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Rural road-induced sedimentation: Severity and local perception in the Phewa Watershed, Kaski District, western Nepal

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ABSTRACT

The aim of this research is to estimate sediment source and its severity in the Phewa watershed resulted from rural roads construction, and to evaluate local people's perception towards it. A total length 63 km in twenty five rural roads accounts up to 269752 m^3 of sediments with 4292.00 m^3 per kilometer in average. Similarly the rural road-induced landslides contribute about 25593 m^3 sediments with average of 1024 m^3 per landslide. This signifies the severity of sedimentation problem posed by unplanned rural road construction. The people living in the rural road areas have positive responses towards rural transportation and other socio-cultural dimensions. However, it has several negative consequences in relation to conservation of upstream and downstream infrastructures and social values. The amounts of sediments resulting from the road construction and associated landslides are threatening. It warrants for concerted efforts to reduce sediment load by implying environmentally sound construction techniques, policy and process.

Key words: Rural road construction, sediment source, road-induced landslide, Phewa Lake, local perception

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INTRODUCTION

Phewa watershed comprises 19 sub-watersheds with area of about 123 km^2 including Phewa Lake. The Phewa Lake has been endangered due to rural road construction in its watershed contributing a large quantity of sediments. The Phewa watershed lies in one of the most fragile Lesser Himalayan meta-sedimentary zones with folded, faulted and fractured rock strata. The stability condition has been aggravated by intense monsoon rainfall. The geologic structure is dominated by a northwest–southeast trending fault, which runs along the base of the southern slopes, bisecting the watershed into northern and southern halves. Likewise, another fault line, albeit smaller, runs parallel to the base of the northern slopes. In the western half of the watershed, two other faults run along the north and south sides of a secondary ridge line. These fault lines correspond to the valleys of the Andheri Khola and Sidhane Khola, which are the major tributaries to the main drainage channel, the Harpan Khola (Rowbotham and Dudycha 1998). The rural road construction in this zone has been causing extensive soil erosion and several landslides in the upstream areas. It has resulted in sedimentation problem in the Phewa Lake. As the rural roads are significant producers of runoff and sediment at catchments scale, they should be included in watershed management (Rijsdijk 2007). Landslide and soil erosion at watershed areas are caused by unplanned rural road construction without slope treatment and lack of environmental education among the people. Loss of fertile soil and crop yield, decrease of land holding size, and the creation of obstacles for tillage operations are the effects of road rural road constructions (Nyssen 2002).

High priority of the government and rural communities of Nepal in rural road construction has brought positive change to rural communities in relation to rural transportation and other socio-cultural dimensions. However, it has several negative consequences in relation to conservation of upstream and downstream lands, infrastructures and natural entities. Despite of several watershed management activities implemented in the Phewa Lake watershed such as rehabilitation of landslide hazard zone, river training works, eco-zoning based land use planning along the lake shore and solid waste management (JICA 2001) study on sedimentation in this watershed by rural road construction has not been carried out yet. Therefore, this research is aimed to estimate sediment source contributed from rural roads construction in the Phewa watershed. The paper also discusses on the severity of sedimentation by rural road construciton and local perception towards it. The research

outputs will be helpful to national planner and related development organizations for effective soil conservation measures.

STUDY AREA

The research site extends from latitudes 48°17'65"N to 49°90'09"N and longitudes from 31°22'90"E to 31°29'38"E. The area is located in the Kaski District, western Nepal (Fig. 1). Topography of the area is gentle and geologically lies in the Lesser Himalayan Zone of western Nepal.

MATERIALS AND METHOD

Among 25 rural roads, 61 rural road-induced landslides with area greater about 50 m^2 were considered for the study. Necessary cross sections were taken in recent rural roads whereas Naudanda-Kaskikot-Sarangkot-Pokhara, Kande-Salyan and Sarangkot-Kaule being old roads were observed only for road-induced landslides. The detailed design reports of roads constructed around the study area were taken as reference to study the soil mass calculation in the road construction. Field verification by the team of experts was performed to check ground reality with reference to the design report and any significant differences in the site. The usual volume calculation formula for road earthwork was applied to calculate the mass of earthwork for which longitudinal as well as cross sectional leveling was carried out along the routes. Altogether 527 cross sections leveling along 62.85 km longitudinal profile were carried out by measuring tape and vertical pole to calculate the earth mass by using prismoidal formula. The volumes and location of the landslides were computed by measuring length, breadth and height. The social data of the study area were collected by using both primary and secondary sources of information through participatory approach. The main tools of field research include Household (HH) survey, Focus Group Discussion (FGD), Key Informant Interview (KII), formal and informal discussions and field observations. In total, respondents from 75 households along the newly constructed rural road were interviewed purposively by using pre-tested structured and semi-structured questionnaire with some close ended and some open ended questions. Due care was given while selecting the households in order to make the respondents more inclusive in terms of age, sex, caste, and ethnicity. Published/unpublished reports and documents relevant to this study were used to obtain necessary secondary data. The data acquired from primary and secondary sources

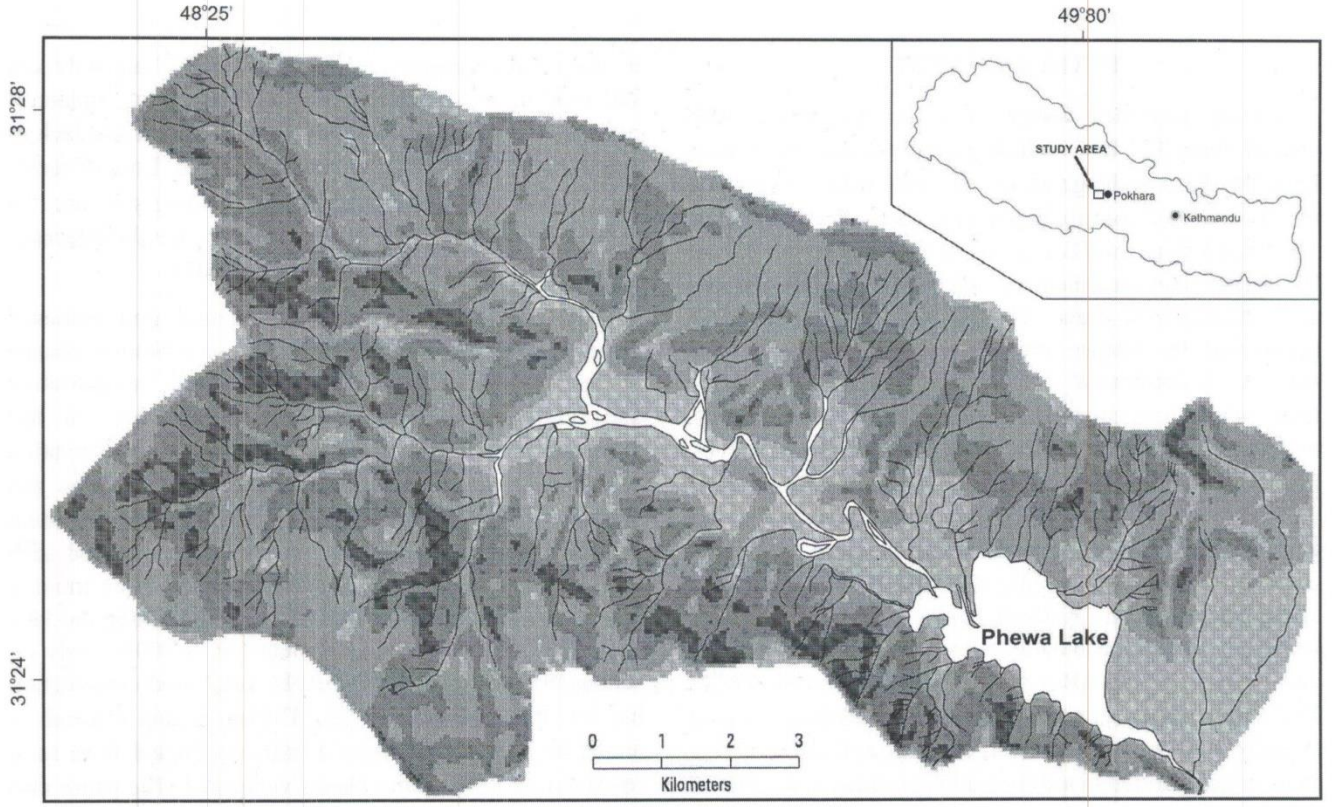

Fig. 1: Location map of the study area, Phewa watershed, western Nepal.

were categorised for analysis and interpreted through the descriptive statistics.

RESULT AND DISCUSSION

The collected cut/fill data of rural road and rural road-induced landslides are included to discuss the sediment severity whereas the social data from the field are for local people's perception.

Sediment source in the Phewa watershed

The assessment of sediments in Phewa Lake has showed that the rural roads are the main sources, i.e., the volume of sediment resulting from the road construction activity is alarming (Fig. 2a). The next source of sediments was found to be the unstable slopes resulting from earthwork excavation in rural roads, inadequate cross drainage system in stream crossing, haphazardly thrown earth in down-hill, wash out of unpaved gravel and dirt roads (Fig 2b). The frequency of landslides due to rural roads in the Phewa watershed is maximum at Naudanda-Kaskikot-Sarangkot-Pokhara road followed by Dharapani-Bhadaure road and Ghantichhina-Makawanpur road. The total volume of material cut in rural roads and rural road-induced landslides are 25593 m^3 and 2697520 m^3 respectively (Table 1). A total of 295346 m^3 sediments were from 25 rural roads and 61 rural road-induced landslides. About 11687 m^3 sediments were from Naudanda-Kaskikot-Sarangkot-Pokhara road. About 98257 m3 (37.12%) was caused by the 9 roads with each of length 2–4 km followed by about 86577 m3 (32.83%) by 3 roads each of greater than 6 km length, about 66391 m^3 (25.13 %) by 3 roads each of 4–6 km length and about 13008 m^3 (4.92 %) by 3 roads each of 0–2 km length (Table 2 and Fig. 3).

Considering the total volume of the Phewa Lake as 4600000 m^3 (Sthapit and Balla 1998), only about 5 per cent per year of sediments from rural roads construction and road-induced landslides can fill up the Phewa Lake within 310 years even if other sources of sediment like erosion, natural landslides (Table 2), encroachments etc. are omitted.

Local perception

Local perception towards the rural road construction and its contribution for the sedimentation to the Phewa Lake was assessed in the field.

Majority of the respondents (53%) were arguing that the process was not conducted in proper manner and inducing landslide and sedimentation in the downstream areas (Table 3). That is also indicated by the status of the roads during the study time. The degrading condition of roads in Chapakot

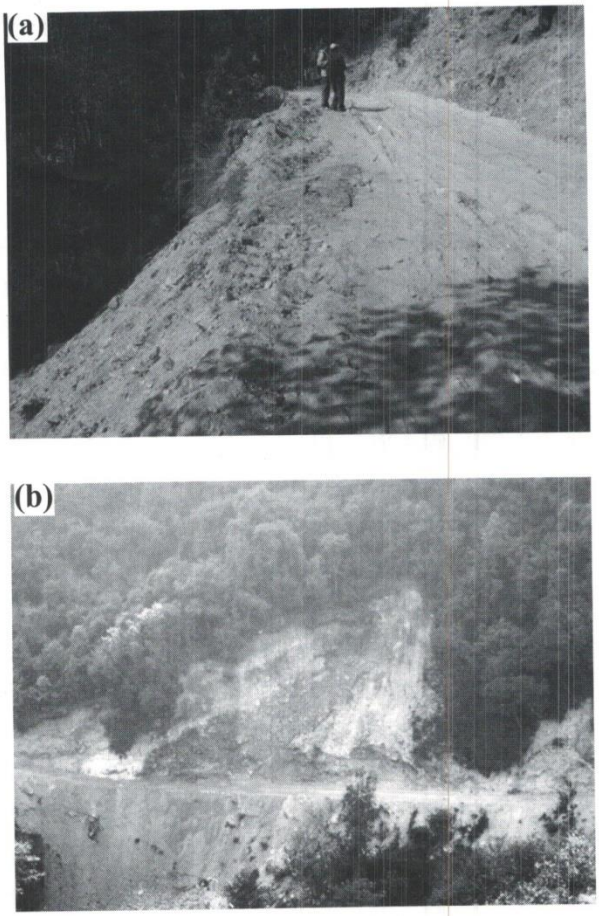

Fig. 2: Sediment sources in the Phewa watershed. (a) Rural roads. (b) Unstable slopes (landslides) resulting from earthwork excavation or road construction.

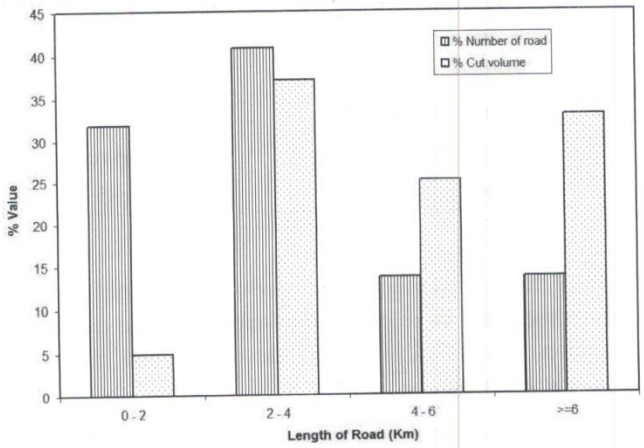

Fig. 3: Volume cut with respect to road length.

areas, Bhadaure to Thulokhet section and some link roads of the Sarangkot area are the best example to verify the local peoples saying. In contrast, about 40% of the respondents

Table 1: Characteristics of rural roads and rural road-induced landslides

S.N.	Road name	Road Length (km)	Total volume of cut (m^3)	Average Breadth (m)	Volume of cut/ km length (m^3/km)	Road-induced landslides	
						Frequency	Volume (m^3)
1	Aiseluchaur	1.50	3720.55	4.94	2479.04	NA	NA
2	Banpale-Guntechaur	2.19	6053.16	5.09	2758.33	1	95.33
3	Bhadaure-Thulakhet	6.82	34814.15	4.95	5103.59	2	114.96
4	Bhadaure Tamagi Link	4.69	14545.76	3.77	3101.44	4	1022.39
5	Serachaur branch	0.28	1718.96	5.28	6216.85	NA	NA
6	Chapakot-Wangdi	2.06	8194.20	4.73	3969.48	NA	NA
7	Dharapani-Bhadaure	4.51	29570.02	4.78	6550.3	5	1965.66
8	Ghatichhina-Aiseluchaur	3.34	11327.95	3.94	3389.07	NA	NA
9	Ghatichina-Makwanpur	2.44	18321.44	4.87	7516.8	5	525.65
10	Guntechaur-Pame	2.97	9318.61	4.54	3137.47	NA	NA
11	Naudanda-Adhikari Dada	4.41	22275.01	4.36	5045.42	1	22.46
12	Pame-Gumba	6.06	38031.85	4.57	6279.61	NA	NA
13	Pipaldali-Guntechaur	2.15	4847.96	4.61	2253.71	5	6556.79
14	Primisti-Bhadaure	0.67	1923.95	4.15	2878.01	1	97.41
15	Serachaur	2.00	5519.76	5.10	2761.95	4	547.27
16	Sarangkot-Toripani	2.37	5870.05	4.87	2479.53	4	825.86
17	Sarangkot-Sintal	0.43	1844.92	5.83	4285.53	3	742.90
18	Sarangkot Bus Stand Tower	0.34	1015.00	5.25	2989.69	NA	NA
19	Sarangkot Tower Link	1.55	2784.68	5.81	1791.94	NA	NA
20	Sarngkot-Gyarajati-Pipaltari	6.31	13730.93	5.29	2176.85	2	58.66
21	Vanjyang-Pame	3.29	10695.16	4.90	3249.43	1	30.27
22	Wangdi-Okhaldhunga	2.46	23628.23	4.16	9605.75	1	36.62
23	Naudanda-Kaskikot-Saragnkot-Pokhara	Old rural road				16	11686.93
24	Kande-Salyan	Old rural road				3	699.38
25	Sarangkot-Kaule	Old rural road				3	564.76
	Total	62.85	269752.30			61	25593.30

thought that the process was conducted in right manner and claimed that there exist other causes for the degrading condition. About 7% of the people were found not aware about the process.

From the field study, it is found that there was discrepancy in the response of the people regarding the management of the surplus sediment from the cutting process. The settlement areas below the road have reported of living in a fear and uncertainty especially during the time of monsoon due to the absence of the proper mitigation works and lack of the drainage channel along the road alignment. Fig. 3 shows variation in response of the respondents regarding the management of the surplus sediments. Majority of the respondents (51%) has explained that surplus sediment from cutting was thrown haphazardly causing deposition of the sediments to the agricultural fields and settlement area. Similarly, about 37%, 7%, and 5% of the respondents had reported that the surplus sediments was used in the same road, dumped in safe area and used for others purposes, respectively.

Response of local people about the cause of the landslide whether it was due to newly constructed roads or not is

Table 2: Summary of observed and projected sediment sources in the study area.

S.N.	Categories	Volume (m^3)	Projected sediment sources resulted from Phewa watershed by rural roads construction and road-induced landslide (m^3)/year			
			5%	Silted up year	10%	20%
1	Sediment source by rural roads	269752.30	13487.62	341.05	26975.23	53950.46
2	Sediment source by road induced landslide	25593.30	1279.66	3594.7	2559.33	5118.66
3	Total	295345.60	14767.28	311. 5	29534.56	59069.12

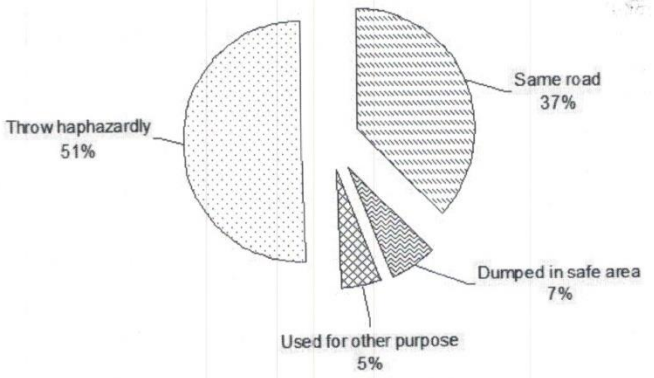

Fig. 4: Responses on use of surplus sediments from cutting.

Table 3: People response on cutting and filling process during road construction.

Category	Cutting and filling processes is in proper manner during road construction			
	Yes	No	Do not know	Total
Response frequency	30	40	5	75
Percentage Value	40	53	67	100

Table 4: People's response about the landslide due to rural road construction.

Category	Landslides due to the rural road construction			
	Yes, main cause	Yes, some cause	No cause	Total
Response frequency	45	23	7	75
Percentage value	60	31	9	100

shown in Table 4. During the field visit, it is found that the land of a small holder (dalit householder) near Harpan village was fragmented in many places that are no more useful of agriculture and settlement purpose. In addition, the houses where they are living are in the risk of the collapse due to the road above and below. Majority of the people (91%) think that the newly constructed road is the main cause for the increasing landslides along the road alignment and about 9% of the people think that there is no relation of the landslide to the newly constructed road (Table 5).

Rural road management and maintenance committee is desired for the participation of the local people and intact management of the road. During the HH survey and FGD were performed to know about the status of the management committee. The responses are listed in Table 5. From the survey, it was found that 47% people felt that there were management and maintenance committee during the construction of the road but it was not functioning later on.

Pairwise ranking exercises showed the people's opinion on the negative effects of rural road construction in the Phewa watershed area of Kaski District. From 10 FGDs, loss of cultivated land has got the highest score (94) followed by destruction of virgin lands (88), loss of vegetation area (82), displaced households/increase number of vulnerable settlement area (81), decrease number of trekker and impact to trekking business (72) and then increase tendency to relocate/migrate at roadside, increased dependency on market oriented products (low production of indigenous products), loss of natural water sources (well, springs, ponds), damage to irrigation canals/water

Table 5: People's response on rural road management and maintenance.

Category	Information on presence/absence of rural road management and maintenance committee				
	Yes, it is functioning well	Yes, it is functionless	No any committee	Do not know	Total
Response frequency	25	35	10	5	75
Percentage value	33	47	13	7	100

Table 6: Ranking of the negative effects of rural road construction/landslides by the people of Phewa watershed area of Kaski District.

Negative effects	Score obtained from FGD (10 groups)										Sum (Score)	Average	rank
Loss of natural water sources (well, springs, ponds)	5	7	7	7	9	5	6	5	6	5	62	6.2	8
Damage to Irrigation canals/water pipelines	5	6	7	6	8	5	6	5	6	5	59	5.9	9
Loss of vegetation areas (Forest / shrub / Grazing land)	6	7	8	9	8	7	11	10	9	7	82	8.2	3
Loss of cultivated land	10	8	10	11	11	8	9	8	9	10	94	9.4	1
Displaced households/ increase number of vulnerable settlement area	9	7	7	6	8	6	9	10	9	10	81	8.1	4
Increase in crime (robbery, smuggling)	5	6	6	6	7	5	6	5	5	5	56	5.6	10
Increase in health and psychological problems	5	6	5	6	7	5	5	5	4	5	53	5.3	11
Decrease number of trekker and impact to trekking business	6	8	11	8	9	6	6	6	7	5	72	7.2	5
Increase tendency to relocate/migrate at roadside	5	7	10	8	9	5	6	6	7	5	68	6.8	6
Increase in road traffic accident	5	6	5	4	3	4	4	4	4	5	44	4.4	12
Increased dependency on market oriented products (low production of indigenous products)	5	7	8	8	9	5	6	6	6	5	65	6.5	7
Destruction of virgin lands	8	10	9	10	8	10	8	8	8	9	88	8.8	2

pipelines, increase in crime (robbery, smuggling), increase in health and psychological problems, increase in road traffic accident respectively (Table 6).

It is clear that first negative impact from the rural road/ landslides is loss of cultivated land, the second is destruction of virgin lands and the third is loss of vegetation area in this Phewa watershed of the Kaski District (Table 6). Natural, social, economical, environmental, and biological negative effects were faced directly or indirectly in various levels by the people of this watershed area. The responses to process of rural road construction, negative impact on environment and positive impact on socio-economic condition are categorized in three Likert scale as agreed (1), moderately agreed (2) and disagreed (3) and responses is shown in Fig. 4. From the interview with the people of rural road of Phewa

watershed area of Kaski District, it was found that majority of the people (53%) were marginally satisfied with the process of rural road construction. It was also revealed that the satisfaction level had seen between agree to moderate agree with the value of 1.93, i.e., 80 % people were in favour of the satisfactory level with the construction process of rural road. Only 20% people were dissatisfied on the process of rural road construction. This also indicates that consensus mechanism was not followed on the process to construct rural road. On the other hand, based on environmental issue, about 60% people opposed about the negative impact of rural road on environment. This shows that the week level of awareness about the environmental issue in the watershed area. Only 13 % people were in favour of the negative impact of such type of constructed rural road. The rural roads have also significant positive role for the development of the area in general and enhance the availability of the civic amenities in particular. That may be one of the reasons for low environmental consideration about the impact of the rural road construction. In this regard, about 92 % sampled people were in favour with average perception value 1.5, i.e., between agree to moderate agree on rural road construction so that it has positive impact on the increasing of socio-economic conditions.

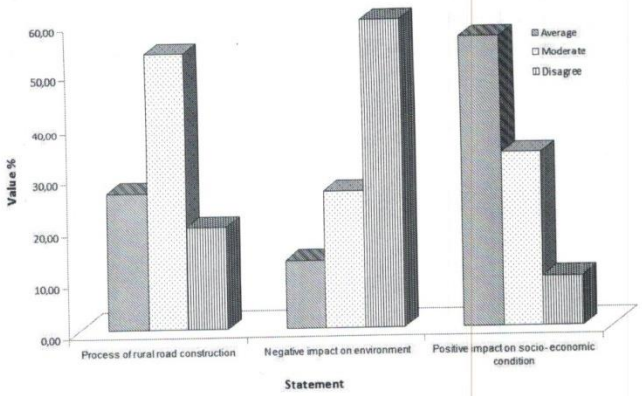

Fig 5: Responses on process and impact of rural road construction.

Table 7: Thinking of people on process of cutting and filling in road construction.

Category	Cutting and filling processes in right manner during road construction			
	Yes	No	Do not know	Total
Response frequency	30	40	5	75
Percentage value	40	53	7	100

CONCLUSION

Twenty five rural roads of total length 63 km surveyed in six Village Development Committees of Kaski District in upstream area of the Phewa Lake accounts 269752 m^3 sediment sources with 4292 m^3 per kilometer. Similarly the rural road induced landslides contribute about 25593 m^3 sediments with average 1024 m^3 per landslide. This signifies the severity of sedimentation problem posed by unplanned rural road construction and urgently draws attention towards technically sound, environmental friendly and participative rural road construction process.

The people of studied rural roads have positive responses towards rural transportation and other socio-cultural dimensions. However, it has several negative consequences in relation to conservation of upstream and downstream lands, infrastructures, natural entities and migration of some people due to the vulnerability of land-sliding and subsidence.

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