Journal of Indian Geomorphology
Volume 3, 2015 ♦ ISSN 2320-0731
Indian Institute of Geomorphologists (IGI)

Terrain Evaluation and Landform Utilisation in the Lower Bino Basin, Uttarakhand

Devi Datt Chauniyal[1], Surajit Dutta[1] and U. C. Mainali[2]
[1]*Department of Geography, HNB Garhwal University, Srinagar, Uttarakhand-246174*
[2]*Department of Geology, SGRR PG College, Dehra Dun-248001*
E-mail: dutta.surajit34@gmail.com (Corresponding author)

Abstract: *Terrain evaluation is a basic requirement for carrying out various developmental projects and environmental planning. Geomorphological mapping can fairly depict the landform units present in the area. Remote sensing is the quickest and cheapest technique which has proved its effectiveness in such mapping. The study area is dominated by exposures of low to high grade meta-sedimentary rocks of the Dudatholi group. Number of mega to micro level structural deformations indicates multi-stage neo-tectonic activities. Investigation of geomorphic evolution of landforms, their classification and utilisation have been carried out in the study area. Neotectonic activity and possible environmental hazards have also been taken into consideration while attempting a classification of the lower Bino basin into terrain units.*

Introduction

Natural resources provide the base for development of any country. The various aspects of Earth Science can provide full information regarding these natural resources. Lack of information and unscientific utilisation may prove harmful and its long term effects may lead to various insurmountable problems. Hence scientific planning and management is necessary for optimum utilisation of natural resources. Careful evaluation of the terrain can help in delineating the areas suitable for different uses. Conventional methods of such delineation are time consuming and expensive Remote sensing techniques for geological and geomorphological mapping have advanced to a great extent from visual to digital interpretation of multi spectral data. Remotely sensed data is now a useful tool for terrain analysis. This technique provides sufficient information for the identification and mapping of landforms in the difficult Himalayan terrain.

Geomorphological studies of the Himalayan terrain are also very important for geo-environmental planning and watershed management. Unfortunately very little is known about the geomorphological processes operating in the Himalayan region. There is an urgent need to produce reliable qualitative and quantitative data that can be used for watershed management in the Himalaya (Rawat and Rawat, 1994).

Study area

The study area falls in Survey of India Toposheet No. 53 O/1 and covers 43km^2 area. Administratively it is a part of Syalde block in Almora district of Uttarakhand. The lower part of Bino basin extends from Ulmara to Burhakedar. The Bino river is a 5th order spring fed tributary of the Ramganga, which originates from southern slope of the Dudhatoli range on the lesser Himalaya (Fig. 1). The landscape is predominantly fluvial

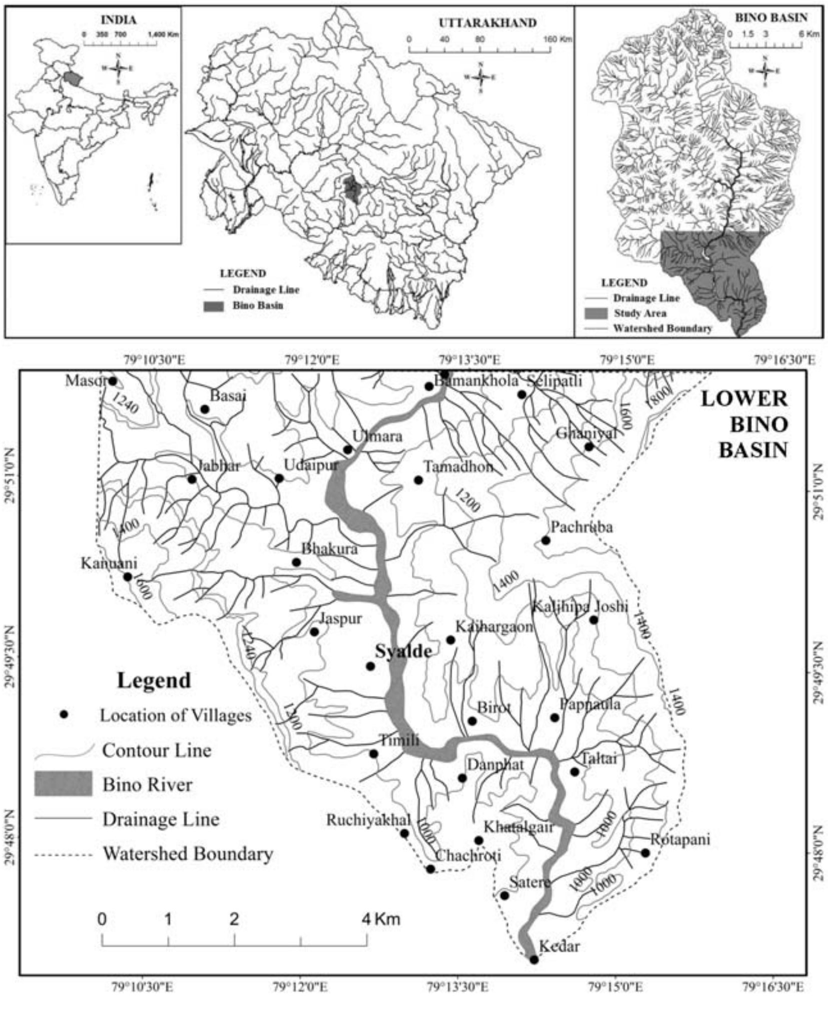


Figure 1. Location map of the lower Bino basin

with wide flat valley bottom, multi level terraces and alluvial fans. Located in the southern limb of Dudhatoli syncline, the study area is composed of Dudhatoli crystallines. Dudhatoli group of rocks are well exposed all around the area. These rocks have been considered to be of Pre-Cambrian age (Valdiya, 1976). The present geomorphic character of the Bino basin is influenced by geological structure and past climatic conditions.

Objective

The main objective of the present study is to evaluate and classify the terrain of the Bino basin into different morpho-terrain units in relation with the prevailing landuse.

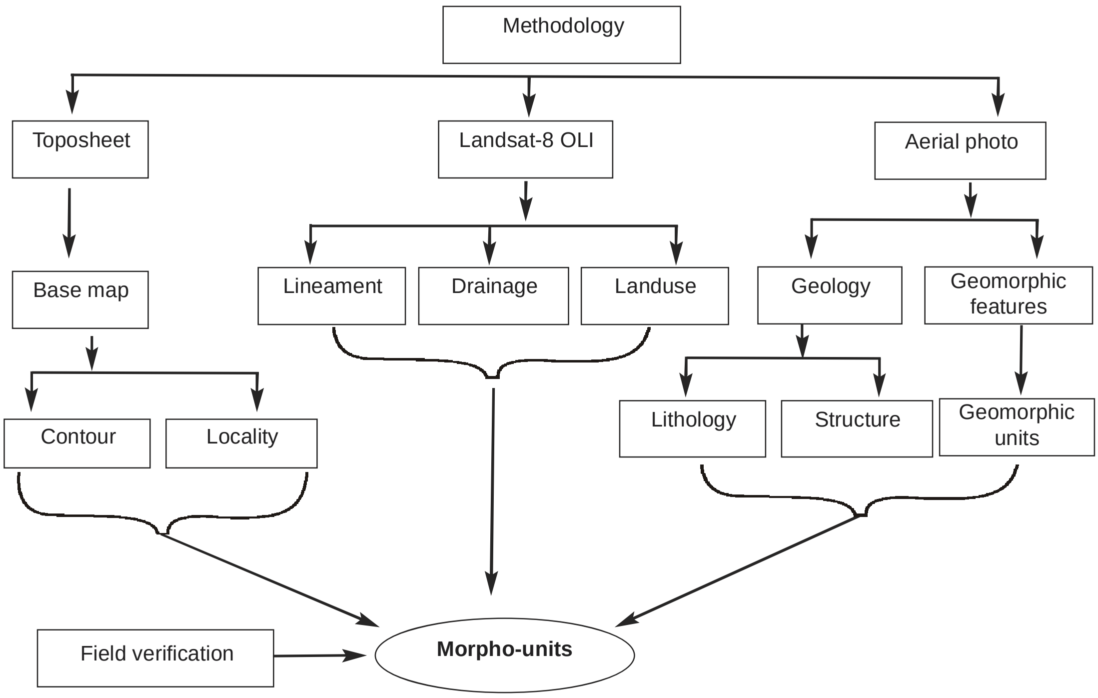
Material and method

The spatial data used in this work include (i) Survey of India topographical sheet 53 O/1 on 1:50,000; (ii) Survey of India panchromatic aerial photographs of 1960 on approx 1:40,000; (iii) Landsat-8 OLI image of 14 November 2013.

The base map is prepared on the basis of topographical map. Aerial photo pairs were studied under stereoscope to extract geological, structural and geomorphological features to delineate various lithological boundaries and geomorphic units. The drainage, lineament and landuse is visually interpreted from georeferenced satellite FCC and the details are incorporated in the base map. Subsequently the study area is classified into different morphological units (Fig. 2). The final results were verified in the field and modified where it was necessary. A number of field traverses were taken to cover the entire area. The methods followed in the work are summarised in the diagram below.

Observation and results

Geological and structural interpretation is



carried out on the basis of aerial photo and satellite image interpretation. Different litho-structural and topographic features are identified and interpreted with tone, texture, pattern, shape and size as the identifications keys.

Lithology

Gneiss, schist and phyllite interbedded with quartzite are three major litho-units well distributed in the study area which control the topography and landforms.

GNEISS: It is well exposed in Bamankhola, Tamadhon, Puchrubo Palla, Rikhari and Kaljhipa Joshi in the north eastern part of the study area. On the basis of texture, structure and mineralogical composition, the gneiss can be classified in two types — (i) Augen and (ii) Foliated. Augen nature is developed due to the porphyroblast of plagioclase crystals and this is clearly seen along the road-side cut near Bamankhola and Titeshwar Mahadev. The foliated gneiss is much compact and hard in nature compared to Augen gneiss. The foliation character is developed due to biotite and muscovite minerals. The foliated gneiss is exposed near Pachrubo and Tamadhon village.

SCHIST: Good exposures of schist are seen around Kaihargaon, Birot, Papnaula and Ulamara, southwestward from the gneissic exposure at the left bank of the Bino. The colour of schist varies from dark brown, pinkish brown to light grey. At some places weathered rock of friable nature with sub-rounded crystals of garnet are seen. Biotite and muscovite are the main constituent minerals and their orientation defines the schistosity plane. Quartzite is also found as interbeded layers, separated by some micaceous material. Quartz veins are often traversing the schist horizon. Micro folds are seen along the river section.

PHYLLITE: Major portion of the study area from right bank of river Bino towards west is covered by phyllite with interbedded quartzite. It is brownish grey and green in colour. Chlorite with quartz and feldspar are the dominant minerals present in phyllite and the lineation is basically developed due to chlorite. At Chachroti, Burhakedar and Ruchiyakhal the phyllite is highly fractured, jointed and crushed due to folding. In folded structures quartz veins are cutting through the foliation planes. Isoclinal folds are well preserved in quartzite, exposed at road and stream sections.

Structure

The study area has undergone multiple phases of deformation which is evidenced by multi-folded structures in schists, phyllites and quartzites. Lineament analysis also supports this fact (Datt, 1993). The impacts of multi-deformation phases have badly affected the resistance of rocks. Geomorphic signatures of such deformation include diversion of drainage lines, terrace formation, stream piracy etc.

Folds are important structural features seen in the area. According to size these can be grouped into mega and micro folds. On the basis of shape and orientation of beds rocks, the folds show diverse forms like isoclinal, closed and chevron folds. Numerous quartz veins are traversing through the folded phyllite and schist outcrops.

On the basis of satellite images, supported by aerial photographs the following major and minor faults and lineaments are identified in the study area (Fig. 2).

TAMADHON-CHACHROTI FAULT (TCF): This fault runs along the Bino river from Deghat-Tamadhon to Chachroti village (Fig. 2) in NW-SE direction. This steeply eastward dipping Fault (>75°) is also known as Bino-Ramganga-Naurara valley fault by Goswami and Pant (2008). It cuts the water divide of Bino-Khataron Gad at Chachroti and formed a fault gap (saddle), locally known as Khal and joins Ramganga at Turachona (Fig. 3). This sharp linear structure was developed during early stages of deformation. The fault runs nearly parallel (N-S direction) to North Almora Thrust.

Table 1. Landform units of lower Bino basin

Features	**Local Name**	**Slope**	**Geomorphic Characteristics**	**Land Use**
Channel course	*Gad*	2°	It remains underwater throughout year. Sandy bank, boulders, braided channels are prominent features.	Waterbody
Floodplain	*Baggar*	2°–°5°	*Baggar* is a part of flood plain that forms a narrow strip of low lying area which is closely attached to the river. In rainy season, *Bagger* is submerged into water**.** Rest of the year it is dry and used for pasturing.	Grazing land
Lower terrace	*Talli taya*	< 5°	Name given to lower cultivated Terrace which is immediately above the *Baagar* and is irrigated. Thick alluvial soil and continuous supply of water allows intensive land use.	Intensively cultivated land (irrigated)
Upper terrace	*Malli taya*	<8°	*Malli taya* locally called to upper cultivated terraces. Imperfect drainage and severe erosion is prominent.	Cultivated land (unirrigated)
Sloping terrace	*Ukkhar Taya*	15°–20°	The uppermost terraces are dissected to form scarps and convex surface formed by fan material derived from Hill slopes.	Barren land
Fan/ cone	*Rokhar*	8°–12°	Alluvial fan/cones are gradational features formed due to the material derived by small *Gadheras* (first or second order streams) in which coarse fragments are found in upper part and medium to fine clastic is in lower part.	Cultivated and cones are barren
Spur	*Uproan*	15°–25°	Spurs are prominent features with convex slopes from hill crest to the valley floor.	Cultivated land
Ridge/ divide	*Dhar / Danda*	20°–30°	*Dhar* or *Danda* are water divide whose height is relatively higher than its surroundings. These can be divided into rounded and conical form according to its crest shape.	Forested land

BHATI-PILKI FAULT IN KHATRON GAD (BPF): This fault runs parallel to the previous one in NNW to SSE direction in Khatron Gad. Two tributaries coming from north and south follow this fault line. Kanuani-Chachroti asymmetrical ridge is parallel to this fault (Fig. 2).

TIMALI-TALTAI FAULT (TTF): This fault is transverse to Tamadhon–Chachroti fault and has NE to SW orientation. The Bino river changes its course from north-south to east-west orientation due to this fault at Dhanpat village. The origin of this fault is later than Tamadhon-Chachroti fault because it cuts across latter.

PAPNAULA-BURHAKEDAR FAULT (PBF): This fault is developed during third or fourth phase of structural deformation. The general trend of the fault is N-S and truncates the earlier transverse faults near Taltai village. From this place the Bino river takes a sharp right turn and flows through a straight, narrow fault-guided gorge up to Burhakedar.

JUNIYAGARHI GADHERA FAULT (JGF): This fault extends from NW to SE direction along the Juniya Gadhera stream. It has displaced the Tamdhon-Chachroti fault at Udepur and Ulmara. It is a second generation strike-slip fault parallel to the Dudhatoli syncline. At the juncture of lineaments at Tamadhon, Udepur and Ulmara localities there are geomorphic features bearing evidences of neo-tectonic activity like tilting and displacement of terraces and landslide features found on quaternary deposits.

Neotectonism

The Himalaya is a tectonically active region. Several studies carried out by Nakata (1975), Valdiya (1989), Choubey and Litoria (1990) have reported about neotectonic activities in the Himalayan region. Such activities are manifested by high level unpaired terraces, displacement in terraces, old landslide scars, active landslides, blocking of stream chanels, stream capture and diversion and active mass movement. For the present study the neo tectonic faults which are clearly visible in the aerial photographs were marked on map (Fig 2) and also verified with associated geomorphic features. One of the tilted terrace beds is reported along the motor road section near Govt. Inter College, Syalde. This tilted structure is also reported by Goswami and Pant (2008). The 4th level terraces are also tilted SW at an angle of 20° to 25° near Udaipur village. Khatalgair hill and Burhakedar area is surrounded by three fault lines (Fig. 2) showing upliftment of the terrain. Active landslide is marked along neotectonic fault at Galgaon. High level displacement of terraces is observed at the confluence of the Ramganga and Bino. High level terraces at Satere village are tilted towards NE forming a steep scarp. Relict alluvial fans formed near the village are also tilted in same direction. Such anomalous disposition of beds of a particular terrace could most plausibly be attributed to the palaeo-topographic characteristics of the depositional surface (Goswami and Pant, 2008).

Geomorphic evolution

The geomorphic development is determined from locational setting of landforms, morphologies, and morphogenic processes working therein (Zuidam-Cancelado, 1990). These processes play significant role to change the shape, size, and morphology of the landforms. Entire geomorphic evolution of the region is ranging between Tertiary to Quaternary period. The

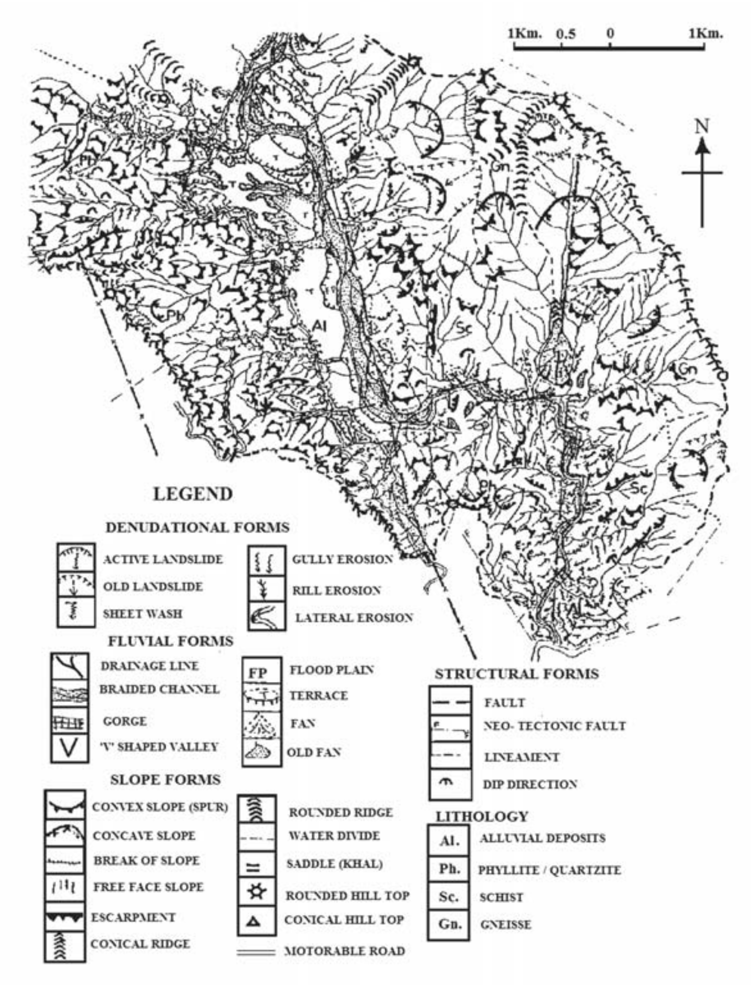


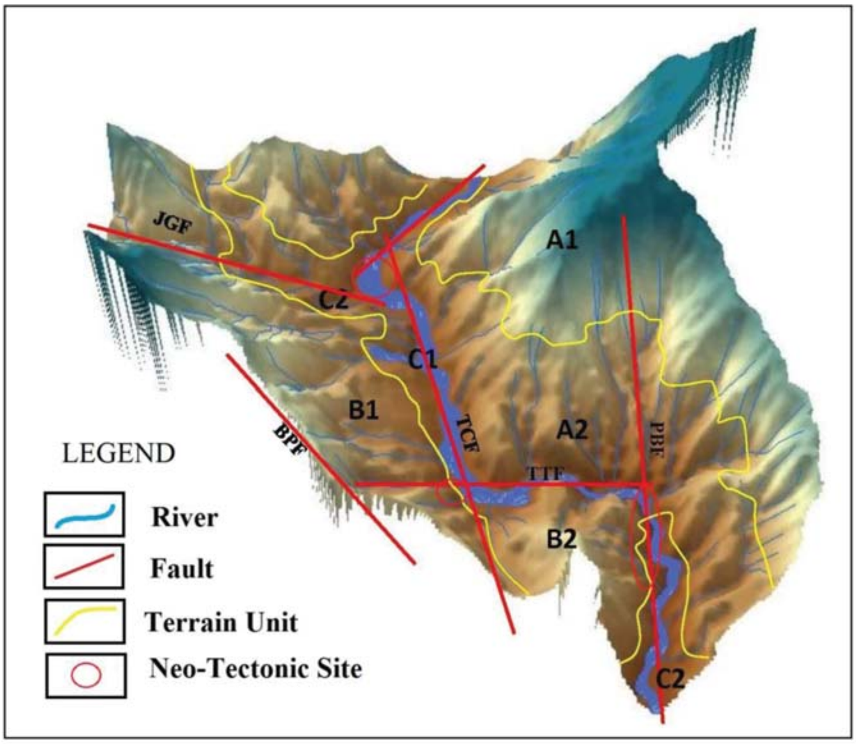
Figure 2. Geomorphic map of lower Bino basin (based on aerial photo mosaic)

Himalaya has experienced lowering of snowline in several glacial and inter glacial periods during past.

The former channel course of Bino river is nearly straight (NW–SE) from Chachroti to Sanana where it meets the Ramganga.

The main channel was obstructed at Danphat village due to tectonic effect and started following the E–W oriented Timlli-Taltoi fault. This right angle diversion of the narrow channel course across foliations, resulted in slow rate of valley deepening. The river started depositing its load by forming a natural lake. Large amount of alluvial material accumulated in which was later deeply incised by river and formed terraces. Further downstream near Taltoi village, the river once again changes its course as it starts to follow the N–S oriented Papanaula–Burhakedar fault through a narrow gorge.

A



B

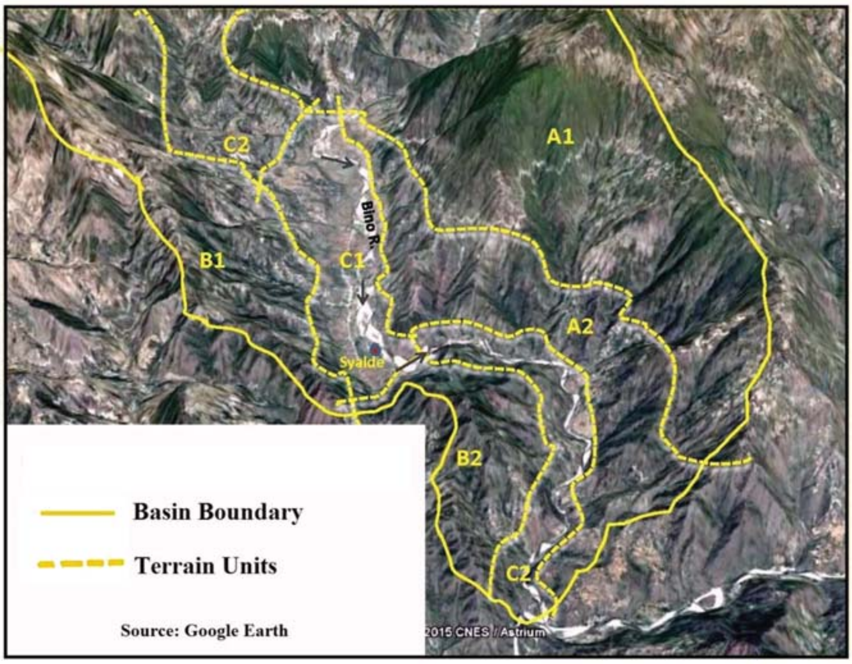


Figure 3. (A) Digital Terrain Model of lower Bino basin. See Fig. 4 and text for explanation of letters (B) Terrain classification of lower Bino basin

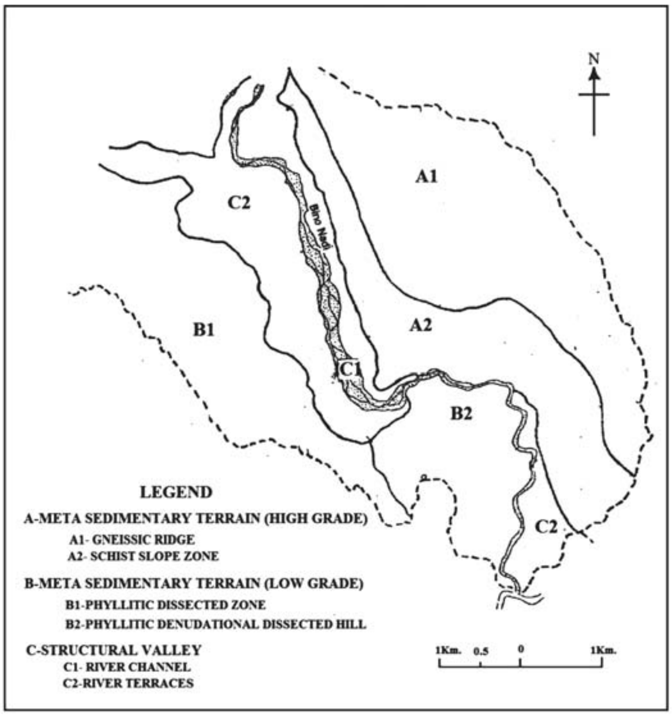


Figure 4. Geomorphic units of lower Bino basin

Investigations revealed that highest level of terrace is located at 1,040 m. The villages of Bhakura Malla, Jospur, Udaipur, Kaihargaon, and Satere are located on it. The height of the Chachroti gap is also 1040 m, which is about 140 m higher from the present riverbed. The former channel of the Bino might have been flowing through this gap. The lineament is clearly seen on aerial photo and satellite images.

Landform units

The geomorphic features are grouped into following landform units: (i) denudational forms, (ii) fluvial forms, (iii) slope forms, and (iv) structural forms.

Low lying areas of the valley are characterised predominantly by river terraces which are locally known as Taya (Datt, 1993). Five terrace levels of considerable size are found in the basin (Fig. 2), which are discontinued by hill slope streams and meandering nature of the Bino. Five levels are clearly seen at Tamandhan, Bhakura, Udaipur and Jaspur on right bank and Kaihargaon on the left bank. The larger terraces are mainly found on the right bank and extend for about 5.5 km from Ulmara to Danphat village. Second and fifth number level terraces have large spatial extension in comparison to others. It appears from the study that due to tilting the river course shifted towards the left bank. The landform units can be differentiated on the basis of geomorphic characteristics as shown in Table 1.

Terrain Units

Terrain units are pieces of land which are characterised by homogeneity in material and process. Terrain classification was attempted

Table 2. Geomorphic units and their characteristics in lower Bino basin

Geomorphic Unit	Sub-Unit	Aspect	Relative relief	Slope	Drainag e	Soil	Intensity of erosion	Land use	Landforms
A Meta- Sedi-mentary, Terrain (high- grade)	A1 Gneissic ridge	Western	Moderate 300 m	Moderate (300 m km^{-1})	Coarse	Coarse	Moderate	Forested land	Rounded crest, structural scarps, old landslides, concave slopes in the downward side and break of slope are dominant features.
	A2 Schist slope zone		Low (200 m)	Moderate (400 m km^{-1})	Fine	Coarse	Moderate to high	Forested land	Old landslide scars, scree slopes, spurs, structural scarps and fans are the main features.
B Meta Sedimentary Terrain (low grade)	B1 Phyllitic dis-sected zone	Eastern	High (700 m)	Steep (500 m km^{-1})	Fine	Fine	Very high	Cultivated land	Asymmetrical rounded ridge crest with saddles and rounded tops, convex spurs, conical water divide, escarpments, old and active landslides, deep valleys are the prominent features.
	B2 Phyllitic de-nudational dissected hill	Eastern	High (660 m)	Moderate (300 m km^{-1})	Fine	Fine	Very high	Barren land	Isolated, rounded and conical hills, radial drainage, old and active fans, landslides (old and active), gully and stream piracy are dominant features.
C Structural Valley	C1 River channel	—	Very low (40 m)	Very low	Well defined	Sandy	Low	Wasteland	Water course, braided channel, point bars, boulders, flood plains, undercuts and river bank erosion are prominent.
	C2 River terrace	Western	Low (180 m)	Very low (120 m km^{-1})	Gully	Alluvium	Low	Cultivated land	Multi levels of terraces, gully, talus cone, terrace scarp erosion, alluvial fan and terraces are predominant.

by early workers. According to Stewart (1968), the basic descriptive unit of land system is terrain unit. The CSIRO in Australia worked on terrain classification (Ollier, 1977). In the Himalayan region, an attempt was made by Kharkwal (1968) to classify the Kumaon Himalaya into morpho-units. Choubey and Litoria (1990) classified the Kalsi-Chakrata area into terrain units in the Garhwal Himalaya.

A digital terrain model is prepared to highlight the litho-tectonic and topographical setting of the study area (Fig. 3a, 3b). It gives an idea on the location of different terrain units and structural feature. The present study area is divided in three main geomorphic units (A, B and C) on the basis of lithology, relief, slope, landforms etc. (Fig. 4). On the basis of physiographic setting and denudation character, the main units are further classified into sub units, as shown in Table 2.

Natural Hazards

Cloudburst, excessive rain, peak stream runoff and floods in rivers are the main agents of erosion of the hills. High-altitude regions of the area experience rockfalls and landslides, which often affect the lower areas. The higher terraces are dissected by gullies — locally known as khaddak — and landslides initiate from the scarps bordering their channels. These processes seriously threaten household food supplies (Datt, 1990). A large number of gullies approach the fourth level terrace from three sides (Fig. 3). The effects of heavy flooding are widespread on the floodplain during monsoons. Sometimes, the floodplain (baggar) and the lower terraces are seriously damaged or completely washed out. The agricultural fields on the terrace are also undercut by the monsoon discharge, loaded with sediment. The fertile soil of terrace is washed away and is replaced by sands and gravels, which seriously damage, the paddy crops every year in the low lying areas of the Bino valley.

Conclusion

Taking into consideration all the lithological, structural and geomorphic complexities, the lower Bino basin is classified into six terrain units which are being utilised for different purposes by the local people. It is observed that such type of landform classification can be successfully applied to watershed management and planning. The method can have a wide range of application, especially in the mountains, provided some basic information about the relief, lithology, structure and land use is available.

Acknowledgement

The authors express their gratitude to the Dean, IIRS and the Head, Geosciences Division for providing facility in the institute for guidance, interpretation and discussions. The authors are also grateful to Mr. D.K. Jugran (retired scientist) for his help and suggestions during photo-interpretation and discussions.

References

Choubey, V.D. and Litoria, P.K. (1990) Terrain classification and land hazard and mapping in Kalsi-Chakrata area, Garhwal Himalaya, India. *ITC journal*. 1990-1991, Netherlands: 58–66.

Datt, D. (1990) Land system, land use and natural hazards in the lower Bino basin, lesser Himalaya, India. *Mountain Research and Development*. The United Nations University, International Mountain Society, Colorado, USA 11(3): 271–276.

Datt, D. (1993) Bino basin: *A study of landforms and land utilization,*. Unpublished D.Phil. thesis in Geogrphy, Garhwal University, Srinagar (Garhwal): 125–146.

Goswami, P.K. and Pant, C.C. (2008) Morphotectonic evolution of the Binau-Ramganga-Naurar transverse valley, southern Kumaun, lesser Himalaya, *Current Science*, 94(12): 1640–1645.

Kharakwal, S.C. (1968) Classification of Kumaon Himalaya into morpho-units, The National *Geographical Journal of India*, XIV: 84–86.

Nakata, T. (1975) On Quaternary tectonics around the Himalayas. Tohoku Univ. Sci. Rep., 7th Ser.(Geography) 25: 149–152.

Ollier, C.D. (1977) Terrain classification: methods, applications and principles. In Hails, J.R. (ed) *Applied Geomorphology*. Elsevier Scientific Publishing Co, New York: 277–316.

Rawat, J.S. and Rawat, M.S. (1994) Accelerated erosion and denudation in the Nana Kosi watershed central Himalaya, India. *Mountain Research and Development*. 14(1): 25–38.

Rupke, J. (1994) Stratigraphic and structural evolution of the Kumaun, lesser Himalaya. *Sedimentary Geology* 11: 81p.

Stewart, G.A. (1968) *Land Evaluation* (Ed.). Papers of a CSIRO Symposium, The Macmillan Co., Melbourne, Australia: 392p.

Valdiya, K.S. (1976) Himalayan transverse faults, folds and thrusts parallelism with sub-surface structure of north Indian plains. *Tectonophysics* 32: 353–386.

Valdiya, K.S. (1989) Problem of mass movement in part of the Kumaun Himalaya. *Current Science*, 58(09): 486–491.

Zuidam-Cancelado, F.I.V. (1990) Geomorphologic development of the Aljucen rver basin. *ITC Journal*, 1990-1994, Netherlands:

Mitchell, C.W. (1973) Principles of terrain evaluation. Longman Group Limited, London: 46–62.

Date received: 15 December 2014
Date accepted after revision: 25 October 2015