Chapter-3

STUDY AREA

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3.1 Introduction

Uttarakhand state has two rivers with the same name called Ramganga, one is Eastern-Ramganga originated from Pithoragarh district, and another is Western-Ramganga originated from the Chamoli district [104]. The present study is based on the western Ramganga river. Ramganga river (western Ramganga) is a first major tributary of river Ganga. The source of water is mainly from spring, rainfall and during winter it also receives water from the snowfall in the hilly reaches. It originates from a spring called Ramnalli (30°6'8.28"N, 79°17'37.68"E) located in a temple at an elevation of 2550 m above mean sea level near Gairsen, Chamoli District of Uttarakhand state [105]. It has a total catchment area of around 30,635.1 km^2. Ramganga river is about 590 km long, out of which, ~160 km is in the Himalaya and ~ 430 km in the Gangetic plain [106]. This represents around 2.8% of the total area of the Ganga Basin (861404 km^2). It supports a population of 18.6 million, which is primarily dependent upon groundwater irrigated agriculture [105]. The main-stem and its tributaries are highly regulated with dams, barrages/weirs and associated irrigation canals.

The Ramganga river enters into the Gangetic plain region at Kalagarh, Uttarakhand after flowing over the Lesser and Shiwalik Himalaya [106]. The river oscillates its channel south-east to south-west direction below the foothill zone. The major tributaries of Ramganga river include –, Sona, Playan, Binao, Gagas, Nair, Badangad, Khoh, Gaagan, Dehla, Kosi, West Baigul, Aril Dhara, Pili, Phika, Mandal and East Baigul [105]. The Ramganga traverse through two states Uttarakhand (12%)

and Uttar Pradesh (88%) and becomes an inter-state river system. The Ramganga finally joins the Ganga river near Kannauj district in Uttar Pradesh [107].

The study area is located between 27°3'5" N and 27°47'5" N latitudes and between 79°32'0"E and 80°0'0"E longitudes in the Ramganga basin (Fig. 3.1). The study area covers around 2297 km^2 area and approximately 125 km length of the Ramganga river. The study area has been divided into two segments for an in-depth analysis of the dynamics of lower Ramganga river. Segment A (W1) includes the river reach between the confluence of Ramganga and Bhagul to the distributary of Gambhiri river (old Ramganga), and Segment B (W2) consists of the river reach between Gambhiri river (old Ramganga) to the confluence of Ramganga and Ganga river.

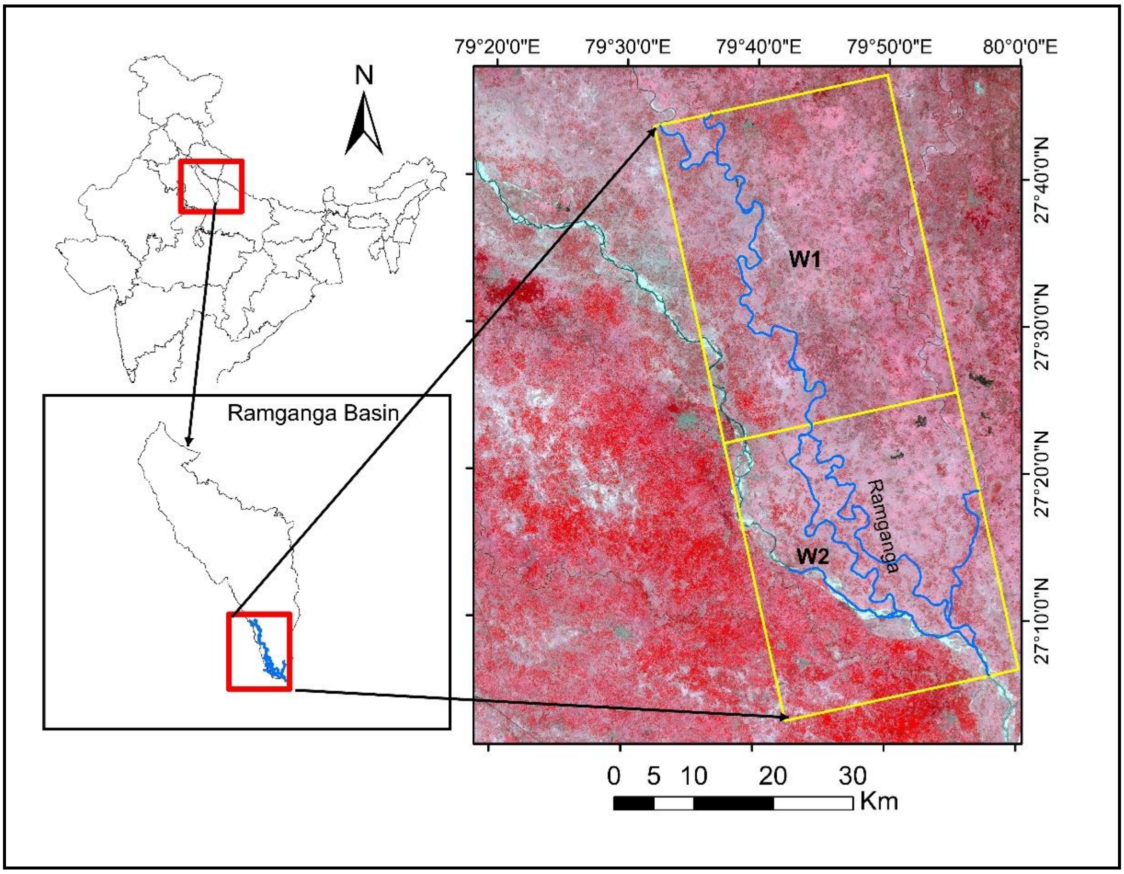

Figure 3.1 Study area showing the lower course of Ramganga and its tributary and distributary

The average yearly water discharge of this river at Dabri is 406.73 m^3/s, which is the last downstream gauging location and average annual sediment load was 15689.14 metric ton/day during 2009–2011[108]. This region is frequently experienced by floods. Due to the deposition of the silt by floods and the alluvial nature of the floodplain, the river changes its course frequently [109].

3.2 Land use/ land cover

The Ramganga river basin has witnessed the rapid urbanisation, industrialisation and agriculture growth during and after the 1970s, which results in changes of Land Use and Land Cover (LULC) in the basin [110]. The land use/ land cover analysis for the river basin is done using Landsat-8 data in Google Earth Engine (GEE), which is a cloud-based remote sensing image processing platform on a large scale. In its present time, GEE has proven to be a powerful tool by providing access to a wide variety of satellite imagery in one consolidated system [95, 96]. Land use directly affects the river ecosystems across the Ramganga river basin, and it is essential to analyse these impacts for developing overall river management activity. The land cover maps were created in GEE environment using random forest supervised classification. Land use/ land cover mapping of the basin was performed with high overall accuracies of 90% and Kappa coefficients of 0.85. Land use/ land cover maps were classified into five classes built-up lands (Urban land), cropland, water bodies, forests and fallow land. The given diagram shows the percentage distribution of classes in the Ramganga Basin for the year 2018 (Fig. 3.2).

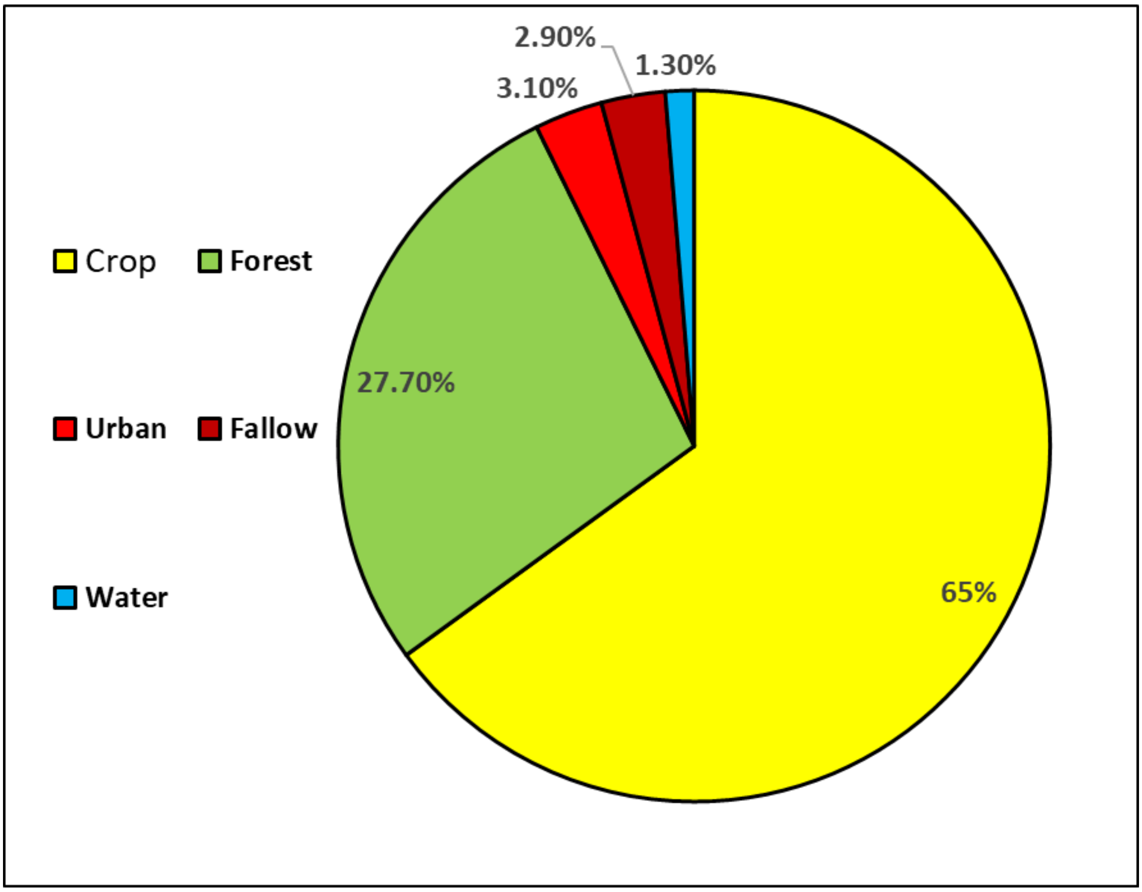

Figure 3.2 Distribution of land use/ land cover in Ramganga Basin based on Landsat -8 data

Land use/ Land cover change has directly affected the channel planform dynamics and vice versa [113]. In the downstream part of the Ramganga basin, the river is highly dynamic, which affects the significantly land use and land cover (Fig. 3.3). During the flood due to bank failure, a vast amount of land has been eroded, which directly affect the livelihood of erosion victims who are settled in the flood plain of the Ramganga river. Most of the erosion-affected rural areas which experience land erosion in the downstream remain underdeveloped. Channel planform dynamics also affect the small water body like the village pond of the study area. People tend to convert water bodies into agricultural land and settlement as per their necessity [110].

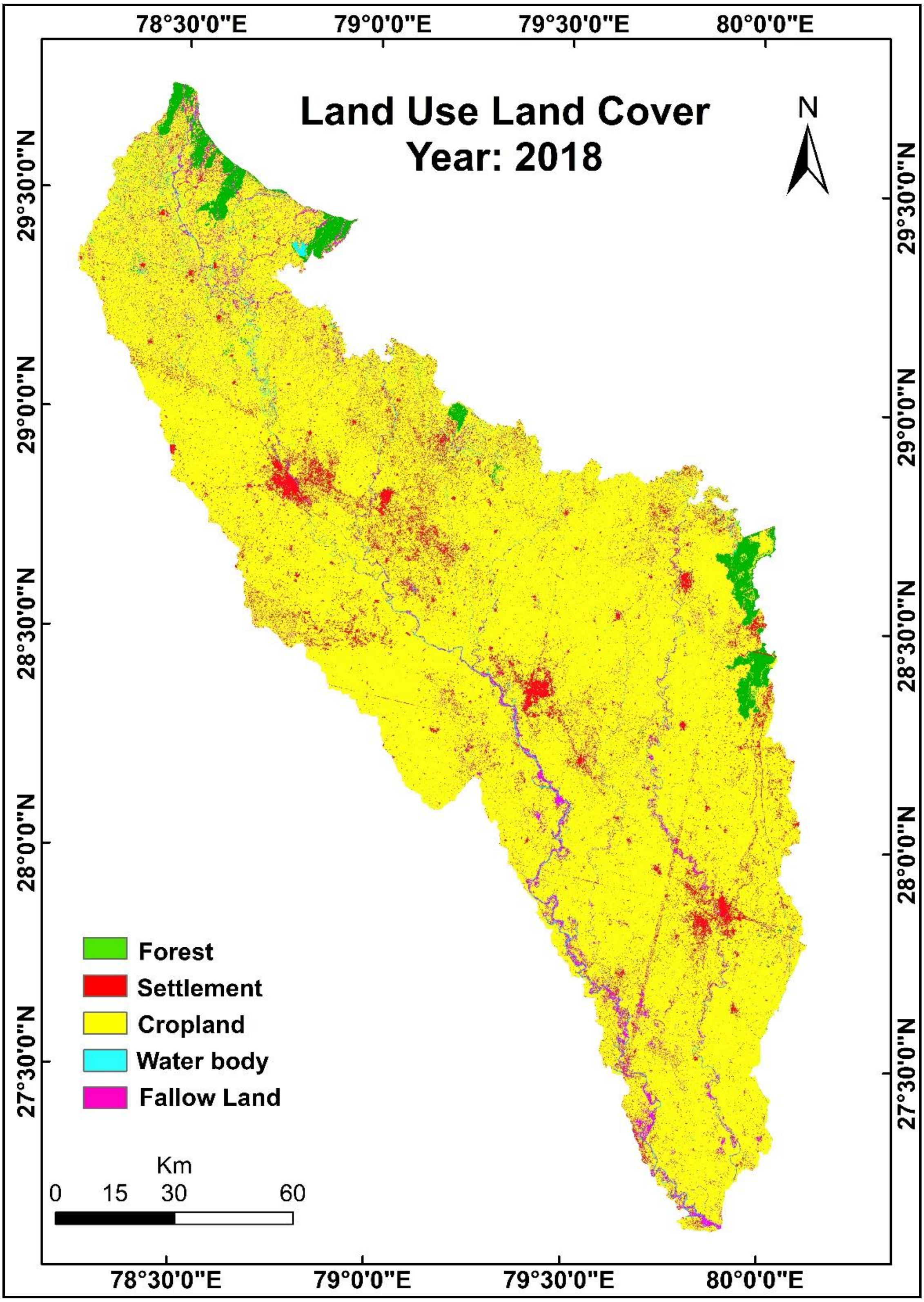

Figure 3.3 Land use/ Land cover map of the Ramganga river basin based on Landsat-8 data

3.3 Climate

The climate of the region is predominately sub-tropical monsoon. The large variation in altitude across the basin results in diverse climatic conditions. The temperate of the study area is mild and normally warm. The average yearly temperature is 25.7 °C, which rises above 40°C in summer and goes below 10 °C in the winter. Maximum portions of the study regions experience monsoonal rainfall of 90–100 cm/year. The monsoon rainfall occurs during July–September of each year, whereas the rest of the year remains mostly dry. On average, the western parts of the basin receive more rain than the eastern parts. During the summer season (April - June), some of the river flow is a result of snowmelt [105].

3.4 Geology

Ganga alluvial plain comprises three Quaternary lithostratigraphic sequences as (1) Varanasi older alluvium with two facies, i.e., sandy facies and silt clay facies, (2) Ganga/Ramganga terrace alluvium, and (3) Ganga/Ramganga recent alluvium; (4) Channel alluvium is mainly concentrated in the river bed of Ganga and Ramganga [114].

The Varanasi older alluvium is extensively developed in the doab of Ganga and Ramganga rivers which is the oldest among the Quaternary formations. Its thickness varies from 300 to 517 m in the plain. Ganga terrace alluvium is composed of alternate beds of unoxidized silty clay and fine to medium sand, which is present between the paleobanks of Ganga and Ramganga. The sands of Ramganga terrace alluvium is slightly coarser in size than the sands of Ganga terrace alluvium. The Ganga and Ramganga recent alluviums are contained within the present-day bank limits. These sands are generally fine to medium grained and grey coloured sands. Thin drapes of silt are also present in the form of channel and point bars [115].

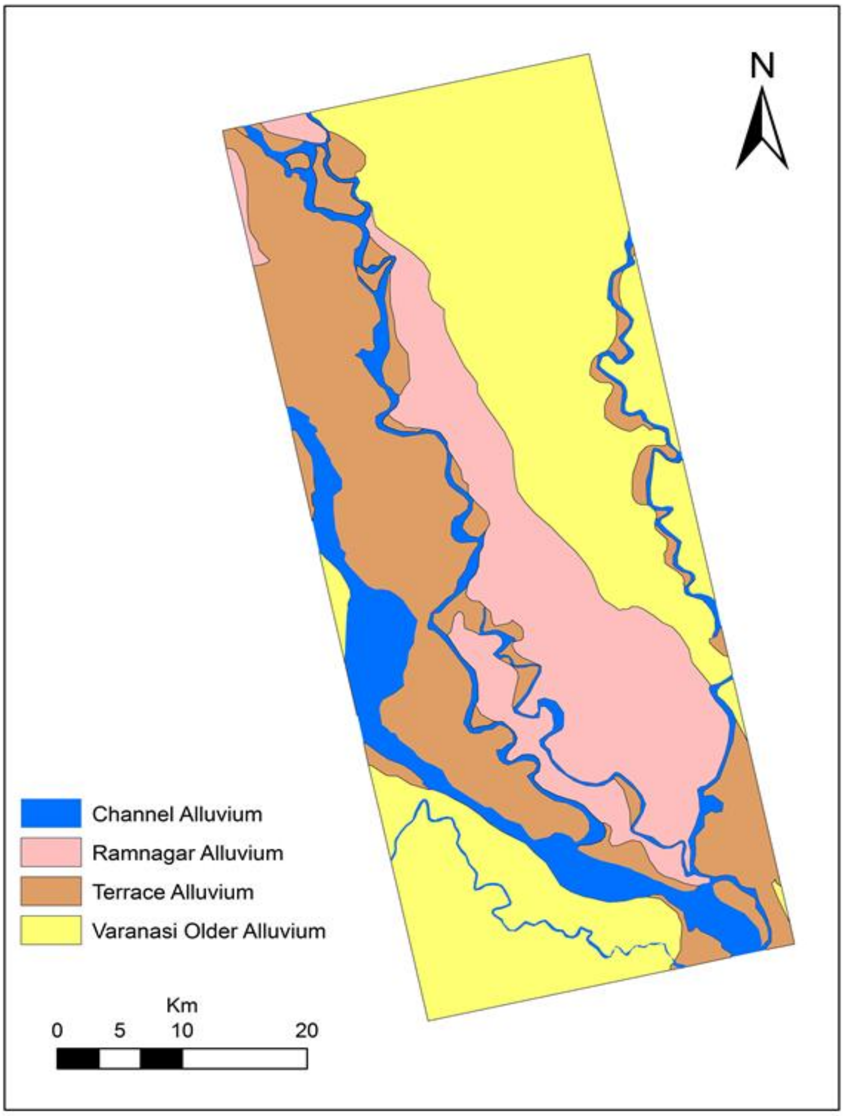

Figure 3.4 Geological map of study area based on the geological survey of India map (54M)

Geological map based on the Geological Survey of India (1977) reveals that the study area has undergone significant channel movements. It geologically consists of channel alluvium, Ramnagar alluvium, Terrace alluvium and Varanasi older alluvium. The geology map shows that river flows between terrace alluvium in east and Ramnagar alluvium in the west (Fig. 3.4). The Ramganga recent alluvium formed in the new river valley terrace, and it is located above 2–6 m above the channel floor (Fig. 3.4). Ramganga terrace alluvium is related to older floodplain and upland terrace plain, located about 5–15 m above the channel floor [106]. Geology of Ganga alluvial plain could be a reason for shifting of the river when flowing through fertile agricultural lands of the study area [108].

3.5 Soil type

The soil of this area is developed from the alluvial deposited by the river Ganga and Ramganga. The alluvial material originated from the soft dolomite rocks of the Himalayas from which these rivers originate [116]. The alluvium is very deep except for the riverine areas which receive sediments annually over the sandy beds and have very thin soil layers. At times the depth of alluvium exceeds a few hundred meters without any evidence of parent rocks. These alluvial soils vary considerably from location to location, but all of them are essentially basic in character. Alluvial soils are developed in medium and fine-textured material derived from alluvial deposits. Most of these soils used for agricultural activity which has higher productivity but they are greatly affected by water erosion and loss in productiveness [116].

The texture is one of the essential properties of soils. Different types of soil textures have different soil hydraulic characteristics like water retention and hydraulic conductivity, and soil thermal parameters, such as thermal conductivity and heat capacity [117]. The Ramganga basin has mainly two types of soil textures: loam and sand with a negligible amount of gravels. The soil map shows the presence of sand soil is close to the main channel, and the rest of the basin is mainly covered with loam soil (Fig. 3.5). Typically, the loam is more susceptible to erosion than sand and sandy loam [118]. Sand also has higher erodibility which are near to the channel bank, and this soil is more susceptible to soil erosion during the high discharge. Broadly it can be concluded that Ramganga and its tributary have high erodibility. The riverbank erosion primarily depends on soil erodibility parameters [119]. The soil erodibility parameter is dependent on the silt- clay percentage [82]. High the percentage of silt and clay leads to higher riverbank erosion. The downstream of the Ramganga basin soil has more than 85 % silt-clay percentage, which is a principal factor of fluvial erosion.

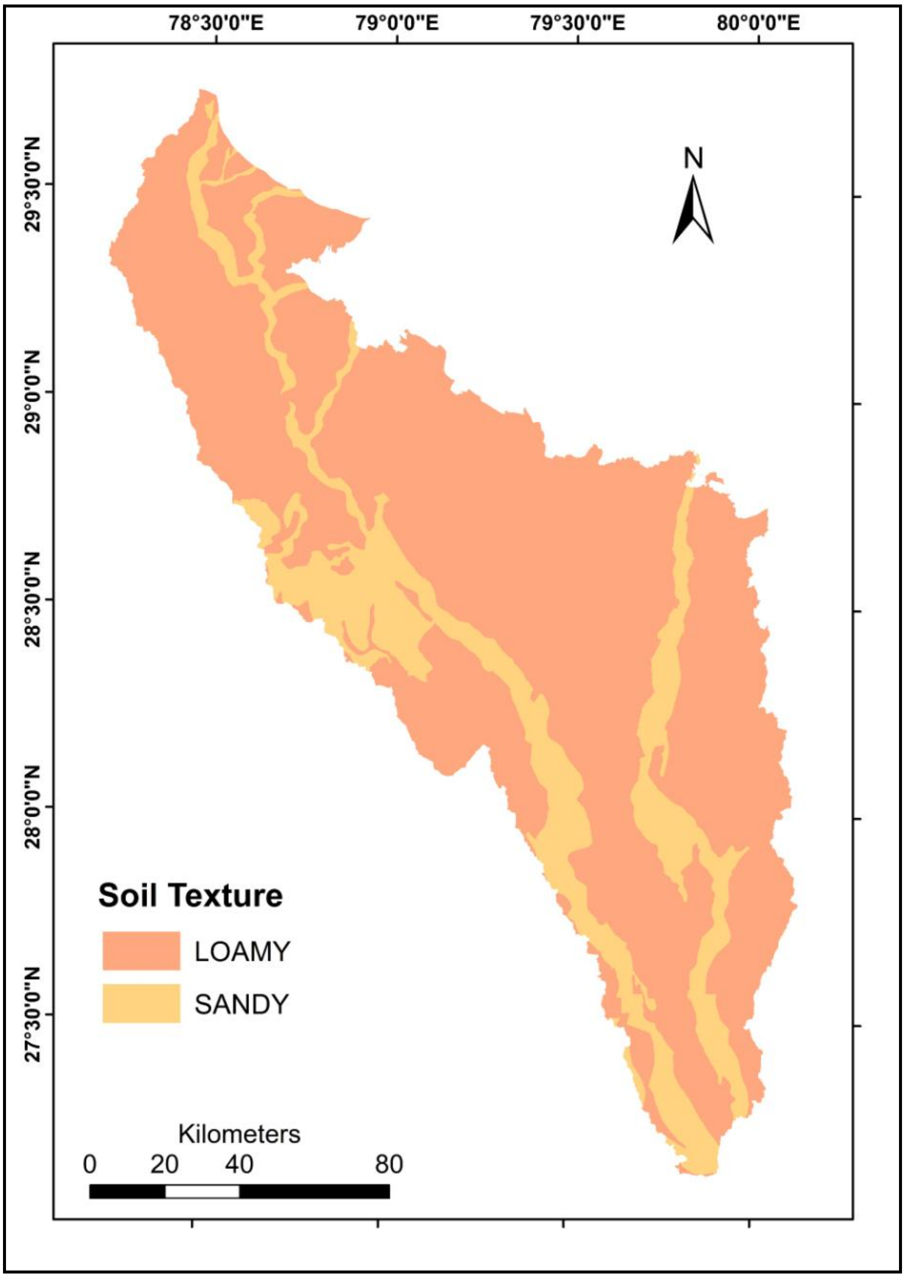

Figure 3.5 Soil map of the Ramganga basin (Source: NRSC (2005))

3.6 Hydrodynamics

The Ramganga and its tributaries are highly regulated with dams, barrages, and weirs, much of which is designed to support an extensive irrigation canal system. One of the largest water supply infrastructure is Kalagarh Dam which one is located three kilometres upstream of the village of Kalagarh. This dam is a part of the multi-purpose project that was completed in 1974. In addition to the Kalagarh Dam, there are a further ten dams, nine barrages, and one weir within the basin, which supply approximately 0.44 BCM per year and are primarily used for irrigation [104].

According to the report published by Central Water Commission, India in 2012, the Ramganga river have the mean annual discharge of 537 m^3/s. During the rainy season, the discharge of the river is 10000 m^3/Sec, whereas only 5 m^3/Sec during the summer season is observed. The average annual rainfall is observed 900 mm, with the total number of rainy days being 75 from 1996 to 2000 [120]. The present study belongs to central parts of Gangetic alluvial belt. The drainage is being provided by southeastern flowing Ganga.

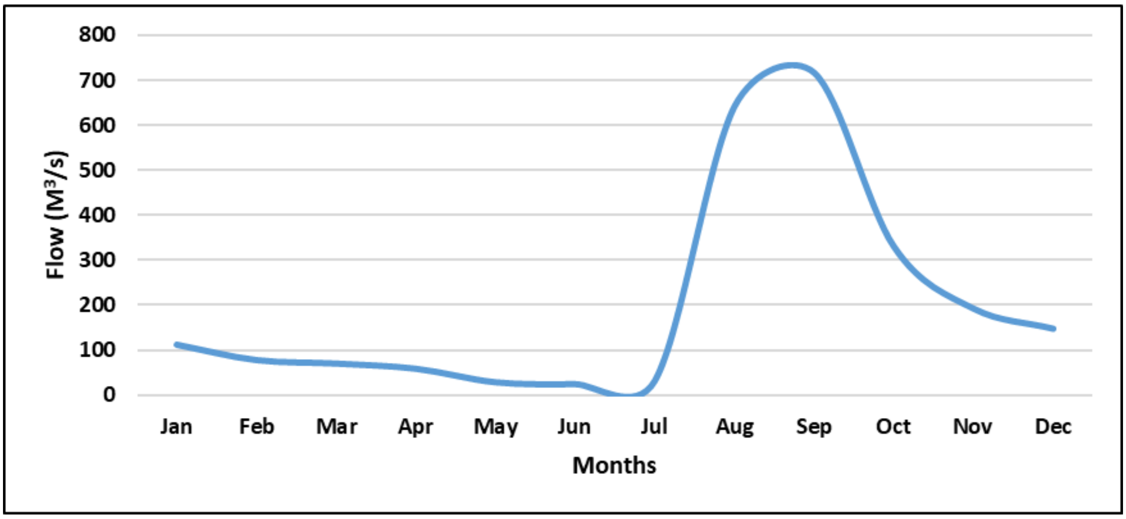

Figure 3.6 Annual average hydrograph of the Ramganga river (Data source: CWC, 2018)

The yearly hydrograph at Dabri hydrological station from the Central Water Commission (CWC) shows the water level rises sharply during July–august when the monsoon starts and falls rapidly during (October–November). Ramganga river shows the greater discharge during the monsoon months (June – September) compared to the non-monsoon months (Fig 3.6). In the monsoon period, fluvial erosion is highly active in the channel, which led to the channel shifting in this season.

3.7 Summary

The Ramganga river is the first major tributary of Ganga river. Ramganga basin is highly populated, and agriculture activity is dominating in this region. The major land use utilised in agriculture activities, and there is no significant forest cover is observed in the downstream area. Agriculture activity is dominating in the rural area of the basin. In the downstream area, mainly the rural settlement is found along the river. These rural settlements are highly prone to erosion due to its meandering nature. Some part in the downstream of the Ramganga river is controlled by the hidden geological structure. The soil of the area is highly erodible, which is mainly loam and sandy, and the percentage of silt and clay is also very high. This soil texture makes this soil as highly erodible. The hydrological characteristics of Ramganga river basin controlled by the monsoon of north India which affect the flood frequency. Annual average hydrograph shows that the probability of flood is very high during the monsoon period. Monsoonal rainfall increases the discharge in the channel more than six to seven-time than the lean period. Such frequent monsoonal flood causes a change in the morphology of the rivers.