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Landform and Landuse Analysis of Thongjaorok Basin, Manipur

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Abstract

Based on the visual interpretations of Topographic maps, LANDSAT Imagery and field checks different types of landforms have been identified in the area, which include: structural hills, denudational hills, valleys, flood plains and associated features. On the basis of magnitude these landforms are divided broadly into two categories, i. e., major and minor landforms that are utilized by man and nature for different purposes. On the basis of the data generated from the visual interpretation of Topographic maps (1970) and IRS-ID-LISS-III Geo-coded FCC (2000) on 1:50,000 scale and field-checks, nine different categories of land-use / land-cover are identified in the Thongjaorok River basin. Between 1970 and 2000 there have been drastic changes in the land use/ land cover patterns in the area. It is intriguing to note that there is increase in the forest area, settlement and water bodies while decrease in the open scrub areas. Increase in the forest area is mainly due to the social forestry taken up by the Forest Department, Govt. of Manipur.

Introduction

Thongjaorok, a rain-fed river, originates from the Laimaton-Loiching Hill Ranges between Bishnupur and Oinam on the western side of the Imphal valley. Since most of its tributaries originate from the western side of the hill ranges, it is an excellent example of the asymmetrical basin. It has a total catchment's area of about 28.55 sq. km that lies between Longitudes 93^0 42' to 93^0 49' E and Latitudes 24^0 36' to 24' 43' N (Fig.1). Out of the total catchment's area about 15.75 sq. km lies in the hilly terrain and remaining 12.8 sq. km in the plain. Total length of the river from its source to the confluence with the Loktak Lake at Tekra Pat is about 15.5 km, out of which about 8.5 km is spread in the hilly and remaining 7 km is in the valley portion. Though it is a very small, but one of the most active rivers of the Loktak catchment which contributes maximum amount of debris to the lake.

Physiographically, the study area is partly hilly and partly plain and can be divided into three regions:

a) **Hilly Region**: It is characterized by moderate to high structural cum denudational hills.

b) **Piedmonts**: Piedmont-zone is found all along the foothills and dominantly consists of pebbles; boulders, cobbles and matrix derived from the hill slopes and brought down under the influence of gravity by the Thongjaorok and its tributaries.

c) **Plain**: Plain region is made up of alluvium deposited by Thongjaorok and its

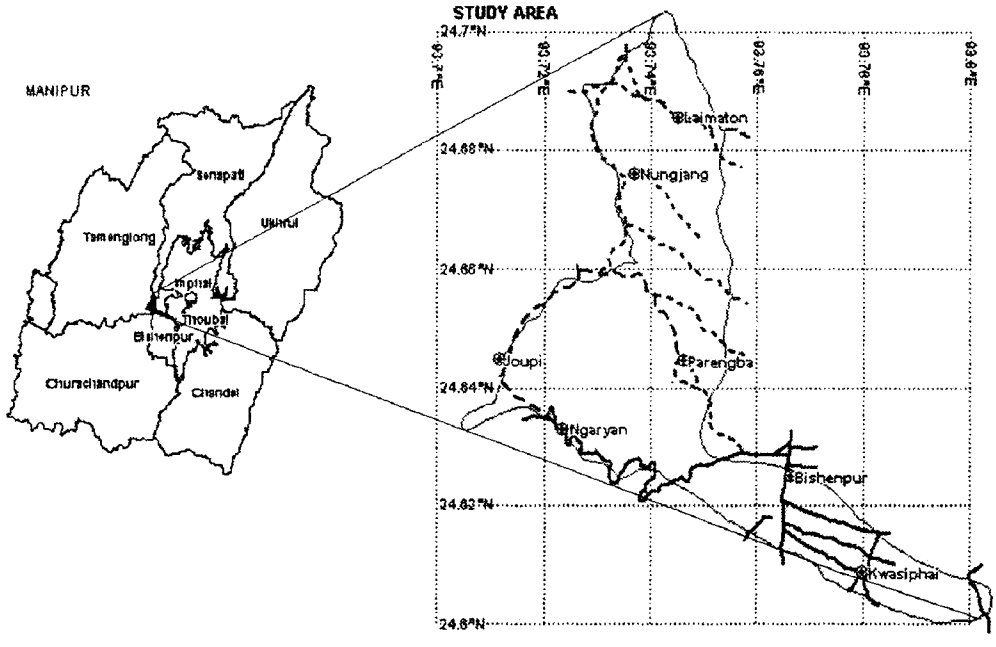

Fig 1: **Location Map of the Study Area**

tributaries and the Loktak Lake, which has been divided into two, i.e., the older and the younger alluvium. Older alluvium is deposited on either sides of the Thongjaorok River, mainly on the western side and occurs at the lower elevations than the piedmont zone. At higher level it occurs on gentle hill slopes and along terraces. The younger alluvium occurs all along the river-bed and at the lower elevations than the older alluvium. It is dominantly composed of variable size materials viz., sand, silt to very fine clay-size sediments. Alluvium deposited by the Loktak Lake is characterized by dark gray to black coloured and very fine-grained mud.

Geology of the Study Area

The geological formations occurring in the area comprise the Disang and the Barail groups and Alluvium. Different litho-units along with their brief descriptions are given in Table-1.

i) The Disang Group: The term Disang in geology was first coined by Mallet (1876) to describe a thick, dark grey to black coloured splintery shales, interbedded with siltstones and fine-grained sandstones. In the study area, this Group of rock is exposed only near Chinil Ingkhol. It is characterized by dark grey, thinly laminated, highly splintery shales with small lenses/ pockets of siltstones. Splintery nature of the Disang Group is mainly due to the intersection of laminations and a prominent set of cleavage. The contact between the Disang and Barail groups is generally of gradational nature, but in the study area it is marked by a high angle reverse (thrust) fault.

ii) The Barail Group: Evans (1932) used the term Barail to describe thick intercalations of sandstones and shales, overlying the

Table1: **Litho-Stratigraphic Succession of Thongjaorok Basin**

Unit	Age	Lithology
Alluvium	(Quaternary-Holocene) (?) Older	Clay, silt, sand, gravels, pebbles and boulder deposits on the foothills and older river terraces.
Stratigraphic Break		
Barail Group	Upper Eocene to Oligocene	Massive to thickly bedded sandstone. Alternation of shales and sandstones constituting rhythmite sequence. Flysch sediments of Turbidite character.
Faulted Contact		
Disang Group	Cretaceous to Upper Eocene	Dark grey to black, splintery shales with intercalations of shales, siltstones and fine sandstones at places occasionally, shows rhythmite characters.
Stratigraphic Break		
Basement	Complex	Unseen

Disang Group. The rocks of this Group are exposed over the major part of the Thongjaorok catchment. They are characterized by light to brownish grey, fine to medium-grained sandstones, often interbedded with brown to grey coloured shales. Near the bridge (Old Cachar road) towards the up-current direction, the Barail Group is represented by the rhythmic intercalations of shales, siltstones and fine-grained sandstones, which gradually grade into thickly bedded to massive coarse-grained sandstones. Presence of the primary sedimentary structures like ripple-marks, cross-beddings and different types of trace fossils suggests shallow depth of the depositional basin.

iii) Alluvium: In the study area, it occurs at many places. Along the river course it occurs as channel-lag deposits, channel-bars, point-bars, terraces, and along the foothills in the form of alluvial fans and is mainly composed of boulders, pebbles, and granules with little amount of sand-size and clay-size materials. The lower reaches of the basin are covered by the flood plain deposits, dominantly consisting of fine sand, silt and clayey materials.

Landforms and Landuse

Earth surface is constantly modified by a number of endogenic and exogenic processes, which lead to the formation of different types of landforms. Howard and Spock (1940) defined landforms as "any element of the landscape, characterized by a distinctive surface expression, internal structure or both and sufficiently conspicuous to be included in a physiographic description". Of all the surface forming processes, rivers are the most important agents in shaping the earth surface. Men and nature utilize these landforms for various purposes, even though there is often confusion between the two terms: land-cover / land-use. Land-cover or the surface cover refers to all the physical (man made) and biological (vegetation

cover) features over the earth's surface and land-use is the total arrangement and activity that human-beings undertake on the landforms. According to the changing needs of the society, time-to-time, use of the land also changes. In order to fulfill the changing needs man has been using, misusing/ over-using and under-using the land.

A) Landforms

Various types of landforms identified in the Thongjaorok basin are based on the visual interpretations of Topographic maps, LANDSAT Imagery on 1:50,000-scale and field checks. These include: structural hills, denudational hills, valleys, flood plains, alluvial fans, terraces, point-bars, channel-bars, natural levees etc. On the basis of the dimensions, these landforms are classified into two categories, i.e., major and minor landforms.

a) Major Landforms: The landforms that are large enough that can be identified on the Topographic maps and the LANDSAT Imageries are categorized as major landforms. These landforms are identified on the basis of variations in tonal and textural patterns, on LANDSAT Imagery and variations in the contour patterns on the Topographic maps and are verified by the ground checks. Major landforms of the study area include; hills, valleys and floodplains.

i) Hills: Hills are the most striking and conspicuous geomorphic features in the study area. These hill ranges are the products of diastrophic forces like folding and faulting and shaped by the Thongjaorok River and its tributaries. They occur as a series of straight or rectilinear ridges with their height is ranging from 926m (Chinil Ingkhol) to 1780m (Laimaton). On the basis of altitude, they are categorized as moderate to low hill ranges. The hill ranges, which form the eastern boundary of the catchment, are an example of rectilinear hills. For some distance it runs almost north-south and at Bungte Chiru it takes sharp turn towards north-west. Laimaton is the highest hill range running east-west but beyond the catchment area it swings towards north-west. These hills are characterized by steep to moderate slope, high to moderate relative relief and conical to flat tops.

ii) Valleys: After hills, the next important landform is valleys. The valleys are the products of erosion of weak zones, like fold-axes, fault-planes, fractures, joints and bedding-planes by the Thongjaorok River and its tributaries. Due to structural and lithological complexities, geomorphic features of the valley are highly variable. In the hilly area, the valleys are narrow and form deep gorges, while sporadically they suddenly become wide and shallow, this may be due to the intersection of faults or sudden changes in the lithology. Middle and lower reaches of the valley are characterized by the presence of alluvial fans and terraces. In the plain area, the valley is relatively wider with steep sides suggesting youthful stage.

iii) Flood Plain and associated features: Flood plain can be defined as the flat track of alluvial plain adjacent to a river after flooding, when there is a significant rain in catchment area. Low to very low slope and gentle relief characterize such plains and are formed by the sweeping of the meanders down the stream. During the time of flood, sediments are deposited along the banks and in channel itself. This process elevates the

riverbanks above the level of the flood plain. These raised banks are known as levees, and lower portion behind them as swamp.

In the study area, the presence of flood plain and associated features has been observed in the lower reaches of the Thongjaorok River, before its confluence with Loktak Lake. Major portion of the flood plain is utilized for agriculture and settlement. Part of the flood plain is marshy and covered with tall grasses.

b) Minor Landforms: Due to their relatively smaller sizes, minor landforms could not be recognized on the LANDSAT Imagery. However, they are interpreted and mapped on the basis of changes in the contour pattern on the Topographic maps and by field survey. Minor landforms identified in the study area include: smaller alluvial fans, terraces, point-bars and channel-bars, etc.

i) Alluvial Fans: Alluvial fans are formed at the foothills where river and stream emerge from the hills and enter in the plain. At these points stream loses their carrying capacity, as a result coarser sediments are deposited like a segment of low angle cone and spreading out in a fan-like form into the lowland away from the hills. In the study area smaller size fans are found in the middle reaches of the river where valley becomes relatively flat and is joined by the tributaries along the foothills. These fans are utilized for the settlements and terrace cultivation. The largest township in the study area, Bishnupur is situated on such an alluvial fan.

ii) Terraces: Terraces are nearly level surfaces, relatively narrow bordering river and terminating in steep banks. A river terrace marks the position of the former flood-plain, which developed when river flowed at a higher level. It usually consists of a bench on either sides of the valley, covered with the usual flood plain deposits of clay, sand and gravels. The terraces may be classified as paired and unpaired one. The former may develop by rejuvenation of the river causing down-cutting incision like hack-saw, through the existing flood-plain and the development of a new one at the lower level. These types of terraces are symmetrical and occur at the same level on either side of the stream. Unpaired terraces are the results of meandering during down-cutting stage of a river, which forms terraces at different levels on either side of the river. In the study area, both paired and unpaired terraces are common. Unpaired terraces are more common in the upper reaches, while paired terraces are not un-common and have been observed along the foothills and low-lying areas

iii) Point-bars and Channel bars: A variety of landforms develop within the river channel. Many of these features depend upon the complex interaction between the stream velocity and sediment sizes. When the river channel becomes wide it loses the carrying capacity, thus coarser sediments are deposited in the middle of the channel, forming channel bars. Such features are observed in the middle reaches of the Thongjaorok River, where the valley is wider. It dominantly consists of granules, pebbles, gravels and boulders. Point-bars are arcuate deposits, usually sand-size along the convex inner edges of the meanders of the streams and build outward as the stream channel migrates. They develop where stream flow is locally reduced because of friction and reduced water depth. In the Thongjaorok River point-bars are common at the lower level/reaches of the river.

B) Land use classification of Thongjaorok basin

There are many schemes for land use and land cover classification, suggested by different organizations and authors. On the basis of the literature survey and data generated from the visual interpretation of Topographic Maps (1970) and IRS-1D-LISS-III Geo-coded FCC (2000 Nov.) on 1:50,000 scales, and field survey, these landforms of the Thongjaorok basin have been classified, using the scheme suggested by National Remote Sensing Agency (NRSA), Department of Space, Govt. of India (Table-2). Different types of land use/ land cover identified in the Thongjaorok river basin are shown in Fig. 2.

Analysis of Table-2 reveals that significant changes have occurred in the land-use pattern since 1970 to 2000. During 1970s, the central part of the basin, i.e., starting from the south-eastern side of Chinil Ingkhol upto Laimaton, the area is occupied by the open-scrub. Agricultural area occupies southern part of the Nungjang village and at places along the bank of the mainstream. The land between Chinil Ingkhol and Kwasiphai villages is mainly used for agriculture. Dense and moderately dense forests were observed in the southern and central parts of the basin, i.e., Laimaton, Nungjang, Joupi and Kaigongjen villages. During that time, small portion of the northern and northwestern side of the basin was used for the settlements. However, most of the settlements in the catchment area were confined to the southeastern side of the river. Barren land was almost absent at that time.

Interpretation of Fig. 3, derived from IRS-1D-LISS III, 2000, reveals that moderately dense forest occupies the largest area spreading over the northern and southern parts of the basin. There is increase in cultivated agricultural land, dense-forest and moderately dense-forest, due to the aforestation (under social forestry schemes) by the Forest Department, Govt. of Manipur and also due to plantations surrounding the settlements. On the other hand, from 1970 to 2000 there has been decrease in the settlement areas, because of ethnic clashes in the area during 1990s.

There is increase in the area of waterbody due to the construction of ponds for aquaculture. Due to excessive practice of

Table 2: **Classification of The Land-use/ Land-cover Categories in Thongjaorok Basin**

Sl No.	Landuse Categories	Based on Topo-sheet of 1970	Based on IRS 1D-LISS-III 2000	Difference
1	F	1.9	6.5	4.6
2	M	2.7	8.0	5.3
3	Sc	-	4.4	4.4
4	O.S.	17.15	-	17.15
5	D.S.	0.45	-	0.45
6	B	-	1.2	1.2
7	A	4.0	6.4	2.4
8	St	1.5	1.0	0.5
9	Water (W)	0.3	0.5	0.2

the jhum cultivation, there has been drastic changes in the barren land area between 1970 and 2000. The Barren land area, which was negligible in 1970, increased to 1.2 sq. km in 2000. Due to jhumming on the hill slopes, the rate of erosion in the upper part of the catchment has increased considerably. This not only caused high rate of siltation in the Loktak Lake, but also disturbed the ecological balance of entire catchment, and consequently, is a major threat to the wild-life of the area. The unscientific and excessive quarrying for construction materials from the river-bed at lower reaches, further accelerated erosion of the surrounding areas and caused heavy siltation in Loktak Lake. The excessive quarrying in the future may further pose threat to nearby settlements, along National Highway and the bridge.

Conclusions

The Thongjaorok River is a rain-fed river originating from the Laimaton-Loiching hill ranges and is a typical example of asymmetric basin. After traversing for about 8.5 km through rugged hilly terrain, and about 7 km in the plain river the Thongjaorok River drains into the Loktak Lake near Tekra Pat. It is a small basin covering about 28.55 sq. km area but contributes maximum detritus to Loktak Lake.

Geologically, the study area forms a part of Indo-Myanmar Ranges. The geological formations occurring in the basin belong to the Disang, the Barail groups of rocks and recent alluvium. At most of the places in the area, the Disang-Barail contact is of gradational nature but in the Thongjaorok basin it forms a structural contact due to a reverse fault.

The Disang Group of rocks in the study area is observed near Chinil Ingkhol as small outcrop. It is characterized by dark grey colour, thinly-laminated, highly splintery shales. The overlying Barail Group of rocks occupies the rest of the catchment's area. The Barail Group of rocks is characterized by the rhythmic intercalations of shales and fine-grained sandstones, which gradually grade into coarse-grained, thickly bedded sandstones. Sedimentary structures, like ripple-mark, cross-beddings and trace fossils are very common, which indicate shallowing of the depositional basin.

On the basis of magnitudes, landforms of the study area have been divided into two broad categories. Landforms large enough to be visualized on the Topographic maps and LANDSAT Imagery are categorized as major landforms and those, which could be identified only in the field, are categorized as minor landforms. The major landforms include: hills, valleys and floodplain, while, the minor landforms are represented by alluvial fans, terraces, point-bars and channel-bars. Different types of land-use /land-cover in the Thongjaorok basin are classified, on the basis of the visual interpretation of the Topographic maps (1970), IRS-1D-LISS-III Geo-coded FCC (2000 Nov.) on 1:50,000 scale and confirmed by field checks. The different types of land-use/ land-cover identified in the study area are forest, open scrub, agriculture, settlement, water bodies and barren lands. In the study area, since 1970 to 2000 there have been significant and drastic changes in their patterns. There is slight increase in the forest area, settlement and water bodies and decrease in the open scrub. Increase in the forest area is mainly due to the social forestry taken up by the Forest Department, Govt. of Manipur. The barren land could not be identified on the Topographic maps, may be at that time there

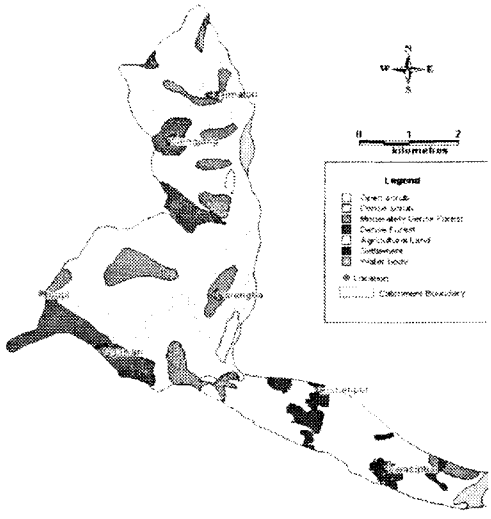

Fig 2: **Land-use/Land-cover Map (1970) Thongjaorok Catchment**

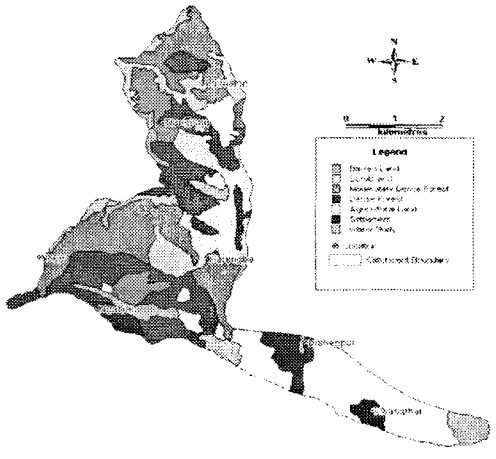

Fig 3: **Land-use/Land-cover Map (2000) Thongjaorok Catchment**

(Source IRS-1D LISS-II Data)

was hardly any barren land in the basin. Mostly forest and open-scrub developed in the areas with moderate relative relief and moderate slope. Agriculture, settlements and water bodies are found in the areas relatively having low relative relief and gentle slope. Moderate relative relief and high slope characterize barren land.

In order to minimize the erosion in the catchments area and siltation of the Loktak Lake, it is necessary to check the jhum cultivation and the local inhabitants should be made aware and be encouraged for practicing terrace cultivation on moderate to gentle hill slopes. The high hill slopes should be reserved for forests. Low-lying water logged areas near the Loktak Lake can be best utilized for the aquaculture.

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