MORPHOTECTONICS AND RESULTANT FEATURES IN KALIANI RIVER BASIN (ASSAM)

Ação Morfotectonica e Paisagens Resultantes na Bacia Hidrográfica de Kaliani (Assam)

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ABSTRACT: *The surficial structure and impressions upon the crust due to endogenetic and exogenetic mechanisms are witnessed all around us. These landforms have evolved as a result of plate movements, subsidence, upliftment and various erosional processes. This concept can be collectively referred to as morphotectonics of any region and can be used as a key to understand its genesis as well as present physical state. Morphotectonics refers to forms and shapes that have evolved in the past or in recent times as a result of past or recent tectonic activity. The most vivid evidences of past tectonic activity can be assessed through drainage lines, in any area which are guided and controlled by physical structures over which they flow.*

Keywords: Morphotectonics. Lineaments. Faulting. River rejuvenation . Waterfalls. River terraces.

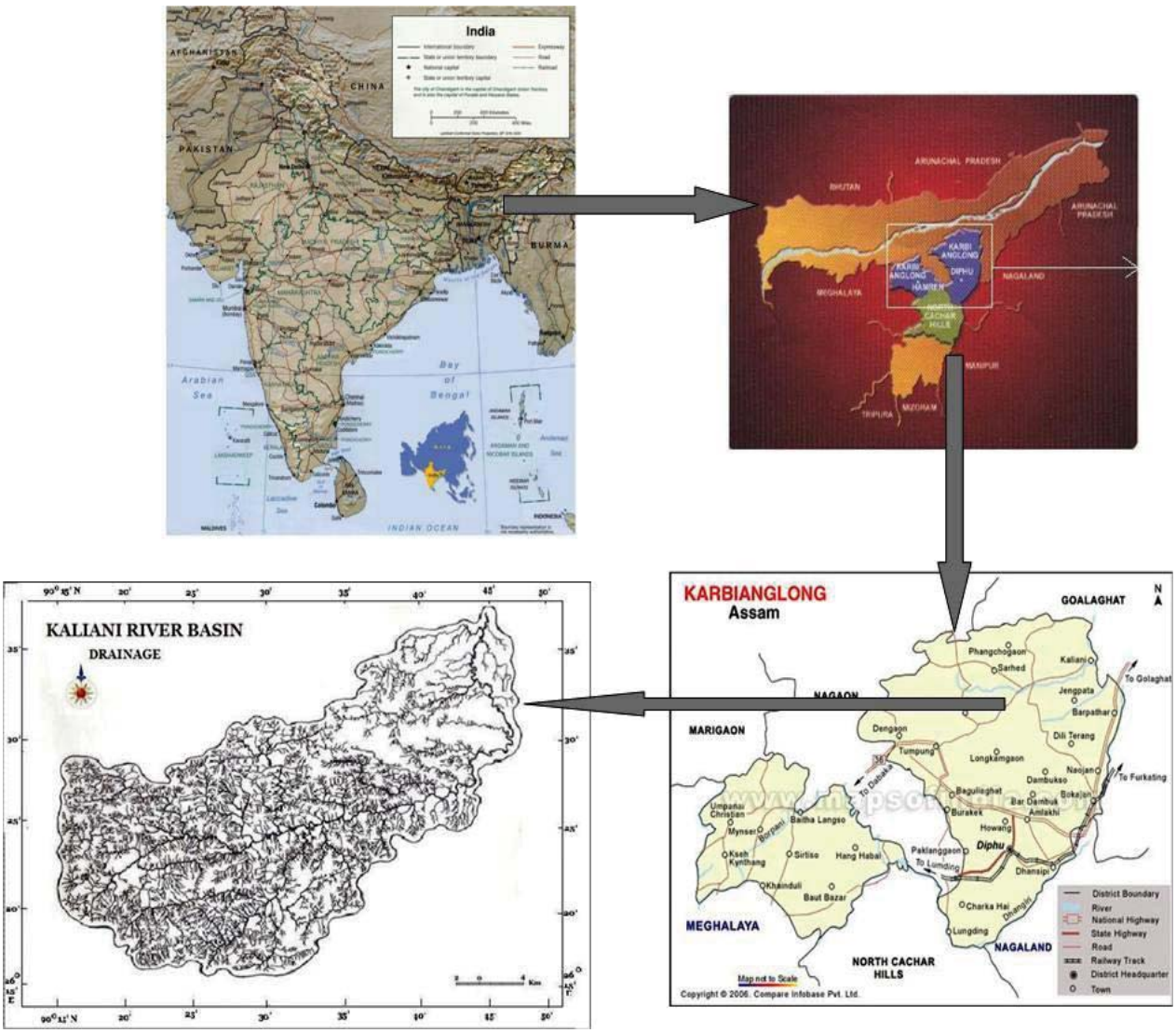
RESUMO: *A estrutura superficial e impressões sobre a crosta devido a mecanismos endógenos e exógenos são percebidos em torno de nós. Estas formações têm evoluído como resultado de movimentos de placas tectônicas, afundamentos, elevações e vários processos erosivos. Este conceito pode ser coletivamente referido como ação morfotectonica em qualquer região e pode ser usado como uma chave para compreender a gênese das feições, bem como o estado físico atual. Morfotectonismo refere-se a formas que evoluíram no passado ou em tempos recentes, como resultado de atividades tectônicas do passado ou recentes. As evidências mais vívidas de atividade tectônica passada podem ser avaliadas através de linhas de drenagem, em qualquer área, pois são guiadas e controladas por estruturas físicas sobre as quais fluem.*

Palavras-chave: Morfotectonismo. Lineamontos. Falha. Rejuvenecimento do rio. Cachoeiras. Terraços fluviais.

INTRODUCTION

The Kaliani River Basin situated in the North Eastern part of the Karbi Anglong district of Assam between geo coordinates 26º 13'47" N - 26º 40' 38" N latitudes and 93º 12' 28" E to 93º 46' 15" E longitudes covering an area of 1200 Km² , exhibits a wide array of distinct morphotectonic lineament patterns due to numerous tectonic upheavals that have taken place since Proterozoic times (Figure 1). The drainage pattern in the region is witnessed having significantly straight channels of both consequent as well as subsequent streams, as there are numerous lineaments both major and minor. Places overlain by older and deep sedimentary cover have developed dendritic and relatively meandering patterns of drainage. There are narrow gorges not only along the headwaters but also along the midcourse as a result of extensive erosion by the Kaliani River, which is an antecedent stream and flowing over masses of unyielding Precambrian rocks. River terraces, pointing to the different periods of upliftment along with knickpoints and cases of river rejuvenation are also seen. The steep sided valleys in this region are narrow and have steep sides with sharp ridges rising up on both banks of the Kaliani River. Valley bottoms are flat and the banks of the main channel are narrow offering limited scope for riverine debris brought downstream to be deposited.

Figure 1: Location of the Study-Area



Physiographically the Kaliani river basin is part of Chenge Arnam Plateau and geologically composed of granite, gneiss of the Archaean group, quartz and quartzite including patches of Sylhet Trap and few Tertiary formations. The present study has been undertaken to ascertain the impact of tectonic changes upon the Kaliani river basin and how it has been instrumental in shaping the region physically till date. The hard metamorphic basement offers strong resistance to easy erosion and how this has affected the landcover, as well as the landuse potentiality is also a part of this analysis.

METHODOLOGY

The strong evidence of tectonic influence upon the morphology of the Kaliani River Basin have been witnessed while interpreting satellite images and topographical sheets (Survey of India) nos. 83 F/7 , 83 F/ 10 , 83 F/ 11 , 83 F/ 14, 83 F/15. The evidences have been witnessed in forms of terrace emergence, subsidence, faulting, thrusts and river rejuvenation at various points along the river course.

The present study involves observation and analysis of various geomorphic features which have developed along the course of the Kaliani river valley as a result of tectonic influence The study has been undertaken chiefly to ascertain the role of tectonic movements in shaping the morphology of the river valley and its surrounding landscape. The steps involve , mapping of the major as well as minor lineaments and analyzing them in relation to structure of the landforms in the study area. The lineaments and landforms have been identified and demarcated using GIS technique involving common terrain characteristics like drainage pattern, slope, relief, river profiles and digital processing and interpretation of satellite imagery dated 22nd April 2008 LISS – III. Detailed field analysis has also helped in assimilating and verifying the authenticity of the available images.

GEOLOGIC AND TECTONIC HISTORY OF THE STUDY AREA :

The Jurassic rocks lie over the Archaeans which are overlain by Tertiary rocks. The Quaternary deposits comprising alluvium and laterites are found overlying these formations along the river valley on the eastern fringe along the Dhansiri river valley. Rocks which comprise the Meghalaya Plateau as well as the Mikir Hills region represent the eastern shield of the peninsular Indian plateau. The occurrence of Upper Cretaceous carbonatite – ultramafic complex along a NE fracture zone in the east- central part of the plateau and in the Kaliani river basin, Mikir hills is noted. N –S to NW – SE trending active faults/ fractures are found in this region. To the west of the Mikir Hills the NW – SE Kopili lineament (NANDY, 1980) is very prominent and was later identified as the Kopili fault (DASGUPTA; NANDY, 1982) is an important tectonic feature . The NW trending Bomdilla fault marks the northeastern limit of the Mikir hills. Lineaments chiefly are surficial evidences of past neotectonic movements which do have a record of reactivatio (NANDY, 2001) .

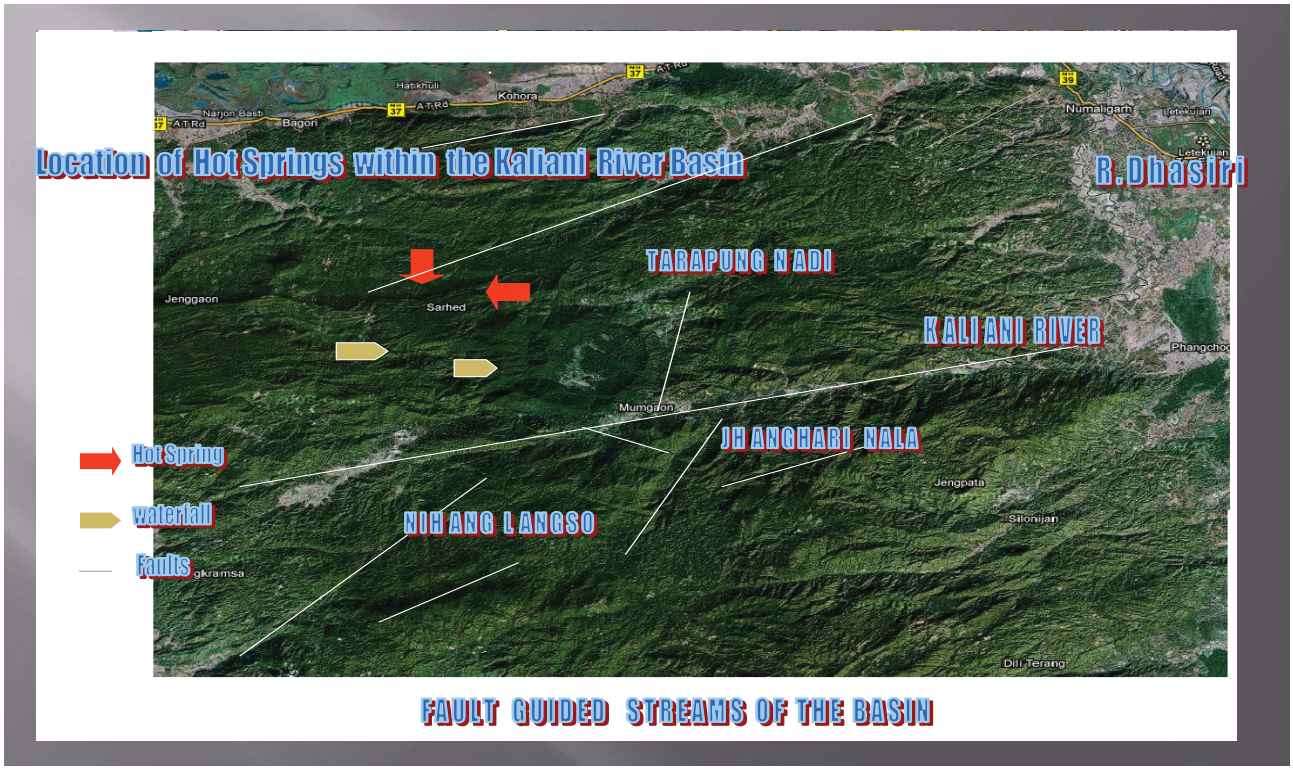
Tectonic Evolution of the Kaliani River Basin.

Tectonically the Kaliani river basin has experienced three phases of upliftment:

i) During the end of Jurassic to early Creteaceous times a dominant E – W, vertical to subvertical fracture / fault system started along the southern margin of the Meghalaya plateau when block faulting took place simultaneously to its north.
ii) During the second phase in Oligocene time , uplift and erosion occurred north of the Dauki fault and many basement faults were reactivated. (WANDREY, 2004. 7 p.).
iii) Upliftment along the Dauki fault system became very pronounced during the Mio – Pleistocene time with the deposition of huge sediments in the southernmost down faulted block of the Sylhet Trap (NANDY 2001).
iv) The present height of the Meghalaya Plateau has been achieved mostly by repeated upliftment along the Dauki fault system over a long span of time (NANDY, 2000. 126 p.).

The region represents a block uplifted and later peneplained over a surface of gneissic rocks with sediments deposited chiefly along the Eastern edge of the basin. The drainage pattern shows uniqueness in its straight courses along the faults and lineaments , with rapid headward erosion by antecedent streams. The drainage of the basin is West to East. The basin is characterized by long, narrow incisive consequent valleys due to lack of sedimentary cover over a Precambrian base. The present physiographic configuration of the Plateau was attained through different geological events since Mesozoic to the present day as indicated by the polycyclic erosional surfaces at various levels (NANDY, 2000. 112 p.). Deposition of late Proterozoic to early Palaeozoic porphyritic granite plutons in the Mikir Hills was also fracture controlled, the dominant trend being NE – SW. This continued till Lower Palaeozoic. Since then the landmass experienced peneplanation till the Upper Jurassic times, which has resulted in formation of flat surfaces preserved till today. By the end of Jurassic – early Cretaceous, a dominant E – W , vertical to sub vertical fracture / fault system started acting along the southern margin of the Meghalaya Plateau (Figure 2). The earliest of such faults is the E – W Raibah fault traversing along the Khasi and Garo Hills, which served as a fissure for placement of the Sylhet Trap. Dykes associated with this effusion got emplaced along N E fractures in the gneissic basement north of the Raibah Fault. (NANDY 2001).

Figure 2: The structural faults and lineaments of the Kaliani River Basin (www.google.com)



After the deposition of the Sylhet Trap during Upper Cretaceous time, isolated bodies of ultra mafic – carbonatite complex got emplaced with a NE trend in the Proterozoic basin of the Shillong Group. This led to upwards arching of the crust, developing E –W fractures and the NE – SW fractures becoming active as a result. This may be the reason behind a hot spot over a triple junction of NE –SW and E –W trends.

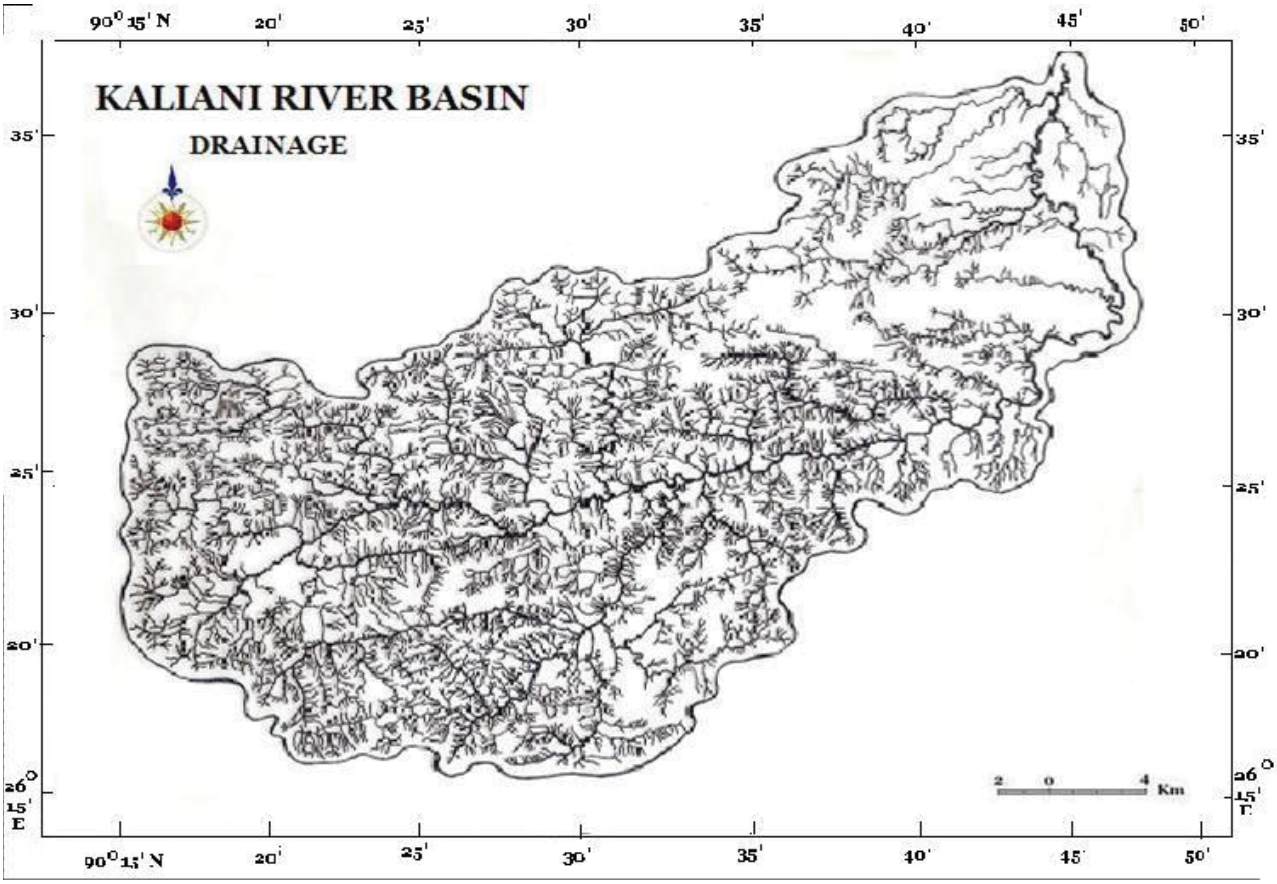
Seismic Activity in the Study Area

Plate movements caused by convection currents beneath the surface of the Earth are of two types: ascending and descending. These currents either cause convergence when the plates move towards each other or divergence when the plates move away from each other. The study area has been considerably influenced by the plate movements of convergence eg. the Himalayas formed as result of convergence of the Inadian and Eurasian plates. This has resulted in upliftment of the adjoining landmasses, the study area also being a part. From the analysis of seismic velocity of different crustal and subcrustal layers, gravity and seismic data by Rao et al. 1997 it was concluded that the present upliftment was caused by compressive forces acting upon the plateau from all sides particularly from the E – W forces conductive from the Indo – Myanmar orogen and not due to isostatic adjustment and thermal causes as the upper mantle beneath the Meghalaya plateau has ceased to be hot .

Land form features as a result of Morphotectonics

The most sensitive parameter to ascertain tectonic changes over the surface level are drainage lines. The Kaliani River Basin is chiefly characterized by **trellised pattern** of drainage (Figure 3). This type of drainage pattern develops upon surfaces which are influenced by structural controls by the underlying geology. Here channels tend to align themselves parallel to the joints and faults or lineaments with the minor channels joining at right angles. The faults and lineaments here have imparted a rectangular pattern to the main channel and to 4 tributary streams selected for study. The steepness of the river valley along with occurrence of non-cohesive materials are yet another factor for the parallel pattern of flow of the major and minor channels.

Figure 3: Drainage Pattern of Kaliani River Basin



The Kaliani river along with its tributaries Jhangari Nala , Majangari Langso, Nihang Langso, Langlakso Nadi, Arnam Langso, Langtangkang Lakso, Tarapung Langso all flow through very ***narrow gorges*** which point to the resistance of valley sides to lateral erosion due to the igneous origin of the rock masses (Figure 4). Knickpoints and gorges along the longitudinal profile of the Kaliani River indicate rapid upliftment of the basin and the channel trying to attain base level after each phase. ***River terraces***, floodplains on both sides of the channel and stream sections with wide valley bottoms point to aggradation during periods of standstill (Figure 5). The presence of three prominent levels of terraces indicate that the Kaliani River Basin has undergone three phases of aggradation after upliftment and degradation since Precambrian to Tertiary times.

Figure 4: Digital Elevation Model of the Kaliani River Basin where some distinct Landform features have developed as a result of Tectonic activity in the past. Here some fault guided tributary streams are *1.Jhangari Nala 2.Nihang Langso 3.Langkangtang Langso 4 Tarapung Langso*

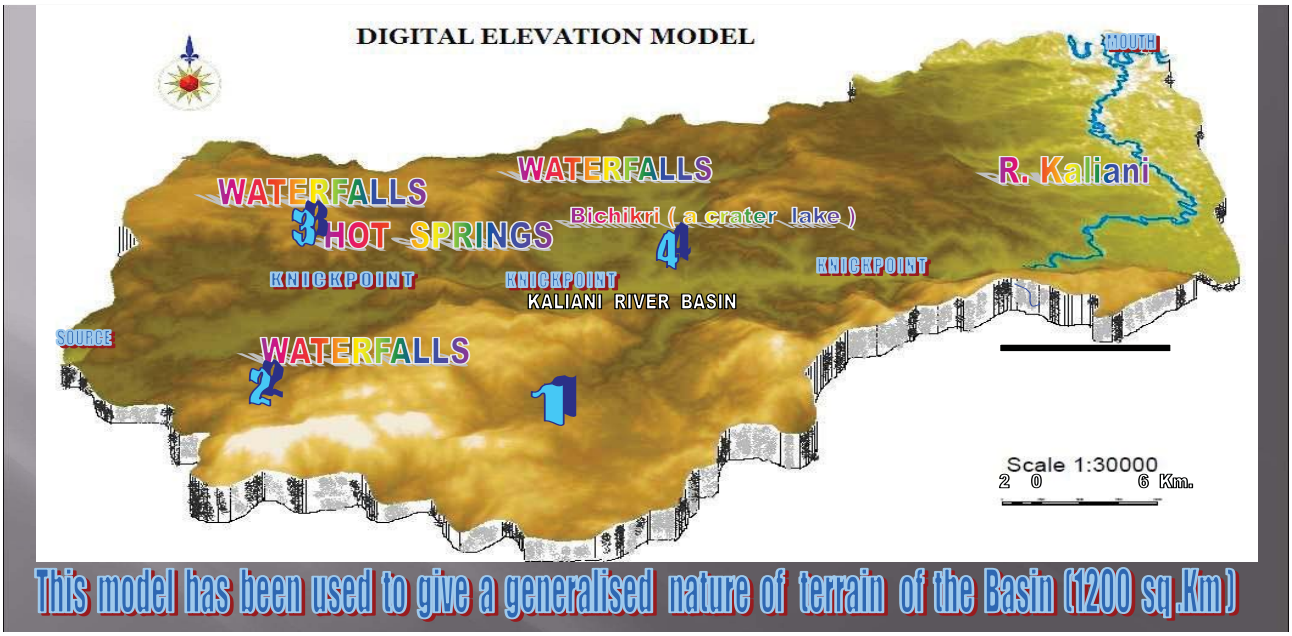
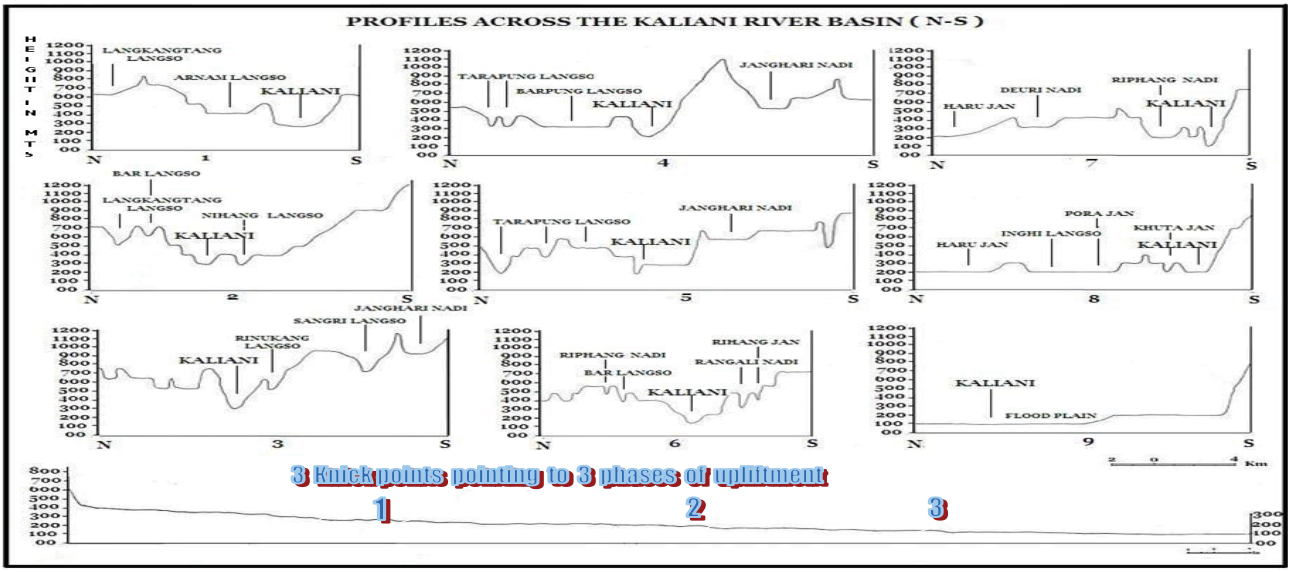


Figure 5: Three Knickpoints in the longitudinal profile of the river indicated by numbers 1, 2 and 3



GEOMORPHOLOGICAL INTERPRETATION OF THE KALIANI RIVER BASIN

The major drainage network comprises of the Kaliani River the trunk stream, which is of fifth order. It is 105 Km in length. There are total 3783 first order streams, 857 of second order streams, 238 of third order streams and 28 fourth order streams. The slope of the land is towards east with the western portion of the basin reaching to a height of 800 metres. The basin area is 1200 Km² (approx.). The river flows from south west to east for 56 Kms and turns north near Kanaighat and flows over the western fringe of the Golaghat plains, meandering and widening its channel. 1 Four tributary basin have been selected for study and longitudinal profile for each have been drawn. The EW and NS cross sectional profile of the entire basin has been done to determine and ascertain morphological features of the river valley. The river basin is composed of harder and resistant Archaean rocks in the western portion with the south western portion being higher. The spot height for the south west part of the basin is 1281m at Inglang Ikpi while that of northwest is 855 m at Theisibi Anglang. The western portion of the basin is relatively younger than the Eastern part. The basin has an elongated shape pointing to its low efficiency in draining floodwaters. The shape of the basin is controlled by the presence of faults. The northern part of the basin tributary Lantangkang Lakso Nadi has two prominent ***waterfalls*** of 8 metres and 6 metres in vertical height which flow over transverse faults. There are numerous water falls in the basin along with hot springs on the northern part of the basin. This is due to faults lying transverse to the flow of the channel and some being reactivated to form *hot springs*. ***River rejuvenation*** is seen in the upper reaches of the Kaliani River with most of the tributaries joining the trunk stream at right angles. The 3 ***knickpoints*** are found at 400 m about 45 Km from source, at 200 m about 50 Km from source and 100 m about 85 Km from source. The lower reaches are characterized by features found in late mature like alluvial plains, an oxbow lake called Kaliani Beel (Beel is the local term for abandoned oxbow lake), marshy river banks and flat floodplains which are cultivated extensively. The lower reaches of the river exhibhits dendritic pattern of drainage due to softer rocks which facilitate rapid erosion.

Figure 6: Deposition of fluvially eroded sediments lateric in nature, near Kanaighat.

Figure 7: Initial phase of an oxbow lake at Kanaighat .

The western portion of the basin has chiefly trellis pattern of drainage best examples being the tributaries named Barpung Langso I, Langtangkang Langso, Nihang Langso and Tarapung Langso. The basin has also examples of radial drainage pattern for tributary streams like Jhangari Nadi in the south, at Warekmushak Anglang at an elevation of 1049 m. which is a resistant batholith like feature. The Percentage Hypsometric curve for the Kaliani River Basin shows a concave shape with the Hypsometric Integral value at 33% and Erosion Integral at 67%. This reveals that the basin development is at late mature stage with knickpoints occurring in the youth at points of rejuvenation, depositional surface forming at the lower reaches of the river channel. The breaks in the percentage hypsometric curve reveals the discontinuous evolution of the drainage basin topography due to creases formed as a result of pressure from surrounding areas during the phases of upliftment. The high rate of erosion integral points to the rapid downcutting of the river to attain base level after each phase of upliftment.

The longitudinal profile of the Kaliani River can be divided into ***seven morphological*** sections due to tectonic influence:

i) near the mouth where it forms a small alluvial fan
ii) near Kanaighat where it has begun to meander
iii) near Chowkihola where dykes are noticed midstream as one advances west
iv) further upstream where the river bends due to presence of monadocks
v) Knickpoints where the river is youthful due to reactivation of faults and Channel plunges down to a depth of about 5m .
While downstream it is merely 1 m at the most.
vi) the sinous flow of the channel to avoid hard rocks and flow over some limestone and coal deposits which occur with the gneissic rocks
vii) the origin of the Kaliani river from a waterfall situated at an elevation of more than 600 m.

Figure 8: Percentage Hypsometric curve of the Kaliani River Basin reveals a late mature stage of geomorphic development of the basin. Three knickpoints have been noted and marked to identify the points of river rejuvenation.

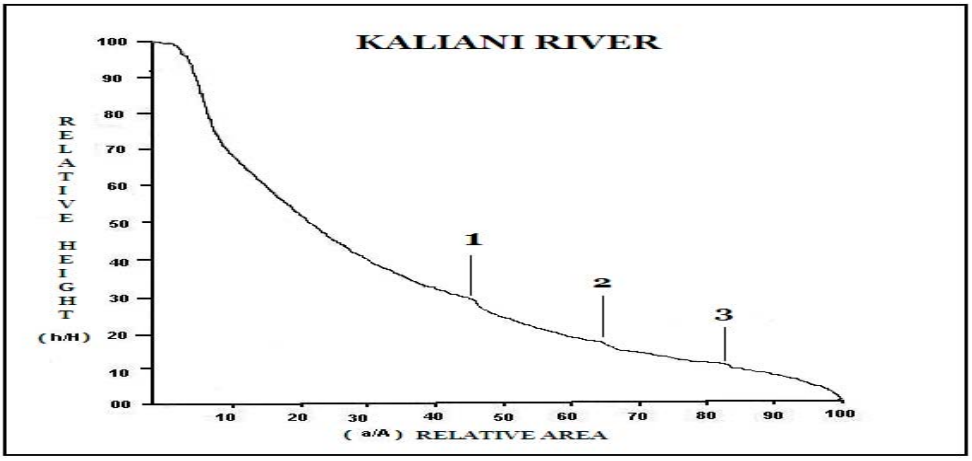


Figure 9 : The steep side of the river bank near its mouth offers limited area for deposition of eroded debris. The plates show the R. Kaliani meeting the Dhansiri river at Kamargaon.

LEFT BANK RIGHT BANK

RESULTS AND DISCUSSIONS

The above observations and analysis points to the influence of not only local tectonic impacts but also influence of regional tectonics as well. The Kaliani River basin has been influenced by the Dauki Fault near the Meghalaya plateau in the south and the Naga Thrust occurring all along the southern portion of the region. It is notable to state that the Kaliani River which flows W- E aligned to the lineament located within the basin and follows the same direction as the Naga Thrust i. e the channel turns north before Silonijan when it encounters the plains of Golaghat and is resisted by the rocky terrain of the Daigurung water divide . The upper parts of the basin are in a younger stage than the lower parts and regional thrusts have imparted a polycyclic stage of basin development in terms of erosional activity. The lower reaches of the Kaliani River is capable of abandoning its present course in future while the upper reaches are actively involved in rapid downcutting of the channel floor.

CONCLUSION

From the point of planning and development, the Kaliani river basin offers scope for construction for civil purposes in the lower reaches as it is least affected by tectonic events in the eastern part and has a deep older alluvial cover. The densely covered forest of the basin which is a part of the Mikir Hills Reserve Forest offers ample scope for development of bio – reserves for flora and fauna. Since the area is a rugged terrain, anthropogenic influence to change the natural surroundings will be minimal. Many parts of the basin are inaccessible to humans and this is encouraging from the point of view of protecting the natural environment of that particular ecological patch. Human encroachment always alters the natural organization and interaction between the biotic elements which is detrimental ultimately. The local Karbis who inhabhit the region co-exist in harmony with their natural surroundings. Setting up of Bio Reserves will aid in protecting the biodiversity of the basin and the adjoining areas and also provide for livelihood opportunities for the local populations.

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