"What makes a river so restful to people is that it doesn't have any doubt—it is sure to get where it is going, and it doesn't want to go anywhere else."

– Hal Boyle

TERRAIN CHARACTERISTICS 3

The Himalayan regions owing to intense tectonism and periodic upheavals of the mountain range have perceived episodic rejuvenations. The phases of rejuvenation in the river valleys were responsible in revitalizing the various surficial processes, imprinting innumerable superimposed landforms and the Kali River valley is amongst one of the conspicuous regions considered to be the most tectonically active even today.

PHYSIOGRAPHY

Geomorphologically, the Kali watershed with its tributaries viz. Kuti, Dhauliganga, Ramganga, Goriganga, Saryu, constitute a major drainage system, predominantly draining the terrains of Central Kumaon Himalaya. The Study area viz., The Tawaghat – Jipti Route Corridor exhibits a unique setting covering the Great Himalaya and Lesser Himalayan terrains. The Great Himalayan terrain is characterized by precipitous scarps, steep and narrow gorgeous valleys and turbulent reverberating rivers; illustrating a very

youthful topography, whereas the Lesser Himalayan terrain displays a comparatively mild and mature topography with gentle slopes and deeply dissected valleys.

The Kali River basin exhibits a highly rugged topography with wide relief variations falling within the altitudinal limits of 3256 - 1040 m. The area is characterized by lofty interspersed hills and elongated ridges, dissected by a number of deep and narrow tributary streams and rivulets. Some of the prominent height points in the Tawaghat – Jipti Route Corridor are viz: Jiunti Gad (3192m), Tankul (3256m), Galagad (3432m), Baj Lekh, Nepal (3013m). The overall shape of the Kali River valley segment exhibit a typical bottle necking in the upper reaches (Plate III.1) and quite open and wide in the lower reaches (Plate III.2). It is also observed that couplets of joints/fractures controlled triangular facets in-variably leading to the development of narrow V – shaped valleys (Plate III.3).

The study area also shows development of incised meanders within narrow and deep valley segments (Plate III.4). Within the study area the Kali River flows in SW direction; and the slopes show a general trend of SE on the Indian side and NW in Nepal side. It is conspicuous that where the Main Central Thrust (MCT) and North Chipplakot Thrust cut across the river, a sharp right angle bending is observed and it swings from its general course from SW to E-W direction there by, suggesting a strong control of tectonic elements.

DRAINAGE CHARACTERISTICS

The drainage pattern of rivers contains unique information about the past and present tectonic regimes. The recognition of drainage patterns is very significant as they reflect the successive episodes by which a surface has been modified that includes uplift, depression, tilting, faulting, folding etc. Thus the rivers or the drainage system embody a long record of the geologic history (Zernitz, 1932). The study of drainage patterns helps in identifying the lithology as well as the geologic structures.

The study area includes the main Indian tributaries of the Kali River originating from the Great Himalayan Ranges at Kalapani near the Lipulekh Pass. Its tributary streams Kuti-Yangti, Dhauliganga, Goriganga, and Saryu all following roughly a south-eastern

direction. The small streams (gad) and ravines (gadheras) joining the trunk stream flow parallel to the structural strike and drain the areas either eastward or westward. In the study area Jiunti Gad, Shymkhola Gad (India) and Ritha Gad (Nepal) drain into Kali River. The most common drainage type encountered in the basin area is the dendritic and trellis type. However, radial and re-curved trellis is also commonly observed (Figure 3.1).

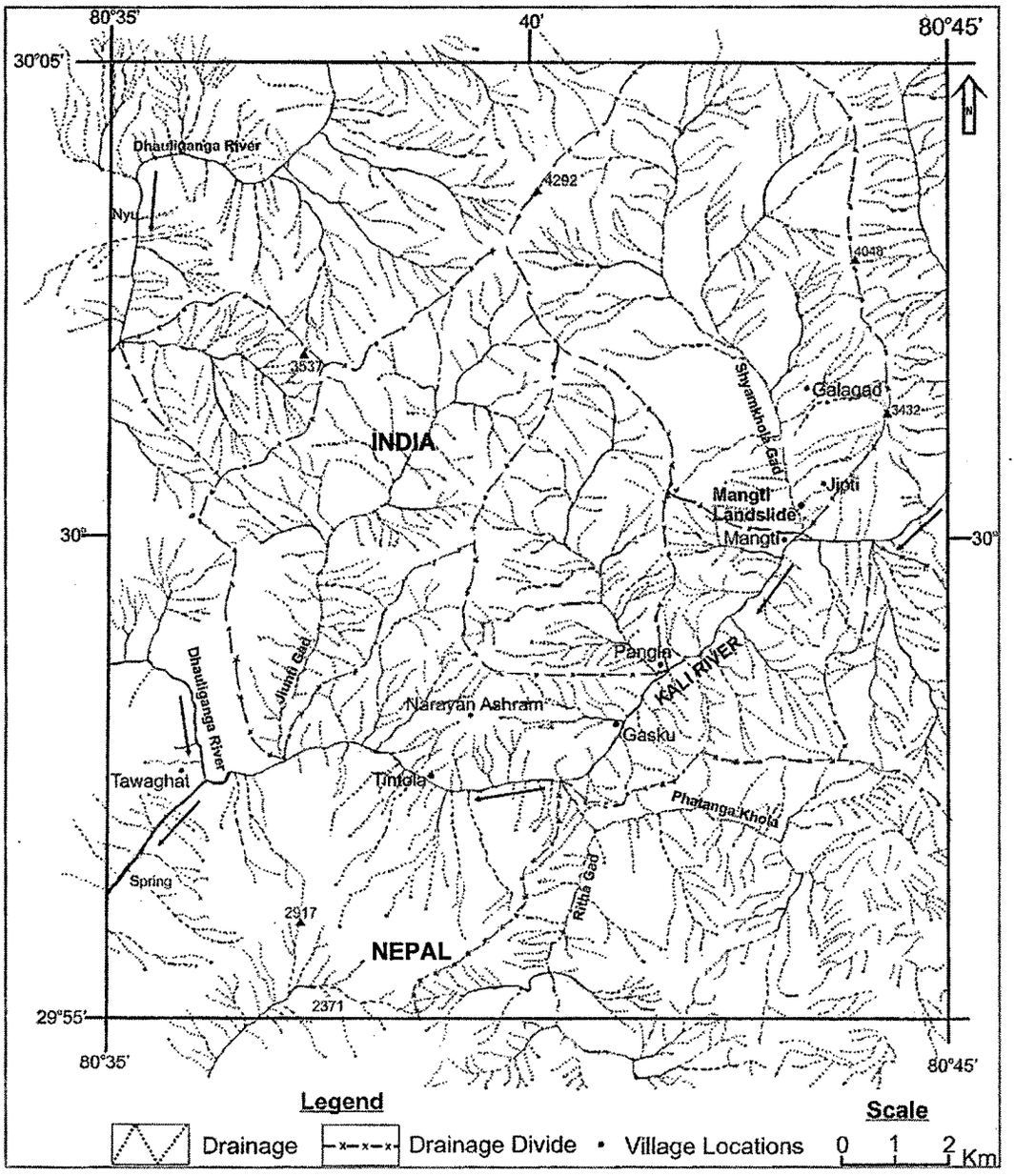


Figure 3.1 – Drainage Map of Tawaghat – Route Corridor

Plate III.1 - A downstream view of Kali River segment characterized by deep gorgy, 'V' shaped valley (Loc. Mangti landslide)

Plate III.4 - Field photograph showing development of incised meanders and point bars (Loc. U/S of Pangla village)

Plate III.2 - Panoramic view of wide - open Kali River valley (Loc. D/S of Balwakot village)

Plate III.3 - Development of Triangular Facets in Sirdang Quartzites leading to formation of narrow V- shaped valleys (Loc. Pangla village)

LANDFORM FEATURES

The episodic orogenic cycles were responsible for an overall upheaval of the entire mountain chain, giving rise to significant uplift to the Himalayan range. The resultant rejuvenation of fluvial, glacial, etc. processes has given rise to variety of Landforms. The landform features witnessed in the study area (Figure 3.2) are the products of different agencies that have operated since the rising of the mountains. The various geomorphic features can be enumerated as glacial, glacio-fluvial, fluvial, mechanical, tectono-genetic and anthropogenic.

Detailed description of observed landforms using Satellite imagery, toposheets and followed by field validation is given as under-

GLACIAL LANDFORMS

Areas confining to higher reaches, abound in glacial and periglacial features. Studies in adjoining areas has corroborated that during the Pleistocene, the glaciers had descended up to 1600-1800m altitudes (Pal, 1986, 1988; Nair, 1995), spread in different parts of Himalayas. Such landforms are formed due to the scouring action of ice over the rocky surface. The glacial erosion is several times more than the fluvial erosion. The enormous erosive strength of the glaciers is responsible for the large-scale plucking of the bed - rock material and huge boulders are transported along with the glaciers. Such type of glacial deposits are encountered in the Shyamkhola Gad valley at an altitude of 2400m Most prominent features indicating past glaciations are the presence of peculiar amphitheatric valleys, hanging valleys, cascades, horn, cusp shaped ridges, etc (Chansarkar, 1974; Nair, 1995). River valley portions at Aktu, Simkhola, are an illustrative site of amphitheatric landforms. Moreover, the occurrence of moraines virtually in all the river valleys especially in the upper reaches viz. Galagad in the Shyamkhola Gad valley is a testimony to the above fact (Plate III.5).

GLACIO-FLUVIAL LANDFORMS

The moraines and glacial outwash are the products of weathering. Debris are restricted to the glacier front, and are brought down by the valley glaciers to lower altitudes where they undergo transportation and reworking under fluvial action and are deposited at suitable sites. The resultant deposits forms the glacio-fluvial terraces of

varying thickness (Pal, 1986). Such terraces are seen at Aktu village, which is established on one such deposit having a thickness of about 35 - 40m. These glacio-fluvial deposits comprise clasts of gneisses and amphibolites having size range between 10 and 500cms in diameter.

FLUVIAL LANDFORMS

As it has already been stated that the Kali River forms one of the major watersheds in the Kumaun Himalayas, it's erosional and depositional processes could be attributed to the factors of climate and tectonism. The river has carved out plenty of fluvial features which are endorsed in their landforms. The aggradational activity of the rivers has resulted into several erosional features like the V-shaped valleys, erosional terraces, steep rocky cliffs, fracture controlled meanders, etc.

The erosional terraces can be seen downstream of Mangti between Dharchula – Jauljibi route. Thick pile of terrace deposits standing vertically for tens of meters are present (Plate III.6). Steep rocky cliffs produced by the erosional activity of the rivers have been witnessed more commonly in the upper reaches beyond MCT and it is very conspicuous in the Great Himalayan terrain. The area north of Mangti village towards Malpa exhibits such topography. The river channels in the study area, exhibits meandering pattern at number of places. These meanders or sinuosity are the product of either decrease in river gradient or the litho-structural configuration. Some typical meander shapes observed in the study area are semi-circular, V-shaped. The high order of sinuosity in the river channels has been correlated with the antecedent drainage system, rejuvenated after attaining maturity due to the upliftment of the mountain range (Chansarkar, 1974). The depositional or a gradational features include terraces, channel bars, points bars, bar islands, meander scrolls, etc. The development and distribution of these depositional landforms is dominantly controlled by the factors of channel configuration and the flow regime. The area along T- J Route Corridor exhibits a very youthful topography. The river bed slope is very high as a result the force of water current is very strong.

The area is characterized by steep gorgeous valleys and high energy conditions therefore do not favour sediments deposition. The channel bars are the manifestations

of sudden change in river channel nature, causing abrupt reduction in gradient and branching in river course. Although the area exhibits a very youthful gorgeous topography, there exist pockets of point bars and channel bar deposits near Pangla and in between Gasku - Tintola village segment. This is on account of flattening of the river bed by accumulation of landslide debris mass and hence there is a decline in velocity of water flow, which has favoured the deposition of sediments.

MECHANICAL LANDFORMS

The landform features developed by the process of mechanical disintegration in fact is a function of number of variables viz., nature and composition of rock, fracture frequency, moisture control and climatic parameters. The combined action of these variables is responsible in the mechanical breakdown of rock masses, yielding voluminous sediments, which in turn rolls down the valley slopes under the action of gravity. The large scale accumulation of mechanically broken sediments at the pediment portions gives rise to a variety of landforms e.g. Colluvial fan, debris fan, cone, talus, scree, landslides, escarpment, etc. In the study area, the mechanically developed landforms are so ubiquitous that all along the river valleys, these features are discernible from a distance. Such illustrative features are observed in various parts of the study area viz., colluvial fans produced by the landslides at Tintola, Gasku, Pangla and Mangti (Plate III.6).

It is significant to note that these features are abundantly seen in the crystalline rocks and that too in the vicinity of the major tectonic lineaments, particularly the fan, talus, scree associated with the landslides and the escarpments. At places between Tintola and Gasku village the colluvial fans have been peneplainated i.e. fan terraces, by the subsequent action of fluvial agencies. Such peneplainated fans have been observed on the left bank of Kali River in the Nepal side.

TECTONOGENETIC LANDFORMS

Apart from these, the study area shows scarps and ridges rising hundreds of meters high with corresponding narrow and deep valleys, which is attributed to episodic rejuvenation of the valley during successive phases of uplifts (Valdiya, 1986). The hill sides are relatively steep, fairly unstable and evidences of extensive rock-slides are

encountered in the vicinity of the regional thrusts and faults. Such landforms are attributed to the neotectonic activities that have been constantly taking place since the rising of the Himalaya along the major thrusts, faults and other lineaments. The effects of such activities are noticeable in the tilt of fluvial terraces, river capturing, instability of hill-slopes, straight courses of rivers, upliftment of terraces, landslides, gorges, knick-points and innumerable rapids in the river bed and waterfalls etc. (Plate III.7).

Looking to the tributaries and streams draining the watershed, one observes that all of them maintain a straight course indicating their flow along certain planes of weakness. The presence of active landslides along T - J Route Corridor is also an indication of reactivation of the existing thrusts and faults. Gorges are seen virtually in the entire route corridor and waterfalls and cascades as high as around 120 – 150m has developed at MCT near Mangti village. Also such waterfalls are associated with other thrusts and faults in the downstream region. Various other geomorphic features such as abrupt change in the stream course, entrenched meanders, etc. provide a clear-cut evidence of emergence during the Quaternary Period (Valdiya, 1993).

ANTHROPOGENIC LANDFORMS

Included under this category are the landforms which have been modified by man for one or other purpose. The highly rugged terrain and the paucity of leveled land has compelled the local inhabitants to modify the natural slopes developed over the hills, fans and other landforms, for farming and construction works. These benches or planation surfaces developed over the hill spurs and stabilized colluvial fans are being utilized for cultivation and housings e.g. peneplanated debris cones at Tintola is the site of village settlement. Gasku, Pangla, Galagad, Tankul, Dumlin (Nepal) are all established settlements over the fluvial deposits over which terrace / step farming is also practiced. Similarly the road construction, which has been one of the major activity has led to modification of slopes and has in turn accentuated the slope failures; causing a numerous landslides.

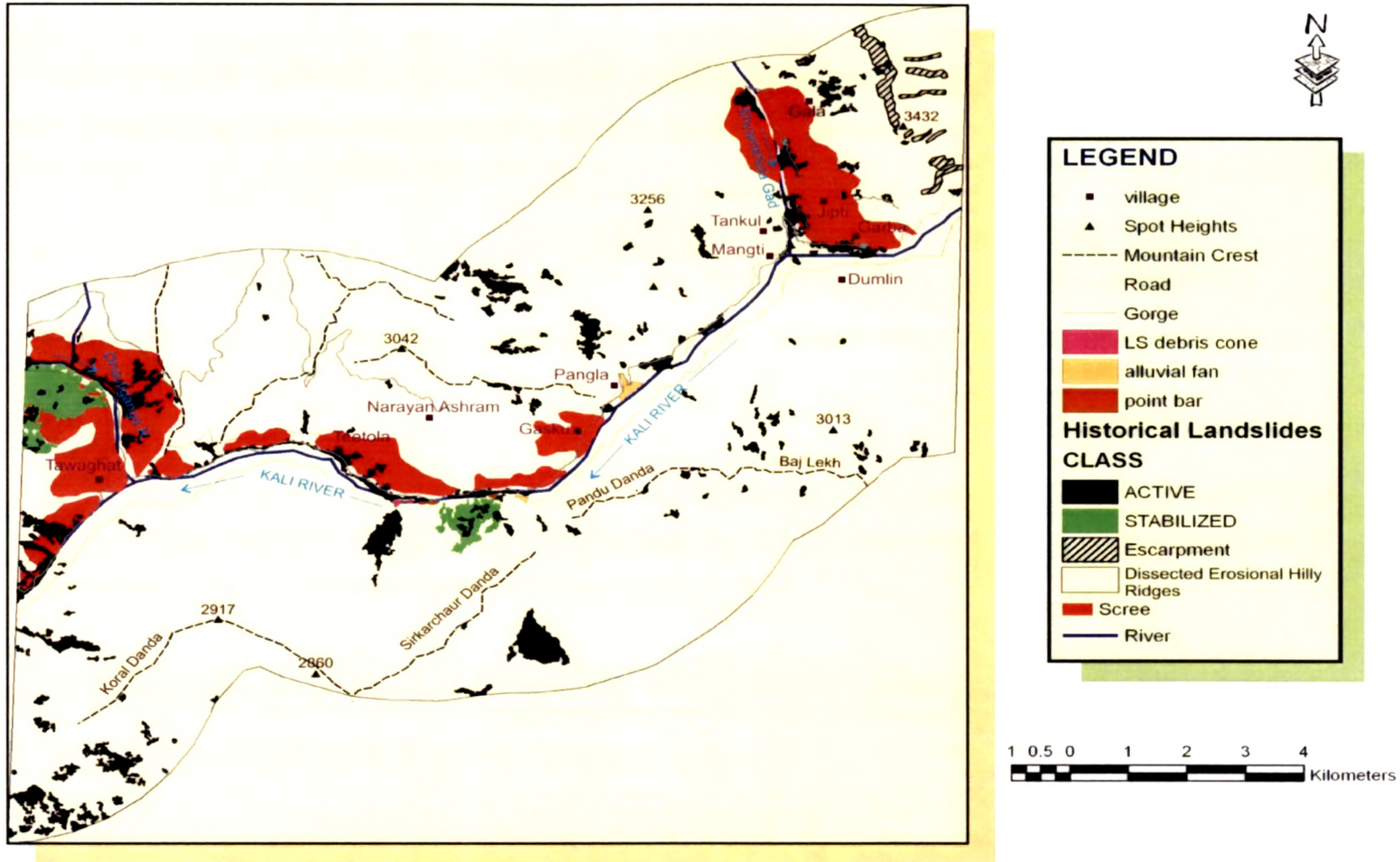
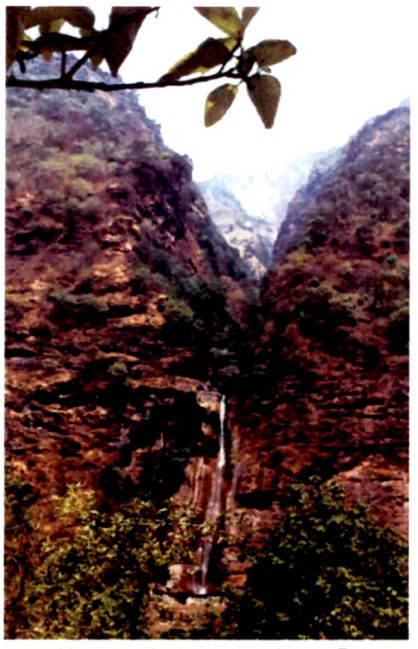


Figure 3.2 - Geomorphic Attributes of Tawaghat – Jipti Route Corridor

View of Cascade and Cusp Shaped Hanging Valley

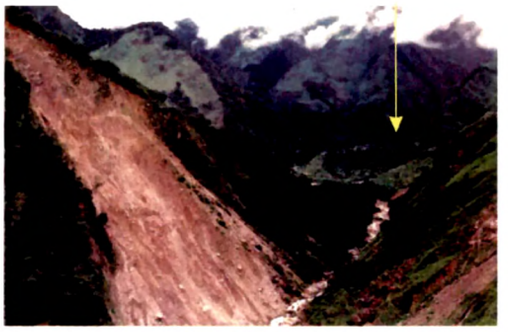


Hanging Valley with Water Fall

A View of Panchachuli with Glacial Landforms viz. Horn and Cirques, Hanging valleys

A View of Horn

View of Morainic Ridge (Esker) in far Ground Valley



Amphitheatre Valley

Plate III.5 - Field Photographs of Glacial and Peri-Glacial Landform Features in the Study Area.

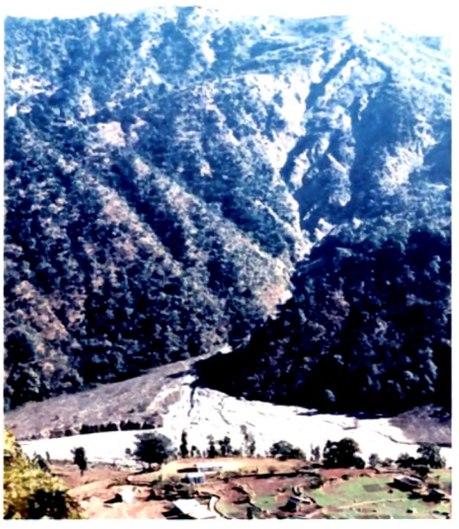
A view of Narrow River terraces

A view of straight, narrow V – shaped valley

A view of eroded colluvial fan

A view of Kali river terrace at Dharchula

A view of Kali river terrace at Jauljibi



A View of Paniplanated Colluvial Fan

Plate III.6 - Field Photographs of Fluvial Landforms in the Study Area

A view of Narrow & Deep River Gorge

A view of Rapid

A view of Water Fall & Rapid

A view of Steep Rocky Cliff

Plate III.7 - Tectonic Landform Features Along Kali River Channel