CHAPTER II

REVIEW OF LITERATURE

2.1 Drainage Basins, the Units for Resource Management

Drainage basins are the fundamental units for the management of land and water resources (Moore et al. 1994). They have been identified as planning units for administrative purpose to conserve the precious natural resources (Anon, 1985; 1987; Honore, 1999; Khan, 1999). The concept of watershed management recognises the inter-relationships between land use, soil and water and the linkage between uplands and downstream areas (Tideman, 1996).

2.2 Geomorphology and its Analysis Using GIS and Remote Sensing

The term morphometry is used in several disciplines to mean the measurement and analysis of form characteristics; however in geomorphology it is applied to numerical analysis of landform, which may be more appropriately termed geomorphometry (Gardiner, 1982). Geomorphology is associated with topographic landforms, which in turn are related to surface runoff and infiltration. Geomorphologic studies involve the identification and characterization of the fundamental units of landscape. Geomorphologic processes are generally complex and reflect inter-relationship among the variables such as climate, geology, soils and vegetation (Buol et al. 1973).

A major emphasis in geomorphology over the past six decades has been on the development of quantitative physiographic methods to describe the evolution and behaviour of surface-drainage networks (Horton, 1945; Leopold and Maddock, 1953;
Leopold and Wolman, 1957; Abrahams, 1984). These parameters have been used in various studies of geomorphology and surface-water hydrology, such as flood characteristics, sediment yield, and evolution of basin morphology (Jolly, 1982; Ogunkoya et al. 1984; Aryadike and Phil-Eze, 1989; Jensen, 1991; Breinlinger et al. 1993).

The underlying lithology, slope and the type of existing drainage pattern influence the genesis and processes of different geomorphic units (Singh et al, 2010; Sarmah et al. 2012). The geomorphic units distinctly separated each other by topographic change in slope segments similar to the morphological mapping techniques (King, 1962; Savigear, 1965; Dalrymple et al. 1968)

Detailed geomorphological mapping is one of the principle means of studying the morphology, genesis, distribution and age of forms, which in turn helps to interpret the geomorphic history of any evolved landscape. The detailed analysis of landforms is an important aspect of any environmental or resource analysis and planning (Blarzcsynski, 1997; Prakasam and Biplab, 2011). Geomorphologic survey is primarily concerned with the classification and mapping of relief forms through differentiation of morphographic patterns with respect to their genesis and processes (Reddy et al. 2002). The synoptic coverage and high precision of remotely sensed data coupled with marked cost effectiveness and time efficiency in data acquisition and analysis procedures have made geomorphologic mapping an extremely effective tool for management of natural resources and environment (Srinivasan, 1988; Reddy et al. 2002; Prakasam and Biplab, 2011). The remote sensing data and GIS based detailed geomorphologic and degraded lands analysis ensure better understanding of landform-eroded lands relationship and distribution to assess the status of land.
degradation at micro geomorphic unit for reclamation, geo-environmental planning and management (Shanwad, 2006). Similar study also helps in the areas of natural resource management, environmental planning and management, watershed management and hazards monitoring and mitigation (Reddy et al. 2002).

In India Joglekar (1965) and Varsheney (1975) have suggested a number of enveloping curves for the prediction of sediment yield for different catchment areas. Correlation studies conducted by Jose and Das (1982) reveals that area alone does not have any significant association with sediment production rate (SPR) and hence there is scope for multivariate analysis using climatic and physiographic parameters. Statistical models on a spatially distributed basis have been developed by Mishra and Satyanarayan (1991) and Bundela et al. (1995) for small watersheds in river Damodar in east India.

The description of drainage basin characteristics and stream channel networks has evolved from a qualitative study to a quantitative analysis in recent years (Branson et al. 1972). Horton (1945) was the pioneer of these systematic studies, and more recently, Strahler (1954) and his students have expanded on Horton's work (Fuller and Fish, 1978). These quantitative variables have been the basis for inter-basin comparisons and evaluation of hydro-raphic responses.

One of the easiest physical hydrologic characteristics to measure is the areal extent of a particular watershed. The size or area of a drainage basin is an important consideration in that the total volume of water is directly related to the size of the basin. Generally, large watersheds have greater runoff than small watersheds (Anderson, 1957). However, the runoff per unit of area decreases as the area of the watershed increases (Schumm and Hadley, 1961; Wolman and Gerson, 1978; Molnar
Another important consideration is the effect of watershed area on peak flows. As is the case with total water yields, higher peak flows are usually associated with larger areas. However, when such outputs are expressed in terms of flow per unit watershed area, it is the smaller watersheds that characteristically have the greatest rates of flow (Avery, 1975).

The outline form or shape of a watershed strongly influences its hydrographic patterns (Fuller, 1976). Although watershed shape is difficult to quantify, several different indices comparing the configurations of different watersheds have been proposed. Two of these methods quantitatively express the compactness or degree of circularity of a basin's form.

a. When a watershed is a perfect circle it will have an index of 1. The closer a shape index is to 1, the greater the likelihood that precipitation will be quickly concentrated in the main channel, resulting in peak flows (Avery, 1975).

b. Miller's Circularity Ratio (Miller et al. 1964) expresses the departure from circularity of a watershed. In this instance, a perfect circle would have a circularity ratio of 1 and all others would have a ratio of less than 1 (Chorley, 1969; Branson et al. 1972).

Both of these shape coefficients express quantitatively that circular watersheds have high runoff and low sediment yields. This relationship can be explained by the fact that circular watersheds concentrate water faster and runoff travels shorter distances, allowing for less evaporation and less opportunity for channel storage. However, long narrow watersheds tend to have steep slopes with consequently higher overland velocities and sediment transport capacities (Branson et al. 1972; Fuller, 1976).
The pattern or arrangement of natural streams in a watershed is another important physical characteristic for two reasons. First, they provide evidence of the efficiency of the drainage system and therefore its hydrologic pattern; second, as Horton (1933) points out, "It is an excellent indicator of soil permeability."

Three such indices are useful in determining the pattern of natural streams. Drainage density (Branson et al. 1972) is an expression of the closeness of spacing of stream channels in a watershed. In general, low drainage densities are indicative of regions of highly permeable sub-soils, dense vegetative cover, and low relief (Avery, 1975). Schumm and Hadley (1961) indicate that when drainage density is plotted against mean annual runoff, the results suggest that drainage density, if not dependent simply on runoff, is at least dependent upon the same variables that influence runoff.

A second index is a quantitative approach to classifying streams (stream ordering) in a basin. This classification is a systematic ordering of the branches of a stream network and it was first proposed by Horton (1945) then revised by Strahler (1952, 1957) and Shreve (1967). According to Gregory and Walling (1973), the Strahler (1964) modification of Horton's method (1945), which essentially designates all fingertip tributaries as first order, two first order streams produce a second, two second order streams produce a third order and so on, has been used most extensively.

The third index is a qualitative classification of the overall drainage pattern. These classification systems have been described by many researchers (Gregory and Walling, 1973; Avery, 1968; Small, 1970; and Leuder, 1959).

Slope and elevation are also important hydrologic characteristics. The slope of a watershed channel, expressed in the number of feet of elevation drop per mile of stream channel, greatly influences the velocity and therefore the erosion potential of
stream flow. Slope is also related to infiltration, evapotranspiration, soil moisture, and groundwater contribution to stream flow. The variations in elevation of a watershed are important factors with respect to temperature and precipitation patterns, especially in mountainous topography (Avery, 1975; Fuller, 1976).

Each of these hydrologic characteristics in its own way influences the hydrographic pattern of a watershed. Therefore, a comparison of each of these characteristics for each watershed can provide a quantitative basis for inter-basin similarity analysis (Fuller and Fish, 1978).

Land morphometry represents the topographic expression of land by way of area, slope, shape, length etc. These parameters affect catchment stream-flow pattern through their influence on concentration time (Gregory and Walling, 1973). The significance of these parameters was pointed out by Morisawa (1967), when she expressed catchment stream-flow pattern as a general function of geomorphology of a watershed. This assertion still stand valid; as various studies have also observed that geomorphic characteristics of a river basin play a key role in controlling the basin hydrology (Adejuwon et al. 1983; Ogunkoya et al. 1984; Pitlick, 1994; Ifabiyi, 2004).

2.3 Watershed Prioritization

Watershed prioritization is the ranking of different sub watersheds of a watershed according to the order in which they have to be taken for treatment and soil conservation measures. Prioritized watersheds based on the sediment production rate for adopting suitable soil conservation measures (Suresh et al. 2004; Khare et al. 2007). Information derived from remote sensing data is being widely used in watershed prioritization. Erosion hazard assessment and prioritization based on morphometric parameters like relief ratio, drainage density, drainage texture and
bifurcation ratio have been studied by Chaudhary and Sharma, 1998; Biswas et al. 1999; Londhe et al. 2010 and Sethupathi et al. 2011.

Several methods such as Sediment Yield Index (SYI) method proposed by Bali and Karale (1977) and Universal Soil Loss Equation (USLE) given by Wischmeier and Smith (1978) are extensively used in the prioritization of watersheds. Several researchers have adopted these techniques depending upon the purpose and the information availability (Suresh et al. 2004).

The rapid advancement in remote sensing technology and continuous inflow of satellite data has given input and realization for periodic updating of the priority status of sub watersheds.

2.4 Run-off and Sediment Production Rate

For assessing erosion, several empirical models based on the geomorphologic parameters were developed in the past for quantifying the sediment yield (Linsley et al. 1982; Misra et al. 1984; Jose and Das, 1982). Garde and Kothari (1987) developed an empirical relationship involving catchment area, catchment slope, drainage density, vegetation cover factor and annual precipitation for average annual sediment yield estimation using a data of 50 catchments located in the plain region of India.

Increasingly, linear, areal, and relief relationships evolved beyond basic analysis and have been refined to predict geomorphic processes. For example, they have been used to predict flood peaks, assess sediment yield, and estimate erosion rates (Jolly, 1982; Jensen, 1991; Breinlinger et al. 1993; Glennon, 2001).

Remote sensing data provides accurate, timely and real-time information on various aspects such as size and shape of the watershed, land use/cover, physiography,
soil distribution, drainage characteristics, etc (Shanwad, 2006). It also assists in identification of existing or potential erosion-prone areas and provides inputs to many of the soil erosion, sediment yield and runoff models. Satellite imagery has been widely used in the fields of agriculture, forestry, watershed management, hydrologic modeling etc. (Still and Smith, 1985; Pande and Saha 1994; Sudhakar et al. 1994; Jose et al. 1994; Saxena et al. 2000; Daniel et al. 2010). Remote sensing data can permit hydrologists to derive the curve number as percentage basis from the Soil Conservation Service (SCS) table which is used for computation of runoff by applying digital land use/land cover information obtained from the IRS satellite (Ragan and Jackson, 1980; Tiwari et al. 1991). In Northeastern states of India, run-off and sedimentation rate have been studied by many researchers (Kothyari, 1996; Starkel et al. 2002; Sharma, 2004; Singh et al. 2010; Singh et al. 2011).

2.5 Normalized Difference Vegetation Index (NDVI)

The most commonly used vegetation index is the NDVI which is based on the difference between the maximum absorption of radiation in infrared radiation (R) as a result of chlorophyll pigments and the maximum reflectance in near infrared radiation (NIR) spectral region as a result of leaf cellular structure (Tucker, 1979). Tucker and Choudhury (1987) found that NDVI could be used as a response variable to identify and quantify drought disturbance in semiarid and arid lands, with low values corresponding to stressed vegetation. It has been used in monitoring desertification (Tucker et al. 1991), land-use change (Anon., 1997; Panhalkar and Pawar, 2011) and the effects of global warming in high latitudes (Myneni et al. 1997).
More recently, Ji and Peters (2003) found that NDVI is an effective indicator of vegetation response to drought in the Great Plains of United States, based on the relationships between NDVI and a meteorologically based drought index.

Tisdell and Roy, 1997; Talukdar et al. 2004; Sharma and Sharma, 2009; Sharma and Sharma, 2010; Sarmah et al. 2011 and many more have studied land use changes in north-eastern states of India.

2.6 Phytosociology

The northeast region of India is considered as one of the richest biodiversity centres of the Indian continent. According to Takhtajan (1988), it is the centre of origin of angiosperms. Meghalaya, a constituent of Indo-Burma biodiversity hot spot, harbours 3128 species of angiosperms which include 1237 endemic species and 53 threatened plant species (Khan et al. 1997). The biodiversity of primary forests of Meghalaya has been studied by workers like Upadhaya (2002), Jamir and Pandey (2003) and Tripathi et al. (2006). Almost all types of world’s natural forests have been commercially logged to cope with the demand of forest products and land for agriculture (Uma Shaankar et al. 1998). Millions of hectares of natural forests have been degraded by logging (Putz et al. 2001) and for agricultural uses (Lenne & Wood, 1999). It is generally considered that human exploitation causes major changes in the biodiversity of these forests, even though research on this subject has been limited and results often controversial (Turner, 1996). Some studies reveal conspicuous reduced species richness in secondary rain forests (Parthasarathy, 1999), even in over 100 years old regrowth stands (Turner et al. 1997), while other studies have reported increase in species richness in secondary forests (Kappelle et al. 1995). The disturbances of ecosystems results in loss of species and reduce its resilience to stress.
Arunachalam and Arunachalam (2005) were of the opinion that diversity of plant species may affect the functional processes in a disturbed ecosystem. Tynsong and Tiwari (2011) reported that the conversion of natural forests in Meghalaya to arecanut agroforests have impacted the density and basal area of woody species.

2.7 Agriculture and Socio-economy

Agriculture is the main occupation of the people of Meghalaya. Jeeva et al. 2006 reported that about 83% of the total population of state depends on agriculture for their livelihood. However, agricultural land is accounted as only 48% of the total geographical area of the state. The state offers scope for cultivation of a wide variety of agricultural crops because of highly diversified topography, altitude and climatic conditions. Terrace cultivation is predominant in the state, bringing land under permanent cultivation in later case (Anon, 1998). The ethnic communities of Meghalaya follow two major types of agricultural practices such as shifting cultivation or slash and burn agriculture, and terrace or bun cultivation. Shifting cultivation is practised in and around forests, and terrace cropping is practised in valleys and foothills, and inside plantation forest (Jeeva et al. 2006).

Meghalaya produces a variety of agricultural crops such as food grains, commercial crops, horticultural crops, etc (Munda, 2002; Singh, 2002, Singh and Saxena, 2002; Gupta, 2002). Of the total agricultural land in Meghalaya, 62% is used for food grains, 25% for cash crops, 9% for horticultural crops and the rest 4% is used for raising miscellaneous crops (Bhakta, 1995).

The State’s population is 2, 318, 822 persons as per 2001 Census as against 17, 74, 778 in 1991 showing a decadal growth rate of 30.65%. Nearly 80.4% of the population resides in the rural areas. The population is predominantly tribal which
constitutes nearly 86% of the State's population. The sex ratio is 972 in 2001 Census for the State. The State's average density is 103 persons per square kilometer with East Khasi Hills district having a population density of 240 persons per sq.km followed by West Garo Hills with 139 persons per sq.km.

According to 2001 Census the literacy level in the State is 62.6%, which is below the national average of 65.4% (nnurm.nic.in/wp-content/uploads/2010/12/Shillong_Chapter2.pdf).
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