CHAPTER II
GEOGRAPHICAL BACKGROUND OF THE STUDY AREA

2.1 The Noa-Mangaldoi River system

Originating from the Khampajuli Hill ranges of Bhutan at an altitude of about 1750 m the Noa-Nadi is an important northern tributary of the Brahmaputra river system. Receiving several tributaries and rivulets during its journey, it traverses a total length of 103 km from source to outfall at Brahmaputra near Dastaki (Figure 2.1). Out of its total length only 9 km lies in Bhutan and remaining part falls in Assam (India). Though the river has a general slope from north to south direction in the hills of Bhutan, it has a small reach with easterly direction called Bhola-Nadi. After traversing the Bhutan territory, near Harisinga (Assam) at an altitude of 450 m it takes the name Noa-Nadi and flows in southern direction up to outfall into the river Brahmaputra by following a zig-zag course over the floodplain. The upper reach of the river system (Bhola-Nadi) is characterized by steep terrains, small narrow gorges and rocky boulder bed. No important sub-tributary meets Bhola-Nadi in this reach.

The plain reach of Noa-Nadi has a total length of 94 km. In this course it meets several major sub-tributaries. In fact, Laksmijuli or Khampajuli is a left bank sub-tributary of Bhola-Nadi, which is later known as Noa-Nadi. Originating from Khampajuli Hills of Bhutan, it enters Assam near Khirkhira tea-garden (Darrang district). After traversing a distance of 14 km in the plain it bifurcates near Santipur. One stream flows by the name Bikhaiti, while the other by the name Lakshmi Nadi. About 8 km distance from the point of bifurcation they fall into Noa-Nadi on its left bank just adjacent to each other. Thus, Noa-Nadi meets its first two left bank tributaries after traversing 22 km in Indian Territory. It takes its second sub-tributary Batiamari Nadi, the only right bank tributary at village Dhalkata. Another very important sub-tributary, the Mangaldoi Nadi is intercepted by Noa-Nadi about 10.5 km up-stream of the outfall near the village Kamarpara. This is the largest tributary of Noa-Nadi. Before joining on the left bank of Noa-Nadi near Kamarpara, the Mangaldoi river receives its only sub-tributary Bega-Nadi on its left bank near Bandarchuba which is just 4 km upstream from Kamarpara. Thereafter, Noa-Nadi flows southward. After crossing a
Figure 2.1 Noa-Mangaldoi river system
distance of only 1.5 km it takes a south-west ward turn near Mowamari Chapari and receives a small tributary stream on its left bank coming from Dighalee beel. By maintaining the same direction and travelling a distance of 4 km downstream, Noa-Nadi falls into a small bifurcated channel of Brahmaputra known as ‘Brahmaputra Suti’ near Dastaki. After falling into the Brahmaputra Suti, a channel bifurcates from the suti and flows west-ward taking the former name Noa-Nadi. Thus, about 2 km from the point of bifurcation near Dariapara it takes the Kuyapani, a small right bank tributary. About 3 km downstream from this confluence, it then takes Saktola river on its right bank near Kacharipara. Further 1.5 km from Kacharipara, the Noa-Nadi again meets the Brahmaputra Suti and flows south-west ward to finally reach the Brahmaputra near Garusuti.

![Figure 2.2: Longitudinal profile of the Noa-Nadi](image)

The Noa-Mangaloi river basin with a well-defined network of both right and left bank tributaries is one of the most important north bank river systems of the Brahmaputra. With 26° 21’ N to 26° 58’ N latitudinal and 91° 56’ E to 92° 05’ E longitudinal extension, the basin lies partly in Samdrup Jongkhar district of Bhutan and partly in Darrang and Udalguri districts in Assam. The total catchment area of the basin is 745 km², out of which about 651 km² lies in the plains of Brahmaputra valley and the remaining 94 km² falls in the sub-Himalayan domain of Bhutan. The river maintains a steep channel gradient of 27.24 m/km in its upper reach to relatively a gentle gradient of 0.22 m/km downstream (Figure 2.2).
2.2 Relief and slope

Most of the area of the entire basin is an alluvial flat plain mainly composed of old and newer alluvium. The northern part along the foothills where lies the pediment plain formed by coalescence of several alluvial fans consists mainly of boulders, gravels, pebbles and sand. The extreme northern part is characterized by structural hills and hillocks ranging from 1750 m to 350 m height. The lower alluvial flat plain has an average height of about 52 m with some small dotted swamps and *beels* having height less than 45 m. In between these two extreme elevations, the middle part has the elevation which varies from 200 m to 150 m from the sea level (Figure 2.3). Thus, the upper reach which is characteristically of structural hills and hillocks occupies about 109.11 km² and shares 14.64% of total basin area with an approximate relative relief of

![Figure 2.3: Relief pattern of Noa-Mangaldoi Basin](image-url)
about 1400 m. In contrast, the lower reach ranging from 120 m to 60 m height having 60 m relative relief is occupying about 517.17 km$^2$ and it represents almost 69.4% of total basin area. In between these two extreme relief conditions, the middle reach has about 280 m relative relief and with 118.75 km$^2$ it represents about 15.93% of the total basin area.

A slope may be defined as the angular inclination between hilltops and valley bottoms (Strahler, 1956). Though the maximum development of slopes takes place in the hilly areas, slopes are common and universal character even for a small land-surface over the earth’s surface. Scientific analysis of slope always helps in identifying the stage of landform development as the degree of slope controls run-off, velocity of river, erosion, transportation and deposition (Gautam, 2009).

![Figure 2.4: Slope pattern in the Noa-Mangaldoi basin](image)
From topographic point of view the entire basin is characterized by high terrain topography with steep hill slopes in the north and flat plain of very low gradient towards southern extremity. With exceptionally abrupt relief towards north, the entire basin has thus a gradually decreasing slope gradient towards south upto its outfall, i.e Brahmaputra. The upper reach of the basin thus has its slope ranging from $5^0$ to above $50^0$ against a slope even below $1^0$ at the lower reach. A moderate slope ranging from $1^0$ to $5^0$ has seen in the middle reach of the basin.

2.3 Geology and geomorphology

As a part of the Brahmaputra river system, the Noa-Mangaldoi basin is exhibiting peculiar physiographic expression comprising various geologic, geomorphic and seismotectonic characteristics. Geologically, the entire basin can be divided into three distinct units of south, central and north. The lower part of the southern part of the basin adjacent to the river Brahmaputra is actually a northward extension of the Precambrian Shield of Shillong Plateau. On the other hand, in the north along Bhutan border the rocks belonging to the Timpam group (Miocene) of Tertiary age are exposed. These Tertiary rocks are again overlain by some rounded boulders and pebbles of gneisses, granites and quartzites of Pleistocene age. With these coarse clastic sediments of boulder, pebbles and various grades of sands, this formation is highly porous and permeable. The northern geological unit along the foothill of Bhutan border can necessarily be sub divided into two sub-groups, viz. high level piedmont and low level piedmont zones. The high level piedmont zone contains larger size of coarse clastic sediments than that of the low level piedmont zone. In between these two geological units of north and south, the central plain part of the basin is made-up of alluvium consisting of sand and clay in varying proportions. In this plain from the bank of Brahmaputra to the foothills of Bhutan, there is a tendency of increasing the grain size of alluvium sediments (CGWB, 2007).

The various geological units together with complex structural base, the basin has been characterized by the assemblage of five distinct geomorphic units (Brahmaputra Board, 1998). These include from south to north – the active flood plain, younger alluvial plain, older alluvial plain, pediment plain and structural hills (Figure 2.5). The Noa-Mangaldoi basin has an active flood plain extending for about 2-4 km
from the bank of the Brahmaputra river towards the north. This part of active flood plain is necessarily composed of unconsolidated gravels, pebbles, sand and clay.

The younger alluvial plain consists of gravels, sand, silt and clay covering a major part of the basin. It extends from the foothill regions of north towards the lower reach of south. Meandering, cut-off, abandoned river courses, small flood basins, swamps are the characteristic features of this plain. The area of slightly higher elevation where small tea-gardens are located is mostly occupied by older alluvium. This plain consists of weathered materials comprising pebbles, sand, silt and clay. These are the alluvial deposits of earlier floods.

**Figure 2.5:** Major geomorphological units in the Noa-Mangaldoi basin
In the northern part along the foothills a small pediment plain exists. It is about 8 to 15 km in width and mainly characterized by coalescence of several small alluvial fans formed by the sediments brought down by the rivers from the foothills. Structurally, it is consisting mainly of boulders, gravels, pebbles, sand and silt with occasional occurrences of clay. Besides, structural hills are found along the foothills and some small such hills are also exposed in the east of Khaling-Duar Reserve Forest. They are mostly composed of grained grey to brownish colour rocks of moderately hard sandstone.

2.4 Climatic characteristics

Being an integral part of the Brahmaputra valley, the Noa-Mangaldoi basin clearly falls under the regime of monsoon climate of sub-tropical belt. The climatic conditions of the basin have marked similarities with the climate of adjoining parts of Nepal, Bhutan, Bangladesh and North Myanmar. It has the experience of having an average annual rainfall of about 2500 mm. Rainfall generally occurs during monsoon months during June to September. From the month of November to February the basin enjoys a dry climatic condition with occasional winter rains. Thus winter starts by November and continues till February. The coldest climatic condition is generally experienced in the month of January when the mean dry temperature comes down between $15^\circ$ and $18^\circ$ C. It should be mentioned that in winter season low pressure waves start passing eastwards and it experiences cold spells of a day or two days, when the maximum temperature falls below $5^\circ$ C in the cold season and the sky generally remains clear. Thereafter the temperature starts rising from March to the end of the June and thus summer starts. Though the basin’s average temperature ranges between $10^\circ$ and $30^\circ$ C, it ranges between $28^\circ$ and $39^\circ$ C during day and between $20^\circ$ and $37^\circ$ C at night during summer.

Regarding humidity condition it can be said that the area is highly humid throughout the year. During monsoon period since there is heavy rainfall, the basin experiences a maximum of about 90% relative humidity. Of course, during non-monsoon period it ranges between 50% and 75%. It needs mention that relative humidity comes down to about 50% to 60% between the months of February and April, especially in the afternoon.
Besides this general climatic condition, minor spatial variations are also marked with varied topographical characteristics of the basin. Records show that the northern part along the foothills of Bhutan, the basin is colder than the rest of the part since it is covered by hills and thick forest. The rainfall distribution also has a similar trend of increasing intensity towards north from the south. The northern part of the basin has the maximum annual rainfall of about 2873 mm, whereas the southern plain has an average annual rainfall of 1908 mm (Figure 2.6). Thus, the locational characteristics along with diverse physiographic set-up have, to some extent controlled the overall climatic condition of the basin.

**Figure 2.6:** Rainfall distribution in Noa-Mangaldoi basin
2.5 Soils

The basin with varied geological and topographical expressions has a wide range of soils characteristically of various colour, composition, texture etc. The various soil types of the Noa-Mangaldoi basin are shown in the figure 2.7. The soils of the northern foothills are characterized by high acidity with pH values ranging from 4.5 to 6. With deep reddish colour, the texture of these soils varies from clayey to sandy loam.

Figure 2.7: Soils of Noa-Mangaldoi river basin
The area just below the foothill zone with slightly higher elevation where tea-gardens are located is mostly composed of older alluvium. This soil contains sand, silt and clay. The soils of greater part of the plain are younger alluvium and have developed from the transported sediments derived from the Himalayan rocks in the north. The soils are light yellowish to light gray in colour. The texture of the soil ranges from sandy loam to silty loam in nature with \( \text{pH} \) value from 4.5 to 7.5.

The soils of the active flood plain just extending about 2 to 4 km from the Brahmaputra are developed under complete fluvial environment of the river Noa-Nadi and its tributaries, and thus clearly fall under new alluvium group. These soils contain sand, silt and clay. Near the Brahmaputra the grain size is coarser and hence sandy and away from the bank the grain size gradually reduces. Thus, the soil texture ranges from sandy loam to clayey loam. The soils of the structural hills, on the other hand, are mostly red loamy type having high content of humas, oxygen and acid but deficient in phosphate and potash.

2.6 Natural vegetation

Natural vegetation constitutes one of the major forms of natural landscape. The Noa-Mangaldoi basin with characteristic topographical, climatic and pedological expressions bears a mixture of tropical deciduous and tropical semi-evergreen forests alongwith different species of grasses. Most of the areas of the flood plain have the tropical moist and dry deciduous forest as the flood plain receives an average annual rainfall of 80 cm to 200 cm. The most common species of tropical deciduous forest that are found in the basin include Sal (Shorea Robusta), Teak (Tectona Grandies), Gamari (Gmelina Arborea), Simul (Bombax Malabaricum), Khoir (Acacia Catechu), Au Tenga (Belinia Indica), Jack Fruit (Atro carpus Intrgifolla), Kadam (Anthocephalus Cadamba), Amora (Spondias Pinnata), Am (Mangifora India), Jam (syzygium Cumini) etc.

The northern hills and foothills are generally rich in tropical moist and deciduous forests which cover an area of about 65.63 km\(^2\) or 8.81% of the total basin area. The important species are Sirish (Albizzia Lebbeck), Sonalu (Cassia Fishula), Segun (Tectona Grandies), Sissoo (Dalbergia Sissoo), Gamari (Gmelina Arborea), Nahar
(Mesua Terrea), Amlakhi (Emblica Officinalis) etc. Various types of bamboo, tall grasses are also common vegetation.

About 6.81km² area of the basin occupies by beels, swamps and marches which have a variety of aquatic and marshy grasses. Some very common species are Meteka (Echornia crassipes), Shigari (Trapa bispinosa), Lily (Nymphaea Lotus), Tara (Alpinia Allughas) etc. Besides, the small patches of sandy areas near the rivers contain some riparian vegetation of which riparian grasses are most common.

2.7 Population and settlements

The Noa-Mangaldoi basin is a part of old Darrang district (now Darrang and Udalguri district) of Assam and Samdrup Jongkhar district of Bhutan. It represents 21.40% and 4.37% area of old Darrang and Samdrup Jongkhar districts respectively. About 146 villages of Darrang district and 139 villages of Udalguri district fall within the Noa-Mangaldoi river catchment. According to 2011 census, the total population of all these villages is 11,22,376, out of which the total male and female population are 5,73815 and 5,48561 respectively. The percentage share of S.C population to the total population has been found to be 5.59% against 9.01% of S.T population. The entire basin with varied geo-environmental conditions has shown marked variation in population density. Though the average population density of the entire basin is about 456 person/km² as per 2011 census, the lower flood plain has a density of more than 500 person/km². This may be attributed to the availability of flat rolling surface suitable especially for agricultural activities and other developmental works. Of course, the northern piedmont zone with inadequate agricultural land and limited scope for other economic activities has the lowest density of 55 person/km² (Figure 2.8). Some of the villages which have a population density of more than 1500 person/km² are Mangaldoi, Kalaigaon and Harisinga railway block. Mangaldoi, the single urban centre of the entire basin has the highest population density of 2394 person/km². There is no any single better yardstick to assess and evaluate the socio-economic development of a society than literacy rate. About 51.1% population of the basin has been found literate as per 2011 census. Of course, a higher percentage of literacy is seen in male than the female. Thus, as per census report against 55.47% male literacy, the female literacy is 46.57%.
Generally the geometrical form and shape of settlement is known as the settlement pattern. The study area is an integral part of middle Brahmaputra valley having subsistence agriculture and thus its population is by and large rural. There are about 294 villages located in different parts of the basin. A careful field observation of the rural settlements reveals that its form and pattern vary from place to place. The responsible factors for such variation are physiography, alignment of the river, road etc. near the villages, effect of flood and erosion, availability or permanent source of water, socio-cultural factors like caste, religion, population density etc. The common settlement patterns that are found in the study area are linear or elongated alinged along
the roads and rivers, cluster found mostly in the thickly populated Mangaldoi town, Kalaigaon, Harisinga market centres, star-like settlements found in Mangaldoi town and isolated pattern found in the forest lands and foothill areas etc.

2.8 Landuse and landcover

The landuse and landcover of an area reveals the areal as well as temporal distribution and utilization of land resources. Landuse landcover does not remain static, rather it changes in time and over space. Landuse landcover is the interplay of various physical and socio-cultural attributes. The Noa-Mangaldoi basin of lower Brahmaputra floodplain of Assam falls under Agro-climatic zone, i.e upper Brahmaputra valley (north) (Bhagabati and Dutta, 2001). The landuse and landcover map for the basin has been prepared based on the toposheets (Figure 2.9). The major categories of landuse landcover that have been identified within the basin are the agricultural land, homestead

![Figure 2.9: Landuse landcover of Noa-Mangaldoi basin](image-url)
Table 2.1: Distribution of landuse landcover in the study area

<table>
<thead>
<tr>
<th>Land use/land cover categories</th>
<th>Area in ha.</th>
<th>% to total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural land</td>
<td>36466.01</td>
<td>48.94</td>
</tr>
<tr>
<td>Homestead and riparian vegetation</td>
<td>11289.23</td>
<td>15.15</td>
</tr>
<tr>
<td>Settlement</td>
<td>8785.05</td>
<td>11.79</td>
</tr>
<tr>
<td>Forest</td>
<td>6563.11</td>
<td>8.81</td>
</tr>
<tr>
<td>Grassland</td>
<td>6525.02</td>
<td>8.75</td>
</tr>
<tr>
<td>River</td>
<td>2214.31</td>
<td>2.97</td>
</tr>
<tr>
<td>Tea Garden</td>
<td>1277.00</td>
<td>1.71</td>
</tr>
<tr>
<td>Sand</td>
<td>692.03</td>
<td>0.92</td>
</tr>
<tr>
<td>Wet land</td>
<td>681.2</td>
<td>0.92</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>74492.96</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Source: Toposheets 1968-69 (SOI) and computation done by the researcher

and riparian vegetation, settlement, forest, grassland, river, tea-garden, sand cover and the wetland. Areas under each of these categories are shown in table 2.1. As about 63.75% of the basin is rolling flat surface occupied by rural people with agriculture as their mainstay, agricultural land of 36466.01 ha areal coverage has been found to be the largest landuse landcover category in the basin. This category of landuse landcover is seen to occupy the alluvial plain of middle and lower reach of the basin. It accounts about 48.94% of total basin area. The homestead and riparian vegetation category has an areal extension of about 11289.23 ha which is nearly 15.15% of the total area of the basin. The settlements, mainly the rural settlement that covers most part of alluvial plain together with the only urban centre, i.e Mangaldoi town and some small service centre located in the built-up area may be considered as the third largest landuse landcover category in the basin. It covers about 8785.05 ha and accounts for 11.79% of the total area of the basin. The forest which covers the upper reach of the basin including the foothill zone may be considered as one of the vital landuse landcover category in the basin. By covering an areal extension of 6563.11 ha it represents about 8.81% of the total basin area. This category includes evergreen, semi-evergreen, deciduous, degraded and scrub type of forest. The land under permanent patches of grass near the villages of the alluvial plain where cultivation of crops is not suitable can also be identified as one of the important landuse landcover categories. This category occupies about 6525.02 ha which is nearly 8.75% of the total basin area. The Noa-Mangaldoi river system with various tributaries are found to cover about 2214.31 ha of the basin area. It represents a
major share of the total water bodies of the basin. This category represents about 2.97% of the total basin area. In the foothills and flood free high old alluvial zone, tea plantation occupies relatively less area of the basin. It is also an important landuse landcover category found in the basin, which shares 1.71% of the total basin area. The small char and chaparies including tiny sandbars found along the river channels may be considered as one type of landuse landcover in the basin. With a very small areal coverage of only 692.03 ha it represents 0.92% of the total basin area. Finally, all the small beels, marshes and swamps scattered all over the alluvial plain may be another type of landcover. This category occupies about 681.2 ha and represents only 0.92% of the total basin area.

2.9 Transport and communication

The development of every nook and chook of a region always stands on a single stone, which is known as transport and communication. Except the air transport service, the entire basin is almost served by all other modes of transport. The middle and lower reaches of the Noa-Nadi basin have a fairly good network of road communication system (Figure 2.10). Through Mangaldoi township the 15 National Highway passes across the lower part of the basin. The total length of this highway in the basin is about 13.46 km. This can be treated as the life line of the basin as it has connected the basin with nearest town Sipajhar to east and Dhekiajuli, Tezpur to the west. Many small roads of village and panchayat level that run from north to south and south to north are connected with this national high way thereby developing a good road network to serve the entire basin. Among such roads, the major village road which run from north to south across the villages of Khoirabari, Lesinggaon, Chamuaapara, Dhlakata, Tepakhat, Amguri, Chinatgaon, Kalaigaon, Dekargaon, Barangabari, Mangaldoi etc. are notable ones. The total length of all the mattled and unmattled roads is about 228 km, though there are marked variations in the distribution of roads in the basin. Out of the total 228 km length of roads, 13.46 km is mattled with black toping, 116.08 is km mettled and remaining 98.46 km is unmattled road. The northern portions of the basin are not sufficiently covered by road network. With maximum road density of 1.25 km/km² in the lower plain, the entire basin has the average road density of about 0.31 km/km². The Rangia-Jonai of broad-gauge section of N.F Railway which passes across the middle portion of the basin is the single railway line serving the entire area. This railway line
plays a major role in the surface communication system of the basin. During high floods with longer duration, the people also use country boats as a means of transport.

![Transport network in Noa-Mangaldoi basin](image)

**Figure 2.10:** Transport network in Noa-Mangaldoi basin

Besides, all modern communication services which include post and telegraph services, internet services etc. are also found available in the towns, market centres and developed rural areas of the basin. Of course, the remotely located villages along the northern foothills and the char areas along the Brahmaputra river are still deprived of these services.