A literature review is an evaluative report of information found in the literature related to the selected concepts of study. It gives a theoretical base for the research and helps the author determine the nature of the particular research work. It is not just a descriptive list of the materials available, or a set of summaries, but, it also, enables a better understanding of the particular research topic.

Since agriculture is the oldest form of human activity, the growth and development of agricultural geography is, also very old. However, the beginning of agricultural geography as a distinct field of study is a very recent development. During the period of Greek and Roman colonization (ancient period) and their supremacy, agricultural products and ideas were exchanged throughout the region of their influence and even beyond it through intermediate traders (Symons 1967). References on different agricultural practices, crops and their patterns and agricultural products have been given in the writings of Strabo, Caesar, Pliny, Verenius, Von Humboldt, Ritter etc. of the Medieval Period.

Young, A (1770), whose approaches were of environmental determination, is considered as the pioneer in the field. In 1770, ‘Young’ published his work, “Environment and Cropping patterns in England”, in which he attempted to establish the role of physical environment in regional variation of agricultural activity. He established temperature, rainfall and soil as the major determinants of cropping patterns of a region. Schwenz gave the first account of spatial distribution of crops in Germany in his book, “Environment and cropping patterns in Germany” in 1816. According to him, temperature and rainfall conditions control the existing agricultural activities and cropping patterns. Humboldt included ‘Land use in Cuba and South America’ in his work “Cosmos”, in 1807, in which he described the agricultural practices that he has observed in those countries.

Von Thunen, the ‘founder father of economic location theory’, introduced a model of the location of agricultural activity in 1826. In his spatial model of agricultural land use, he attempted to explain the prices of farm products and the way
in which such prices control agricultural production of any plot of land. In 1883, Engelbrecht prepared crop regions of North America.


Agricultural Geography studies agricultural regions, agricultural productivity, land use patterns, cropping patterns and crop combinations which vary with space and time. Hence, identification and demarcation of agricultural regions became the first step in the study of agricultural geography. Regionalization in agricultural geography is the process of delineation of an area or a country into agricultural activity regions having uniformity with the help of certain relevant agricultural indicators. Delineation of agricultural regions and description and explanation of agricultural systems of the respective regions were the major themes of the pioneering works produced by eminent scholars, during the first half of twentieth century. Jonasson’s (1926) “Agricultural Regions of the World”, was the first attempt on agricultural regionalization. Baker, one of the leading American geographers, published his work, “Agricultural Regions of North America”, in 1926. In it, Baker divided North America into regions of Wheat, Maize, and Cotton. Similar works include Jones’s (1928) “Agricultural Regions of South America”, Shantz’s (1940) “Agricultural Regions of Africa” and Whittlesey’s (1936) “Major Agricultural Regions of the Earth”. There has been much discussion on problems of agricultural typology and allied problems of regionalization.
Majid Husain (2003) is of the view that the study of the ways in which patterns of agricultural activity vary from place to place, involving both the description of those patterns and the attempt to explain them, is known as Agricultural Geography. Laut.P (1970) defines agricultural geography, as the study of the description of the spatial distribution of agricultural activities and the factors which create peculiar forms of agricultural in particular places. Morgan, W.B. and Munton, R.J. (1971) have suggested the basic principles and concepts of agricultural geography as (a) resource utilization (b) comparative advantage (c) exchange of goods and (d) optimum utilization of the resources. Most of these studies have been oriented either on agricultural land use or cropping pattern and crop combination.

Mohammed Shafi (1983) defined agricultural productivity “as the ratio of the index of total agricultural output, to the index of total input used in farm production. It is, therefore, a measure of efficiency with which inputs are utilised in production, other things being equal”. In other words, it is simply an input output ratio. Grigg.D (1982) defined agricultural productivity as “the increased efficiency with which inputs are processed into outputs”. He also, suggested the use of labour productivity and land productivity, to measure the agricultural productivity. According to Hussain.M (1996), “agricultural productivity is a function of interplay of physical and cultural variables and it manifests itself through per hectare productivity and the total production”. According to Jasbir Singh (1976), “agricultural productivity is a function of a set of several elements, namely, physical ecology, cultural ecology, socio-economic factors, bio-chemical mechanical elements and the like”. To Grigg D.B (1984), the yield of crop varies a great deal because of differences in climate, soil and other inputs.

Shafi.M (1960) modified the ranking co-efficient of Kendall, by taking the weighted average of ranks. The cropped area is taken as weighted measure for the ranks of yield. Oommen.M.A (1962) measured the productivity in agriculture of Kerala State, on the basis of yield per acre. Dayal.E (1984) has attempted to analyse the spatial agricultural productivity, in India. According to Dayal, the measurement of agricultural productivity enables a comparison of the relative performance of farmers, between farms, between types of farming and between geographical areas.
To a large extent, land is used for agricultural purposes, and, also, a variety of crops are grown in different parts of the world. Naturally, an individual crop may dominate a region covering a large area, but it may not find a significant place in other regions. This makes an area differentiation of cropping patterns. On the basis of relationship between the areas of significant ones, different crop combinations are identified. In a region, a set of combinations of certain crops may form a continuous belt. A number of statistical procedures have, so far, been introduced to deliberate the crop combination regions. The most viable statistical formula of crop combination analysis was advanced by J.C. Weaver (1954). To him; crop combination analysis provides an adequate understanding of individual crop geography. He is the first to use statistical technique to establish the crop combination regions in his work “Crop combination region in the Middle West U.S.A”. This method was widely accepted and also applied for demarcation of crop combination and agricultural regionalisation.

Doi’s (1957) method, of delimiting crop combinations, may be considered as a modified form of Weaver. Whereas, Rafiullah S.M (1965) introduced a modification of Weaver’s method to delimit the crop combination units. In Rafiullah’s method, the difference of actual value is calculated from middle values of the theoretical standard. Rafiullah used the maximum positive deviation value, to arrive at the crop combination of an area. Singh. J (1964) examined the cropping pattern and described the occupancy of various crops in crop land, with the help of standard statistical algorithm, namely, the least squares. It has been observed that the technique of least deviation of actual percentage from the standard theoretical combination value is of little help for identification of crop combination in the enumeration units. Kanwar, J.S (1972) is of the view that cropping pattern means the proportion of area under various crops, at a point of time. Quite often, the area statistics are used to denote the cropping pattern. A committee constituted by the government of India, under the commissioner, with the government of India, determined the cropping pattern according to relative acreage of various crops, in a district or a group of districts.

Kashid Dhanajilahu and Kashid Nitadhanaji (2010) studied “crop concentration in Sindhudurg district”. This article represents the cropping pattern and crop concentration of selected crops, in the study region, Bhatia’s method was used for calculating the crop concentration. Data from two different years were used for calculating the indices of crops i.e., 1981-86 and 1996-2001. The spatial variation in
the degree of crop concentration area are found to be the result of the different interaction such as physiographic, hydrological, socio-economic and technological factors in organizational of an area. Aggarwal.R.K (2013) worked on “effect of rainfall on cropping pattern in mid Himalaya region”. This analysis concentrates on 20 years rainfall data from 1991 to 2010. The variation in precipitation was analyzed season wise, that is, summer, autumn, winter and spring. 15 years of yield data of the four major corps in the study region had been analyzed. This study implies that the crop yield is not affected by rainfall, significantly. Also, this study reveals that there is no trend in rainfall, in the region.

Punithavathi.J and Baskaran.R (2010) worked on “changes in the cropping pattern, crop concentration, agricultural efficiency in Papansam Taluk, Thanjavur district, Tamil Nadu”. According to Zimmerman (1915), agriculture would mean the cultivation of the land (Saini (1965), Majid hussian (1970), Morand Mounton (1981) Kurosaki (1999), Timmer and Szirmai (2000), Huffman and Evenson (2001), Kurosak.T and Fafchamps (2002), Misra and Govind Rao (2003), Hayami (2003) Ainsworth and Leakey (2008)). There are many previous investigations available. But, agriculture includes animal husbandry tree culture, forestry and many other varied activities. Bhatia’s method was used for finding out the agricultural efficiency in the study region. This work is concentrated on, within five major crops i.e., paddy, cotton, pulses, sugarcane and oilseeds. Paddy is the first ranking crop, pulses occupy the second place, oilseeds and sugarcane was in third and fourth place and cotton was in the last ranking place. Aloka Kumar el al., (2013) have studied “agricultural production trends and cropping patterns in Uttar Pradesh”. Findings reveal that during the period from 1950-51 to 2011-12, production of wheat has increased, and production of pulses shows a negative trend, during the entire period.

2.2 STUDIES ON LAND SUITABILITY

The suitability of a given piece of land is its natural ability to support a specific purpose. According to the FAO (1976) methodology, this is strongly related to the “land qualities” such as erosion resistance, water availability, and flood hazards that are not measurable. Since these qualities derive from “land characteristics”, such as slope angle and length, rainfall and soil texture which are measurable or estimable, it is advantageous to use these later values, to study the suitability. Thus, the land
characteristics parameters were used to work out land suitability for irrigation, crops and forest. Land suitability assessment for agriculture is meant to evaluate the ability of a piece of land to provide the optimal ecological requirements of a certain crop variety. In other words, assessing the capability of land is enabling optimum crop development and maximum productivity. Without respect to economic conditions, a physical suitability evaluation indicates the degree of suitability for a land use (Rossiter, D.G. and A.R. Van Wambeke, 1997). Suitability categorization with very highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and not suitable (N) only, are being used by many researchers for different crops, like Pyrethrum flower production in Kenya (Wandahwa and Ranst, 1996), Robusta coffee in Brazil and date palm in the Middle East. However, in Nepalese context, highly preferable, medium preferable and low preferable pockets, are for vegetable cultivation, as has been identified by an expert panel. In this system, existence of the not suitable land, has strictly been omitted (MOA 2005). Soil properties important to favorable rooting depth and available water capacity are the prime choices. Some productivity indices rely on a few critical soil properties, such as pH and bulk density, to rate soils (Pierce et al., 1983; Kiniry et al., 1983). Sys et al., (1991) express the effects of unfavorable land characteristics on the land production potential using a soil index.

Gurjar (1987) studied the Indira Gandhi Canal System of Rajasthan and considered irrigation as a vital infrastructure of modernization of agriculture. Pawar.C.T (1989) studied the impact of irrigation on agricultural economy of the upper Krishna basin Maharashtra. Farida Perveen et al in their article, entitled crop land suitability analysis. It was a prerequisite to achieve optimum utilization of the available land resources for sustainable agricultural production. This article concentrates mainly on determining physical land suitability for rice crops, using a multi-criteria evaluation (MCE) and GIS approach. It also, concentrates on comparing present land use to Potential land use. Terra/ASTER satellite images were used for land use land cover study. The total rise cultivated area was 6727.88 hectares. Here, 37% of the land was labeled as highly suitable and a substantial portion (35%) was labeled as marginally suitable areas. The results showed that, agricultural practices, which prevailed in the study area didn’t match with the potential suitability in the marginally suitable area. Thus, the average yield of the study area was substantially
affected, because of a significant proportion of rice crop being labeled as marginally suitable areas. This research provided information at local level that could be used by farmers to select cropping patterns and suitability.

Guoxin TAN (2000) et al, in their article entitled “the study of global land suitability evaluation”, combines the methodology GIS spatial analysis technique with a land evaluation methodology termed Agro-Ecological Zoning (AEZ) and a simulation model developed by FAO for calculating crop potential maximum biomass and yield. Finally, a case of global potential productivity estimation for wheat is tested. Weekly average temperatures and precipitation are interpolated with quality control models from weather station networks with time series of daily maximum, minimum temperature and precipitation. The growth period, in which climate will permit rain-fed crop production and global wheat potential productivity, is determined. The computed values of net biomass production and yield show that the potential productivity estimation methodology is actually possible to be used for global land suitability evaluation. Huynh Van Chuong (2005) studied the evaluation of physical land suitability for the Thanh Tra pomelo crop in Hue, Vietnam; this study is related to study physical land suitability areas for the Thanh Tra pomelo production and sustainable agriculture development of a representative village, Thug Bang Hue, Vietnam. The methodology used for this, is multi criteria evaluation approaches within the GIS context. Thuy Bang was selected as a representative village for this study, with an area of 2298 hectares, with 16 soil units. Its slope varies from 3° -25°. The soil depth is 30cm to more than 100cm, water resource is scarce and the soil fertility is poor to moderate. The study was carried out by overlapping all individual maps with GIS techniques for land suitability classification. Results showed that there are 32 land evaluation mapping units in the study village. A total of 1322.27 hectares were suitable for “Thanh Tra” pomelo production, of which 10% was moderately suitable and 90% was marginally suitable. Lack of irrigation, erratic rainfall and poor soil fertility are the most serious problems influencing yield and quality of Thanh Tra pomelo.

Ali Asgher Jofarzadeh and Goldastch Abbasi (2006) researched, and evaluated qualitative land suitability, for the growth of onion, potato, maize and alfalfa on soils of Khalat pushan. This article jointly showed their capabilities in the evaluation and assessment of suitable sites for a variety of crops, by use of Simple Limitation
Method (SLM). The Limitation method regards number and intensity (LMNI) and Parametric, such as square roots and the stories method. This method showed that the most important limitation factors are climate, PH, OM, texture and gravel alone, or in combinations. Finally, the result there, was an optimal climatic condition for irrigated potatoes and onions. This made the region receive a rating of ‘high suitable class’. Unsuitable conditions were rated for Maize crops, and moderately suitable was rated for Alfalfa crops. According to the results of the square root method, cultivation of Alfalfa, Potatoes and Onions can be recommended, except for soil profile 2, which is not suitable for onions. Bhagat.R.M et all (2009) researched “land suitability analysis for cereal production, in Himachal Pradesh”. It has showed that land suitability analysis is a prerequisite for sustainable agriculture and it plays a pivotal role in the niche based agricultural planning, in mountainous regions. In this paper, different parameters such as climatic, topographic, soil type, and land use and cover have been used in order to perform the land suitability evaluation for cereals, and food grain crops. The methodology to derive basic spatial profiles for their different parameters was dependent on a large GIS database. The TOPOGRID method was used to interpolate DEM which had an output resolution of 50 m and its land use type was derived from LISS III satellite imageries obtained from NRSC. In comparison to the actual area under cereal crops, the possibility of further expansion under each cereal crop was determined. These discriminated areas appear suitable for growing these crops and can be harnessed efficiently for achieving long term sustainability and food security.

Jaruntorn Boonyanuphop et al (2004) research is entitled, “GIS based land suitability assessment for Musa”. The aim of this paper is to constrict the geographical data base of land suitability for Musa, using GIS, and to select the possible land for new banana plantations. An effective method of assessing environmental suitability for the extending banana plantations, is needed. This approach used the GIS, which is a combination of five environmental factors, consisting of nineteen variables, to express land suitability in five classes. One site was chosen for site assessment. This site fell into a range of categories from highly suitable to not suitable. To supply future demand for dried banana products, information had to be integrated from land use types, current environmental conditions, soil characteristics
and the possibility for adjusting environmental conditions to make them more suitable for future growth.

Abdollah Ghasemi Pirbaloti (2009), represents his article, entitled “GIS based land suitability evaluation for rapeseed oil crop”. It concentrates mainly on biophysical variables. To identify suitable areas for rapeseed crop production through GIS, relevant environment components such as climate, soil, agronomic management and topography at different spatial and temporal resolutions were considered. The result of overlay maps for biophysical suitability evaluation using simple limitation approaches, indentified 0.003% of the land surface area highly suitable, 22% are moderately suitable, 15% of the land area marginally suitable and 63% of the land surface area, not suitable, in the study area. Ali Asgher Jofarzadeh and Goldastch Abbasi (2006) researched qualitative land suitability evaluation for the growth of onions, potatoes, maize and alfalfa on soils of Khalat pushan. This article jointly showed their capabilities in the evaluation and assessment of suitable sites for a variety of crops, by using of Simple Limitation Method (SLM) which is the method involving numbers and intensity (LMNI) and Parametrics, such as square root and the stories method. This method revealed that the most important limitation factors are climate, PH, OM, texture and gravel alone or in combinations. The results indicated that with an optimal climatic condition for irrigated potatoes and onions, this makes the region receive a ‘high suitable’ class, and an ‘unsuitable condition’ for Maize crops, and moderately suitable for Alfalfa crops. According to the results of the square root method, cultivation of Alfalfa, Potatoes and Onions can be recommended, except for soil profile 2, which is not suitable for onions.

Alejandro Ceballos-Silva and Jorge López-Blanco (2003) researched “Delineation of suitable areas for crops using a Multi-Criteria Evaluation approach and land use/cover, mapping: a case study in Central Mexico”. The application of a Multi-Criteria Evaluation (MCE) approach to identify suitable areas for the production of maize and potato crops in Central Mexico is presented. Maize and potatoes are the most important crops in the Rural Development District of Toluca (RDDT). Climate, relief and soil databases were used to integrate GIS coverages. Relevant criteria for crops and suitability levels were defined. This information was used to obtain the criteria maps, which in turn were used as input into the MCE algorithm. Several decisions supporting procedures in the Idrisi GIS environment
were applied to obtain the suitability maps for each crop. A 1996 Landsat TM image was processed using GIS capabilities, by means of a supervised classification to obtain a land use/cover map. These land use/cover and the suitability maps were crossing to identify differences and similarities between the present land use in the suitable areas for the maize and potato crops.

A. Ghaffari et al (Iran) researched and produced the article entitled, “Assessing land suitability for crop production in the Karkheh river basin”. In this paper, the author analyzed both climate, and soil site models, to assess climate change impacts on land suitability for rain fed winter wheat. They focus was on the potential effects of temperature increase and rainfall variables on the land suitability. The methodology is the Simple Limitation Approach (SLA) in preference to a GIS model, and it is mainly concentrated on soil and climatic conditions. The results showed that under current climate conditions, 8.7% of the area is highly suitable for winter wheat, 7.6% of the area is moderately and 28% of the area is marginally suitable for winter wheat and the remaining 55.7% is unsuitable. On the basis of soil, only 28% of the land is suitable for wheat.

Bandyopadhyay. S et al., (2009), has made an in depth study regarding “land suitability potentials for agriculture”. He has attempted to analyze in Land suitability, that potential evaluation is an important step in detecting the environmental limit in sustainable land use planning. It deals with the assessment of land performances for the specific use of crop production. The parameters taken into consideration were soil texture, organic matter content, soil depth, slope and land use/land cover. An integrated Land Suitability Potential (LSP) index was computed, taking into consideration the contribution of various parameters of land suitability. The study demonstrates that a watershed can be categorized into spatially distributed agriculture potential zones, based on the soil properties, terrain characteristics and analysis of present land use.

2.3 STUDIES ON LAND EVALUATION

According to FAO (1976) Land evaluation (LE) is the assessment of land performance, when used for a specified purpose, involving the execution and interpretation of surveys and studies of land forms, soils, vegetation, climate and other aspects of land. These are done to identify and make a comparison of promising kinds
of land use, in terms applicable to the objectives of the evaluation. Land suitability evaluation can also be defined as the assessment or prediction of land quality for specific use. This process includes identification, selection and description of land use types relevant to the area under consideration; mapping and description of the different types of land that occur in the area and the assessment of the suitability of the different types of land for the selected land use types (FAO, 1976). Rossiter, D.G (1995) stated that the modern era of land evaluation began with the publication of the FAO “Framework for Land Evaluation” (1976) and subsequent guidelines for land evaluation of general kinds of land use (FAO, 1983; 1984; 1985; 1991). Prakash, T.N (2003) stated that Land suitability evaluation is the prerequisites for sustainable agricultural production. It involves evaluation of the criteria ranging from soil, terrain to socio-economic, market and infrastructure.

Land evaluation for ecological regions, and territories, aims at creating a new good production power together with stability and sustainability (Jamal, 2003). Land suitability evaluation requires specialists of different disciplines like soil scientists, agro-ecologists, socio-economists and planners. The evaluation relates to the environmental and socio-economic conditions of the area, since it includes a consideration of inputs and projected outputs of production processes.

This is the process of estimating the potential of land units for alternative kinds of uses (Dent, D and Young, A. 1981). Land suitability evaluation can, also, be defined as the assessment or prediction of land quality for a specific use, in terms of its productivity, degradation hazards and management requirements (Austin and Basinski, 1978). Abiotic, biotic, and socioeconomic factors decide the success of a crop. So the assessment regarding crop values should include the abiotic, biotic and socio-economic factors that determine the profitability (Prakash, T.N, 2003). The system that evaluates land in accordance with development and generation, viewpoint in Russia claimed that (Docuchaev, 1983), according to him, land evaluation should indicate the soil types and natural quality of land. These are subjective and reliable criteria. He proposed some rules in land evaluation, stating that factors for land evaluation must be clearly and stably identified, the factors must be distinguished subjectively and scientifically, there must be research and study to improve land productivity in localities and in the whole country and finally there must be economic statistics and agricultural statistics to propose the best land use measures.
Stephen J. Carver (1991) used the integration of multi criteria evaluation techniques with GIS, as providing the means to evaluate various alternatives on the basis of multiple and conflicting criteria and objectives. This study was based on the search for suitable sites for the disposal of radioactive wastes in UK. D. De la Rose and et al., (2003) studied land evaluation for agricultural soil protection in the Mediterranean region with micro LEIS DSS, since the early 1990’s it has evolved towards an agro-ecological decision support system.

FAO and Agricultural Organization of the United Nations in (1976) published a framework for land evaluation for better soil resources development and conservation. They provided a clear cut idea of the land characteristics, land qualities and diagnostic criteria. They, also, provided land suitability classifications and ranges of classifications. Mukhtar. Elaalem and et al (2010) compared two land evaluation techniques for barley using fuzzy AHP and TOPSIS method for a test area within the Jeffara plain of Libya. The AHD technique has the ability to incorporate different types of data and to compare two parameters at the same time, by using the pair wise comparisons method, the base requirement for the AHP method. The land evaluation is a tool for strategic land use planning. It predicts land performance both in terms of the expected benefits from and constraints to productive land use, as well as, the expected environmental degradation due to these uses.

2.4 STUDIES ON LAND USE AND ITS CHANGES

Land is the most significant among the natural resources of the country. Land utilization survey provides relevant informations related to the crops and crop land use patterns. The basic aim of land use study is to record the distribution of land under various uses in different socio-economic and environmental conditions (Noor Mohammad. 1981). Owing to the increasing pressure of population on land and the ever growing demand for food and raw material, there is a direct way. According to Shanthakumari.A (1986) the understanding of the existing use of land is a prerequisite for land use planning, which occupies a pivotal place in the agricultural planning of any country.

In modern land use studies, the pioneer land use work was carried out by Thaer. A. D. (1811), who was one of the first to apply a systematic method in land use analysis. Stamp L.D has pioneered the land use studies in Britain in 1930’s. In those
days, this survey was compared with that of ‘Domesday Survey’, conducted for the purpose of taxation. The land use survey initiated by Stamp, was aimed to record the use of every parcel of land in Britain. Therefore, intensive field work was conducted with the involvement of students. The main emphasis of this survey was laid on the classification of land use into nine major land uses. With the result, a series of coloured land use maps, on one inch to one mile scale, were prepared.

Incorporating the findings of the survey, Stamp.L.D (1960) published a voluminous book, “Land of Britain. Its use and misuse”, Stamp's land use survey inspired Prof. Samuel Van Valkenburg, the Head of Graduate School of Geography at Clark University, Worcester, to present a project on ‘land use inventory for all countries in the world’. The commission formed for this purpose met at Worcester, Massachusetts, in 1950, to formulate various schemes for a ‘World Land Use Survey’. The commission first adopted a uniform system of classification and notation for land use in all parts of the world and did a number of pilot studies, under various environmental conditions, notably in Tanganyika, Nyasaland and Cyprus. Following the information of the commission, Canada, Japan, India, Pakistan, Iraq, Burma, Malaysia, Ghana, Nigeria and many other European countries had started their land use survey. The commission published papers like “Land Use of Hong Kong”, “A History of Land Use and Arid Lands” etc and also recommended survey and publication of maps on the scale of 1: 1000000.

The Second land use survey of England and Wales was undertaken under the direction of Coleman and Maggs (1961), and numerous maps and reports were also published. Similar land use studies have been made in USA, by Baker.V.R. (1973), who published his article “Land Utilization in the United States-Geographical Aspects of the Problem”, in which he portrayed the trends in land utilization and emphasized the need for land use surveys and land classifications. In China, Buck (1937) and his colleagues conducted land use study.

In India, land use surveys are carried out using the pattern of Britain, by receiving the inspiration from Stamp, who attended the session of Indian Science Congress held at Calcutta in 1938. Prof.Stamp gave an idea about the scheme to try a study in India. The Govt. of India established a National Committee for the purpose of land utilization survey under the guidance of Chatterjee (1941). He conducted land
use surveys of Parganas and Howrah districts in 1945 and 1952 and prepared eleven land use map sheets on the scale of 4 inches to 1 mile. In 1951, Shafi carried out land utilization surveys in the Eastern Uttar Pradesh, combining the land capability in relation to its quality.

B.S. Bisht and B.P. Kothyari (2001), compiled their article entitled, “land cover change analysis of Gurur Ganga watershed using GIS and remote sensing technique”. It mainly concentrated on land use land cover class during the periods 1963-1996 and 1986-1996 were analyzed through topographical sheet and visual interpretation of LANDSAT 5 TM image bands 2-3 and 4 using GIS.

Land use is characterized by the arrangements, activities and inputs people undertake in a certain land cover type, to produce, change or maintain it (Di Gregorio and Jansen, 1998; FAO, 1997). It is a series of operations on land, carried out by man, with the intention to obtain products and/or benefits through using land resources. According to Huizing et.al. (1995) land use can lead to the positive or negative impacts on land cover because land use is the human activities of natural environment (as defined by Di Gregorio and Janse, 1998 and FAO a report). The land use changes significantly due to various physical and socio economic factors. The land-use pattern of an area is directly related with the level of techno-economic advancement and the nature and degree of civilization of its inhabitants (Whyte, 1961). Urbanization is the process of the twentieth century. Its impact on agricultural land use changes is a major problem faced by man today. Hart.J.F (1976) drew attention to the wide variations in estimates for the transfer of agricultural land to urban uses. Von Thunen (1826), an economist, was the pioneer who initiated studies in the field, with his remarkable work on the pattern of agricultural land use. He had introduced a theory on location of agricultural land utilization. However, the first land use survey was conducted by a geographer, Dudley Stamp in Britain, in the year, 1930. In the year, 1936 the land use survey was conducted in Tennessee Valley Authority in the U.S.A. These two studies may be considered as the pioneer work on land use studies.

Indian geographers played a major role in analysing the land use pattern in many parts of the country. Chatterjee.S.P (1941), emphasized the role of geographers in carrying out land use studies in India. Shafi.M attempted an
intensive land use study of Uttar Pradesh in the year, 1951. Saravanan, E. (1979) has analysed the cropping pattern and crop combination in the Madurai district.

Stamp.L.D (1948) has classified the needs of man into seven major categories, namely the need for work, home, food transportation, Communication, defence and recreation. Changes in the socio economic conditions, technical knowledge and institutional aspects may have an impact on land use. Specific land utilization types may lose their relevance with time, while new types become important. The concept of land use therefore, revolves around man's accomplishments in conversions of land from one use to another. Nanavathi (1957), states that the use of land changes according to the changing needs of man. Land use studies are cyclic and dynamic in the application of human and artificial resources. The resulting changes in land use patterns have implications for human wants and needs, from time to time. Love Joy (1979) viewed that “cultivation patterns reflect the evolution of man’s technology, which is changing rapidly”. The complex intricate pattern of land use or non use is the result of the action and interaction of many factors. Some are physical, such as elevation, slope, drainage, soil, rainfall and temperature, while others are historical such as ownership and tenure. Some others are purely more economic, such as working costs and agricultural prices (StampL.D. 1960). An analysis of land use systems in different regions highlights the imbalance in agricultural production in the existing systems and extent of low productivity as well as inefficiency in agriculture. In view of performance in agricultural sector in our own economy, it is necessary to understand the existing land use pattern through land use planning.

Shafi (1956) presented a paper with all aspects of this land use survey. Prof.Stamp himself appreciated Shafi’s work, and many geographers were inspired by this work. Shafi also contributed many papers on land use studies such as “Pattern of Crop Land use in the Ganga-Yamuna Doab”, “Measurement of Food Production Efficiency in India” etc. He was the first person to state that “the carrying capacity of land is considerable that it can feed five times that of India’s population, if it is coaxed well”. In1956, Prakash Rao had evolved a scheme of land use classification and its mapping. Prakash Rao (1959) pointed out the influence of morphological feature on land use and suggested a micro regional approach to land use planning. Arunachalam (1959) conducted a micro level study on rural land use of Vanamadevi village of Tamil Nadu. There are some notable contributions from the agricultural
geographers in the study, on agricultural regions of India. Spate (1957) has taken geographical factors like topography, climate and density of population, as the basis of identification of the agricultural regions of India.

Shanthakumari.A (1986) studied changing patterns of crop land use and modernization of agriculture among rural farmers in the Madurai district, Tamil Nadu. Dhian Kaur (1991) in a study of “Changing Patterns of Agricultural Land use of Bist Doab, Punjab” analyzed the spatial variations in agricultural land use changes. In 1958, the Planning Commission of the Govt. of India constituted a study group under the chairmanship of D.R.Gadgil to measure the benefits of selected irrigation schemes like Sarola canal (U.P), Tribeni Canal (Bihar), Damodar canal (West Bengal), Cauvery Mattur Project (Tamil Nadu), Nijamsagar Project (Andhra Pradesh) and Ganga Canal (Rajasthan). These studies concluded that irrigation leads to the intensive use of land, increase in cropping intensity and increase in gross production (Gadgil).

Tamilarasi Bose (1998) studied the land use changes in Madurai district and assessed its impact on the changes in cropping patterns and occupational structures. A micro level study at village level was attempted by Gunasekharan.P (2000) to identify the impact of occupational changes in land use and cropping patterns in Vadipatty Panchayath union, Madurai district of Tamil Nadu state. He has selected 1971, 1981 and 1991, the three census time points to bring to light the changes in occupational type cropped areas of selected crops. He has used ANOVA, one way classification to measure the significance of such change. He has concluded that the migration of cultivators to nearby urban areas has resulted in a transfer of cultivated land to urban use. This has lead to jobless agricultural labourers. Also, the area under coconut has increased significantly with a simultaneous decrease in area under paddy cultivation. In the Kerala State Land use Board, Thiruvananthapuram conducted project studies of selected districts of Kerala with the aim at conservation, development and management of land resources for sustainable development, using satellite data. The Board studied Attapady Block of Palakkad district (1994), Payaswani Watershed of Kasaragod district (1995) and Thirukkulum Water shed of Malappuram district (1996).Apart from these, the Board has attempted to identify Zones of Land Degradation in Kerala (1996), Coastal Ecosystem of Kerala state (1996), Waste Lands in Kerala (1989), Agro -ecological Zonation in Kerala(2001) etc.
In light of the above discussion, it could be concluded that studies on spatial analysis of various agricultural activities have gained significance. In the present day world, on the one hand, agricultural lands are a prey to rapid urbanization and industrialization. On the other hand the increasing population has created an increase in the demand for food production. The solution towards food security to the teeming millions, lies in understanding the existing utilization of land and the problems within the same. A spatio-temporal analysis of land utilization is very much essential to formulate plans for conserving the lands for the future generation.

Bhagawat Rimal (2011) studied an application of remote sensing and GIS, land use/land cover change in Kathmandu metropolitan city, Nepal. Five classes have been identified i.e., urban or built up area, water body, forest area, open field and cultivated land. GIS and Remote sensing software were used for analyzing the study area. The Markov chain model has been applied to predict future changes. Markov chain models are particularly useful to geographers concerned with problems of movement, both in terms of movement from one location to another and in terms of movement from one “state” to another. “State”, in this context refers to the size class of a town, income classes, type of agricultural productivity, land use, or to some other variables (Lyndhurst Collins 1995). Four different years data were used to identify the land use land cover changes i.e., 1976, 1989, 2011 and 2009. The final result of this study predicts the land use changes in the year of 2017. Yacouba Diallo et al., (2009) studied “applications of remote sensing in land use/land cover change detection in puer and simao counties, Yunnan Province”, using two different years of land set imageries, for identifying the changes in the study region i.e., 1990 and 1999. ENVI 4.3 and Arc GIS software’s were used for image classification and for analysis purposes. Highlights of this study gave an importance of digital change detection in apprehending the environmental situation in the southern part of Yunnan Province.

Selcuk Reis (2008) presented a study, called “analyzing land use/land cover changes using remote sensing and GIS in Rize, North-East Turkey. The study area is located in Northeastern Black sea region in Turkey, inclusive of the whole coastal part of Rize and the area that reaches by 30 km of distance to the inner part, starting from the coast. In this study, LULC changes are investigated by the use of Remote Sensing and Geographic Information Systems. The main change observed for the time period of 1976-2000 was that the area of agriculture had increased and the forest area had

Muthusamy.S et al., (2010) have studied “land use and land cover changes detection using multitemporal satellite data, in these areas: Cuddalore coastal zone, Sea-coast of India”, topographical maps, in 1977, 1991 and 2006. Landsat satellite data were used for identifying the land cover classes and the changes were detected. As a result of this, it was identified that rapid growth occurred in built up land between 1977 (4.73%) to 2006 (8.87%) with a population explosion .Construction of buildings and factories occurred. During the last two decades, numerous studies have been published concerning accuracy assessment of land cover classification (Rosenfield and Fitzpatrick Lins, 1986, Foody 1992 and Congalton 996). Temporal changes in land cover have become possible in less time at lower costs and with better accuracy, through remote sensing technology (Kachhwaha 1985).

Prabhbir Singh and Kamlesh Khanduri (2011) worded on “land use and land cover change detection through remote sensing & GIS technology: case study of Pathankot and Dhar Kalan Tehsils, Punbaj”, stating that the main objectives were to detect land use changes between 1991 to 2006. Vemu Sreenivasalu and Pinnamaneni Udaya Bhaskar (2010) has studied “change detection in land use and land cover using remote sensing and GIS techniques”. Four different years of satellite imageries were used for analysis purpose i.e., 1958, 1979, 1990 and 1998. This article concentrated on four classes, only i.e., agriculture with habitation, mixed forest mainly pine, open scrub and scattered tress and water body. Tripath and Manish Kumar (2012) have studied land use land cover dynamics in takula block, Almora district (Uttarkhand. Land sat TM satellite (1990) and land sat ETM + (2005) images were used for analysis proposes. The result of this study is, that water bodies, crop land and built up areas increased, forest area and fallow land decreased. Mohit Kumar and Rajan.K.S (2014) had studied “modelling land use changes in Gidavari river basin: A
comparison to two districts in Andhra Pradesh”. This work explored the use of agent based models. Agents are land owners, farmers, migrants or policy makers. This study was based on two different periods i.e., 1985 and 2005. This model gives a 92 percent accuracy in all the classes and 97 percent accuracy in major classes, such as agriculture, forest and urban areas.

2.5 STUDIES ON MORPHOMETRY OF RIVERS

The year 1945, is essentially a major historical landmark in the growth and development of geomorphologic thought. Horton (1932, 1945) provided a new paradigm in geomorphology. A quantitative study of relative relief of sample drainage basins of Ranchi Plateau had been done by Savindra Singh in 1979. It is concluded that the whole of the Ranchi Plateau is believed to have been preplaced before the Tertiary uplift resulting into a vast flat surface dotted with minor reliefs as the relics of previous cycles. A geomorphologic study of drainage density of small drainage basins of the Ranchi Plateau has been attempted by Savindra Singh in 1979. It is summarised that geological structure, rainfall intensity and slope appear to be dominant controlling factors of drainage density in the different physiographic regions of the Ranchi plateau.

Hasan Ozdemir (2012), who worked on Geomorphometric Analysis of Albania river basins, focused on land surface parameters and explained the digital elevation models. In general, there are three sources of DEM data: Ground survey techniques, existing topographic maps and remote sensing (Webster et al, 2006; Nelson et al., 2009). DEMs can be derived from four types of sources in remote sensing: stereo photos and images (e.g. Wolf and Dewitt, 2000; Lane et al. 2000; Smith, 2005), LiDAR (e.g. X. Li et al., 2001; Norheim et al., 2002; Smith, 2005; Webster et al., 2006; Xiaoye, 2008; Rayburg et al. 2009) and RADAR (e.g. Hensley et al., 2001; Northeim et al., 2002; Rabus et al., 2003; Rodriguez et al. 2005). The final result of this study is that it gives an opportunity to understand the geomorphic evolution and flood risk of the basins.

Sukumar.B and Ahalya Sukmar (2013) studied morphometric and terrain analysis of the Payaswani river basin of Kerala and Karnataka states using GIS. The study area has covered 1342 km². Within this area, 42.02 percent is in the Kasargod
district of Kerala state and 57.08 percent is in the Karnataka state. Topographical maps and SRTM data and Arc GIS and Spatial Analyst Module were used for the analysis. Most of the study area was affected by erosional landforms. The bifurcation ratio indicates that there was neotectonic activity in the lower region of the basin and in general, the landscape indicates structural control over the landform development.

Vimla Singh (2012) has studied the linear aspects of Naina-Gorma river basin, Morphometry, Rewa district, Madhya Pradesh. The Naina sub-basin covers an area of 386.30 sq.Km, Odda sub basin covers an area 605.98 sq.Km. and Gorma sub basin covers an area 427.43 sq.Km. The total length of all the tributaries is 2317.961 km. Topographical maps are used for boundary demarcating. The result of this study is the area has undulating topography and most of the area is of quite permeable nature. The morphometric analysis of the drainage network is dendritic to sub dendritic patterns with sixth order streams in all sub basins, except Naina sub basin. The dendritic pattern indicates the homogeneity in texture and lack of structural control while the sub dendritic pattern indicates gentle, uniform slopes, with less resistant bed rock.

Vineesha Singh and U.C.Singh (2011) studied basin morphometry of Maingra River, Gwalior district, and Madhya Pradesh. They concentrated on linear and aerial aspects of the study region. The pattern of the study region is to dendritic to a parallel drainage pattern. The drainage texture of the study indicates it's in the very coarse drainage texture class, circularity ratio and from its factors, indicates that the study region is elongated in shape and flows for longer duration. Reddy (1983) analysed the terrain characteristics of the Swarnamukhi basin of semi-arid Southern Rayalaseema of Andhra Pradesh. It is revealed that most of the area has a very low relative relief, i.e., 75% of the area of the basin has relative relief of below 76.2m (250 feet). Quantitative geomorphology of Kabani and Meenachil river basins of Kerala State has been analysed by James.E.J (1987). The study revealed that good linear relationships were obtained between stream number and order for all the sub-basins of the Kabani and the Meenachil.

Ganesh.A. (1988) made an attempt to study the morphometric characteristics of Upper Vaigai basin, South India. The morphometric analysis of the Bhogdoi River basin of Assam has been made by Munidra Konwar (2007). From the study, it has been concluded that the morphometric variables of seventh order drainage basin
of the area are influenced by lithology and structure. The longitudinal profile of the basin suggests headwater area hails under steep slope-prone to landslide due to slight tremors. Thakur (2008) attempted to describe the morphometric characteristics of Ghaggar basin. It is revealed that Gaggar basin has an elongated shape which indicates that the shape of the basin does not support stronger and higher velocity floods and more discharge of runoff during the off monsoon season. Pawar et al., (2011) attempted to look into the morphometric analysis of Panchanganga River, emphasising the linear aspects of the basin.

The scientific approach to the hierarchical classification of streams and basin area was initiated by (Horton R.E., 1945) who defined several drainage basin characteristics that were measurable on topographic maps. The significance of these landscape parameters was earlier pointed out by Morisawa (1959), who observed that stream flow can be expressed as a general function of geomorphology of a watershed. However, Morphometric characteristics of drainage basin exhibit spatio temporal variation, hence the need for detail investigation of basin characteristics, not only from one area to another, but also from time to time. (Carson and Krikby, 1971). There are relationships between drainage basin morphometric parameters and flood potential. For instance, it has been discovered that the higher the drainage density, the faster the runoff and the more significant the degree of channel abrasion is likely to be for a given quantity of rainfall. Also, drainage density provides a link between the form attributes (morphometry) of the basin and its erosional process (Bates.N 1981).

Pisal.P.A et al (2012) has studied the morphometric analysis of Bhoyavathi river basin, kolhapura district in Maharashtra state. Dendritic drainage pattern in the area shows that the area consists of homogeneous rock material, which is structurally undisturbed. The Bhoyoavathi river basin is passing through an early mature stage to that the study region is highly elongated and flood flows are easier to manage than that of circulatory basins. Some of the authors like Pawar.D.H and Raskar.A.K, (2011) have carried out morphometric analysis of the Panchaganga river basin of the Kolhapur district. Yadav.A.S and Sawant.P.T, (2011) have studied morphometrical parameter estimation of Sheri Nala basin, Sangli district. Jangle.P and Patil.Y.V (2010) both have done morphometrical parameter estimations of the Nalganga river. Buldhana, Maharashtra. Nageswara.R.K and et.al., (2010), have carried out morphometric analysis of the Gostani river basin in Andhra Pradesh.
Aravinda.P.T and Balakrishna.H.B (2012) have studied the morphometric analysis of vrishabhavathi watershed. The total area of the study region is 381.46 km². Topographical maps were used for demarcating the boundary lines of the study region. Morphometric is the measurement and mathematical analysis of the configuration of the earth’s surface, shape, dimension of its landforms (Clarke.J.J 1966). This study is focused on three kinds of parameters i.e., linear, aerial and relief aspects. The result of Rb indicates that the watershed has suffered less structural disturbances, and it may be regarded as an elongated one. Senthilvelan.A et al (2012) has studied the linear and areal morphometric aspects of Porandalar watershed, Amaravathi sub basin, Tamil Nadu. The result of this study is that, the Porandalar river flows through mountainous and dissected regions. It is also concluded that the watershed has a well developed drainage network and quantitative analysis in terms of form factors, elongation ratios, circularity ratios and lemniscates ratios. Together, this reveals that the study region has an elongated shape.

A drainage basin is the part of the earth’s surface that is drained by main stream and its tributaries. The drainage basin is a fundamental geomorphic unit of land and all flow of surface is governed by its properties. It is an open system into which and from which energy flows. A drainage basin is a fundamental, precise and usually ambiguous unit that is recognized as a reliable and useful planning unit. It has now formed a framework for human activities like agriculture and has guided river navigation towards sustainable agriculture (Ofomata et al., 2000). The assertion still stands valid following Jain and Sinha (2003), Okoko and Olujimi (2003) and Ifabiyi (2004) who reported that the geomorphic characteristics of drainage basins play a key-role in controlling the basin's hydrology. Another reason for the high positive correlation between basin area and discharge is the fact that basin area is also highly correlated with some of the other catchment morphometric characteristics which influence runoff, such as, basin length and stream length (Gregory and Walling, 1973; Ebisemiju, 1976; Jain and Sinha, 2003; Ifabiyi, 2004).

Horton (1945) felt that the main stem stream should be of the highest order. He defined a first - order stream as one receiving no tributaries. That is, it’s a headwater stream with no tributaries. A second - order is formed by the junction of two – first – order streams and can receive other first – order tributaries. A third –
order stream is formed by the junction of two streams of like order forming a stream of next higher order, which can receive tributaries of any order lower than its own.

Strahler (1952) modified Horton’s system by allowing his provisional scheme to determine the final ordering, such that; fingertip channels are designated order 1; where two first order channels join, a channel segment of order 2 is formed; where two channel segments of order 2 joint, a segment of order 3 is formed; and so on. Horton’s system further demands that, after all streams have been classified, an investigator starts at the mouth of the basin study and reclassifies part of the streams (Broscoe, 1959 and Haggett and Chorley, 1969).

In the early days, most basins were described as well-drained or poorly drained or they were connoted descriptively in the Davisian scheme as being youthful, mature or old (Gregory and Walling, 1973). Traditional, manual methods of delineating drainage networks require questions related to the scale of the work, sources of information, and the techniques available to be taken into consideration before selecting the most appropriate method. Difficulties can appear when delineating first-order channels, as some criteria must be established to discriminate between gullies and real channels (Gardiner, 1975). According to Horton, Stream order is a dimensionless term because of the extent of order number of streams is directly proportional to the size of watershed, channel dimension and to stream discharge basin plays first step in analysis of drainage basin. This pattern is characterized by a tree like or fernlike pattern with branches that intersect primarily at acute angles. The properties of the stream networks are very important to study the landform making process (Strahler.A.N et al., 2002).

The order wise total number of stream segment is known as the stream number. (Horton R.E., 1945) laws of stream numbers states that the number of stream segments of each order form an inverse geometric sequence with plotted against order. Most drainage networks show a linear relationship with small deviation from a straight line. This means that the number of streams usually decreases in geometric progression as the stream order increases. The designation of stream order is the first step in the drainage basin analysis. It is defined as a measure of the position of a stream in the hierarchy of tributaries (Leopord, Wolman and Miller, 1960). The properties of the stream networks are very important to study the landform making
process (Strahler.A.N and Strahler.H.N 2002). Stream length is the ratio between the mean lengths of streams of any two consecutive orders. Horton’s law (1945) of stream length states that the mean length of stream segments of each of the successive orders of a basin tends to approximate a direct geometric series, with stream lengths increasing towards higher stream order. Changes of stream length ratio from one order to another indicating their late youth stage of geomorphic development (Singh.S. and Singh.M.C.1997). It is the total length of streams in a particular order. The numbers of streams of various orders in a sub watershed were counted and their lengths measured. Generally, the total length of stream segments decrease with stream order. Deviation from its general behaviour indicates that the terrain is characterized by high relief and moderately steep slopes, underlain by varying lithology and probable uplift across the basin (Singh and Singh 1997).

Slope is a basic element for analyzing and visualizing landform characteristics. It is important in studies of watershed units, landscape units, and morphometric measures (Moore et al., 1992). Slope, an important element of landform, plays an important role where mechanization is concerned. Sys et al., (1991) believe that on slopes steeper than 20% mechanization becomes impossible and for slopes less than 29% there are still important variations in productivity according to variation in slope.

The bifurcation ratio method has been defined by Horton (1945) and Strahler (1952) as the ratio of the number of stream of one order to the number of next higher order. The bifurcation ratio can also show which parts of a drainage basin is more likely to flood. Strahler (1957) demonstrated that bifurcation ratio shows a small range of variation for different regions or for different environment dominates. Bifurcation ratios are related to the structural control on the drainage (Nautiyal, 1994; Strahler, 1964; Chow.V.T. 1964). Bifurcation ratios characteristically range between 3.0 and 5.0 for basins in which the geologic structures do not distort the drainage pattern (Strahler, 1964). In homogeneous bedrock, bifurcation ratio influences the landscape morphology and plays an important control over the “peakedness” of the runoff hydrograph (Chorley 1969). The Bifurcation ratio is an indicative tool for the shape of basin. Elongated basins have low Rb value while circular basins have high Rb value (Morisawa 1985).
The higher than 10.0 where structural controls play dominant roles on the other (Chow et al., 1988) the shape of watersheds also exerts a significant control on Rb (Verstappen 1983), whereas the lower values indicate that the watersheds are less affected by structural disturbances (Stahler, 1964; Nag, 1998; Vittala et al., 2004). A lower Rb range suggests that structure does not exercise a dominant influence on the drainage pattern. Higher Rb indicates some sort of geological control (Agarwal, 1998). If the Rb is low, the basin produces a sharp peak in discharge and if it is high, the basin yields low, but extended peak flow (Agarwal, 1998). In well developed drainage network the bifurcation ratio is generally between 2 to 5 (Horton, 1945; Strahler, 1964). According to Kale and Gupta (2001), bifurcation ratios ranging from 3 to 5 indicate natural drainage system characteristics within a homogeneous rock. Bifurcation ratio a measure of the degree of ramification of drainage network (Mesa.L.M 2006).

Horton (1932), introduced the drainage density (D) as an important indicator of the linear scale of landform elements in stream eroded topography. It is the ratio of total channel segment lengths cumulated for all orders within a basin to the basin area, which is expressed in terms of mi/sq. mi or km/sq. km. The drainage density indicates the closeness of spacing of channels, thus providing a quantitative measure of the average length of stream channel for the whole basin. It has been observed from drainage density measurements made over a wide range of geologic and climatic types that a low drainage density is more likely to occur in regions of highly resistant of highly permeable subsoil material under dense vegetative cover, and where relief is low. High drainage density is the result of weak or impermeable subsurface material, sparse vegetation and mountainous relief. Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture (Strahler, A.N. 1964).

According to (Strahler A.N 1964) values of drainage density fewer than 12 are low density; those with values of between 12 and 16 are medium density basins, while basins with values above 16 are high density basins from this classification. Langbein (1947) recognized the significance of D as a factor determining the time of travel by water within the basin and suggested that it varies between 0.55 and 2.09 km/km2 in humid region. The measurement of Dd is a useful numerical measure of landscape dissection and runoff potential (Chorley, 1969). On the one hand, the Dd is a result of
interacting factors controlling the surface runoff; on the other hand, it is itself influencing the output of water and sediment from the drainage basin (Ozdemir and Bird, 2009). The calculation of drainage density is fundamental and reflects geology, hydrology climatic condition, topography and vegetation, (Reddy.G et al 2004, Ritter DF 1986). The measurement of drainage density again, provides hydrologists and geomorphologists with a useful numerical measure of landscape dissection and runoff potential (Pidwirny, 2006).

Stream frequency is the number of stream segments per unit area (Horton, 1932, 1945). Stream frequency of the basin may be defined as the ratio of the total numbers of segments cumulated for all orders with a basin, to the basin area (Horton, 1945, Wisler and Brater, 1959; Chorley et al 1985). The Fs decreases as we move to higher altitudes from south to north of the catchment. The drainage texture is defined as the relative spacing of drainage lines. The drainage density and drainage frequency have been collectively defined as drainage texture (Smith, 1950).

Schumn S.A 1956 defined elongation ratio (Re) as the ratio of diameter of a circle of the same area as the basin to the maximum basin length. It is a very significant index in the analysis of basin shape which helps to give an idea about the hydrological character of a drainage basin. Values of elongation ratio ranging between 0 and 0.6 indicate rotundity and low degree of integration within a basin and values between 0.6 and 1.0 assumes pear shaped characteristics of a well integrated drainage basin (Strahler A.H 1964).

Miller (1953) defined a dimensionless circularity ratio (Rc) as the ratio of basin area to the area of circle having the same perimeter as the basin. It is influenced more by the length, frequency and gradient of streams of various orders rather than slope conditions and drainage pattern of the basins. He described the basin of the circularity ratios range 0.4 to 0.5 which indicates strongly elongated and highly permeable homogenous geologic materials. Like form factor, it is also a dimensionless ratio to express outline of drainage basin (Strahler A.H 1964) and Re is uniform between 0.6 and 0.7 for homogenous rock types and 0.40 and 0.5 for quartz terrain and is influenced by length and Df of streams, geological structures, vegetation, climate, relief and slope of the basin. Basin circularity is an index which attempts to express the degree of circularity of a drainage basin. (Raghunath.H.M
A form factor nearer to zero indicates a highly elongated shape and the value that is closer to 1 indicates circular shape. The basins with high form factor value have high peak flow for short duration whereas elongated basin with low form factor will have a flatter peak flow of longer duration. Flood flows in elongated basins are easier to manage than that of the circular basins (Nautiyal.M.D 1994). Quantitative expression of drainage basin outline form was made by Horton (1932) through a form factor ratio (Rf), which is the dimensionless ratio of basin area to the square of basin length. Basin shape may be indexed by simple dimensionless ratios of the basic measurements of area, perimeter and length (Singh, 1998).

M. Imran Malik, et al., (2011) researched about watershed based drainage morphometric analysis of lidder catchment in the Kashmir valley using geographical information system. The quantitative analysis of drainage system is an important aspect of characterization of watersheds. Using watershed as a basic unit in morphometric analysis is the most logical choice because all hydrologic and geomorphic processes occur within the watershed. Lidder catchment which constitutes a segment of the western Himalayas with an area of 1159.38 km$^2$ (10% of the river Jhelum catchment) has been selected as the study area. Various linear and areal aspects of the catchment were computed at watershed level. This was achieved using GIS to provide digital data that can be manipulated for different calculations. The analysis has revealed that the total number as well as total length of stream segments is maximum in first order streams and decreases as the stream order increases. Horton’s laws of stream numbers and stream lengths also hold good. The bifurcation ratio between different successive orders is almost constant. The drainage density values of the different watersheds exhibit high degree of positive correlation (0.97) with the stream frequency suggesting that there is an increase in stream population with respect to increasing drainage density and vice versa.

Virendra Kumar & Ashwani Kumar Srivastav did studies on Geographical Information Systems based Morphometric Analysis of Ghat Gad and Gheria Gad Microwatersheds of Ladhiya-Lahaghat Watershed of Sarju River in Champawat, District, Uttaranchal 2010. The study area covers 74.57 sq. kms having 34.67 and 39.9 sq.kms respectively for Ghat Gad and Gheria Gad drainage basins, and comprising 10 micro watersheds. The drainage network of 10 micro watersheds was delineated using SOI topographical maps on 1:50,000 scale and compared with IRS-
IC LISS III, 23.5 meter resolution, geocoded imagery of the same scale. The resistance of topographical surface is determined by its altitude, slope, resistance to erosion of soil and land use/land cover. Interrelationship between these factors and their distribution has played a major role in the development of the present state of drainage basin topography. The morphometric analysis of 10 micro watersheds has been carried out using GIS software. The drainage network shows that the terrain exhibits dendritic to sub dendritic drainage patterns. Stream order ranges from fourth to fifth order. Drainage density varies between 3.28 to 3.58 km/km. Texture ratios of the drainage basins are 4.91 & 6.38 and categorised as moderate to fine textured in nature. The drainage frequency of Ghat Gad and Gheria Gad is 4.93 and 5.48. In this area both drainage basins show high DF which indicate high relief and low infiltration capacity of the bed rock. The relief ratio ranges from 0.132 to 0.136. The bifurcation ratio ranges from 2.6 to 5.15 and 2.0 to 5.61 for Ghat Gad and Gheria Gad drainage basins, respectively, and the watersheds do not fall under normal basin category. The elongation ratio is 0.57 to 0.59, showing that both drainage basins have moderately elongated patterns. Hence, from the study, it can be concluded that remote sensing data, coupled with GIS techniques, prove to be a competent tool in morphometric analysis.

Nageswara Rao. K et al., studied Morphometric Analysis of Gostani River Basin in Andhra Pradesh State, India Using Spatial Information Technology 2010. Spatial information technology (SIT) i.e., remote sensing (RS), geographical information system (GIS) and global positioning system (GPS) has proved to be an efficient tool in delineation of drainage pattern and water resources management and its planning. GIS and image processing techniques have been adopted for the identification of morphological features and analyzing their properties of the Lower Gostani River Basin (LGRB) area in Andhra Pradesh state, India. The basin morphometric parameters such as linear and aerial aspects of the river basin were determined and computed. The area is occupied by 96% khondalite group (quartz, feldspar, garnet, sillimanite gneiss) of rocks. It is 7th order drainage basin and drainage pattern mainly in sub dendritic to dendritic type. It is observed that the drainage density value is low which indicates the basin is highly permeable subsoil and with thick vegetative cover. The circularity ratio value reveals that the basin is strongly elongated and highly permeable homogenous geologic materials. This study
would help the local people to utilize the resources for sustainable development of the basin area.

Geena.G.B., and Ballukraya.P.N article entitled Morphometric analysis of Korattalaiyar River basin, Tamil Nadu, India: A GIS approach 2011 Watershed development and management plans are very important for harnessing surface water and groundwater resources. To prepare a comprehensive watershed development plan, it becomes necessary to understand the topography, erosional status and drainage pattern of the area. This study was undertaken to determine the drainage characteristics of Korattalaiyar river basin and the area of the basin, which is $3,625\text{km}^2$. The morphometric parameters are computed by using the Geographic Information system (GIS). GIS was used in the evaluation of linear and areal aspects of morphometric parameters. The drainage patterns of the basin are dendritic and include a seventh order stream. The quantitative analysis of various aspects of river basin drainage network characteristics reveals complex morphometric attributes. The streams of lower order mostly dominate the basin. The development of stream segments in the basin area is more or less affected by rainfall. The erosional processes of fluvial origin have been predominately influenced by the subsurface lithology of the basin.

Abha Mishra, et al., did studies of the Morphometric Analysis of Tons basin, Rewa District, Madhya Pradesh, based on the watershed approach, 2011. In the present paper, an attempt has been made to study the morphometric characteristics of sub watersheds in part of Tons basin, which itself, is part of the mega Ganga basin in Satna district, Madhya Pradesh. For the purpose of drainage basin analysis, the study area is divided into six sub watershed units. A drainage map of the study area has been prepared with the help of Ilwis 3.4 software. The stream numbers, orders, lengths and other morphometric parameters like bifurcation ratio, drainage density, stream frequency, shape parameters etc. were measured. The low values of bifurcation ratio (mean value of 3.6) and drainage density (mean value of 0.71) suggest that the area has not been much affected by structural disturbances. The sinuosity index value ranges between 1.25 to 1.8, with a mean of 1.5, indicating that the streams are deflected from their straight path and follow somewhat transitional courses. The calculation of shape parameters show that the basin is elongated. Watershed wise groundwater level dynamics for the years 2006, 2007, 2008 and 2009 has also been
summarized. On this basis, the greater depths of water level values can be related with low values of stream frequency and infiltration number. The drainage basin study suggests that most of the rocks in the area are of quite permeable nature and there are good chances of infiltration.