Chapter 2
GEOMORPHIC EXPRESSION

This chapter deals with the physical setting of the study area on aspects of geology and landform, including a critique of two land-system classifications of Nepal. Assessment of geomorphic change is restricted to the extent of landslides as evidenced by the set of aerial photographs (1958 & 1996) and repeat photos (1962-2002).

1. Geology

Landform is the surface expression of geomorphic processes of degradation operating over the geological foundation. The high relief contrast of the study area is matched by the area's geological diversity. The Himalayan structural geology is marked by two major thrust faults. One is the Main Boundary Thrust (MBT) which separates the Sub-Himalayan and Lower Himalayan zones and the other is the Main Central Thrust (MCT) that separates the lower Himalaya and Higher Himalaya. It is significant that the latter, MCT, traverses through the northern part of the study area (Amatya and Jnawali 1994). This major structural uncomformity is marked by a hot spring, as elsewhere, at Nunkhani (Figure 6). The MCT in Marsyangdi area has a east-west strike with a northerly dip varying from 15° to 40°.

This tectonic line represents a contact zone whereby the higher pre-Cambrian formation is thrust over the Lower Palaeozoic formation. The former one is known as the Higher Himalayan crystalline or Himalayan gneiss zone. The latter one is called then Lower Himalayan or Midland formation (Colchen et al. 1986). The Himalayan crystalline formation is composed of highly metamorphosed rocks of gneiss, quartzite, and marble. In places, it is intruded with granite and sillimanite.

The Midland formation below the MCT is composed of unfossiliferous clastic rocks of phyllite, limestone, quartzite, and sandstone. Around the study area, the succession is represented by phyllite and a sub-ordinate amount of sandstone with distinct graded bedding, and they gradually change downwards into a slate-rich succession (Ohta and Chiba 1973). Those nearer the MCT are rich in calcareous dolomite. The geological cross-section of this schist formation (BB) has numerous dykes and sills between Nunkhani and Khudi (Figure 6). There are two intrusions of calcareous dolomite (GU) north of the Marsyangdi-Ngadi confluence. Taranche village is entrenched by dykes of calcareous dolomite (RD) north and south of it respectively, whereas Khudi lies over quartzite exposure (G). South of it extends a broad formation of meta-sediments composed of schist, phyllite, and sandstone.

Figure 6: Geological map (after Colchen et al.)

2. Landform

There have been two exercises with regard to land classification of the Nepalese topography. The first attempt based on landsat images was to demarcate ecological land units with emphasis on their watershed condition (Nelson et al. 1980). It designated the highland area of Nepal into three zones: Middle Mountain, Transitional, and High Himalayas. Accordingly, the Lamjung area, including the locale of the present study, was labelled the Central Transitional Mountain System (II. D. 1).[1] The Transition zone was defined as:

> *"land between the heavily used hills of the Middle Mountains and the sparsely populated High Himalayas"* (Op.cit, p.49)

within the elevation range of 750 to 3,200m. The lower Middle Mountain Zone was placed south of the Marsyangdi-Khudi confluence, outside the study area.

The second attempt at land classification was made by the Land Resource Mapping Project (LRMP) based on aerial photographs (Carson et al. 1986). The output was three sets of maps on land systems, land capability, and land use. The boundaries of the land systems were based on the ecological land units mentioned above with minor modifications. However, there was some divergence in the nomenclature used by the two studies as given below.

Particular	Ecological Land Units (Nelson et al.)	Land Systems (LRMP)
Major unit	Zone	Region
Component	Region	System
Macro hierarchy	Transition Zone	High Mountain

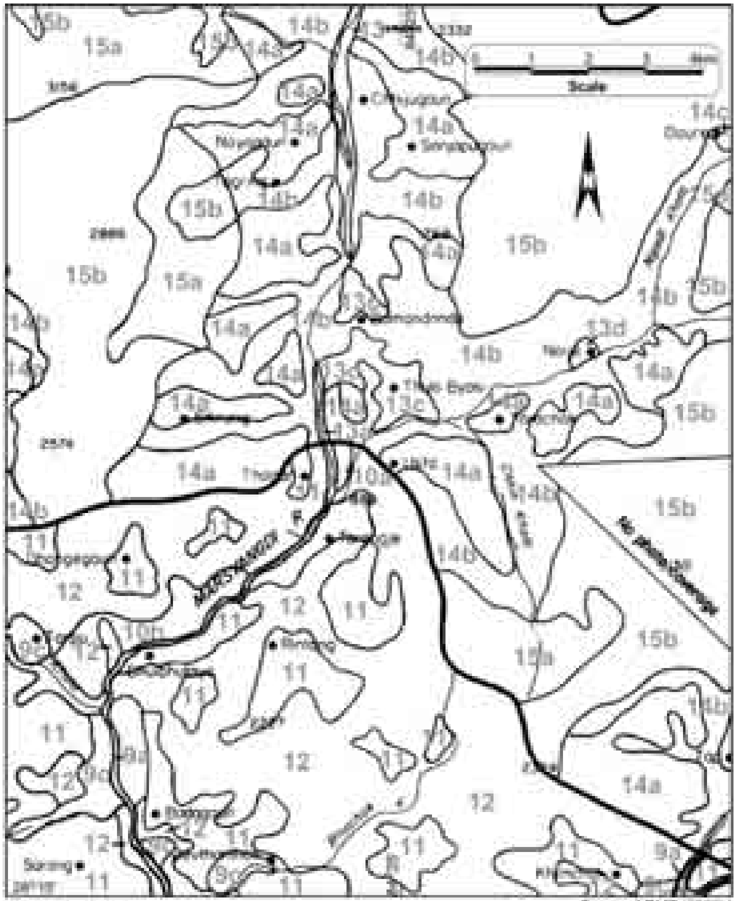
The southward shift of the High Mountain Region boundary in the LRMP map placed the study area's northern part in the High Mountain Region and its southern part in the Middle Mountain Region (Figure 7). Accordingly, the study area includes land systems 9,10,11,12 (Middle Mountain) and 13, 14 (High Mountain).[2]

In fact, the above so-called High Mountain Region land system is more characteristic of the sub-tropical zone, as described by the ecological land units' study, than the temperate mountain zone. The land systems' report states that:

> *"Physiographic regions (Terai, Siwaliks, Middle Mountains, High Mountains, and Himal) are well recognised by Nepalese geographers, geologists, foresters, soil scientist and agronomists alike"* (Carson et al. 1986).

[1] Op. cit, Land system map of Nepal (East sheet), Scale c. 1:500,000
[2] Land system map, sheet No. 71 D/17, see Figure 7

Figure 7: Land systems (after LRMP)



Source: LRMP ([illegible])

Legend

High Mountain Region

15b Past glaciated, very steep slope >30°
15a Past glaciated, moderate to steep slope <30° - Above arable zone
14b Past glaciated, steep to very steep
14a Past glaciated, moderate to steep - Below arable zone
13d Ancient alluvial terraces
13c Fans
13b Recent alluvial plain
13a Active alluvial plain

Middle Mountain Region

12 Mountain terrain, steep to very steep slope >30°
11 Mountain terrain, moderate to steep slope <30°
10b Terraces, dissected
10a Ancient lake/river, non-dissected
9c Alluvial fans
9b Alluvial plains
9a River channel

The above observation is incorrect since the terms used for the three highland zones are geographically inappropriate (Gurung 2000). The distinction between 'Mountain' and 'Himalaya' is spurious as both refer to snow ranges in the Nepalese context. The epithet of 'high' to them is superfluous whereby the label 'Middle Mountain' becomes redundant. The 'Middle Mountain' zone of Nelson et al. (1980) and the same region for Carson et al. (1986) actually relates to the hill zone/region. In fact, there are Nepalese terms that recognise the distinction between the hills with no snow as 'pahar', ranges with winter snow as 'lekh', and ranges with permanent snow as 'himal'. In the study area, in land systems designated as 13 and 14 (High Mountain Region), there is no snowfall even in winter (Figure 7).

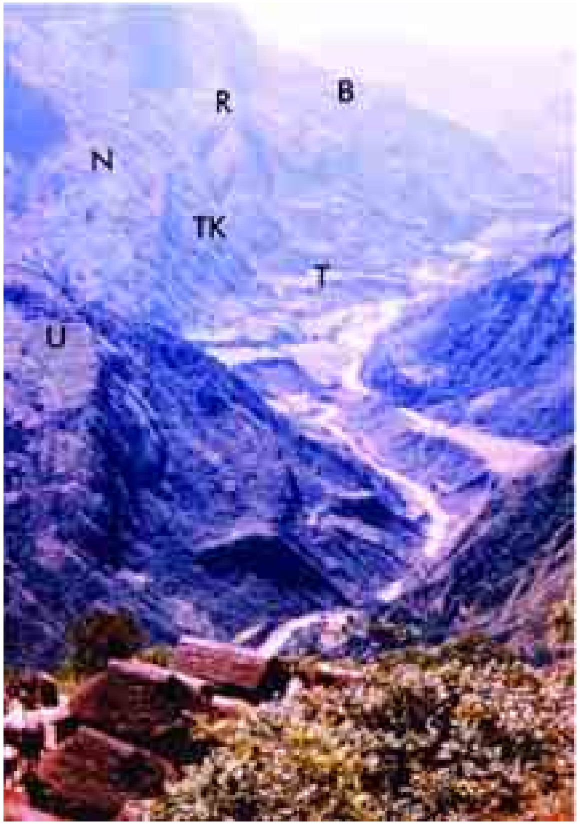
The dominant landforms of the study area are three high ridges and their lateral spurs (Figure 2). They have a homoclinal structure with north-dipping rock strata (Figure 8) and present a hog-back profile of scarp face to the south. Marsyangdi River has carved a deep valley trending due south until Dobhanchaur. Thereafter, its NW-SE trend is aligned to that of the tributary Ngadi Khola, NE-SW, suggestive of the fault structure. The amplitude of relief from the Marsyangdi floodplain to the enclosing ridges on average exceed 530 metres around both Nunkhani and Taranche. Such a steep declivity is, however, tempered lower down by a series of river terraces. Thick deposits of diluvial and alluvial materials along major rivers are a characteristic feature of landform in the central hills of Nepal (Dollfus and Usselman 1971; Gurung 1965/2002). These were deposited during the Quaternary period and have since been eroded into stepped terraces which are called 'tar'. The one at Tarkughat, 24 kilometres downstream from the present study area, has four levels of river terraces (Dollfus and Usselman 1971).

Two approaches have been adopted to describe the numerous river terraces of the study area. That is, they have been grouped into two levels (upper and lower terraces) for the meso scale area and elaborated into four levels for the focussed area at Taranche. At the meso scale, the terraces appear as distinct level surfaces at various elevations above the floodplain (Figure 9). The upper or ancient terraces are extensive in both the Marsyangdi and the Ngadi valleys. They are particularly pronounced at Baisthopla, Thulibensi, Taranche, and Khudi (Figure 10). The lower level terraces are restricted to limited areas, notably between Dobhanchaur and Khudi.

There is an increase in elevation difference between the upper terrace and river level progressively upstream. These range from 78 metres at Khudi, 95 metres at Taranche, 116 metres at Ustabensi, 132 metres at Nemane, to 164 metres at Baisthopla. The terrace surface is inclined southwards or downstream. The Baisthopla terrace is 265 metres higher than the Khudi terrace, 12 kilometres south with a gradient of 22 metres to a kilometre. For the same distance, the gradient of the river is about 18 metres per kilometre. This indicates that the rate of down-cutting by the river was much higher when the terraces were deposited than at present.

In contrast to the patchwork of terraces at the macro-scale, those at Taranche constitute an extensive landform. These are very well displayed in Figure 8 as seen from the

A. October 1962



B. March 2002

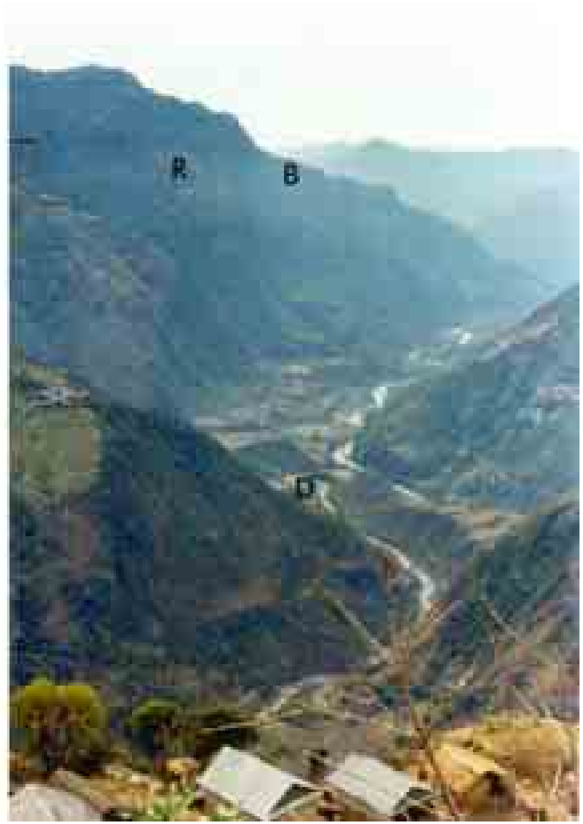


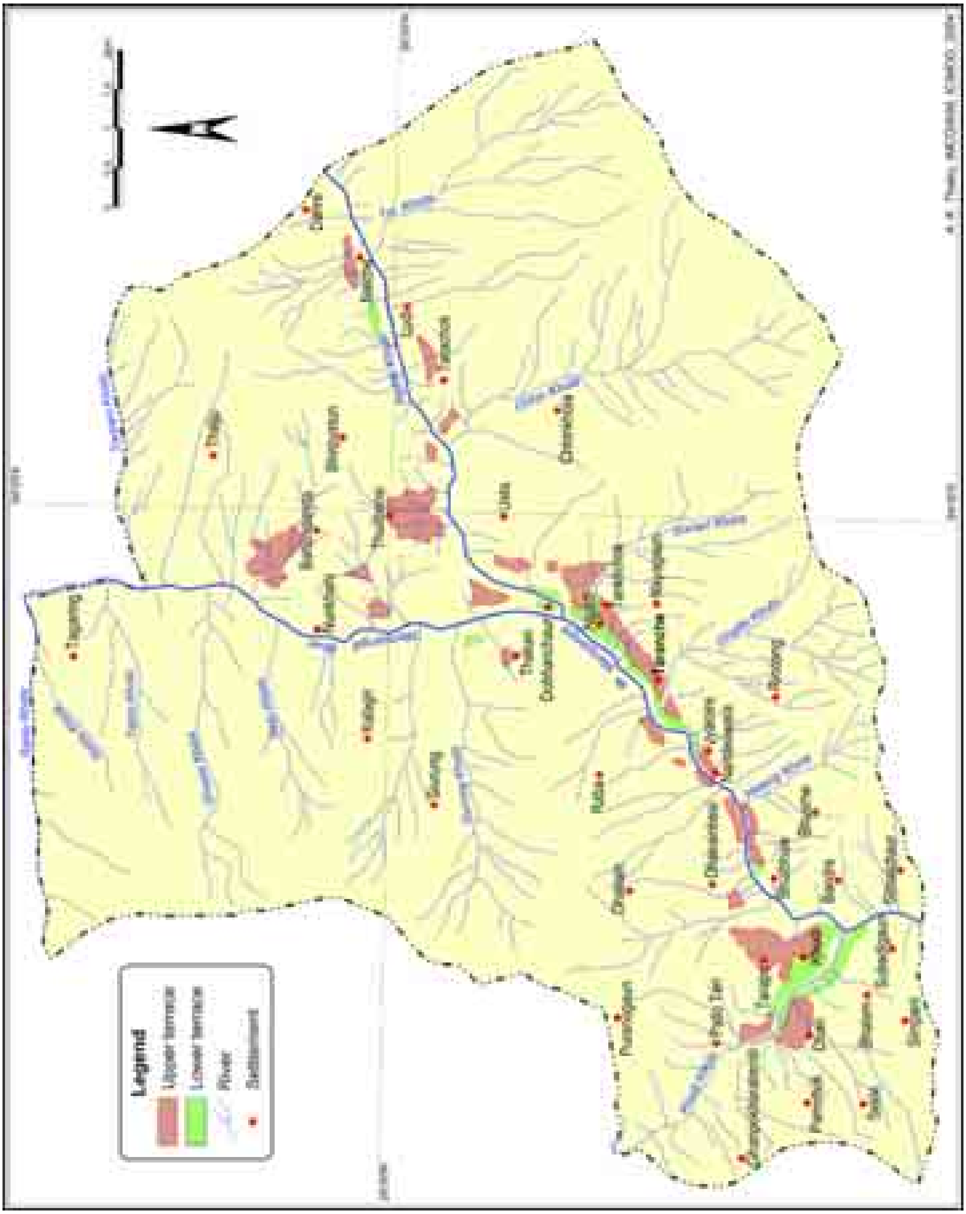
Figure 8: Taranche area from the north: Bhirpustun (1,888m) provides a panoramic view of the study area: Taranche (T) and Tanklichok (TK). Usta (U), Nayagaon (N), Rindang (R) and Bhusme (B) are located on a north-facing dip slope (Figure 8A). The 2002 photo shows a new bazaar at Dobhanchaur (D) on either side of the Ngadi bridge (Figure 8B). A run-of-the river barrage of the upper Marsyangdi project will be sited between Dobhanchaur and Ngadi Bazaar. Ustabensi (910), left of Dobhanchaur, had no houses until 1976.

A. October 1962

B. January 2002

Figure 9: Taranche area from the south: The study area on the left side of the Marsyangdi (M) with Himalchuli in the background. Taranche (T) and Tanklichok (TK) localities can be seen on high river terraces in the middle distance (Figure 9A) Further beyond are Usta (U) and Bhirpustun (B), the Marsyangdi gorge west of ‘B’, and Ngadi Khola between ‘B’ and ‘U’. The January 2002 photo has similar cumulus clouds over Thulnagi (Figure 9B). Some houses in Taranche (T) have tin roofs while the landslide scar near Tanklichok (TK) is much subdued. Ngadi (N) is a new bazaar settlement on the alluvial fan of Sisneri Khola. Note the river terraces below Usta and Bhirpustun.

Figure 10: River terraces, Marsyangdi - Ngadi



north. Despite their intricate pattern, four levels of terraces can be recognised (Figure 4). The oldest terrace, level 4, at Taranche village is about 95 metres above the river level (Figure 11). Terrace-3 extends northward with two subsidiary levels and terminates at Tanklichok. Terrace-2 is to be found as discontinuities at Sera, Sirubari, and Nandeswanra. Terrace-1 is similarly spread out at four locations. There is wide variance in the elevation difference between the terrace levels indicating fluctuation in the duration of deposition and uplift stages. All the terrace levels slope towards the south. Their gradient varies from 15 to 20 metres per kilometre, which is less than at the macro-scale due to their restricted linear extent. Of the 320.5-hectare area of Taranche locality, 15.3% is terrace land. The area by respective terrace levels is as given in Table 2.

Table 2: Taranche terraces

Level	Hectare	%
Terrace – 4	7.9	16.1
Terrace – 3	15.2	31.0
Terrace – 2	15.4	31.4
Terrace – 1	10.6	21.6
Total	**49.1**	**100.0**

3. Landslides (1958-1996)

The study area is a land of steep slopes except for the river terraces and alluvial fans. Landslides are a vivid manifestation of surface erosion in which the degree of slope is an important factor. Aerial photographs taken in 1958 show that the study area is replete with landscape scars with remnant images of two catastrophic events. The first one was the major earthquake of 15 January 1934 which precipitated the landslide at Tagaring. It occurred on a dip slope (Figure 12) and originated in temperate oak forest (Figure 13). This large landslide was still active when a mountaineer saw it in 1950 on the way to Manang and made the following perceptive observation (Tilman 1952):

> "*Whether it takes place little by little or in one swift calamity, soil erosion is generally attributed to man's careless greed, his idleness or neglect. It would not, I think, be fair to blame the people of these villages on the Himalayan fringe for the frequent landslides which occur there. In turning the steep slopes into fruitful field they have neither been lazy nor neglectful. Such slopes, of 30° or 40° or more, are laboriously built up in terraces from 10 to 30 ft. wide, whose retaining walls may be from 5 to 15 ft. high, according to the angle of the slope. I have not counted them, but I can well believe there might be a couple of hundred of such hard-won fields on a hillside particularly favoured in soil and aspect whose every foot is put to use. The task of building must be spread over years and their maintenance calls for constant labour over and above that of routine farming. One might say that on such hill sides the forest should never have been cleared, in which case the country must be left uninhabited, or that belts of trees should have been planted which would imply first the giving up of their goats by villagers.*"

In 1958, Tagaring landslide still covered an area of 787 hectares extending over two kilometres (Figure 14). The 1962 situation was no better with new slumps at its head (Figure 13A).

A. 1971/72 by D. Messerschmidt

B. March 2002

Figure 11: Taranche from the west: Taranche (T) locality perched on a high terrace between the Marsyangdi (M) and Ghatte Khola (G). The school area (S) had three Gurung and six Chhetri houses that were swept away by the landslide of 22 July 1955. Six Chhetri perished and Gurung households shifted to Tanklichok (Figure 31). The site was donated to a primary school established in April 1956. The 1971/72 view from Raba (1,600m) shows the landslide below 'S' to have stabilised with shrub vegetation (Figure 11A). The school was upgraded to a high school in 1998. A recent photo shows houses with tin roofs and much improved vegetation cover on steep slopes (Figure 9B). Also visible are four levels of river terrace.

Other events that triggered many small landslides in the area were the heavy monsoon of 1954 and cloudburst of 1955. The slides were more pronounced on the north-facing slopes along the dip of the rock strata. These were in the Chhin, Sisneri, Ghatte, and Hwang valleys (Figure 14). At Taranche, a landslip from Terrace-4 to Terrace-1 swept away nine houses in which six persons perished (Figure 11A). The 1933 Tagaring landslide had caused some households to migrate to Taranche. The 1955 calamity at Taranche, in turn, initiated the outmigration from this village to Chitwan.

According to the 1958 airphoto, land affected by landslides covered 390.3 hectares or nearly 4% of the study area. Of this, Tagaring alone accounted for one-fifth. In 1958, the area had a proliferation of landslides as the legacy of the 1955 cloudburst. By 1996, the situation had changed significantly with only a few landslide exposures. The major one at Tagaring had become stabilised (Figure 13B). In the intervening 38 years, the landslide area declined from 390.3 to 0.4 hectares, a reduction of 90%. Thus, the proportion of slide affected land declined from 4.0% in 1958 to 0.4% in 1996 in the study area. The immense slide at Tagaring showed only three scars (Figure 15). There were some remnants left in Chhin and Sisneri Khola, whereas most others had become stabilised. Some new ones in Ghate Khola, Dhod Khola, and Thakan village, west of the Marsyangdi, were of very limited extent. Overall, the study area showed less land degradation in 1996 than in 1958. This aspect is confirmed by the visual evidence recorded for the period 1962-2002 (Chapter 4).

A. March 1962

B. October2002

Figure 12: Tagaring landslide from the south-east: Tagaring landslide was precipitated by the great earthquake of 15 January 1934 (Figure 12A). The slide actually commenced in the oak forest (2,400m). Its debris blocked Marsyangdi River for some days and submerged a flourishing salt-brine at Nunkhani. Four decades later (Figure 12B), the main landslide has stabilised but smaller ones appear across paddy terraces on the left. Figure 14 provides the frontal view of the slide area.

A. October 1962

B. March 2002

Figure 13: Tagaring landslide from the east: Frontal view of the landslide from Sanjaba (1,800 m). The head of the slide in the oak forest and Tagaring village (T) hemmed in by slide scars (Figure 13A). Forty years later, the main landslide has stabilised with vegetation on the north-facing slope and fields on the opposite side (Figure 13B). Old clumps of trees around Tagaring (1,456m) are no more conspicuous and the lower slide is now covered with vegetation. The paddy terraces on the bottom left belong to Sanjaba, a Gurung village opposite Tagaring.

Figure 14: Landslides, Marsyangdi - Ngadi, 1958

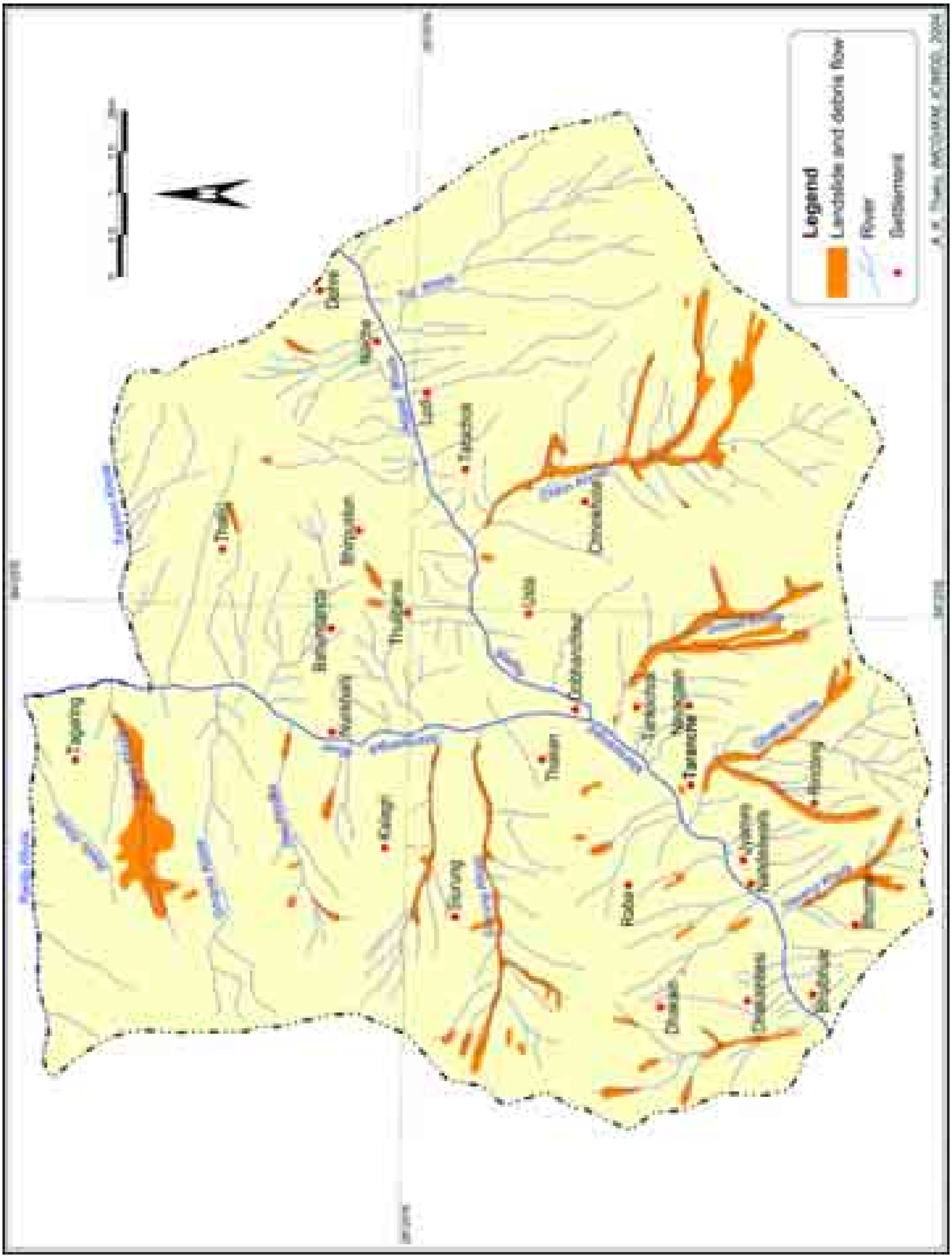


Figure 15: Landslides, Marsyangdi - Ngadi, 1996