Chapter 1

Introduction

1.1 The Land Use Land Cover Concept

Land is considered as a base of resource rather than a resource itself (Mather, 1986). Basic human needs for food, clothing, shelter and energy are fulfilled from the land. Human beings always bring changes in the nature of the land (Brar, 2014).

Human needs both basic and advanced are fulfilled by the natural resources explicitly from land as resource. Land use and land cover of an area is characterized by bio-physical and economic attributes better to say the man-environmental relations.

Land cover describes ‗the vegetational and artificial coverings of the land surface' (Burley, 1961) and thus forms an attribute to the land or terrain. Land use includes ‗man's activities on land which are directly related to the land' (Clawson & Stewart, 1965). In other words man's economic activities for the benefit of human beings are land use and on the other hand, natural vegetation and manmade construction covering land surface is land cover (Burgess & Pairman, 1997). According to Meyer and Turner (2002) land use ―describes the physical state of the land surface: as in cropland, mountains or forest." Land cover is amalgamation of biotic and abiotic components on the earth's surface (Prakasam, 2012; NRSA, 1995). Land cover includes some features on land like vegetation, water bodies, soil, rock characters, artificial or natural cover and other observable structure on the land (NRSA, 1995). Land cover reflects the availability of different resources of particular area like food, timber, fibre, and shelter for biotic organism etc. Land use describes chain of operations on land, carried out by human beings, to obtain products and/or benefits through land resources (Lillesand et al. 2008). Land use refers to agricultural land, built up areas, recreational area, wildlife management (Prakasam, 2012). Human being is the most active agent to remake up of the land quite more than any other creature. The actual use of land by human being of any piece of land is land use (Mandal, 1982). Human beings have been using the land according to their technological skill and adaptation of new methods generation wise to extract maximum benefit through land resources. In terms of agriculture land use study we receive valuable and relevant information regarding cropping pattern and suitable crops for particular

piece of land. Land use land cover (LULC) study provides proper information regarding present scenario and enables human beings to utilise land to a more precise and scientific way and to its highest efficiency.

1.2 Conceptual Framework of Terrain Analysis

Terrain is the expression of the assemblage of geological character, surface structure of the earth‘s crust, and the soil. Terrain represents one of the triad of factors of production: land, labour, and capital. It differs from the others being relatively fixed in location and extent and more amenable to geographical forms of analysis (Mitchell, 1973, 1991). Analysis of terrain integrates different land resource factors like surface materials, soil, water and vegetation commonly on comprehensive basis. In other words analysis of terrain deals with extraction of different geomorphological properties to identify similar geomorphic units (Patel, 2012). Terrain evaluation uses the qualities or characteristics extracted by terrain investigation, along with other properties, to assign a value to a piece of land, expressed either by numerical value or by a interface of its worth in qualitative terms (Mitchell, 1973). Later many other valuable works have done for analysis of terrain and their evaluation mainly concerning economic factors (Vink, 1975). Nix (1968) defined land evaluation as ―land evaluation simply means assigning a value to a specified unit area of land. In practice the final expressions of this value will be in economic terms" (Nix 1968, p. 77). From this we can understand there is always an economic factor which is responsible behind the evaluation of terrain. Requirement for the analysis of terrain for different purposes like recreational use of land, social or political use, agriculture, construction, academic study of earth science, military activities, civil engineering, wildlife planning, meteorology, archaeology and conservation of nature.

1.3 Study Area

The geographical location of this basin is confined within the latitudes of 23˚01′ 52″ N and 23˚ 11′ 36″ N and longitudes of 86˚01′ 22″ E and 86˚12′ 42″ E. The Sanka River is an important left bank tributary of the Subernarekha River (Fig.1.01). The study area is deficient of huge water availability i.e. scarcity of water for drinking, domestic and agricultural purposes. The study area is located within a drought prone area and receives rainfall storms but for a short duration which led to flash floods (*Harka ban*) during the monsoon. Channels are basically non-perennial as a result they are normally dried up in summer and winter and shows very low channel regime. During the summer especially in

the months of March, April and May the basin area suffers from water paucity. Water levels go down in a way that ponds or tanks, dug wells and tube well, render mostly waterless or non-functioning. Most of the forest land areas of the basin are of *Matha* Protected Forest. Preservation of runoff water is hard to so be executed over the surfaces with maximum slope differences (mean relief is 231 m).

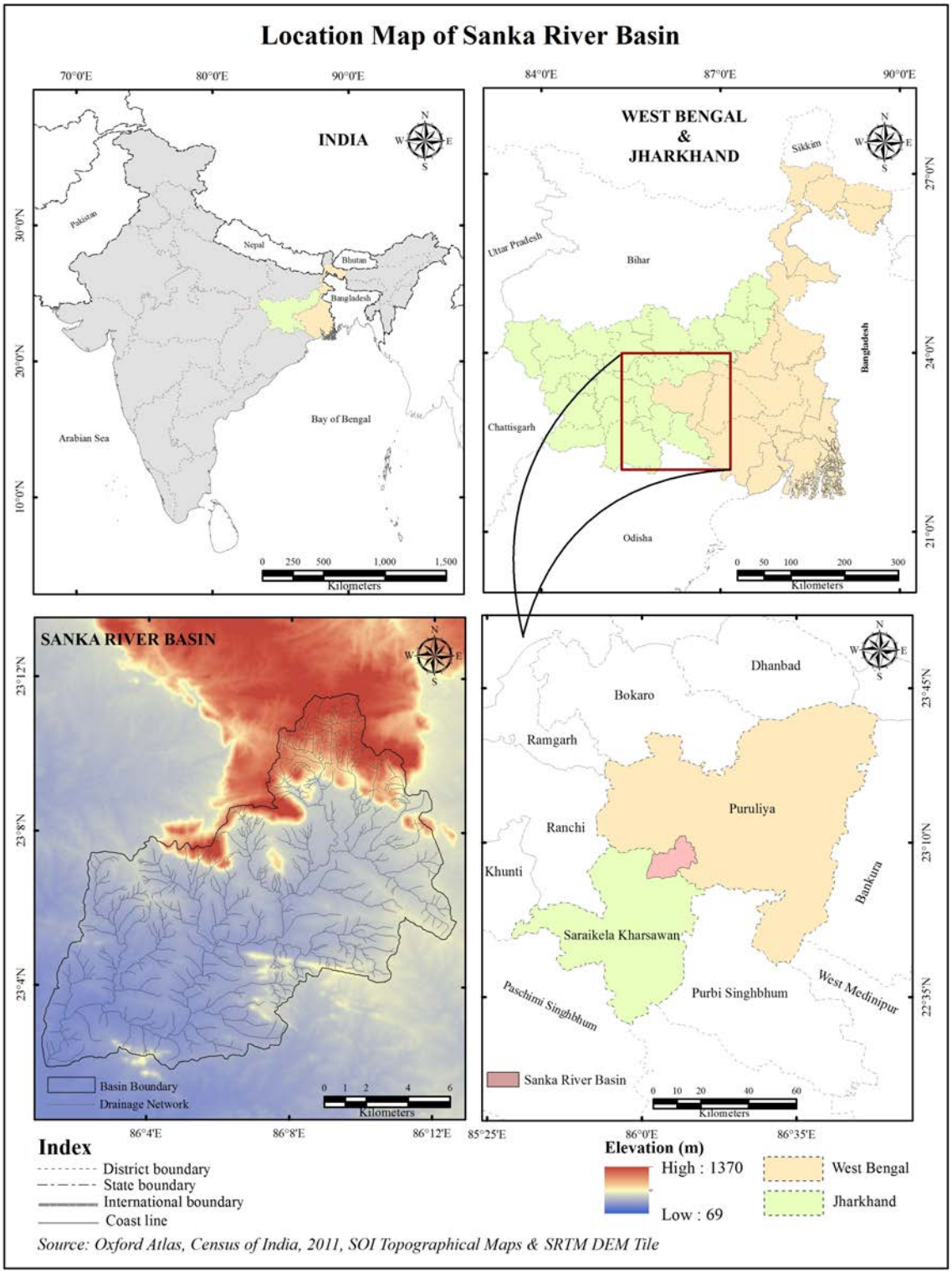

Fig.1.01

Average annual rainfall ranges between 1200 - 1400 mm. Agriculture is the main base of economy dominantly monoculture and sometimes dual-culture on the basis of location of the agricultural farm in respect to the source of water. Irrigation facility is very limited. Indigenous rain water harvesting is observed in agricultural fields to supply the water in dry season. *Chandil* dam was constructed at the confluence of River Sanka with Subarnarekha River but with limited water supply facilities for agriculture.

The Sanka River originates from the *Matha* Protected Forest, where *Gorgaburu* peak (677 m) is located and has been flowing from the south of *Edelbera* and *Puniyashasan* villages of Purulia district to flow southward through a rugged terrain receiving many tributaries on both the banks. In Jharkhand it flows further south and again towards east. It meets with the Subarnarekha River at *Dhatkidiah* near Chandil Dam at a junction of 23° 01′ 22″ N latitude and 86 ° 01′ 22″ E longitudes. Sanka River is the main lifeline of the basin area. The upper reach falls within Purulia district of West Bengal and the lower reach in Saraikela Kharsawa district of Jharkhand. The total area of the basin is 191.2 square kilometres.

The transport and communication system within the basin is moderate and is accessible from all the directions. NH 32 is the prime connecting roadway passing through the basin and Barabhum station is connecting the surrounding areas of the basin by train lines. State Highways, metalled roads and village roads are the connecting modes of the parts of land within the basin area. Dominantly the basin is rural in character with two urban settlements. *Balarampur* and *Ayodha Pahar* both urban areas fall within close proximity.

1.4 Introduction to the Problem

The study area is located within a drought prone belt. The study area receives sufficient rainfall but for a short duration. As already furnished that preservation of runoff is hard to be executed here. The river is prone to receive sudden flash during rains only due to runoff from tributary channels and sudden accumulation of water in the downstream segments. Two physiographic units have been observed (i) Rigorous sloping plateau and (ii) Undulating lower plateau. Both the units comply with steady discharge through the channel.

This study is mainly a focus on the reasons behind the inaccessibility of water affected by terrain characters, temporal changes in LULC with increasing demand of water, impact of

terrain on human life and finding out some measures for societal well being of the inhabitants.

1.5 Aims and Objectives:

- To analyse the geomorphological characteristics of the basin (linear, areal, relief attributes)
- To study the surface soil parameters for understanding fertility status within the basin
- To assess the available surface water resources of the basin
- To study the existing and spatio- temporal changing Land use Land Cover (LULC) pattern within the basin

1.6 Hypothesis:

- Prevailing LULC is the product of terrain characters.
- Temporal variation of surface water availability has direct implications on changing LULC pattern.
- Variation of surface soil fertility over time has affected the land use pattern.

1.7 Methodology:

- The base dataset to study drainage network is Survey of India (S.O.I.) topographical maps (73I/4/NW, 73I/4/NE, 73I/4/SE, and 73I/4/SW) of the scale 1:25,000. Surface lithology of the basin had prepared from District Resource Maps of Puruliya and West Singbhum (scale 1:250000).

- Census of India (2011) data of village wise has used to understand the population pressure, their distribution and composition, land use throughout the basin area.

- DEMs were prepared from the contours of SOI topographic profile, spot heights and studied for relief parameters and geomorphic characteristics. Delineation and extraction of the sub-basin morphometric parameters has done to produce a series of nested basins within the main basin and computation of different linear, areal and relief attributes have carried out. Hypsometric analysis of the basin and its sub-basins for making out terrain features have taken up following Strahler‘s (1952) method. Derivation of hypsometric integral for lower order basins using Pike & Wilson‘s (1971) method have executed. Prioritization using the method of Javed et.al, (2009) has done by giving ranks to selected morphometric parameters

to further calculate the compound parameters to achieve the final priority ranking. The classification of terrain executed by weighted overlay method by considering various morphometric parameters and surface lithology. Topographic sections or profiles are produced considering the elevation of ground surface along a particular line and plotted according to defined scale. The elevations of ground are extracted from contours and spot height of SOI topographical maps. The topography or ground form can be defined precisely and comprehensively by profile lines.

- Samples of surface soil have collected from selected sites and tested specific physical (mechanical) and chemical characteristics.

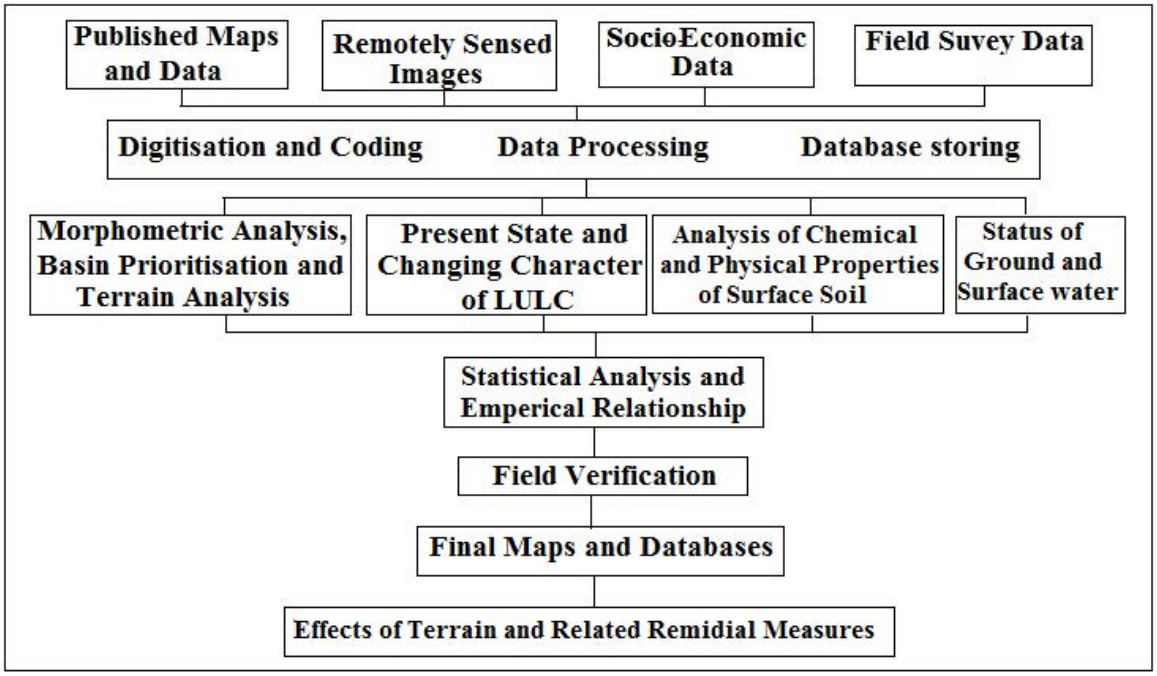

Fig.1.02 Flow chart of step –wise data processing and management procedures

- For identification of changing pattern of land use and land cover of the basin, satellite images over time, in accordance with the SOI topographical maps (73I/4/NW, 73I/4/NE, 73I/4/SE and 73I/4/SW) of land use under GIS environment have done. Ground trusting had done by field visits with GPS sets and plotting them over the base maps to test the level of accuracy of produced LULC maps from satellite images.

- Questionnaire surveys have been carried out to investigate the reasons of changing land use and land cover. For preservation of accuracy at best 60% of villages have

been considered with population statistics of 75. In-depth studies of literatures are the sources of information and data to find out the factors of changing LULC.

- Status of selected dug wells and natural low lands have investigated through field works. Field period were as follows (i) Pre monsoon: April and (ii) Post monsoon: September. An inventory survey had carried out to identify the techniques of rain water harvesting cum water storage for scarce time. Schedule surveys have conducted for perception study of the inhabitants regarding rain water storage for cropping practices.
- The areal extent and village wise distribution of tanks, check dam, dams have identified and analysed with the help of data from SOI Topographical maps and Satellite images. Logistic Regression Modelling (LRM) has executed to identify suitable sites for probable storage of surface water.
- Pearson‘s product moment correlation coefficient has been used to study correlation between physical properties with different parameters of land use and land cover. Multinomial logistic regression has executed to define the interrelationship and interdependence of diverse terrain parameters with LULC classes.

1.8Literature Review:

Acharya and *Nag* (2013) made attempt to study the Ground water prospects of the crystalline rocks in Purulia District. They used satellite images for lineament and hydro geomorphological analyses. Analyses of lineament density, spatial distribution of hydro geomorphic units and lithology have been carried out for the study of groundwater prospects in crystalline rocks. These works may be constructive for this research purpose in chapter six.

Adamo et.al., (2006), emphasized about environmental hazard which caused land degradation and desertification in Argentina to detect the change detection in land use land cover.

Brocq et.al (2008) formulated techniques of terrain analysis in relation to ice-surface plan curvature to basal topography and was applied to the Antarctic Ice Sheets. The technique suggests complex bed topography and a large sub glacial basin greater than 1500 m below present day sea level under the Recovery Glacier and its catchment in East

Antarctica. Understanding of basal topography to evaluate the terrain character in this present work, the literature may be an important source of study.

Chorley, (1969) viewed drainage basin as the –fundamental geomorphic unit". Morphometry in general and drainage basin morphometry in particular developed in leaps and bounds during the aftermath of the Second World War with the work of and studies initiated pertaining towards establishment of empirical relationships between different basin and landform parameters by that time.

Das (2009) in the doctoral dissertation has explained about different land use land cover change detection with modern techniques with object oriented emphasis.

Deng (2007) published his research article entitled *New trends in digital terrain analysis: landform definition, representation, and classification* in which he elaborated an ontological as well as methodological evaluation of recent progress in terrain analysis (SAGE publication). It focuses on six topographic factors, or existences, that are important in characterizing the _biophysical' functions of topography: elevation, surface shape, topographic position, topographic context, spatial scale, and landforms. An index-based approach to the compound function of multiple topographic existences is recognized as successful in modelling surface/subsurface moisture and mass movement potential, but not mountain temperature. This paper may be helpful for terrain modelling at relevant phases of the present research work.

Dury (1952) summarized and assessed the main morphometric methods. Along with these investigations for basin parameters, general morphometric methods were also developed and explored to perform broader landscape analysis and to characterize the terrain of an area.

Evangelin Ramani Sujatha, et. al. (2013) have explained hydrological characteristics of Palar sub-watershed in the Amaravati sub-catchment through the morphometric analysis using ASTER GDEM data and topographical map data under GIS environment.

Florinsky (2012) in his book entitled *Digital Terrain Analysis in Soil Science and Geology* elaborated principles and methods of digital terrain modelling which facilitate modelling in soil and geology.

Foddy (2002), mentioned Land use Land Cover dynamics is a result of complex interactions between several biophysical and socio economic conditions which may occur at various temporal and spatial scale of land cover which is a essential parameter

describing the earth‘s surface. This parameter has considerable impact on terrain and links many parts of the human and physical environments which has been precisely reflected in the research.

Horton (1932, 1945) in his work elaborated principles of stream ordering and enunciated different stream laws. This works emphasised on important elements of basin geo-morphometry and to differentiate the analysis of landforms from physiological measurements of organisms.

Humboldt (1860) and *Ritter* (1829) are considered as the co-founders of modern academic geography, revolutionized studies on terrain landscaping in the early 18th Century has now been passaged to the advanced fields like computer management and manipulation of spatial arrays of heights of terrain, digital elevation models (DEMs) etc., which can quantify and portray ground-surface forms over large areas.

Imbernon, (1999) Change detection is useful in many applications related to Land Use Land Cover (LULC) change, such as shifting cultivation and landscape changes.

Jensen, (1996); *Chen et al*, (2005) made effort on satellite remote sensing which is the most common data source for detection, quantification and mapping of LULC patterns and is suitable for computer processing and accurate referencing procedure.

Li, Zhu and Gold (2000), elaborated few important aspects in terrain analysis and different processes of terrain modelling. They emphasized on digital terrain modelling and requisite methodology which may be very useful for this pursuing research.
Lindsay (2005) described terrain analysis system as a tool for hydro-geomorphic applications using different terrain attributes which may be obliging for this research purpose.

Lu et al, (2004) mentioned as continued historical and precise information for any kind sustainable development program is prime, in which LULC serves as one of the major input criteria for the analysis and mapping of both the present LULC situation, as well as the changes in LULC over time which is recognized to be important parameter for better understanding and providing solutions for many social, economic and environmental problems.

Maune, (2001) implemented routinely diverse morphometric procedures were by geographic information systems (GIS) as well as specialized softwares. The work entitled *Earth Surface* edited in the *Journal of Geophysical Research*, specializing in surface

processes, is one of the latest of many publications creating avenues for terrain modelling.

Nag (2005) made efforts on groundwater which is being a valuable resource in today's world and needs proper evaluation and management for overall development within the region for its judicious use.

Nagendra et.al., (2006) worked on conservation and changes of land cover mainly forest cover areas. The research article emphasized on connection of villages located at the boundary of protected forest with market and related deforestation with comparison of the villages located within protected forest.

Pal (1972) formulated a scheme of classification of morphometric methods under the various heads like - Graphical, Arithmetical, Cartographical Analysis, Statistical Indices and Drainage Network relationships. The above mentioned literatures have highly been supportive in chapter three to conceptualize and quantify different morphometric parameters of the basin and its sub-basins.

Patel and Sarkar (2010), discussed about terrain characterization using SRTM DEM data. This paper emphasized on the methodology of extraction of different morphometric parameters and characterization of terrain which may be valuable for this research work to evaluate the terrain character precisely.

Prakasam (2010) used several multi dated images to monitor the Change detection by remote sensing to evaluate the differences occurring in LULC between the acquisition dates of satellite images that are due to different environmental conditions and human actions.

Romstad and Etzelmüller (2012) have elaborated that terrain segmentation is the process of subdividing a continuous terrain surface into discrete terrain units. They described a new method for terrain segmentation using mean curvature (MEC) watersheds. It may be helpful for studying micro terrain units and their degree of segmentation through phases of weathering and erosion even in this present research.

Rudraiah et al, (2008); *Sitender and Rajeshwari*, (2011) delineated the potential ground water on the basis of geomorphic units alongwith geological settings, lineaments indicating bore well locations using remote sensing and GIS.

Serra et.al., (2008), have mentioned about the change detection of Land Use Land Cover (LULC) caused due to human activity and biophysical causes. This research article is useful for the chapter five.

Sherbinin (2002), explained the term land use that is generally used to describe human usage of land or immediate actions modifying or converting land covers.

Strahler (1950) worked on modification of Horton's stream ordering scheme into a simpler method and addition of stream laws. This research work helped to formulate stream ordering of Sanka river in chapter three and related work on basis of stream ordering.

Wilson and Gallant (2000), made attempts for analysis of digital terrain which included detailed elaboration of methods of terrain analysis and application in various fields like geomorphologic application, hydrological application, biological application etc. This edited book may be constructive for identification and delineation of required linkages in respect to overall societal development.

Wyman et.al., (2010) emphasized in their research paper to identify different drivers of deforestation with the use of remote sensing data, household survey and spatial modelling within Baboon Sanctuary which is community based sanctuary.

Zende, et.al, (2012), used RS and GIS for extracting land features inherent to satellite images. This paper focuses on the study of the terrain and major land features of Upper Krishna Basin (Yerala River) using remote sensing and GIS. Representation of the terrain was based on digital elevation model (DEM). Different satellite images used to extract information about land-resources delineation in the region. This paper may be useful for both chapter three and four to identify and know the required imageries for the present study.

Zhou et.al (2006), made efforts to study the relationship between terrain complexity and terrain analysis based on grid-based digital elevation models (DEMs). The impact of terrain complexity represented by terrain steepness and orientation on derived parameters such as slope and related aspects have been analysed. Experiments have been conducted to quantify the uncertainties created by digital terrain analysis algorithms.

1.9 Research Gap

Extensive literature reviews and pilot surveys helped the author to formulate the research gap. In this area it has observed that LULC pattern is dominantly affected by terrain characters. In many research works it have found that terrain partially impact on different forms of land use. Terrain and soil characteristics also have direct relation specific to the study area and which has not been found in any research work for this study area. Even through extensive literature reviews seldom I could not find out the above mentioned research works. The state wise namely West Bengal and Jharkhand, soil fertility and land use related research work over a broad geographical area did not emphasised minutely on Sanka River Basin. There were some literatures related to scarcity of water, but according to each terrain the availability of water resources and their impact on LULC was not found. This research work has emphasized to fulfill those above mentioned gaps.

1.10 Conclusion

The Sanka River Basin located in a drought prone area of Chotonagpur plateau and the river originates from the *Ajodhya* hill areas. This basin area has water related problems for different purposes due its terrain condition. To identify and mitigate the problem and understand the effect of terrain predominantly on land use land cover in relation to dwellers of the basin area different approaches have determined on the basis of previous work of researcher.

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