Chapter 3

Preparing for Disaster, Reducing Risk, Building Resilience:

Study Results and Recommendations

Community members build gabion walls to prevent the Ratu Khola flooding their farms.

Introduction

Though the loss and damage from some natural hazards are high, in the long run floods cause more damage and devastation than any other natural hazard. Although floods cannot be controlled, losses due to floods can be reduced to a great extent by implementing a proper flood-management programme. A holistic flood-mitigation and management strategy, including pre-flood planning, operational flood management, and post-flood response, is necessary to reduce the loss. An understanding of the level of hazard, risk, vulnerability, and the capabilities of local people to respond to disaster provides the basis for developing holistic flood-mitigation and management strategies.

Building community capabilities to anticipate, cope with, resist, and recover from the impact is important for effective flood mitigation and management. Hazard, risk, and vulnerability mapping and zoning, awareness creation, early warning systems, and preparedness planning are some of the important tools for building a disaster-resilient community. One of the steps in promoting community resilience is to improve its emergency preparedness and capacity to respond. This can be achieved through provision of an emergency population warning system, shelter, evacuation, stockpiling of supplies and equipment, and training of emergency services.

The results of flood-hazard, risk, and vulnerability mapping in terms of location and level of exposure in the Ratu Watershed have been presented in Chapter 2. An attempt is made in the following to assess hazard, risk, and vulnerability in the Ratu Watershed. Socioeconomic vulnerability, focusing on the losses from floods and other water-induced disasters is also discussed. Local coping capacity was assessed in terms of the socioeconomic characteristics of the people exposed to floods and other water-induced disasters. People's responses in terms of flood mitigation and management in the past are also discussed and efforts aimed at promoting community resilience are also briefly described in this chapter.

Methodology

Assessment of hazard, risk, and vulnerability in the Ratu Watershed was based on primary data collected from the field from July to August 2003. Primary data, basically on past hazards, socioeconomic conditions, vulnerability, response capabilities, and efforts made by local people to mitigate floods and other water-induced disasters in the recent past, were collected during field work.

Information on the magnitude, recurrence intervals, and damage from different types of disaster was collected through group discussions with the help of structured checklists. Local elders and knowledgeable people were consulted to collect data from the past.

Socioeconomic data of all the VDCs located in the Ratu Watershed were collected with the help of a structured checklist prepared for this study. In order to assess the response and recovery capabilities of individual households, information on the perception of local people about flood hazards and efforts made to mitigate hazards at household level was collected through household surveys. Because of time constraints, it was not possible to survey all the households in the basin so stratified random sampling was adopted. Stratification or zonation of areas was carried out based on the expected level of hazard: high, medium, or low. Thirty households from each hazard zone (high, medium, low) were selected at random for the survey. Households from different areas were chosen in such a way that all the areas within the basin were represented.

In order to enhance community resilience and equip the communities with necessary information, a micro-level study was carried out to identify and delineate safe areas for evacuation routes and shelters in the downstream area, and training was given to local people on precipitation and river discharge stage reading in upstream areas. The methodology adopted to identify and delineate safe areas for evacuation routes and shelters is discussed below.

The Jaleshwar municipality and its adjoining areas downstream from the Ratu Khola were selected for detailed flood-hazard mapping with enhanced topographic maps (Figure 3.1). For this, a detailed topographic survey was carried out with 20 cm accuracy. After incorporating topographical information obtained from the detailed field survey, a triangular irregular network (TIN) and contour map with intervals of 10 cm were generated. A cross-sectional survey was carried out along the river over a span of 3 km upstream near Gena Bathnaha to 2 km downstream near Dhabauli. Each cross-section contained topographical information covering 200m right and left of the centre line of the river. Detailed information about existing river-training work (mainly levées) and their present conditions, and other features such as roads, mule tracks, land use and land cover, was also collected during the field survey.

The water-surface profile was calculated using HEC-GeoRAS software. The step-wise procedure followed for HEC-GeoRAS during processing has been shown in Figures 2.20 and 2.21 in Chapter 2.

The relationship between rainfall and runoff was examined using the TANK model. Since the Ratu Basin has no observed discharge data, the calibrated parameters of the TANK model for the Bagmati Basin (Gauge stn. 586) was used on the assumption of similar catchment characteristics.

The rainfall of the basin was computed using rainfall data recorded at Tulsi (Stn. 1191) and Gausala (Stn. 1122) on the basis of area weightage of their respective Thiessen polygons. The area of the basin and its percentage weightage for the rainfall for Jaleshwar gauging station were estimated.

The rainfall data for the years 1979, 1980, 1987, 1988, and 1989 recorded at Tulsi and Gausala meteorological stations provided by the Department of Hydrology and Meteorology were used to simulate the corresponding discharge. The rainfall-runoff trends for wet season months (June-September) and their correlation coefficients (R^2) were calculated using linear, polynomial power, exponential, and logarithmic functions. The corresponding regression equation having the highest 'R^2' value was then used to forecast the discharge for different rainfall events.

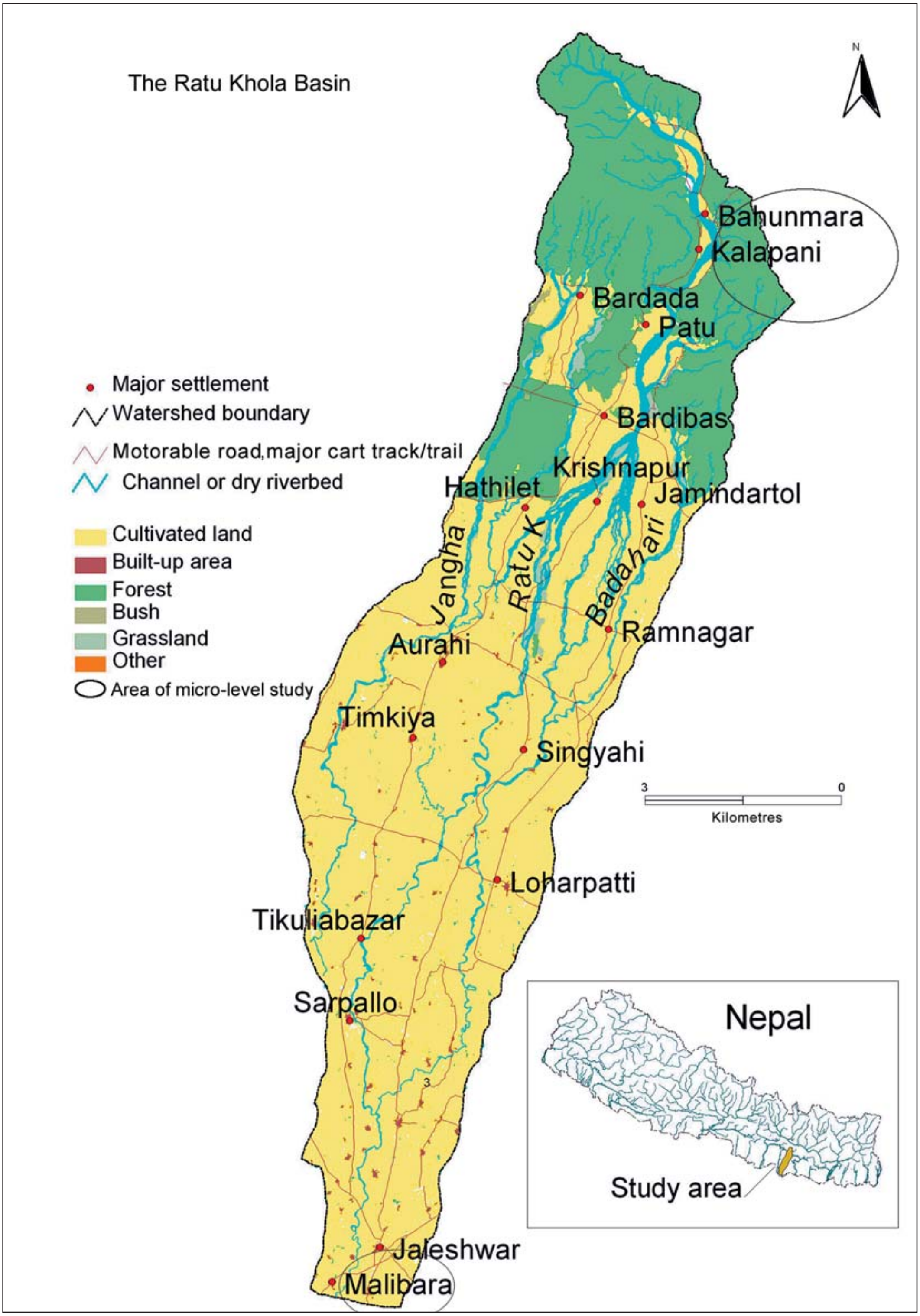

Figure 3.1: **Location of areas selected for the micro-level study**

Frequency analysis for rainfall was carried out. The one-, two-, and three-day maximum rainfall was calculated for return periods of 2, 5,10, 25, 50, and 100 years with Extreme Value Type-I distribution (Gumbel Distribution), the results were presented in Table 2.4 in Chapter 2.

Finally, a flood-hazard map was prepared based on the enhanced topographic information along with estimated flood peaks of a 2-, 5-, 10-, 25-, 50-, and 100-year return period using Dicken's formula (Table 2.2 in Chapter 2) and various flood events obtained from the regression equation having the highest 'R^2' value.

Results

The results of the assessment of flood hazards, risk, and vulnerability are presented below. Attempts are also made to discuss the response and resilience of the local people.

Loss and damage from different natural hazards

Different types of hazards occur in the watershed causing great loss of lives and property. These include landslides, debris flows, floods, riverbank cutting, river-channel shifting, droughts, earthquakes, fire, hailstorms, lightning, windstorms, cold waves, and disease and pests. Since many of the settlements are located in the plains area of Bhabar and the Terai, direct losses from landslides and debris flows are not reported. However, landslides and debris flows occur frequently in the upstream areas in the Churia region triggering water-induced disasters such as floods, bank cutting, channel shifting, and river-bed rise in densely inhabited downstream areas.

Thirty-four floods and 30 riverbank cutting events causing loss of property were reported in the watershed during the 42-year period between 1961 and 2003 (Table 3.1). Floods occur almost every year causing loss of life and property in the watershed. Seven events of river shifting in 37 years (every 5-6 years) and 18 events of river-bed rise in 35 years (every two years) were reported. Only one earthquake causing loss of life and property was reported from the watershed during this period.

Fire is a common disaster in the watershed and occurs in one place or another every year. Other climatic hazards that occur from time to time and cause loss of life and property in the watershed include hailstorms, lightning, droughts and cold spells. A total of 16 hailstorms (one in 2-3 years), 20 lightning strikes (one in 2 years), nine hailstorms (one in 5 years), 22 droughts (one in 2-3 years), five cold spells (every year), and 17 events of pest and disease (1-2 years) were reported from the watershed.

Table 3.2 shows the annual loss of life from different hazards in the watershed. About 46 persons are killed annually because of different hazards. More than 41 people die due to cold spells, followed by pests/diseases (2 persons), and floods (1 person). Lightning strikes, fire, and windstorms are also a cause of death almost every year.

Table 3.1: Frequency of different natural hazards and their recurrence intervals			
Types of hazard	Frequency of occurrence	Number of years covered	Recurrence intervals
Floods	34	42	1.2
Riverbank cutting	30	42	1.4
River shifting	7	37	5.3
River-bed rise	18	35	1.9
Earthquakes	1	42	42.0
Fire	45	60	1.3
Hailstorms	16	44	2.8
Lightning strikes	20	41	2.1
Windstorms	9	28	3.1
Droughts	22	52	2.4
Cold waves	5	5	1.0
Pests/diseases	17	26	1.5

Source: Field survey 2003

Table 3.2: Annual loss of life caused by different hazards	
Types of Hazard	Number of Deaths
Flood	1.0
Riverbank cutting	0.0
River shifting	0.0
Riverbed rise	0.0
Earthquakes	0.0
Fire	0.4
Hailstorms	0.0
Lightning strikes	0.6
Wind storms	0.3
Droughts	0.0
Cold wave	41.2
Pests/diseases	2.3
Total	**45.7**

Source: Field survey 2003

Annual loss of property at the watershed level from different hazards is given in Table 3.3. A total of 273 animals are killed every year. About 323 houses, 1,830t of crops, 96 ha of land, and 11 different types of infrastructure are damaged annually from different disasters in the watershed. Floods account for more than 41% of the total value of private and public assets damaged every year, followed by river-bank cutting (27.7%), cold spells (9.8%), fire (5%), riverbed rise (3%), droughts (2.8%), pests and diseases (1.1%), and wind storms (1%). Average per annum loss per household from these disasters is about Rs 550. Assets

Table 3.3: Annual loss of property caused by hazards							
Types of Hazard	Animals (No.)	Houses (No.)	Crops (t)	Land (ha)	Infrastructure (No.)	Amount	
						Million Rs	%
Flood	30.1	132.9	813.5	39.2	5.1	15.53	41.3
Bank cutting	0.6	13.0	184.8	42.4	2.2	10.42	27.7
River shifting	0.7	0.6	14.7	7.1	2.9	2.82	7.5
River-bed rise	0.8	8.0	59.1	7.5	0.1	1.12	3.0
Earthquake	0.0	2.2	0.0	0.0	0.0	0.06	0.2
Fire	14.1	82.9	33.7	0.0	0.0	1.88	5.0
Hailstorm	0.0	5.9	21.4	0.0	0.0	0.19	0.5
Lightning strike	0.7	0.4	0.2	0.0	0.0	0.03	0.1
Wind storm	0.0	76.8	0.2	0.0	0.5	0.39	1.0
Droughts	0.0	0.0	263.9	0.0	0.0	1.04	2.8
Cold spell	183.0	0.0	414.0	0.0	0.0	3.69	9.8
Pest/diseases	43.2	0.0	24.5	0.0	0.0	0.40	1.1
Total	**273**	**323**	**1830**	**96**	**11**	**38**	**100**

Source: Field survey 2003

amounting to nearly Rs 437 (79.5% of the total loss) is lost from each household at the watershed level from water-induced disasters such as floods, river-bank cutting, river shifting, and river-bed rise. Annual loss of property from households located in hazard-prone areas is extremely high.

A survey of 136 households living in hazard-prone areas with varying degrees of risk (high, medium, and low) shows per household annual income of Rs 90,613 with per capita income of about Rs 12,000 (Table 3.4). The main source of income of households living in hazard-prone areas is agriculture (38.6%), followed by services (18.7%), remittances (13.4%), trade and business (8%), and horticulture and vegetables (5%).

In the hazard-prone areas, annual loss per household from different hazards is reported to be Rs 7,389, which is equivalent to 8% of total annual household income. Floods, riverbank cutting, and channel shifting in combination cause more than 70% of the total losses among these households.

A survey of local perception regarding the trend of occurrence of different disasters and the amount of loss from these disasters showed that both the frequency and the loss from floods and river-bank cutting has been increasing in the watershed in the recent past. More than 76% of households perceived an increase in the frequency of occurrences of flood and riverbank cutting and in losses from these events. Though per event loss from earthquakes is extremely high, the occurrence of high magnitude earthquakes damaging large amounts of infrastructure is not so common. Therefore, in the long run, damage from floods, riverbank cutting, and channel shifting is high in the study area. Losses from fire have decreased significantly in recent times, whereas losses from cold wave have

Table 3.4: Annual household income and losses among households in flood-prone areas		
Sources of income and loss	**Annual income all HHs (Rs)**	**%**
Agriculture	4,760,450	38.6
Horticulture and vegetables	631,760	5.1
Livestock	363,450	2.9
Cottage industries	18,000	0.1
Trade and business	984,000	8.0
Wages	955,450	7.8
Services	2,310,304	18.7
Remittances	1,649,800	13.4
Pensions	121,800	1.0
Other sources	528,400	4.3
Total	12,323,414	100
Per household income		90,613
Per capita income		11,999
Per household loss		7,389
% of loss in total household income		8.2

Source: Field survey 2003

been increasing. The occurrence of and losses from droughts, hailstorms, pests, and diseases are more or less constant compared to the past. However, there is an increase in the occurrence of windstorms and the losses incurred from them.

Loss and damage from floods and other water-induced disasters

It is evident from the above discussion that the loss of property from water-induced disasters – floods, riverbank cutting, and river shifting – is extremely high compared to loss as a result of other hazards occurring in the watershed. Both the frequency of water-induced disasters and the losses from them have been increasing. Drastic changes in land use and land cover (deforestation), excavation of the river bed for construction materials such as gravel, and development of infrastructure (roads, culverts, bridges, buildings) without due consideration being given to draining the natural flow of water are some of the reasons for an increase in the frequency and magnitude of flood and river-bank cutting in the watershed. A survey of 48 VDCs/municipalities in the watershed shows that on average 955 ha of land are flooded every year in the watershed. Highly damaging floods in terms of loss of human lives occurred in 1961, 1977, and 1997 (Table 3.5). However, the loss of assets was high in 1988, 1993, 1995, 1998, 2001, and 2002 (Figure 3.2).

Flooding due to shifting of the river channel and rises in the river bed due to siltation of sand and gravel along the river channel are also common in the watershed. Seven events of river-channel shifting causing heavy loss of life and property have been reported in the watershed (Table 3.6).

Table 3.5: Annual loss of life and property caused by flood hazards								
Year	Area flooded (ha)	People killed (No.)	Animals (No.)	Houses (No.)	Crops (t)	Land (ha)	Infrastructure (No.)	Amount Million Rs
1961	1235	6	25	118	1964	111	4	7.84
1963	342	0	48	39	444	44	1	0.99
1965	976	1	23	120	1648	112	0	11.01
1967	139	0	13	97	207	21	0	1.24
1968	45	0	0	0	11	1	1	0.03
1970	186	0	10	10	173	8	0	0.42
1971	1665	0	105	126	2741	112	10	1.63
1973	165	0	0	6	160	3	2	0.31
1974	24	0	0	0	48	15	0	0.75
1975	3479	2	110	341	1641	75	10	5.99
1977	702	8	100	300	3335	78	4	7.57
1978	944	2	5	152	1585	69	0	7.58
1979	265	0	25	63	361	17	3	2.22
1981	15	2	2	5	45	10	1	2.82
1983	221	0	0	0	143	4	2	1.81
1984	627	0	37	53	1021	66	0	16.48
1985	1542	0	120	180	475	10	13	11.23
1987	3284	3	52	544	2151	56	21	19.28
1988	1967	4	20	372	2770	144	6	49.17
1989	470	0	1	33	267	22	3	3.58
1990	324	0	0	0	98	4	0	1.27
1991	70	0	0	10	121	11	2	2.74
1992	328	0	0	7	163	4	0	1.53
1993	1810	0	10	399	3110	162	12	55.09
1994	1195	1	32	127	390	23	14	16.10
1995	1183	0	36	254	548	37	12	58.98
1996	350	0	0	100	275	0	1	5.13
1997	4133	10	322	519	1815	78	17	54.54
1998	1832	0	25	103	954	55	6	23.44
1999	2060	0	35	250	582	27	20	31.20
2000	715	0	0	154	151	0	4	8.62
2001	1533	1	50	395	808	69	14	63.55
2002	5573	0	58	699	3932	201	30	175.49
2003	720	0	0	7	34	3	0	2.70
Average	955	1	30	133	814	39	5	16.0

Source: Field survey 2003

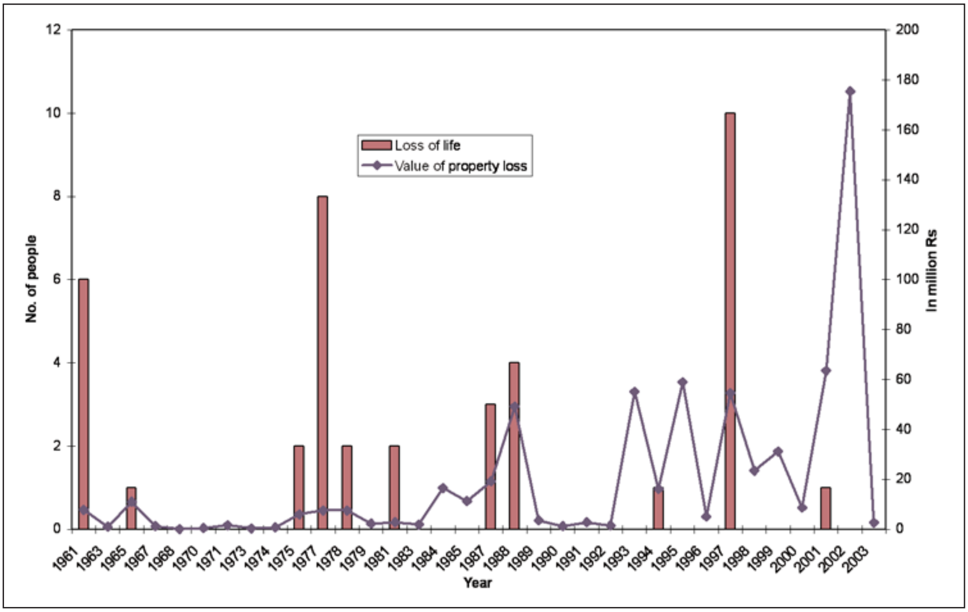

Figure 3.2: **Loss of life and property from flood hazards, 1961-2003**
Source: Field survey 2003

Table 3.6: Average annual losses and damage

	From river channel shifting	From floods triggered by rises in the river bed	From river bank cutting
Number of animals affected	0.7	0.8	0.6
Number of houses damaged	0.6	8.0	13.0
Crops (in t)	14.7	59.1	184.8
Damage land (in ha)	7.1	7.5	42.4
Number of infrastructural installations damaged	2.9	0.1	2.2
Amount of damages (in million Rs)	2.82	1.12	10.42

Source: Field Survey 2003

Seventeen floods triggered by rises in the river bed causing loss of life and property were reported during the field work. On average, 7.5 ha of land, 59t of agricultural crops, and eight houses were damaged amounting to Rs 1.12 million annually from the flood triggered (Table 3.6).

River-bank cutting during flooding is another major cause of water-induced disaster in the watershed. Table 3.6 shows the losses from river-bank cutting. In a span of 42 years, 32 river-bank cutting events have been reported from the watershed. Every year, about 42 ha of cultivated land, 185t of crops, 13 houses, and two different types of infrastructure are damaged due to river-bank cutting, and damages amount to Rs 10.42 million. The losses were comparatively high in 1988, 1993, 1998, and 2002.

Exposure and risk

Attempts have been made here to assess the people and assets exposed to water-induced disasters in the watershed. We attempted to quantify the proportion of people and assets located in areas susceptible to floods and other water-induced disasters. This information was derived basically from group discussions in each VDC and supplemented by the household survey.

People

Large numbers of people in the watershed are exposed to floods and other water-induced disasters such as river-channel shift, river-bank cutting, and so on. More than half (61%) of a total of 53,323 households in the watershed, or 32,593 households, are exposed to flood and water-related disasters (Table 3.7). Among them are 39% of households residing in hazard-prone areas. Another 22% have land and other property in the hazard-prone areas. The proportion of households exposed to floods and other water-induced disasters ranges from 57.8% in the upper region (Churia and Bhabar), to 58.1% in the middle, and 63.8 % in the lower part of the watershed. The proportion of exposed households of some ethnic groups is extremely high. Ethnic groups with a very high proportion of households exposed to disaster-prone areas are the Danuwar (96%), Kayastha (93%), Shah (93%), Kumar (80%), Nuniya (80%), Magar (75%), Newar (75%), and Halawai (70%). The Magar and Newar are ethnic groups of hill origin; the other ethnic groups are of Terai origin.

Property and Infrastructure

Property and infrastructure owned by the households, the community, and government are exposed to floods and other water-induced disasters in the watershed. These include land, agricultural crops, houses, sheds, irrigation canals, and so on. Similarly, community and government-owned infrastructure exposed to hazards includes schools, roads, dams, irrigation cannels, and others.

Table 3.7: Number of households exposed to water-induced disasters

Districts	Region	Watershed		Hazard-prone area			
		HH (No.)	Population	HH living	HH with land only	Total HH	%
Mahottari	Lower	28,607	173,241	11,795	6,469	18,264	63.8
	Middle	13,680	77,787	5,779	2,108	7,887	57.7
	Upper	8,348	46,129	2,470	2,600	5,070	60.7
	Total	**50,635**	**297,157**	**20,044**	**11,177**	**31,221**	**61.7**
Dhanusha	Middle	603	2,982	415	0	415	68.8
	Upper	2,085	10,855	470	487	957	45.9
	Total	**2,688**	**13,837**	**885**	**487**	**1,372**	**51.0**
Total	Lower	28,607	173,241	11,795	6,469	18,264	63.8
	Middle	14,283	80,769	6,194	2,108	8,302	58.1
	Upper	10,433	56,984	2,940	3,087	6,027	57.8
	Total	**53,323**	**310,994**	**20,929**	**11,664**	**32,593**	**61.1**

Source: Field survey 2003

The main land-use type in these areas is agriculture, followed by forests and grazing land (Table 3.8). Nearly 14,112 ha of 'khet' (irrigated agricultural land), 247 ha of 'bari' (unirrigated agricultural land), 89 ha of grazing land, and 870 ha of forest land is located in areas susceptible to floods and other types of water-induced disasters

Table 3.8: **Land use in areas susceptible to flooding**

Land-use type	Area (ha)	%
Khet	14,112	92.1
Bari	247	1.6
Grazing land	89	0.6
Forest land	870	5.7
Total	**15,318**	**100**

Source: Field survey 2003

The major crops grown in the watershed are paddy, maize, potato, sugarcane, lentils, and different types of leguminous crops. Nearly 47% of all the crops grown in the watershed are grown in areas susceptible to floods and other water-induced disasters. Among the crops grown barley, soybeans, red gram, and other leguminous crops are highly exposed to natural hazards. Similarly, more than 55% of all the vegetables and spices grown in the watershed are grown in hazard-prone areas. Mangoes, jackfruit, bananas, papaya, pineapples, litchis, guava, and lemon are the main fruits produced in the watershed; nearly 47% of the fruit is produced in hazard-prone areas.

Nineteen thousand nine hundred and four houses, 6,589 sheds, 72 schools, 105 other public buildings, 157 rice mills, 85 temples, and 235 ponds are located in areas susceptible to floods and other types of water-induced disaster in the Ratu Watershed.

Vulnerability

Exposure of households and property

Hazard-prone areas were classified into three groups based on the level of hazard, high, medium, and low. Rating was carried out by local people based on their experiences and their perception regarding the level of danger from floods and other water-induced disasters. The level of vulnerability to hazards has been classified into four categories – very high, high, moderate, and low – on the basis of the magnitude of household property located in areas susceptible to floods and other water-induced disasters. Table 3.9 shows the percentage of households with different levels of vulnerability to different levels of hazard in the Ratu Watershed. Thirty-two thousand five hundred and ninety-three households, 61.1% of the households in the watershed, are living or have property in areas susceptible to floods. Out of these exposed households, 15,514 households (47.6%) have property in a high-hazard zone, 11,929 households (36.6%) in a medium-hazard zone, and 5,150 households (15.8%) in a low-hazard zone. The number of households having houses and above 50% of their property in a high-hazard zone is 6,845 (21%). These households are the most vulnerable from the point of view of exposure. Similarly, the number of moderately to highly vulnerable households with a considerable proportion of property located in a high-hazard zone is 5,639 (17.3%).

Table 3.9: Percentage of households with different levels of vulnerability					
Level of vulnerability	Household possessions in flood prone areas	Level of hazard			
		High	Medium	Low	Total
Very high	House and above 50% of property	21.0	11.9	4.6	37.5
High	House and property 50% and less	12.7	9.7	3.6	26
Moderate	House above 50% of property	4.6	3.7	2.3	10.6
Low	House but 50% or less of property	9.3	11.3	5.3	25.9
Total		**48**	**37**	**16**	**100**

Note: Total figures are rounded to the nearest whole number.
Source: Field survey 2003

Types of houses exposed to hazards

The roofs of nearly 50% of houses, including sheds owned by the surveyed households, are made of 'khapada/jhingati' (leaves or straw). About 51% of the houses have roofs made of tiles (typical brick). Houses with concrete roofs account for less than 1%. The walls of more than 76% of the houses are made of mud and bricks; about 8% of the houses have walls made of 'tati' (bamboo) and hay; and about 12% of the houses have wooden walls. About 82% of the houses are one storey. Many people are poor and cannot afford to build concrete houses strong enough to resist even the stress from sheet flooding or inundation.

Occupation and sources of income of exposed households

Fifty-eight per cent of the population (15-59 years) is economically active, while 42% is dependent(<15 and above 60 years). Agriculture is the mainstay of 60% of the economically-active people living in flood-prone areas. About 27% of the people are students and the rest are mainly engaged in service (5%), wage labour (3%), and jobs outside Nepal mainly in India and the Middle East (3%). Engagement in trade and business and others only account for about 2%.

More than 46% of total household income in flood-prone areas is from agriculture; this includes horticultural products, vegetables, and livestock. The other major sources of income in the flood-prone areas are service occupations (19%), remittances (13%), trade and business (8%), and wage labour (8%). The income from agricultural sources is highly susceptible to damage from floods and other water-induced disasters. Property equivalent to 8% of total income is lost to floods every year, a very high figure. People have to invest a portion of their incomes to reclaim the land and reconstruct infrastructure. Thus, floods and disaster affect people's livelihoods.

Crop productivity and food sufficiency in the flood-prone area

The main crops grown by households sampled in flood-prone areas are paddy, wheat, maize, sugarcane, pulses, and potato (Table 3.10). More than 80% of the cropped area and the production of paddy, wheat, maize, millet, potatoes, and lentils are from flood-prone areas. Though the productivity of the main crops (paddy, wheat, and maize) is below the national average, at 2,700, 1,900, and 1,800t/ha, respectively, in the watershed, the productivity of paddy in the hazard-prone area is comparatively high at 2,156t/ha in the flood-prone area compared

Table 3.10: **Area, production, and yield in the hazard-prone area**

	Within hazard-prone area			Outside hazard-prone area			% within	
	Area (ha)	Production (t)	Yield (t/ha)	Area (ha)	Production (MT)	Yield (t/ha)	Area	Production
Paddy	98	211,292	2,156	20	37,910	1,896	83	85
Wheat	39	48,652	1,247	8	10,530	1,316	83	82
Maize	17	22,710	1,336	3	3,617	1,206	85	86
Sugarcane	15	619,500	41,300	10	707,200	70,720	60	47
Millet	4	2,696	674	0	0	0	100	100
Pulses	12	8,869	739	4	3,535	884	75	72
Potato	7	39,710	5,673	1	4,615	4,615	88	90
Lentil	1	402	402	0	0	0	100	100

Source: Household survey 2003

to 1,896t/ha outside. Low productivity of main crops in this area compared to the national average implies the population's poor capacity to respond to natural disaster.

About 52% of households do not have sufficient food from their own production (Figure 3.3). This clearly suggests that people are highly vulnerable to flood hazards and their capacity to respond, in general, is very low.

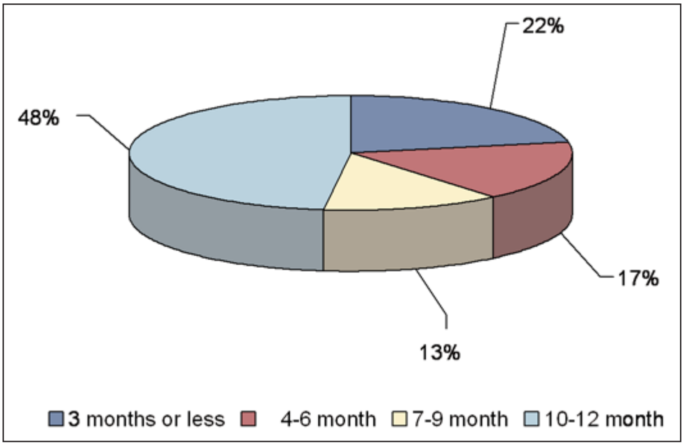

Figure 3.3: **Households with food sufficiency**

Past mitigation and management efforts

Different strategies have been adopted locally by people at individual and community levels to reduce the impact of floods and other water-induced disasters in the Ratu Watershed. During group discussions, it was revealed that emergency and mitigation measures had been implemented in 78 different locations.

Emergency measures

Emergency measures are the most common form of relief response for flood victims. Emergency measures include evacuation and provision of food supplies, tents for shelter, utensils, medicine, and cash. From local sources, it was learned that a total of Rs 4,196,700 had been spent on various emergency measures between 1984 and 2002. This totals an annual investment of Rs 233,150 per year in emergency measures. Out of this amount, the amount spent on food and evacuation was about 49% and 20%, respectively. About 18% was provided as cash to the victims: about 9% was given for the purchase of essential clothing. Money spent on tents and medicine accounted for only 1% (Figure 3.4). The key agencies involved in emergency response are the Nepal Red Cross Society, the District Development Committee (DDC), the Chief District Officer's (CDO's) office, and the Soil Conservation Office, which contributed about 35, 27, 16, and 9%, respectively. Other minor sources of emergency funding are the political parties (2%), the Parliamentary member's fund (1%), and others (10%). However, people still complain that emergency services are inadequate and often lack transparency and equitable distribution.

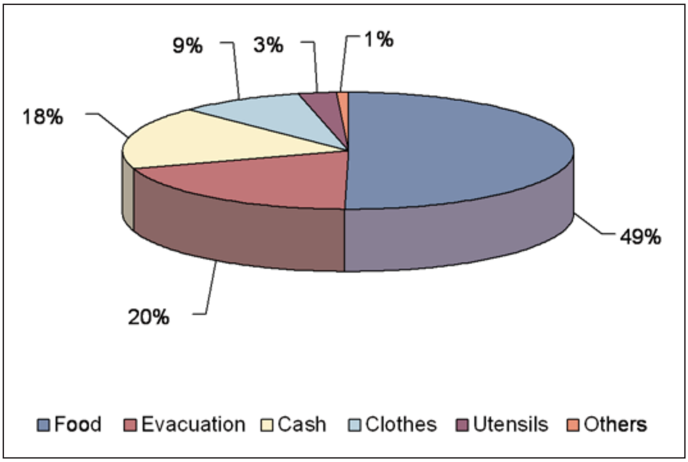

Figure 3.4: **Money spent on various emergency measures**

Flood-mitigation measures

Flood mitigation measures include construction of dams, spurs, retaining walls, plantation and afforestation, and drainage management. During group discussions, it was estimated that about NRs 1.5 million was spent annually on these activities in the watershed. Large sums are spent on the construction and maintenance of retaining/gabion walls, check dams, and spurs (92%). About 5% of the total amount is spent on the construction of dams and retaining walls from local materials and with traditional technology. About 3% of the money for mitigation was spent on plantation and afforestation activities, which are less costly but effective in reducing flood impacts in the long run. The intrusion into natural drainage by the indiscreet construction of bridges, roads, culverts, houses, and other infrastructure without provision of proper drainage has exacerbated the inundation problem recently; and yet a very negligible amount is spent on drainage management. The government and non-government agencies, apart from the local community, involved in mitigation measures are the DDC, VDC, the Water Induced Disaster Prevention Office, Soil Conservation Office, and District Irrigation Office among government agencies; and the Nepal Red Cross Society, a non-government organisation, which has been contributing money for flood-mitigation measures (Figure 3.5). The Churia Watershed Conservation Project, in coordination with the District Soil Conservation and the District Forest Office, has been engaged in watershed management through activities like afforestation and micro-watershed management through erosion and gully controls in the upper catchments.

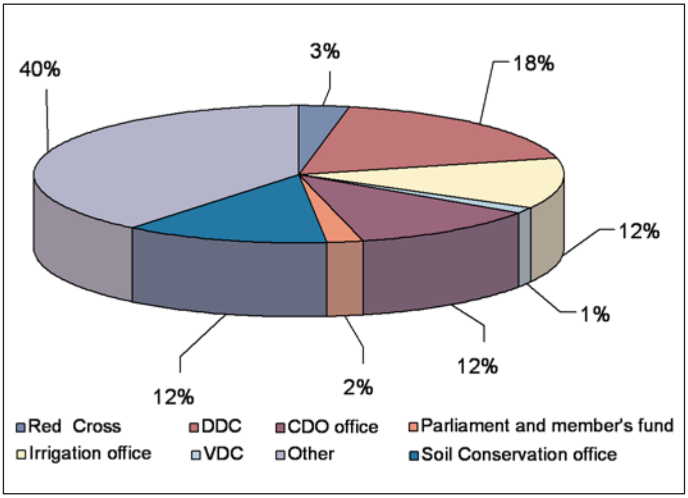

Figure 3.5: **Contributions made by various agencies/institutions for mitigation measures**

Proposed future activities

People have perceived that a fragile basin, heavy and prolonged rain during the monsoon, unstable rivers, growing human occupancy and activities, and development of infrastructure without due consideration for proper drainage are the main causes of increased flood disasters in the area. They have put forward some long-term and short-term flood mitigation proposals for the watershed. The long-term measures include six major components: i) river control through permanent structures such as check dams; afforestation along the river banks and cleaning of the river bed to increase the discharge capacity of the channel; ii) drainage management; iii) conservation of the Churia area through guided human activities; iv) awareness creation; v) improvement in livelihoods through increase in irrigation facilities and providing loans for off-farm employment opportunities; and vi) strengthening local institutions for disaster mitigation. The timely and effective short-term measures recommended by the local people include: i) evacuation of flood-affected people and their portable property; ii) timely provision of tents, food, clothes, utensils, and medicine in a fair and equitable manner; iii) a food for work scheme for the flood victims; iv) provision of shelter with service facilities like drinking water, toilets, and so on in safe localities for the refuge of victims until they can renovate, rehabilitate, or reconstruct their own houses; v) provision of seeds and fertiliser to the victims; and vi) promotion of a rotational fund and a feasible insurance scheme for people living in areas susceptible to flood hazards.

Table 3.11: Estimated cost of proposed emergency measures (million Rs)				
Types of activity	Estimated total cost	Local contribution	Expected outside contribution	% of local contribution
Evacuation	182.14	1.83	180.31	1.0
Food	15.14	0.46	14.68	3.0
Clothes	5.82	0.37	5.45	6.4
Tents	0.77	0.03	0.74	3.3
Cash	4.43	0.24	4.19	5.4
Medicine	1.86	0.06	1.80	3.3
Utensils	0.05	0.00	0.05	0.0
Others	35.56	0.00	35.56	0.0
Total	**246.00**	**3.00**	**243.00**	**1.2**

Source: Field survey 2003

For the measures recommended above, people are willing to contribute some of the money needed for the measures recommended. Of the total estimates for the implementation of emergency measures, people are willing to contribute about 5% to all types of emergency response. On average, they can contribute about 1.2% of the total estimated cost (Table 3.11).

Construction and maintenance of gabion walls, spurs and embankments, drainage management, control of the river course, and plantation were perceived as priority activities for physical mitigation measures. However, the contribution expected from local people to implement these measures is very low, i.e., 2.2% (Table 3.12). People are only willing to contribute substantially for plantation and construction of a traditional retaining wall with mud embankments.

Building community resilience

A preparedness plan to reduce the impact of flood disasters has not yet been developed. Keeping in mind the recommendations made during the workshop organised to disseminate and discuss the findings of the first phase, an attempt was made to develop and test the methodology for delineation of safe areas for evacuation routes and shelters downstream and to strengthen local capacity to establish an early warning system through training. This training focused on reading precipitation and river discharge gauges in the upstream area.

Table 3.12: Estimated cost of proposed mitigation measures (Million Rs)				
Type of activity	Estimated total cost	Local contribution	Expected outside contribution	% of local contribution
Retaining/gabion wall	429.40	15.14	414.27	3.5
Embankment construction and maintenance	567.90	10.06	557.84	1.8
Plantation/afforestation	2.10	0.33	1.77	15.8
Retaining wall with mud embankment	0.80	0.20	0.60	25.0
Drainage management	193.25	0.77	192.48	0.4
Total	**1193**	**27**	**1167**	**2.0**

Note: Totals have been rounded to the nearest whole number.
Source: Field survey 2003

A short training programme was organised in the Bahunmara area. A rain gauge for monitoring intense rainfall was installed in a primary school, to be used to warn the downstream areas prone to flooding. Teachers and students were trained how to read the rain gauge and record precipitation.

Safe areas for evacuation route and shelter in the downstream area at Jaleshwar municipality and its adjoining areas were delineated for different discharge rates. Ratu Khola is not gauged; the discharge was simulated in response to measurement of 24 hours' rainfall using the TANK model. Flood events with discharges of 160 m^3/s, 180 m^3/s, 507.52 m^3/s, and 1,016.37 m^3/s were used for delineation of the floodplain. The figures were subjectively chosen in order to show degrees of flood hazard. The rainfall events producing these flood events during different months are summarised in Table 3.13.

Table 3.13: **Rainfall events (mm) producing flood events (m^3/s)**

Month	Regression equations	Flood m^3/s	160	180	507.52	1016.37
June	$y = 377.72Ln(x) - 1039$	Rainfall mm	23.91	25.21	60.00	230.79
July	$y = 342.3Ln(x) - 974.94$		27.54	29.20	76.00	336.11
Aug.	$y = 42.314x^{0.5516}$		11.15	13.80	90.40	318.36
Sept.	$y = -0.0266x^2 + 11.464x - 163.82$		30.39	32.43	69.90	170.00

In order to visualise the flood hazard in terms of water depth, maps were prepared by reclassifying flood-area grids into flood-depth polygons bounding the water depth at intervals of 0.15-0.5, 0.5-1.0, 1.0-2.0, 2.0-3.0, 3.0-4.0, 4.0- 5.0, 5.0-6.0, 6.0-7.0, 7.0-8.0, and 8.0-9.0 m. The areas bounded by flood polygons were calculated to make an assessment of the flood-hazard level. The results of this assessment are summarised in Figures 3.6 and 3.7.

Total area flooded in the Ratu Watershed with a two-year return period is estimated to be 35.2 sq. km and it is 39.9 sq. km for a 100-year flood. The classification of flood depth areas indicates that less than 9.34% of the flooded areas have water depths of less than 0.15m for a two-year flood and 5.43% for a 100-year flood. Most of the areas flooded (about 73%) have water depths of less

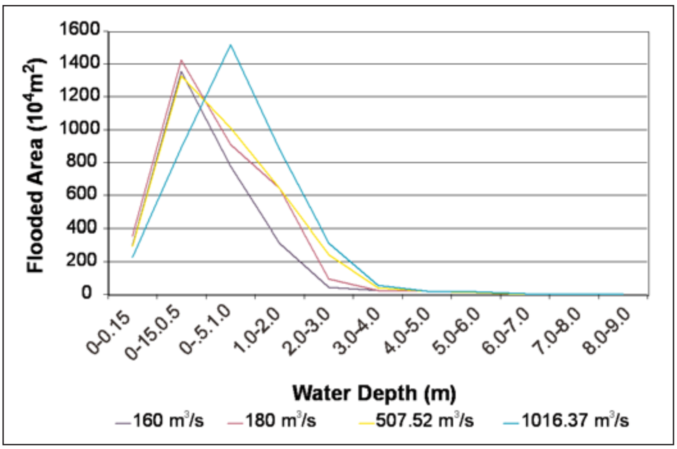

Figure 3.6: **Flooded area versus water depth for different flood discharges**

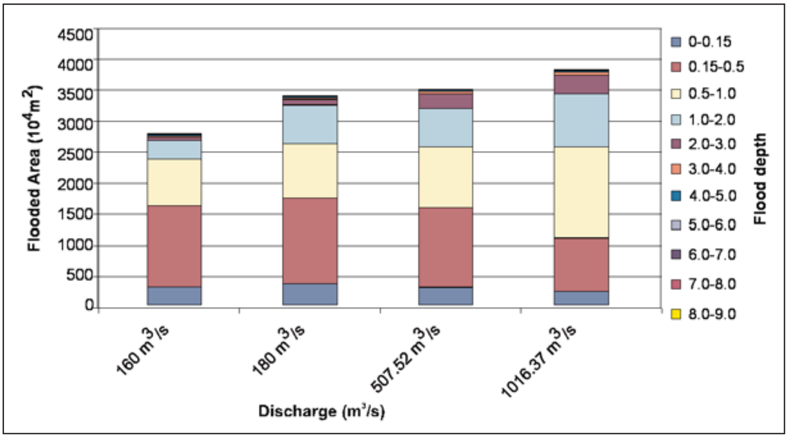

Figure 3.7: **Discharge, flooded depth, and area**

than 1m for a two-year flood and 65% for a 100-year flood. The areas under a water depth of more than 2m are quite small, although the area increases considerably with an increase in the intensity of flooding.

This analysis shows that a flood event of 160m³/s does not inundate the settlement of the study area. Floods of this size are responses to rainfall of 23.91 mm, 27.54 mm, 11.15 mm, and 30.39 mm for the months of June, July, August, and September, respectively. Flood events of 180m³/s inundate the settlement of the study area. The flood event of 180m³/s is the response to the rainfall of 25.21 mm, 29.20 mm, 13.80 mm, and 32.43 mm for the months of June, July, August, and September, respectively. Hence the study area should be warned if the daily rainfall events exceed the value of 23.91 mm, 27.54 mm, 11.15 mm, and 30.39 mm for the months June, July, August, and September, respectively.

Evacuation routes leading to shelter areas for people and their livestock from the flooded zone are traced out on the hazard map following the land with minimum inundation depth. As little as 15 cm of moving water can knock people off their feet (as per FEMA [1995a] recommendation), evacuation must be completed before water levels along the route exceed 15 cm. The routes and the distance to the shelter areas for different localities are summarised in Table 3.14. The campus areas in Jaleshwar, Bakharibhath, and Bela and the western and eastern parts of Bajrahi, Ramaul, and Ratwada have been identified as safe areas for emergency shelter. The levée and road mark the evacuation route for Bela, whereas for other localities only the road network marks the routes.

Besides the small area of Jaleshwar Bazaar, no shelter area is without flooding. Although maximum inundation (up to 2.14 m for a two-year flood) takes place in Bakharibhath, Bela seems the most seriously affected as it floods up to 1.87 m (two-year flood) and evacuation primarily has to follow the levee which may be breached during the period. Evacuation routes for different discharge conditions are shown in Figures 3.8-3.11.

A stakeholders' meeting was organised to disseminate and discuss the results of the mapping exercise to identify safe areas for evacuation routes and shelter. The

Table 3.14: **Classification of relief routes, distance, and shelter areas for different localities**			
Locality	**Relief route**	**Distance (km)**	**Shelter**
Bakharibhath	Road	1.74	Campus
Bela	Levee and Road	2.892	Campus
Bajarahi (East)	Road	-	Bajarahi (East)
Bajarahi (West)	Road	0.338	Bajarahi (East)
Campus Area	Road	-	Campus
Jaleshwar (Bazaar)	Road	-	Jaleshwar (Bazaar)
Jaleshwar (North-East)	Road	0.400	Jaleshwar (Bazaar)
Jaleshwar (West)	Road	0.668	Jaleshwar (Bazaar)
Ramaul	Road	0.915	Bajarahi (East)
Ratwada	Road	-	Ratwada

meeting was attended by 22 participants representing institutions such as Jaleshwar municipality, CPN-UML (Communist Party – United Marxist Leninist), Nepali Congress (D), Nepali Congress, District Development Committee (DDC), the Water Induced Disaster Prevention Office and local leaders and ordinary people from the study sites. During the discussion, many participants highlighted the need for such scientific work in the context of increased flood hazards constraining development activities in Jaleshwar municipality and appreciated the work carried out in the context of it being the first scientific attempt to delineate such areas. However, some participants pointed out that the areas identified as safe sites for shelter are also inundated at depths up to 60 cm during the rainy period and could not be used for evacuation. It was also suggested that these maps could be improved with a dense network of topographical survey points and by involving local people in the survey. Some participants pointed out that almost all the areas are inundated during rainy periods. Hence it is not possible to find a safe area for an evacuation route. Alternatively, boats could be used to rescue people from the inundation zone. It was also recommended that discharge monitoring sites be established along the Ratu Khola and that a siren system be established in the upstream area near Bardibas to warn the community of impending emergency.

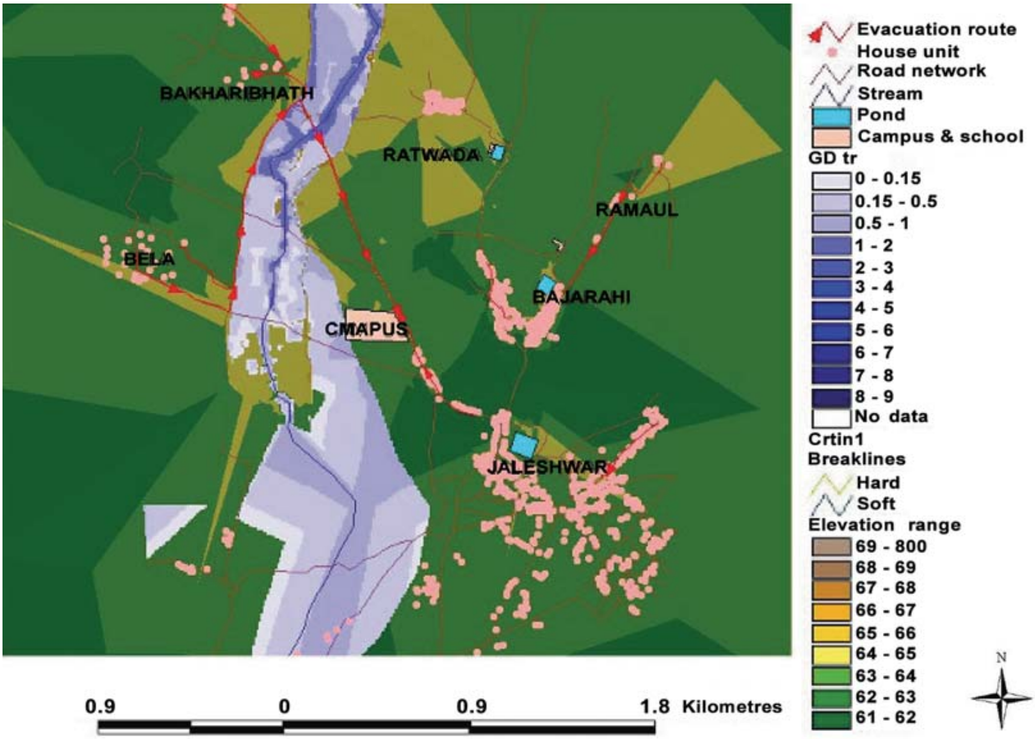

Figure 3.8: **Evacuation route on hazard map for 160m³/s discharge**

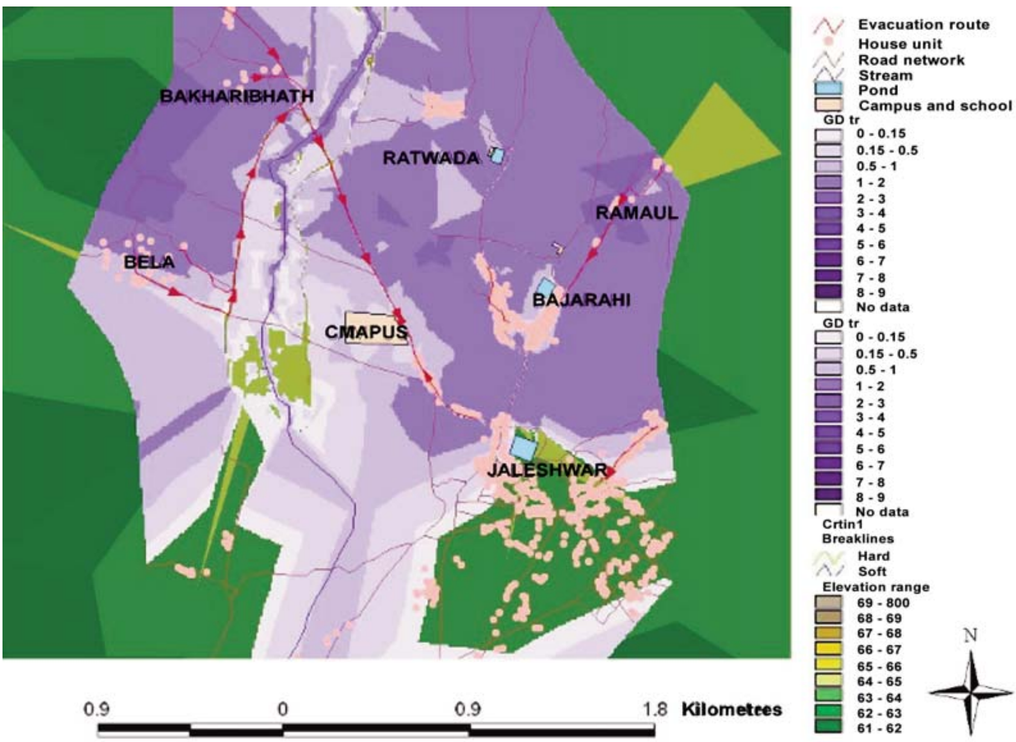

Figure 3.9: **Evacuation route on hazard map for 180m³/s discharge**

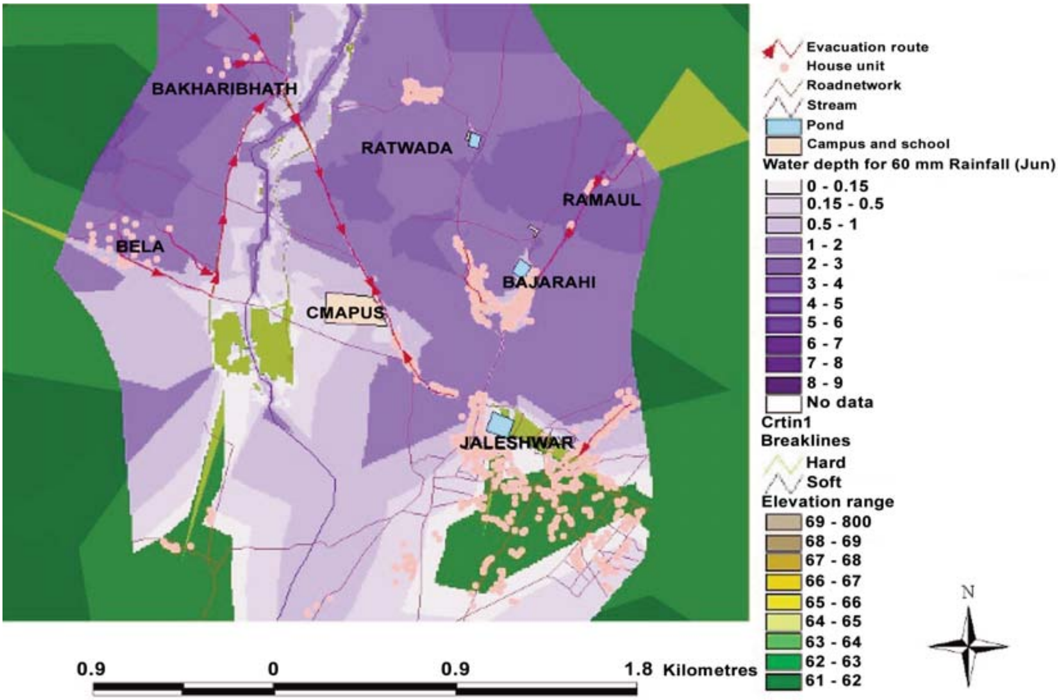

Figure 3.10: **Evacuation route on hazard map for 507.52m³/s discharge**

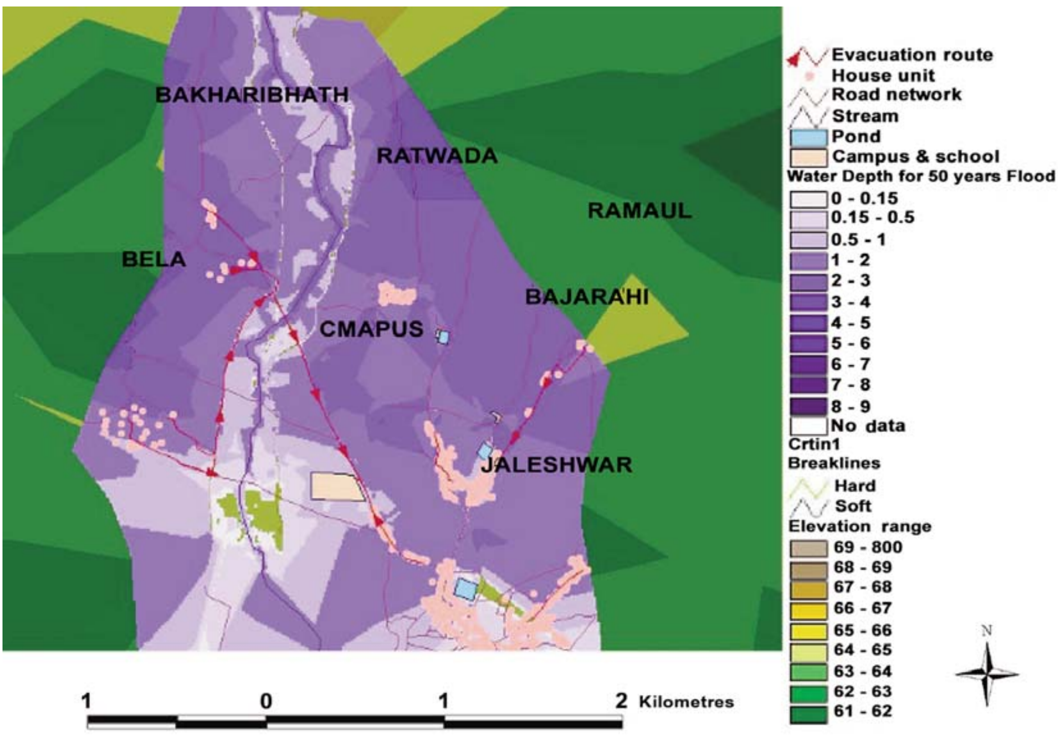

Figure 3.11: **Evacuation route on hazard map for 1016.37m³/s discharge**