Pakistan Economic and Social Review
Volume XXXIX, No. 1 (Summer 2001), pp. 57-74

IMPACT OF LANDSLIDE HAZARDS ON HOUSING AND RELATED SOCIO-ECONOMIC CHARACTERISTICS IN MURREE (PAKISTAN)

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Abstract. Murree, called "the queen of the hills" by the people lovingly, is one of the worst slide-affected area of Pakistan. The problem of landslide hazards in Murree, therefore, has been a cause of great concern for the safety of people and their properties since the earliest times. The paper reveals the delicate difference between slide-proneness and vulnerability. It explains that to be prone is to be threatened, whereas to be vulnerable is to be weak and at the same time threatened. This paper analyzes the extent and nature of the increasing adverse effects of landslides on housing in relation to the elements of socio-economic characteristics of the households. The main objective of this analysis is to draw inferences and establish the relationship of vulnerability of the households to the adverse effects of landslides.

The paper sets out to introduce the town and its landslide problem. After presenting methodology adopted the paper goes on to examine the extent of the adverse effects of landslides on housing, including the degree of damage to housing and the spendings on recurrent slide-related damage in relation to the elements of socio-economic characteristics of the households. The evidence discussed in the paper revealed that the socio-economic factors play a very important role in the vulnerability of households to the adverse effects of landslides.

I. INTRODUCTION

Like many other developing countries]! Pakistan has been frequently subject to a variety of natural hazards. Apart from the vast alluvial Indus plains, where people are mostly vulnerable to devastating floods, waterlogging and related hazards, a major part of the country is mountainous which is gemorphologically active and where people, their houses and other properties are vulnerable to natural hazards of various types like earthquake,

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mass movements, landslides, flash floods and several others. However, of all these hazards the landslides and related failure processes are the most damaging to the work of man because they are an ever-present and frequent danger for the people and their property in the area.

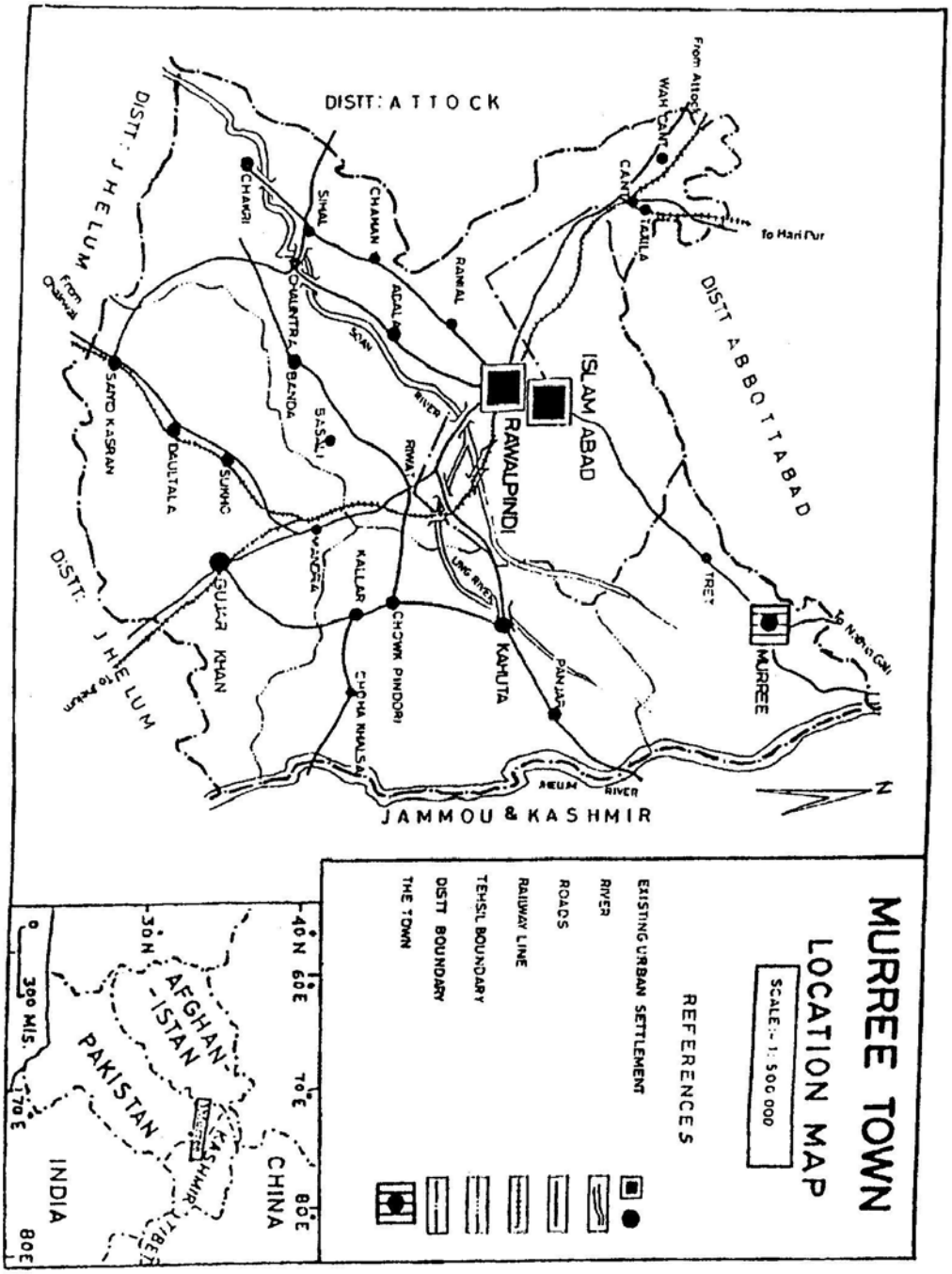
Murree, the most easily accessible hill station and sanatorium of Pakistan (Figure 1), is one of the worst slide-affected areas of Pakistan (Pearce, 1987). It is based on a relatively young and gemorphologically fragile rocks of the Himalayas, with hard gray to reddish sandstone predominantly interbedded with the soft and purple red calcareous shales. These rocks have the highest tendency towards landslides and related phenomena, especially in the presence of high precipitation (Pearce, 1987; Khan, 1992*a* and 1994).

Murree is lying in the sub-Himalayan mountains at an elevation of about 5000 to 7500 feet above sea level. The main town of Murree is actually built on a lateral spur of the Himalayas. This spur stretches at right angles to the plains with general direction from north-east to south-west. Flanked on either side by parallel lines of hills this spur forms the watershed between the Indus and the Jhelum River. The extremities of the spur are known as Pindi Point (7266 feet) and Kashmir Point (7507 feet). It spreads along a narrow ridge of about 4 km long, which at places is only half a kilometre or so in width. The greatest height of Murree (7517 feet) is attained by an eminence between the two extremities. Beyond Kashmir point the Murree spur sinks abruptly and branches off into the hills of Topa to the east and Kuldana to the west. The Murree ridge has a comparatively gentle slope on its north-west side which is covered with a dense forest of chestnut and pine trees. The valley below is deep and irregular. On the other hand, the eastern side of the ridge is steeper and comparatively bare of trees. The valley downward is wide and open, comparatively rich in cultivation and dotted with settlements (Khan, 1992*a* and 1992*b*).

The climate of Murree is of temperate type. Murree experiences cool and mild summers and cold winters. June is the hottest month of the year with mean maximum and minimum temperature of 80°F and 58°F respectively. January and February are the coldest months with mean maximum temperature of 43.4°F and mean minimum temperature of 31.1°F. Murree receives the highest amount of rainfall in Pakistan averaging 66 inches with mean annual number of rainy days of 85. The wettest month of the year is July receiving 15 inches of rain with average number of 15 rainy days (Master Plan Murree Town, 1988; Rabbani, 1986). Murree is famous

FIGURE 1

Location Map of Murree Town



for its snowfall. Snowfall is generally expected by the end of December and it goes intermittently till the end of February. At this season the ground is covered by 5 to 6 feet of snow. Most of the snow melts away rapidly except at some heights on northern aspects. At the time of the year when the hills are blanketed with snow, the wooded side of the Murree ridge presents a magnificent view.

It has been observed that due to natural conditions, like immature geology and highest rainfall, the landslide hazards in Murree have been a cause of great concern for the safety of life and property since the earliest times (MHHPC, 1958; ABAD, 1981). However, these natural conditions in combination with easy accessibility, rapid growth of population and urban development have tremendously increased the likelihood and frequency as well as the adverse effects of landslides in the last three decades (Niederer and Schaffner, 1988; Niederer *et al.*, 1989; Khan, 1992*a*, 1993 and 1994). In Murree landslides adversely affect mankind by continuously disrupting roads and communication lines and damaging houses and other properties. This has seriously endangered people and their property in the area.

II. METHODOLOGY

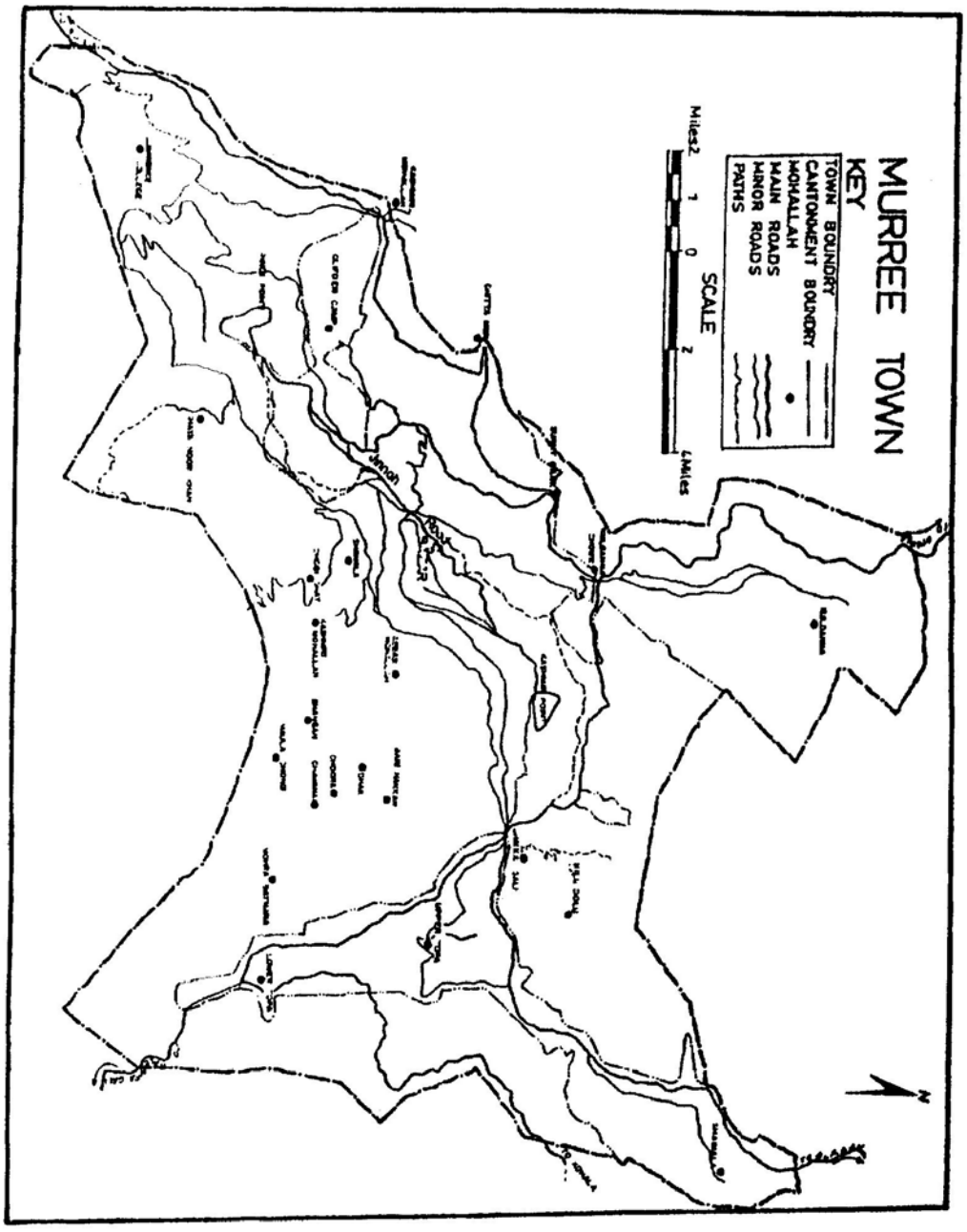
Data required by the study was obtained from primary source, based on a survey conducted among the households from end April to mid October 1990. The questionnaire survey was considered as most appropriate tool for collecting data necessary for the study. Ideally, the entire population of the area should have been interviewed. However, given the time and resources available, it was considered necessary to conduct a sample household survey (Khan, 1992*a* and 1994). Although Murree town is divided into different wards for electoral purposes, ward-wise division is very awkward and politically biased. Therefore, the city was divided into three areas based on environmental characteristics, *i.e.* urbanization, location and people's occupation etc. These areas were named as (*i*) inner city, (*ii*) urban fringe and (*iii*) rural fringe.

The inner city is the main center and commercial heart of the town where people are mainly involved in retail activities. It includes the Station Area and Kashmir Point. The urban fringe includes Chitta More, Kashmiri Mohallah near Bansra Gali, Dhobi Ghat, Abbasi Mohallah (Gharan) and Dhok Jabar Topa, where people are mainly involved in retail, contracting and some farming activities. The rural fringe is semi-urbanized and has influences of the rural environment. Also, with the exception of very few people involved in business and commercial activities in the town, the dominant occupation in the rural fringe is farming. It includes Hill Dholu,

Dhok Jabar, Dhak, Bari Nakkar, Bhangan, Choora, Chawana, Mohra Batnara, Maula Dohongi, Ihata Noor Khan and Murree Brewery (Figure 2).

FIGURE 2

Boundary of Murree Town



A ward-wise electoral list, obtained from the Municipal Committee and Cantonment Board was re-arranged into three different lists, according to the three environmental areas identified. From each of these three lists, every 10^{th} person was selected through systematic sampling with a random start (Bailey, 1987). Although it was presumed that every 10^{th} person in the list was a household head, in the case of the selected person not being a household head, the head of the household was interviewed instead. Samples were taken separately from each environmental area so as to include a proportionate percentage of households from each of them. In this way, 245 households amongst the permanent population were interviewed. The households were distributed among the three environmental areas as follows:

(*a*) Inner city 95

(*b*) Urban fringe 48

(*c*) Rural fringe 102

Data collected, and responses in the questionnaires, were summarized and coded. This coded information was entered into the computer file for the purpose of analysis, through the use of Statistical Package for Social Sciences (SPSS-X3), available at the Cripps Computing Centre, University of Nottingham, UK. Statistical analyses were carried out by using descriptive statistics, such as frequencies, percentages, means and contingency tables. Chi square test of independence was used for categorical data, as the hypothesis that two variables are independent of each other was often of interest in this study. The null hypothesis in all these cases was that the probability of a response/variable in a given column of the contingency table was the same for each cell in the column. A level of significance of 0.05 was generally required to reject the null hypothesis. To measure the strength of relationship between the variables Cramers's V and Gamma measures of correlation were used as relevant in some cases (Blalock, 1979; Bailey, 1987).

III. HOUSING AND LANDSLIDE DAMAGE

Damage to housing was considered to be the determining factor in the extent of the adverse effects of landslides. The study found that almost all houses in the area are slide-prone. It was also discovered that, of all the sectors, housing is the one which is by far the most seriously affected by landslide hazards. In response to the question, "Did landslide affect housing in the area?" all the respondents replied, "Yes". Analysis of responses to the question, "In what way did the landslides affect housing in the area?" revealed that households have full knowledge of how landslides have adversely

affected housing through a sequential manner. The respondents described in detail the process of impact of landslides on their houses. It was found that not all the landslides in the area are of a sudden nature, the majority of them are slow moving slides called 'soil creep'. Therefore, the impact of these landslides on housing and other properties in the area is slow and steady in nature. The first sign of slide impact on housing, according to the residents, appears in the form of small cracks and/or bulges in the walls and/or floor of the house. These cracks expand with time and ultimately lead to either the partial collapse or total destruction of houses, roads and other infrastructure.

HOUSEHOLDS AFFECTED BY LANDSLIDES

The survey revealed that three-quarters of the houses of the sample population have been affected by landslides. In response to the question, "Has landslide affected your house so far?" it was found that a total of 74.3% of the households were affected by landslides (Table 1). Analysis disclosed that among the total of 182 affected households, 38.5% belonged to the inner city, 17% were from urban fringe, whereas 44.5% were living in the rural fringe. When these 63 households, whose houses have not been affected so far (Table 1), were asked "Do you expect any damage to your house in future?" more than half (54%) among them replied, "Yes", 25.4% said "No", whereas 20.6% were not sure about the future damage (Table 2). All this indicates that the dominant majority of the households have already been adversely affected. The effects also seem to be more severe in the rural fringe, followed by the inner city, while in the urban fringe the effects appear to be felt comparatively slowly. Furthermore, a dominant number of households who have not been affected so far also did not feel safe from the adverse effects in the near future.

TABLE 1

Slide-Affected Houses by Environmental Areas

Responses	Environmental Area						Total	
	Inner City		Urban Fringe		Rural Fringe			
	No.	%	No.	%	No.	%	No.	%
Affected	70	73.7	31	64.6	81	79.4	182	74.3
Not affected	25	26.3	17	35.4	21	20.6	36	25.7
Total	95	100.0	48	100.0	102	100.0	245	100.0

SOURCE: *Field Survey* (1990).

TABLE 2

Damage to Houses in Future

Responses	Frequency	
	Number	%
Yes	34	54.0
No	16	25.4
Don't know	13	20.6
Total	63	100.0

SOURCE: *Field Survey* (1990).

TABLE 3

Summary of Relationship of Slide Effects on Housing to Important Socio-Economic Factors

Households Socio-Economic Characteristics	Chi Square	D.F.	Significance	Correlation Coefficients*
Educational Level	1.23497	3	0.7446	0.07100
Major Occupation	6.00162	3	0.1115	0.14651
Income Level	5.06657	3	0.1670	0.14380

*Cramer's V correlation coefficient was used in all these cases. None of these was found significant.

SOURCE: *Field Survey* (1990).

In order to examine if there was any association between the effects of slides on housing and socio-economic characteristics of households, the Chi square test of independence was done. These tests confirmed that the effects of slides on housing had no significant association with important socio-economic characteristics, like education level and occupation of the household heads and income level of households. Therefore, the null hypotheses of no association in all these cases were accepted. This has meant that households with high and low socio-economic status are equally prone to landslide hazards. Even when Cramer's V coefficient of correlation was tested, it was found that correlation was also insignificant in all cases (0.1). A summary of the analysis of both the significance levels of Chi square test and correlation is illustrated in Table 3. It can, therefore, be concluded that

every household in Murree regardless of their socio-economic characteristics is threatened and slide-prone.

DEGREE OF DAMAGE TO HOUSING

Among the affected households, houses of 11.5% (20 houses) had totally collapsed. This meant that 8.6% of the total sample population has suffered serious damage leading to the collapse of their houses. When the concerned respondents were asked to give details of the slide damage to their houses a multiple response answer (upto three) was given by them, making a total of 451 responses as shown in Table 4. Table 4 shows that all the affected 182 respondents (making 40.4% of the total responses) made the point that due to the seasonal recurrence of slides, they get many minor types of damage to their houses every year. Therefore, they repair their damage annually. It is due to this factor that after each monsoon period (summer season) repair of damage to houses has become a regular feature for the residents. Many of the respondents specified the problems for their houses. Prominent among these (25.7%) were cracks and bulges in the walls of rooms or courtyards. A further 14.6% responses were about floor-sinking, 11.5% related to partial collapse, such as damage to wall or roof of a room in the houses, 4.4% were about the total collapse of houses. There were also a few responses (3.3%) about the seepage of water in the houses. These responses came mainly from the Station Area, *i.e.* households of the Lower Bazaar and Shawala.

Apart from the repair of houses each year, all the other responses regarding degree of damage to the houses were further analyzed for various areas of the city (Table 5). It is evident from the data that cases of serious damage, like total and partial collapse of houses, are more common in the rural fringe as compared to other parts of the city. Among the 20 households whose houses were totally collapsed, 50% belonged to rural fringe, 15% to urban fringe and 35% to the inner city. Similarly, among the total of 52 respondents who suffered partial collapse due to slides, 55.8% were from rural fringe, 15.4% from urban fringe and 28.4% from the inner city. Therefore, the major trend shows that as one goes out from the inner city towards the urban fringe, slide damage decreases, but again damage escalates towards the rural fringe of the city.

This study examines the data for various types of damage to housing, as mentioned elsewhere (Khan, 1994), with the socio-economic factors, like education level and occupation of the household heads and income level of the households. Looking at the degree of slide-related housing damage in relation to the educational level of the household heads as shown in Table 6,

TABLE 4

Households Responses for Damage to Their Houses

Responses	Frequency	
	Number	%
Repair every year	182	40.4
Cracks and bulges	116	25.7
Floor-sinking	66	14.6
Partial collapse	52	11.5
Total collapse	20	4.4
Seepage from the floor	15	3.3
Total	451	100.0

SOURCE: *Field Survey* (1990).

TABLE 5

Degree of Slide-Related Housing Damage by Area of Residence

Degree of Damage	Environmental Area						Total	
	Inner City		Urban Fringe		Rural Fringe			
	No.	%	No.	%	No.	%	No.	%
Total Collapse	7	35.0	3	15.0	10	50.0	20	7.4
Partial Collapse	15	28.8	8	15.4	29	55.8	52	19.3
Cracks/Bulges	20	43.1	21	18.1	45	38.7	116	43.1
Floor-sinking	26	39.4	11	16.7	29	43.9	66	24.6
Floor seepage	11	73.3	1	6.7	3	20.0	15	5.6
Total Responses							269	100.0

SOURCE: *Field Survey* (1990).

TABLE 6

Degree of Slide Damage by Education Level of Household Heads

Detail of Landslide Damage to Housing	Household Heads Education Level								Total	
	No Education		Primary/ Middle		Matric/ Inter		Degree			
	No.	%	No.	%	No.	%	No.	%	No.	%
Total Collapse	7	35.0	7	35.0	4	20.0	2	10.0	20	7.4
Partial Collapse	21	40.4	14	26.9	12	23.1	5	9.6	52	19.3
Cracks/ Bulges	39	33.6	35	30.2	30	25.9	12	10.3	116	43.1
Floor-sinking	16	24.2	26	39.4	16	24.2	8	12.1	66	24.6
Floor seepage	4	26.7	6	40.0	2	13.3	3	20.0	15	5.6
Total Responses									269	100.0

SOURCE: *Field Survey* (1990).

TABLE 7

Degree of Slide-Related Housing Damage by Major Occupation

Detail of Landslide Damage to Housing	Major Occupations								Total	
	I*		II		III		IV			
	No.	%	No.	%	No.	%	No.	%	No.	%
Total Collapse	5	25.0	1	5.0	3	15.0	11	55.0	20	7.4
Partial Collapse	18	34.6	12	23.1	–	–	22	42.3	52	19.3
Cracks/ Bulges	28	24.1	14	12.1	3	2.6	71	61.2	116	43.1
Floor-sinking	13	19.7	13	19.7	4	6.1	36	54.5	66	24.6
Floor seepage	4	26.7	2	13.3	1	6.7	8	53.3	15	5.6
Total Responses									269	100.0

*I = Informal sector including farming and casual labourers.
II = Formal sector including teaching, clerical jobs and non-clerical services.
III = Retired servants.
IV = Businessmen including contractors, hoteliers and other small and large scale retail or wholesale traders.

SOURCE: *Field Survey* (1990).

it was found that most of the serious types of damage, like total and partial collapse of houses, occurred to the households whose heads were illiterate or with a low level of education. They were also the households more likely to have a low income. Among the group with either no education or low level (primary/middle) of education, 70% had suffered total collapse of houses due to landslides. Similarly, as high as 67.3% of households who suffered partial collapse had household heads with no education or only primary and middle level education. While looking at the degree of slide damage in relation to the household heads occupation (Table 7), it is evident that majority of the households with serious damages, like total destruction and partial collapse of houses, are either farmers and casual labourers in the informal sector or small scale self-employed businessmen with corner shops in the rural fringe and wheelbarrow holders or stall traders selling cooked food at some strategic points in the inner city. Like education and major occupation, the damage suffered was also related to the income level of the households (Table 8). It was found that 90% of those who suffered total collapse and 73.1% among the group who suffered partial collapse of their houses, were from the lower and lower-middle income level. It can, therefore, be concluded that unlike slide-proneness, vulnerability of households to the landslide damage coincides to a great extent with their education level, occupation and income level. It indicates the importance of these socio-economic factors in any attempt by the government to effectively reduce the adverse effects of landslides on housing.

HOUSEHOLD'S SPENDING ON SLIDE-RELATED DAMAGE

Due to the recurrent nature of landslides repair of slide damages is a regular feature of Murree. Hence, households have to spend a considerable proportion of their earnings on slide-related housing damages. The effected households were, therefore, asked about their spending on slide-related housing damage. In response to the question, "How much of your annual income do you spend on slide-related damage to your house?" it was found that 41.8% of the households spend over half of their annual income on slide-related damages, 34.1% households spend up to a quarter, whereas 24,1% respondents spend between 26 and 50% of their income (Table 9).

The analysis revealed that the percentage of a household's annual income spent on landslide damage had a significant association with the important socio-economic characteristics, like education and occupation of the household head and income level of the household. Looking at the percentage of spending on slide-related damage with education level, it was found that a majority (66.1%) among those with no formal education were

TABLE 8

Degree of Slide-Related Housing Damage by Households Income Level

Detail of Landslide Damage to Housing	Households Income Level								Total	
	I*		II		III		IV			
	No.	%	No.	%	No.	%	No.	%	No.	%
Total Collapse	8	40.0	10	50.0	2	10.0	–	–	20	7.4
Partial Collapse	21	40.4	17	32.7	12	23.1	2	3.8	52	19.3
Cracks/ Bulges	32	27.6	51	44.0	29	25.0	4	3.4	116	43.1
Floor-sinking	20	30.3	26	39.4	17	25.8	3	4.5	66	24.6
Floor seepage	5	33.3	3	20.0	6	40.0	1	6.7	15	5.6
Total Responses									269	100.0

*I = Lower Income Group
II = Lower-Middle Income Group
III = Upper-Middle Income Group
IV = Upper Income Group

SOURCE: *Field Survey* (1990).

TABLE 9

Households Spending on Slide-Related Housing Damage

Spending on House Damage (% of Annual Income)	Frequency	
	Number	%
Up t 10%	16	8.8
11 to 25%	46	25.3
26 to 35%	31	17.0
36 to 50%	13	7.1
More than 50%	76	41.8
Total	451	100.0

SOURCE: *Field Survey* (1990).

TABLE 10

Spending on Slide-Related Housing Damage by Education Level Attained

Spending on Housing Damage (% Income)	Household Heads Education Level								Total	
	No Education		Primary/ Middle		Matric/ Inter		Degree			
	No.	%	No.	%	No.	%	No.	%	No.	%
Up to 25%	3	5.1	21	35.0	21	47.7	17	89.5	62	34.1
26 to 50%	17	28.8	14	23.3	12	27.3	1	5.3	44	24.1
Over 50%	39	66.1	25	41.7	11	25.0	1	5.3	76	41.1
Total	59	100.0	60	100.0	44	100.0	19	100.0	182	100.0

Chi square = 55.01580 Gamma = –0.57202
Significance = 0.0000 Significance = 0.0000
D.F. = 6

SOURCE: *Field Survey* (1990).

TABLE 11

Spending on Slide-Related Housing Damage by Major Occupation

Spending on Housing Damage (% Income)	Household Heads Major Occupations								Total	
	I*		II		III		IV			
	No.	%	No.	%	No.	%	No.	%	No.	%
Up to 25%	1	2.2	4	12.9	3	37.5	54	55.1	62	34.1
26 to 50%	12	26.7	10	32.3	3	37.5	19	19.4	44	24.1
Over 50%	32	71.1	17	54.8	2	25.0	25	25.5	76	41.8
Total	45	100.0	31	100.0	8	100.0	98	100.0	182	100.0

Chi square = 49.98689 Cramer's V = 0.37058
Significance = 0.0000 Significance = 0.0000
D.F. = 6

*I = Informal sector including farming and casual labourers.
II = Formal sector including teaching, clerical jobs and non-clerical services.
III = Retired servants.
IV = Businessmen including contractors, hoteliers and other small and large-scale retail or wholesale traders.

SOURCE: *Field Survey* (1990).

TABLE 12

Spending on Slide-Related Housing Damage by Households' Income Level

Spending on Housing Damage (% Income)	Households Income Level								Total	
	I*		II		III		IV			
	No.	%	No.	%	No.	%	No.	%	No.	%
Up to 25%	–	–	13	18.6	42	97.7	7	100.0	62	34.1
26 to 50%	13	21.0	30	42.8	4	2.3	–	–	44	24.1
Over 50%	49	79.0	27	38.6	–	–	–	–	76	41.8
Total	62	100.0	70	100.0	43	100.0	7	100.0	182	100.0

Chi square = 148.28903 Cramer's V = 0.91489
Significance = 0.0000 Significance = 0.0000
D.F. = 6
*I = Lower Income Group
II = Lower-Middle Income Group
III = Upper-Middle Income Group
IV = Upper Income Group

SOURCE: *Field Survey* (1990).

spending over half of their annual income on slide-related housing damage. On the contrary, an overwhelming majority (89.5%) of degree-holders were only spending up to a quarter of their annual income on this (Table 10). Chi square figure of 55.0158 with 6 degree of freedom, which is significant at 0.0000 level, leads to a rejection of null hypothesis of no association between educational attainment of the household heads and spending on landslide damage. It shows that the two variables had an association significant at less than 1 percent level. There was also a correlation of 0.06 between slide-related housing spending and education level attained by a household head at 0.0000 significance level. It indicates the negative relationship between spending on slide-related housing damage by the households and the educational level of household heads.

While comparing the slide-related spending with the major occupation of the household heads, it was found that as high as 71.1% of the farmers and casual labourers with no permanent sources of income, and 54.8% of the low-salaried formal sector households, were spending over half of their annual income on housing damage. On the other hand, 55.1% of the businessmen with high prospects of annual income were spending less than a quarter of their total annual income (Table 11). With the help of Chi square test of independence, it was found that a household spending on landslide damages had an association with the major occupation of the household head

at a less than one percent significance level (significance = 0.0000). This meant that this association could happen by chance in less than one in a hundred cases. Therefore, null hypothesis of no association between the two variables was rejected. Households annual slide-related spending and major occupation of the household head have also a correlation of 0.50 (Cramer's V = 0.37058), which was significant at less than one percent level. It can, therefore, be concluded that there was a significant relationship between the proportion of annual income a household spends on slide-related housing damage and the nature of occupation of household head.

A household's spending on slide-related damage was also found to be significantly associated with its income level at less than one percent significance level. This, therefore, also leads to the rejection of null hypothesis of no association between the two variables and confirms that the association is not caused by a random error. Analysis unfolds that four out of every five (79%) lower-income households in the sample were spending more than half of their earnings on housing damage caused by landslides (Table 12). Among these households, a majority (71%) said that they spend their entire savings on repairs due to slide damage. On the contrary, slide-related expenses of none of the upper-income group exceeded one-quarter of their annual earnings, 97.7% of the upper-middle group only spend up to a quarter of their income. A Gamma correlation of –0.91 was also found to exist between the income level and the cost of slide-related housing damage of a household. This negative relationship implied that households within the upper-income group are spending a fraction of their earnings as compared to the lower-income group. This, therefore, is a clear indication of the vulnerability of the lower income group to the landslide damages, because they are threatened and at the same time weak as well.

IV. SUMMARY AND CONCLUSION

The main aim of this paper was to explore some of the socio-economic factors affecting the vulnerability of households, to the recurrent and escalating landslide hazards in Murree. During the analysis it was found that slide-proneness of housing has nothing to do with the socio-economic characteristics of the households whereas vulnerability is entirely dependent upon these characteristics. The analyses also revealed that of all the sectors housing is the one which has been most seriously affected by the landslides. It was observed that all the affected 182 (three-quarters of the sample) households repair the slide damages annually. Among these affected households 11% suffered total collapse and 28.6% suffered partial collapse of their houses. Cracks and bulges in the walls and floor-sinking were other

common damages suffered by these households. The analyses revealed that households which suffered partial or total collapse of their houses were mainly those with low-income, low level or no education, and/or having badly paid and insecure jobs. Similarly, due to the recurrent nature of landslides, out of the total affected households, 41.8% were found to spend more than half of their annual income on slide-related housing damages, which includes a fairly high number (36.8%) of those who spent up to 80% of their entire savings on the damage. Among these 41.8% households, 65% of households were those with low socio-economic status.

These findings reflect the importance of elements of socio-economic factors in the vulnerability of a household to the adverse effects of landslides. The results of Chi square tests of independence and correlation coefficients revealed that households with lower socio-economic status are more vulnerable to the adverse effects of landslides as compared to the households in the higher socio-economic bracket. The high correlation of educational attainment, occupation and income level with the annual spending on slide-related damage could be due to the extra amount of finances made available for repairs, after the normal family expenditures have been met. Hence, it can be concluded that the higher income level are more likely to keep the percentage of a household's annual expenditure on landslide damage to a very low level. Any improvement in these socio-economic factors, therefore, makes a positive contribution towards reducing the vulnerability of a household to the adverse effects of landslides.

It was revealed that a household's spending on slide-related housing damage has a significant relationship to educational attainment, occupation and income level of a household. It points to the fact that high level of education, better job opportunities and higher income level of a household could make a positive contribution in reducing the adverse effects of landslides. It can, therefore, be concluded from the analysis that all the households in Murree are equally threatened by landslide hazards, hence, all of them are slide-prone. However, households with a lower income, poor education and insecure job opportunities were weak, and at the same time threatened by landslide hazards. They were, therefore, the hardest hit and the most vulnerable to the effects. So the only difference is that of vulnerability. Weak and poor communities are more vulnerable to the landslide effects on housing than rich, educated and powerful households. It was, therefore, established by the study that vulnerability to slide hazards in Murree is actually a function of the factors like level of income, awareness, access to risk reductions elements etc. All these are variable factors relating to human environment, while the physical environment may remain constant.

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