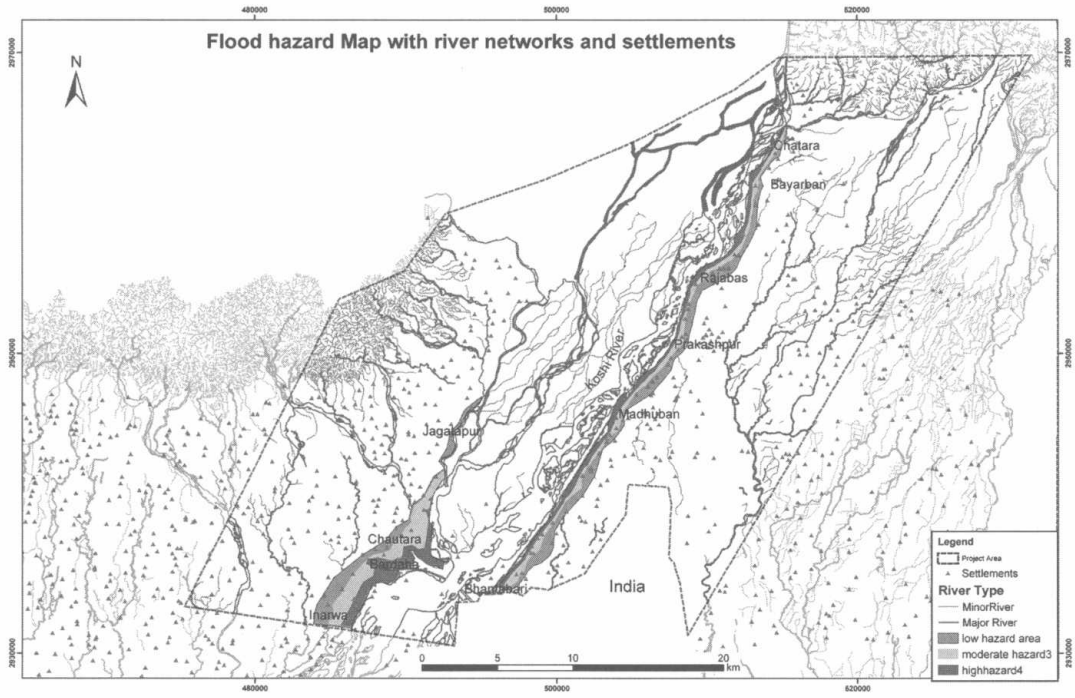

Figure 3. Flood hazard map, showing the low, moderate and high hazard zones

The bottleneck structure formed by the Koshi barrage (Koshi dam) near the Nepal-India border is also facilitating the river to accumulate large volume of water which ultimately discharges water laterally overtopping the fertile land despite the constructed dikes and leeves. Mostly Bardaha and Bhantabari area on the southern part of the map, as shown in Figure 3, frequently suffers from such inundation.

The study showed that the area could be divided into three flood probable zone, low, moderate and high hazard zone. The high hazard zone is characterized by recurrence interval of 4-7 and 10-12 years in moderate hazard area years although inundation of land and soil erosion is frequent in every monsoon season. The high flood hazard zone encompasses an area of 16.21 sq km, moderate 12.15 sq km and the low hazard zone comprises an area of 32.11 sq km respectively. Mostly the flood-vulnerable area is located on the eastern bank of the river, from Chatara to Bhantabari area. The settlements particular of the Prakashpur VDC and Varahkshetra VDC are in potential threat from flooding. Within these VDCs the most vulnerable area is in the Prakashpur VDC, around the Rajabas and Madhuvan. The people residing in the Rajabas areas fall within the probable flood high hazard zone category and are in potential risk from flooding. These areas frequently experience flooding of recurrence interval of 4-7 years although inundation during monsoon season is common. The affected settlements within those localities are Maratol, Joginia, Bhawarahitol, Koiriyonitol, Lavatolia and Bithtol. The affected settlements within the study area are shown in Figure 4.

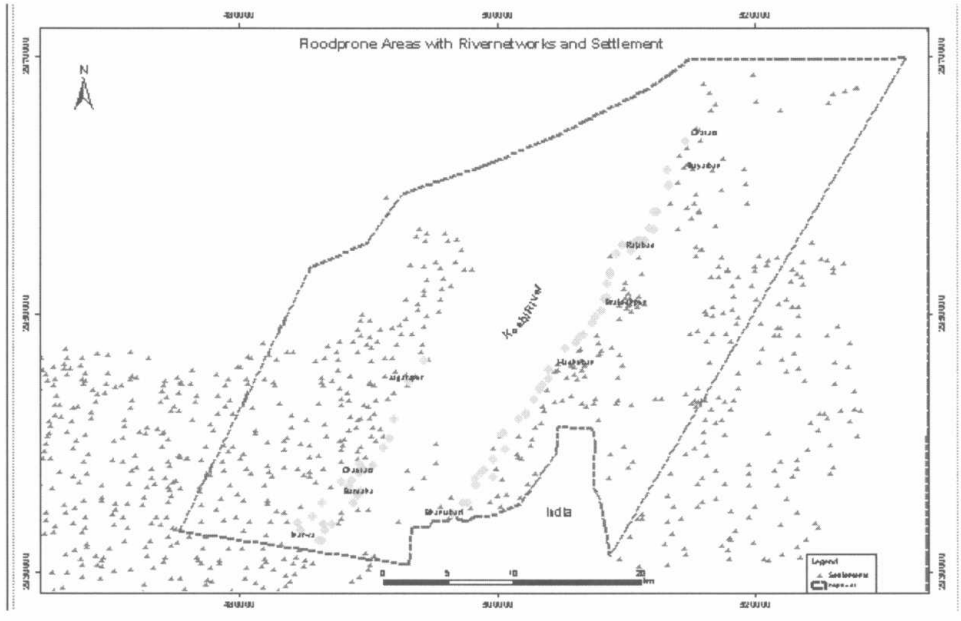

Figure 4. Affected settlements from flooding

The people in Rajabas have suffered already a large loss of life and property in 2037 B.S. The infrastructures such as dikes and spur constructed to protect from flood and rive bank erosion have also been degraded from the sedimentation of the river. Flash floods are mostly seen around the Bhantabari, Bhardaha and Hanuman Nagar area which inundates the land from few hours to 5-7 days. This has degraded the fertility of the cultivated land and even have made crop plantation vulnerable during monsoon seasons. Some protective engineering structures such as dikes are also in danger from the river sedimentation and bank erosion.

Socioeconomic analysis

The study area involves 14 Village Development Committees (VDC) of Sunsari (6 VDCs), Saptari (7 VDCs) and Udaypur (1 VDC) Districts The project area only covers a small portion of the southern tip of Udaypur. The total population of three districts is estimated to be 1,195,915, settled in 221,436 households (2001 Census). These two districts accounts for 30 1 percent of the total population of the eastern region and 5.9 percent of the country's population Population density of the area is estimated at 460 persons/km^2, which is extremely high compared to the national average (157 person/km^2), regional average (188 persons/km^2) and terai average (330 persons/km^2).

Of the 90 respondents interviewed, 84.4% were men and 15.6% women Some of the female respondents were de facto heads of households in the absence of husbands Age of the respondents ranges from 26 to 87 years with an average of 52 years. Over half of respondents are between 41 and 60 years with 28 9% over 60 years. Among the respondents interviewed 8 of them are landless. Initially, most of the people of the Koshi flood plain area are subsistence farmers/agriculturists.

The flood events of various years have done significant loss of land and property. Table 2 shows the major changes in land ownership due to flood events. Though the loss of land has not taken place at once in most of the cases it has resulted into loss of land and ultimately the livelihood of the people of that area. Due to the loss of land the people are compelled to do labor work instead of farming at nearby sub-urban areas. Other activities include jobs in herding, petty commerce, governmental/non-governmental services etc Sixteen of the respondents have salaried employment The 26.66% (24) of the respondents have only agriculture/farming as their occupation.

Initial land ownership	Land ownership after damage due to flood event(s)	% change in land ownership
12 Bigaha	2 Bigaha	83%
8 5 Bigaha	2 5 Bigaha	70 5%
7 Bigaha	6 dhur	99 7%
5 Bigaha	No land	100% (no land)
3 Bigaha	6 kattha	93.3%
1 Bigaha	10 kattha	50%

Table 2. Major changes in land ownership from flooding. *Source:* Field Survey, 2003

Household survey and mass meeting in the VDC was done to understand local people's perception of the flood and their traditional practices to cope with it. Among 90 peoples interviewed, most of them were ignorant about the causes of the floods and think mostly as the intense rain for the primary cause The respondents were asked: whether the flood disaster in lowland (their area) is due to the mismanagement of watershed in upland areas? Most of them (50%) did not mention that as the reason for the heavy flood. While 30% were not sure about this and the remaining 20% told that the flood disaster in lowland, among other reasons, is also due to mismanagement of watershed at upland.

Most of the respondents could not remember the dates of the event (flooding). The respondents could not trace the dates of the flood events with greater damage out So the precise dates could not be traced out because of the categorization of the extent of loss by the flood differed from one individual to other The most repeated dates of flooding events were the events of 2011, 2022, 2025, 2037, 2039, 2044, and 2052 B.S. Due to heavy rainfall during every monsoon land mass wasting/flooding is experienced in the area. The majority of respondents noted that the loss due to flood increase at every 4-7 year interval. However, the devastating effect due to the flood and loss and damage of property experienced every 10-12 years time The main problems mentioned by the respondents were problems in livelihood, loss of land and houses and properties.

These people understand that they are living in the flood risk prone area but can't move to safer places since they don't have sufficient money to migrate/invest to other places. Very few don't believe that they won't get problems from flood in their area.

The other reason they mentioned for living in those flood vulnerable area is the social attachment. "No alternative! What to do and where to go?" said one of the respondents. They do not have land at other safer places. They told that they have no other good alternative, so it's their compulsion and are forced to live there. Some view that the problem due to flood will be reduced or managed after some period. Some told that "Even though we suffer due to hardship, we do not want to leave this place because at least small piece of land is here with us and the relatives are at nearby places".

These peoples are ignorant of the early symptoms of flood and rainfall. Few respondents stated that the early symptom of the flood is the crawling of ants to the tips of the grass found in the riverbanks of the Koshi. Few mentioned that the deepening of the color of the cloud to blackness results into heavy rainfall and subsequently to flood in the River. Other few respondents told that the abnormal movement of birds is also one of the symptoms of heavy rainfall.

It has also been seen that very few people are growing bamboo at gullies and Dalbergia sisoo (Sisoo) at the Koshi flooded area to reduce or lessen the damage from flooding. However, most of the people believe that they can not control the flooding from the Koshi using their traditional methods because of very high discharge in Koshi during the monsoon season.

Local people perception for the control of flood

Almost all of the respondents believe that the effect of flood disaster can be reduced. While asked for the methods to minimize the negative effect of flood disaster they think that the following methods could minimize the extent of flooding:

- Spur and Gabion Wall construction at various risk prone areas
- The problem is due to Koshi Barrage. So, the Indian Government should provide appropriated compensation to the people and develop plans to increase the benefits from the Irrigation Canal
- Only government can do, we can not attempt to control Koshi
- Should block Koshi from both the sides (river right and left) and allow it to flow at one specific direction
- Should build gabion walls at both sides
- Should stop to stone and sand dredging practice
- Should build notch at various points where the river meanders
- Should distribute the water to 3-4 channels along the flow
- Build another Canal from Chatara towards east
- Should conserve forest along the upland areas
- Open all the gates (52) of the Koshi Barrage during heavy rainfall. This will result in reduction of the water level and the damage will be obviously reduced.

Conclusion and discussion

Flood disaster is one of the major disasters that occur every year particularly in the southern part of Nepal. The flood hazard study of the Koshi area, focused particularly around the Prakashpur, Rajabas, Bayarban, Chatara, Madhuban, Chakkraghatti, is performed with a view of risk identification and disaster preparedness for the future events. The study utilized an integrated approach of GIS, remote sensing and socio-economic data analysis as well as hydrological and meteorological data analysis. A detailed field study was also carried to verify information obtained from the RS imagery and GIS.

The Koshi River basin corresponds to a fluvial erosional system dominated powerful river which is considered to be its early mature stage. Active river bank erosion can also be seen mostly on the eastern bank of the river. The river has been migrating laterally from west to east direction eroding the eastern bank and making it more vulnerable.

Flooding in Koshi area can be attributed mainly to the prolonged rainfall over an extensive catchment area that generates high volumes of run-off, which spill out onto the river's natural flood plains and overtops the cultivated land and settlements. Such overflowed water inundates large areas for weeks at a time owing to the long response time of the catchment, and subsequent slow rise and fall of the flood hydrograph. The bottleneck appearance due to the construction of large dam, Koshi barrage downstream near the Nepal India border, has further facilitated the water to move laterally and inundating the fertile lands. The excessive sedimentation near the Koshi barrage is also considered to be the secondary cause for the lateral migration of water overtopping the fertile lands. The local people also blame the Koshi barrage for flooding their area, claiming the flooding was not as intense or frequent before the construction of the Koshi barrage.

Flooding in the study area has also been from the flash floods resulting from intense rainfall of a relatively short duration, which is also a common phenomenon in the hills and mountainous part of the area that has steep slope. The maximum annual precipitation during the monsoon season is 93% of the total precipitation and 37% of the total occur in a single event within 24 hours which generates a very high discharge rate and ultimately flooding the adjacent areas to the river bank. Eastern bank of the area is often impacted by the flash floods creating loss of land and property.

The probable maximum flood calculated using California's method for the recurrence interval of 10, 100, 1000 and 10000 years are 10 cumec, 100 cumec, 15,900 cumec, 21,100 cumec and 26,300 cumec respectively. Similarly the probable maximum rainfall for the recurrence interval of 10, 100, 1000, 10000 years are 2650 mm, 3500 mm, 4350 mm and 5200 mm respectively.

Participatory GIS method together with combination of remote sensing and field survey data interpretations were used for the flood hazard mapping of the area Regional information about the area such as mapping water bodies and flood plain were accomplished using satellite imagery and aerial photograph. The study showed that the area could be divided into three flood probable zone, low, moderate and high hazard zone. The high hazard zone shows the recurrence interval of 4- 7 years although inundation of land and soil erosion is frequent in every monsoon season and 10-12 years in moderate hazard area Mostly the flood vulnerable area is located on the eastern bank of the river, from Chatara to Bhantabari area. The high hazard area encompasses 16 21 sq km and people from six different settlements are living in this area despite the threat from flooding Similarly, the moderate and low hazard area occupies 12.15 sq.km and 32.11 sq.km respectively The most vulnerable area is in the Prakashpur VDC, around the Rajabas and Madhuvan The people in Rajabas have suffered already a large loss of life and property in 2037 B S The infrastructures such as dikes and spur constructed to protect from flood and rive bank erosion have also been degraded from the sedimentation of the river. Flash floods are mostly seen around the Bhantabari, Bhardaha and Hanuman Nagar area that inundates the land from few hours to 5-7 days. This has degraded the fertility of the cultivated land and even have made crop plantation vulnerable during monsoon seasons

The flood has made many people homeless in the past fifty years even with loss of life and property. This has also done a significant loss of the land and has made major changes in land ownership. Though the loss of land has not taken place at once in most of the cases it has resulted into loss of land and ultimately the livelihood of the people of that area. Due to the loss of land the people are compelled to do labor work instead of farming at nearby sub-urban areas

Records showed that the flood victims are mostly poor and homeless people. Interview with peoples depicted that these peoples are aware of the flood but lack of sufficient capital to migrate to safe place have forced these peoples to live in the risk prone areas Some peoples are also socially attached with the areas and do not want to leave their traditional homes. Also, the existence of fertile land next to the riverbank has made people to live in the nearby areas despite the potential threat to the flooding which makes these people more vulnerable during flooding

The flood hazard mapping done from this study will be very much fruitful for proper planning and resource location for disaster preparedness for the concerned line agencies and organization. The resulting flood hazard map, as provided to the VDC will also be very helpful for the local people to distinguish the safe and vulnerable areas from flood. The map will be helpful even for the uneducated people to understand about the existing flood and land condition, as visual display is the easiest and expressive ways for the people to comprehend and understand their existing conditions from the flooding

The involvement of the local people for the modification and changes in the flood hazard map after its completion made the villagers to think the work as their own work and for their own benefit and has raised a feeling of ownership in them. Their willingness and readiness to form a flood fighting committee substantiates their positive feeling towards the project. Also, the commitment of the VDC committee to incorporate the flood study recommendation in their periodic plan shows their readiness for the flood disaster reduction.

Lessons Learned

1) Natural disaster has a significant impact in poverty and has always hindered economy of a developing country such as Nepal There is a significant role between the poverty alleviation and the disaster risk reduction. Frequently occurring flood disaster is one of the main drawbacks for the poverty in the study area. Whenever the disaster occurs, the poor and homeless people are affected the most The frequent flooding has caused a significant amount of economic loss to these peoples burdening them with more financial debts for reforms and seed money to restart the agriculture.
2) Flood victims are mostly poor and homeless people. Interview with peoples depicted that these peoples are aware of the flood but lack of sufficient capital to migrate to safe place have forced these peoples to live in the risk prone areas.
3) Greed to exploit the river flood plain properties, mostly seen around the fertile plains of the river, is one of the major factor as seen during many casualties. Some people with moderate income were seen to be living in the flood risk prone areas Although these people have sufficient fund to migrate to safer places they still insist on living there because of the greed to occupy the land with good yield
4) Existence of fertile land next to the river bank has made people to live in the nearby areas despite the potential threat to the flooding.
5) A proper planning for any program aimed at disaster risk reduction is successful only if it is done through active participation of the local community people, as it awares the people and creates a feeling of ownership in them. Also, it is important during the implementation of the project to involve these local people in the project and respect their thoughts
6) Visual displays are the most effective means for information dissemination. Both the educated and uneducated people understand it. In our context, the flood hazard map was very informative and people from all the age showed interest on it which would be very helpful for these people to understand their local environment and threats from flooding. The different color rated for low, moderate and high hazard, for rivers and landuse types made people clear about their surrounding area in a larger scale, which they have not done before.
7) Initial assessment flood hazard and risk identification is very important to lessen the effects of flooding. Initial assessment of the flood hazard and the flood hazard map was very useful for the proper planning of flood risk reduction and mitigation. The study highlighted the risk prone areas from flooding. It has served as a guide map for the policymakers and stake holders working in the study area to implement any program targeted for the lessening the effects of flooding.

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