2.1 Introduction
The physical configuration of the Balason basin is largely dependent in its geologic structure, being the controlling factor in evolution of landforms. The resultant physical environment in the region is due to different geomorphic processes, each of which has developed its own characteristic assemblage of landforms. There are no flat valleys, no plains, no sizable lakes nor any cultural landscape except where virgin forests have yielded place for tea gardens or terraced fields. The main uplands wrap around and give-off spurs of second & third order in all directions. The valleys thus formed, presents a great variety in climate and elevation.

In this chapter, the physical set up of the Balason basin has been attempted to visualize the nature and extent of variations in landform characteristics. Mostly the Survey of India topographical maps and also available published literatures has been used for the detail study of about the geology, geomorphology, natural vegetation, soils, climate and land use pattern.

2.2. Geology of the Balason basin
The geology of the Balason basin is of complex formation with four major formations extending in N-S direction (Table 2.4.1.). The major portion of the basin (59%) is composed of Archaean formations with Darjeeling gneiss and Daling series rock type covering almost more than half of the total basin starting from the northern limit. The Darjeeling gneiss varies in texture from a fine grained to moderately coarse rock with dips ranging between 24° and 55° towards N-S and NW-SE. The Daling rock series follows the Darjeeling gneiss towards the south with dips of 30° to 80° towards N and NW.
<table>
<thead>
<tr>
<th>Geological periods</th>
<th>Geological structure</th>
<th>Age (million years)</th>
<th>Type of rocks</th>
<th>% of Area occupied in the basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archaean</td>
<td>Daling series</td>
<td>3800</td>
<td>Carbonaceous mica-schists, Granatiferous mica-schists, golden-silvery mica-schists and coarse-grained gneiss. Phyllites surrounded by the pebbles of Quartz, slates (greenish to grey with perfect slaty cleavage), Chlorite-sericite schists with bands of grilty schists injected with gneiss, tourmaline &amp; iron occur as accessories. Granites, pegmatites and quartz veins.</td>
<td>48%</td>
</tr>
<tr>
<td>Permian</td>
<td>Damuda series (Lower Gondwana)</td>
<td>280</td>
<td>Quartzitic (hard &amp; soft) sandstones with slaty bands, shales and slates, semi-anthracitic (graphitic) coal, Lamprophyre silts and minor bands of limestone.</td>
<td>3%</td>
</tr>
<tr>
<td>Miocene or Lower Tertiary</td>
<td>Nahan group; Lower Siwalik deposits</td>
<td>26</td>
<td>Soft greyish sandstone, mudstone, shales and conglomerates along with the bands of limestone, Shale and lignite.</td>
<td>7.5%</td>
</tr>
<tr>
<td>Himalayan Front (Tectonic line)</td>
<td>Alluvium (older &amp; recent)</td>
<td>2</td>
<td>Boulder beds and other sands and gravels, drift formation and younger flood plain deposits comprising sand &amp; gravel, pebbles, etc.</td>
<td>19.5%</td>
</tr>
</tbody>
</table>

(Source: Based on Mallet, 1964 and Ganser, 1987)

**Table 2.1** The rock types and geological structure and their occurrences (in %) in the Balason basin.

The Permian Damuda series rests along a thin belt mostly extending in an E-W direction. The rocks of this group have undergone great crushing and
disturbances along with a great change in their lithological set up. The dips vary between 40° and 90° towards north-westerly direction and the beds have a generalized strike of ENE-WSW. These coal bearing lower Gondwana rocks is disrupted due to northward extension of alluvium patches of Tertiary series in to the eastern and western segments. There exists a continuous belt of semi-anthracitic coal seams between Pankhabari and Tindharia.

Another geological series of rocks named from Nahana of Siwalik hills occurs along foothill zones, with dips varying between 30°-60° towards north northeast. It occurs above alluvium deposits and like Damuda series, its east-west continuation is also interrupted by northward extension of alluvium deposits and thus are divided into three segments. The top beds of this formation are usually pebbly and contain rounded pebbles of quartz, having either a random orientation or are aligned parallel to the bedding plane.

The southern plain of the Balason basin consists of alluvium deposits of recent or Sub-recent Pleistocene. It consists of mostly river deposited gravels and coarse sand forming several alluvial fans, which merges to form the vast piedmont plain of Terai with varying thickness and lithology. Major rivers carries immense load of sediments during rainy season and as soon as they reach the piedmont zone, the large part of sediment is deposited in the form of semicircular alluvial fans (Jana, 1997). In this segment the rock fragments are either fluvial in origin or the product of sub-aerial denudation.
2.3 Geomorphology of the Balason basin

Altitude and orientation of the basin, shape and ground slope of the watershed, relief, rock types and soil mantle and geologic structure are all elements in determining the hydrologic characteristic of a river system (Morisawa, 1968). Elevation of the Balason basin varies from 2416 m (Lepchajagat, Ghum-Simana) to 103 m (confluence with Mahananda river), which flows down from north to south through a funnel shaped basin. The
watershed is delineated on its north by a ridge emanating from the massive Singalila range and going almost straight to the east forming the Maneybhanjyeng-Ghum ridge.

![Figure 2.2 The configuration of contours (m) in Balason basin.](image)

**Figure 2.2** The configuration of contours (m) in Balason basin.

### 2.3.1 Geomorphic units of the Balason basin

A vast portion of an area on the south of the basin is consisted of wide open gently sloping plain where the river of the Balason drainage system have deposited huge amount of eroded materials carried down from the
catchment areas, due to sudden decrease of velocity resulted from abrupt fall of slope. Just immediately above the rolling plain a foothill zone of comparatively higher dissection has started which being associated with active exogenetic processes and various geological disturbances have extended up to the sheared, thrusted and folded transition zone between Damuda – Daling series. Above this zone a comparatively less dissected but rugged zone of middle and upper hill topography having harder rocks of Daling series and Darjeeling gneiss with comparatively lower amplitude of relief has taken place. Thus, on the basis of the above characteristic differences the whole basin can be divided into three distinct geomorphic units.

I. The southern Alluvial Fan Zone.
II. The Dissected Foot Hill topography.
III. The Rugged Middle and Upper Hill Tract.

2.3.1.1 The Southern Alluvial Fan Zone

The deposited detritus carried down by the Balason river system has developed a series of Alluvial fans which are found mainly between 120 m and 400 m and even up to 480 m over the entire alluvial plain of the studied basin. These alluvial fans coalesce to form a pediment zone with textural diversities and different sediment patterns. These fans of the basin fall on the right bank of the Teesta river, the main river system of the region.
2.3.1.2 The Dissected Foot hill zone

The foothill region in the Basin with a series of ridges and varying valley forms, being associated with Siwalik-Damuda Sandstone and Shale with occasional coal bearings seams of the Permo-Carboniferous period, have depicted distinct thrusts between Siwalik-Damuda-Daling series contacts and thereby contributed sheared crusted and folded lithology over the region. Moreover, the sandstone and shale of this region have facilitated the better
incision of the rivers with prominent valley side slope and ridges. The effect of regional episodic uplifts, which are frequent in the Teesta river system (Mukhopadhya, 1983) are also well manifested in the prevalent process and resulting landform characteristics over this geomorphic units with steep mass-wasted slopes, eroded fault scarps, etc. Thus, the whole geomorphic unit has exhibited highly dissected land surface and deeply developed mature soil horizons.

2.3.1.3 The Rugged Middle & Upper Hill zone

At an altitude of approximately 800 m there exists a distinct break of slope, which has separated the foothills below some distinctive characteristics of geologic and geomorphic origin. The entire region consisted of Daling series and Darjeeling gneiss type of rocks which exerts better resistance in the drainage incision as comparatively less valley side slopes with widely spaced ridges. The episodic and jerky uplifts have exerted little influence on these harder rocks of Archaean period and as a result of which this zone has been suffering from lesser amount of geological deformities which facilitated relatively low amplitude of relief and dissection. The initiation of higher amount of source heads and confluence points with occasional mass wasting, triggered up by chemical weathering on ferruginous rocks etc. have altogether made the terrain rugged. Domal topography in and around the Mirik region within the Basin is a peculiar topographic character of this zone.

![Figure 2.4](Image)

Figure 2.4 The coverage of total area (Km²) under different geomorphic units based on major contours.
An attempt has been made to divide the whole basin into different zones on the basis of amplitude or relative relief by considering the highest and lowest elevation falling within the grid of an area of km². The occurrence of various relative relief zones (figure 2.7) ranging from moderate to very high over the Basin under study clearly suggests that the entire hill region has been accompanied by different structural variations resulted from various geologic
disturbances in association with selective weathering and mass wasting in the normal course of sculpturing of the said region (De, 1998).

**Figure 2.6** Area (in %) of Balason basin under different Amplitude or Relative relief zones

The whole basin has been categorically divided into six major relative zones ranging between 0 to 600 m. The maximum or highest amplitude occurs in the northern portion of the basin covering the upper hilly tracts (above 500 m) and it decreases towards the southern lowlands with minimum amplitude of below 100 m.
2.3.3 Average slope of the Balason basin

Wentworth’s (1930) method of slope analysis with the help of contour values has been followed to divide the whole basin into different slope zones. The major break in slope is identified along the southern margin which separates the entire basin into two broad slope zones: northern uplands and the southern undulating lowlands. Both convexity and concavity in slope form are found everywhere in the northern zone. However concavity is more
pronounced along the mid-slope due to massive mass movement (Lama, 2003).

The analysis of slope categories (figure 2.8) indicates that the active down cutting process of Balason river have given rise to steeply inclined land surface over the hill portion indicating that the basin is still in the youthful stage of cycle of erosion. The majority of the basin area falls within the moderate steep to steep slope (10° - 30°), revealing the activeness of the total erosional agents in its upper reaches. The slope zone of 20° - 25° falls commonly in the area of softer Daling rocks easing the high rainfall for erosional activities. The area above 25° slope consists comparatively harder Gneissic rocks which have mostly been deforested and affected by weathering processes.

Figure 2.8 Total basin area (Km²) of Balason basin under different Slope zones.

2.4 Soils of the Balason basin

The parent soil of the region has undergone changes, resulting in the alteration of its nature and it has actually undergone more than single formation (Lama, 2003). The records of its past history have been mostly obliterated, either by the formation of new soil on the truncated top of the older soil or by the complex removal of the original soil by erosion (Sarkar, 1990).
The soils conditions in the Balason basin are generally predominated by very shallow to deep soils. Red-yellow soils, usually gritty have developed in Darjeeling gneiss and schist. Darjeeling gneiss commonly decomposes into stiff red clay. The colour of red soils, derived as it is metamorphosed from gneiss and schist is due to wide diffusion than to high proportion of iron content. This type of soil occurring in the sandy area is mainly silicious and aluminous with free quartz as sand. It is usually poor in lime, magnesia, iron oxide, phosphorus and nitrogen but fairly rich in potassium derived from muscovite and feldspar.

The lower part of the basin mainly consists of fine textured clay loam soils. The area along 200 m contour encompasses with relatively coarse textured soil varying between sandy loams to loamy sand. Moreover, in some places the top soils are relatively finer in textural composition than the subsurface soil. Between 200 m to 320 m, the soils vary between sandy clay loams to sandy clay with distinctively leached horizon (De, 1998).

2.5 Natural Vegetation of the Balason basin

From the classifications of the natural vegetation of this region by some of the noted researchers like Hooker (1854), Champion (1936) Banerjee (1964), Bhujel (1968), etc, the Balason basin is covered by different types of forests. The differences in elevation and variable productivity of soil in combination with high variable temperature are responsible for such varied forests cover in this region. With pace in settlement occupancy enhancing loss of virgin forests, the original vegetation of the land hardly exists. Three major types of vegetation which are further subdivided into sub types could be found.

2.5.1 The Tropical forests (100 m to 800 m)

The tropical vegetation is characterised by the presence of deciduous trees with *Shorea robusta*. The important species in this type includes Khair (*Acacia catachu*) and Sissoo (*Dalbergia sissoo*), found along the Rakti and Rohini khola, in the lower part of the Balason river and around Simulbari. Other species includes Chilaune (*Schima wallichii*), Chikrassi (*Chukrasia tabularis*), Sidha (*Lagerstoeemia perviflora*), Panisaj (*Terminalia tomentose*),
Oodal (*Sterculia villosa*), Simul (*Bombax malabaricum*), Chapalish (*Artocarpus Chaplasha*), Lali (*Amoora wallichii*), Ambake (*Jambora Formosa*), etc. Bhujel (1968) have further sub divided it into four sub types:

1. The Ravine forest.
2. The Sal forest.
3. The Dry mixed forests.
4. The Wet mixed forest.

### 2.5.2 The Sub Tropical forest (800 m to 1600 m)

This type of forests mainly consists of tropical genera and species and covers the area like upper Balason, Rangbang Khola, Marma Khola, Manjwa Jhora, Rakti Rohini khola. The main species includes Panisaj (*Terminalia myriocarpo*), Chilauni (*Nyssa sessiliflora*), Lampati (), Saur (*Betula species*), Angaree (*Phoebe Spec.*), Siris (*Albizzia spec.*), Mahua (*Engelhardtia spec.*), Tite Champ (*Michaelia cathcartii*), etc. In this forest large climbers with undergrowth are also found along with tree-fern thickets along moist and shaded areas.

### 2.5.3 The Temperate forests (1600 m to 2400 m)

The upper reaches of the Balason basin is covered mostly by temperate evergreen trees and which are stag-headed with epiphytes. The important species under this type includes Saur (*Betula spec.*), Toon (*Cedrela Spec.*), Katus (*Castanopis indica*), Lekh Dabdabe (*Meliosma willichii*), Phalado (*Erythrine indica*), Lapche Kawla (*Machilus pdulis*), Musre Katus (*Castanopsis tribuloides*), Lekh chilauni (*Nyssa sessiliiflora*), Walnut (*Juglans regia*), Malata (*Macaranga spec.*), Arupate (*Prunus nepaulensis*), etc.

### 2.6 Climatic characteristic of the Balason basin

The Balason basin is characterised by a great degree of seasonality, due to the wide altitudinal variations and the precipitation brought by the southwest monsoon winds. The shift of monsoon trough towards the mountain margins and the peculiar configuration of the ridges and valleys also
contribute very high intensity rainfall along the parts of southern slope, sometimes causing flash flood.

2.7.1 Seasons

The Balason basin experiences four dominant seasons with altitudinal variations both in duration and extent. The important seasons are as follows:

i. Summer season (May to September)
ii. Autumn season (October to November)
iii. Winter season (December to February)
iv. Spring season (March to April)

The upland portion experiences longer rainy days during summer season with mist and almost continuous rainfall. The winter is usually cold and few to nil rainfall followed by pleasant autumn and spring season. On the other hand, the southern lowlands experiences long humid summer and a mild winter.

2.7.2 Temperature

The mean annual temperature of the whole Balason basin is about 20.94°C. The northern uplands have a mean annual temperature of 12°C while the southern lowlands records 24.70°C. During summer, the mean temperature varies between 16°C to 17°C in the hills and 27°C to 28°C in the lowlands. In winter season, there prevails cold temperature ranging between 1°C to -5°C, whereas, the plain region experiences pleasant temperature between 17°C to 19°C. The air humidity fluctuates from 87% to 58% in the lowlands during summer weather, but in the northern uplands, humidity is mostly high due to excessive cloudiness.

2.7.3 Rainfall

The rainfall in the entire Balason basin area is totally dependent on southwest monsoon winds which contribute about 85% of the total annual precipitation. The average annual rainfall for the whole basin is 2300 mm. The maximum rainfall occurs during the months of June to September. Beside, thunderstorms accompanied by rain also occur during April, May and in
October (figure 2.9). On an average, the number of rainy days with more than 2.5 mm of rain varies from below 100 days in the plains to 124 in the higher altitudes in the northern portion. The annual rainfall fluctuates from 2000 mm to about 5000 mm within the basin area. The foot hill tracts receive more rainfall (3446 mm) than the plains (3272 mm).

![Figure 2.9](image)

**Figure 2.9** Mean monthly rainfall (mm) and temperature (°C) of the Balason basin *(Refer Appendix B Table 2.1).*

### 2.6 Land use of the Balason basin

Out of the total geographical area within the study area, most of it is occupied by tea plantation almost in all directions with patches of forests in the northern portions. Till 1835, the area was densely covered with forests.
with few migratory Lepchas in the hills and the Mechès in the southern foothills. But with the construction of road (Hill Cart Road) in 1839, the degradation of these virgin natural forests slowly started. Soon large tracts of forests were replaced by roads, Tea Gardens railway lines and settlement (Lama, 2003). With time, a pronounced decrease in the forest cover became apparent and at present the forest is mainly restricted in the north and northeastern section of the study area with small natural patches at Singbulli, Selim Hill, and Manjwa and between Pankhabari and Longview (Lama, 2003). Settlements with cultivated waste occur along the areas adjacent to tea gardens and agricultural patches in the middle portions of the study area (figure 2.10).

With the establishment of tea gardens in areas like Ambootia, Makaibari, Soureni, Phuguri, etc after 1860, the forests were cleared and settlement began to flourish along with roads. Hence by 1871, more than 20 tea gardens with approximately 890 hectares of forest area were leased out for tea plantation. At present, tea plantation occupies more than 27% of the total basin area (99.3 km$^2$) while the forest cover is about 26.2% (96.18 km$^2$).

Figure 2.10 The distribution of different land use patterns in Balason basin.
2.8 Conclusions

The study of the physical characteristic of the Balason basin reveals that it is a geologically young and fragile region with intensely metamorphosed rocks like gneiss, schists, phyllites, etc, which are highly weathered, fractured and jointed, vulnerable to slope instability. The basin does not follow the law of absolute relief and slope frequency distribution, since maximum slope zones falls between 800 – 2200 m with relative relief value of 300 – 500 m; indicating the youth stage of the basin. The climatic characteristic also shows wide variation which is largely dependent on the altitude.

The drastic reduction of the natural forests, combined with the high annual rainfall exceeding 3000 mm in most part of the basin, makes the area highly vulnerable to soil erosion and landslides, reducing the soil fertility, choking the streams and leading them to change their courses. Thus, it can be concluded that, the Balason basin being geologically vulnerable coupled with headless deforestation and unscientific changes in its land use pattern poses serious threat to its fluvial characteristic.

References


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