CHAPTER 2

Literature Review
2.1 Introduction

GIS has evolved out of a long tradition of map making. In many respects, modern GIS dramatically increase the amount of information that can be contained and manipulated in a map. On the other hand, many of the same cartographic conventions and limitations apply to digital maps. Like all models, maps are, by necessity, simplified representations of reality. Partly, this is for convenience; it becomes very difficult to draw and interpret multiple information themes on one map covering more than a very small area [41]. Before computers became widely available, thematic maps on plastic Mylar sheets could be laid on top of each other, revealing more information about an area than was possible with any single paper map. Ian McHarg’s classic landscape architecture text, Design with Nature, advocated a rational approach to site planning (which he termed physiographic determinism) by creating Mylar overlays depicting landforms, soil types, vegetation patterns, and geomorphic features [42]. Although the process was cumbersome and the amount of data limited, McHarg’s method looks remarkably like the output of contemporary GIS; colored thematic maps were generated that aided in planning. However, as Burrough and McDonnell note with all of these early systems: “The paper map and its accompanying memoir was the database” [43]. There could be no database of information directly linked to the map and no automation of spatial querying.

A detailed history of GIS is not well understood because GIS technology evolved through multiple parallel but separate applications across numerous disciplines [44, 45]. The development of the GBF-DIME files by the U.S. Census Bureau in the 1960s marked the large-scale adoption of digital mapping by the government. This system led to the production of the Census TIGER files, one of the most important socioeconomic spatial data sets in use today. Important geographic work was also being done at universities throughout the 1950s and 1960s. A grid-based mapping program called SYMAP, developed at the Laboratory for Computer Graphics and Spatial Analysis at the Harvard Graduate School of Design in 1966, was widely distributed and served as a model for later systems [46, 47]. These early GIS packages were often written for specific applications and required the mainframe computing systems found usually in government or university settings. In the 1970s, private vendors began offering off-the-shelf GIS packages. M & S computing (later Intergraph) and Environmental Systems Research Institute (ESRI) emerged as the leading vendors of GIS software. In 1981, ESRI released Arc/Info, a standard package which ran on mainframe computers [48, 49]. As
computing power increased and hardware prices plummeted in the 1980s, GIS became a viable technology for state and municipal planning [50]. In 1992, ESRI released ArcView, a desktop mapping system with a graphical user interface that marked a major improvement in usability over Arc/Info’s command-line interface. By the early 1990s, GIS initiatives existed in all fifty states [49, 51].

In the late 1990s, GIS was being adopted slowly on the sub-municipal level by neighborhood organizations and community-based agencies. The development of ArcView for Microsoft Windows and ArcIMS, which enables distributed mapping and spatial analysis over the Internet and eliminates many of the hardware and licensing expenses of a full software package, has increased the availability of spatial data to marginalized and under funded groups. Although access to both GIS software and spatial data sets has improved, the adoption of GIS as a planning or research tool still represents a significant commitment by community organization [52]. From the early 1960 to till now the computerized GIS is developed, enhanced and used in different fields of science and arts for the urban and rural development in government and private sectors. Some studies on the application of GIS and Remote Sensing in different fields are present here:

### 2.2 Application of GIS and Remote Sensing in Agriculture

Today's economic realities have a lot to do with the progress of GIS in the agricultural industry. Agricultural production, marketing and processing technologies and management systems have become more complex over the years. Technologies like GIS and remote sensing are powerful tools for agricultural development but all these require broad expertise and rapid availability of knowledge. The need for information, education programmes and decision support tools is greater now than at any other time in the history. Hence, the factor of increasing complexity of agricultural technologies and management systems has created a need for GIS and remote sensing. Agriculture sector requires sharing of expertise and resources across countries, institutions and departments, more cooperation with the private sector, improved openness and communication on issues of interest to the community, greater awareness of our role in the world, and a willingness to consider new approaches [53].

The last decades witnessed revolutionary changes in the approaches related to spatial problems because of incredible progress in automation and computer technology especially with the
introduction of modern Geographic Information System (GIS). It is a powerful tool for storing, retrieving analyzing and integrating spatial and non-spatial geographical data apart from drawing any kind of maps. The development of spatial statistical techniques has been accelerated parallel to this rapid growth of GIS technologies and there is a need to integrate the GIS, and spatial statistical techniques and remote sensing.

A number of organizations in India are engaged in developing suitable applications of remote sensing technology. The initial success of these led to the formulation of crop acreage and production estimation (CAPE) project which was first major project launched under Remote Sensing Application Mission (RSAM) and Department of Space (DOS) in 1986. First independent attempt in the country towards the use of satellite digital data was made in karnal district of Haryana using Landsat MSS data by 1989. Dadhawal and Sridhar (1986), Panikar et al. (1987), Dadhawal et al. (1987), Murthy et al. (1996) etc. have made significant contributions towards acreage and production estimation of rice and wheat in the country. Singh, et al. (1992) and Goyal, et al. (1994) presented the use of satellite data along with survey data for improving the efficiency of crop yield estimators. The applications of Remote Sensing and GIS for Land Use Planning under different projects undertaken in the country has been considered by Krishnamurthy and Adiga (1987) [54,55].

Soil survey is an integral part of an effective agricultural research and advisory program. It provides complete information about soils and is an inventory of the soil resource of the area. It gives the information needed for planning landuse and soil management programs. In Tamil Nadu Soil survey is being conducted by "Soil Survey and Landuse Organization", Coimbatore. A soil survey of the Minjur and Panchetty area, part of Chennai basin was conducted during 81-82, by the soil survey and land use organization, Coimbatore. The soil survey report (Report no.59 Soil survey and land use organization.1985) and field samples were used to create a database on soil characteristics. The soil survey report is based on low intensity survey however, it can be used for many planning purposes and hence, it is used to demonstrate the usefulness of GIS in analysis and interpretation of soil data. The attribute data are linked with spatial data. Hence, linking spatial aspect of the soils with non-spatial characteristics forms the soil model. The necessary information and thematic maps could be easily generated using the model. The usefulness of the GIS will be enhanced if these capabilities are operated through the Internet.
Incidentally, it is felt that the data collection process will be easier and comfortable if data owning department puts the information in Internet [56].

National agricultural production, on a sustainable basis, depends on the judicious use of natural resources like soil, water, animal resources, crop/plant genetic resources, etc. with an acceptable technology management under prevailing socio-economic infrastructure. In order to achieve an economically sound society, environmentally benign development and judicious utilization of natural resources, it is necessary that a comprehensive information system be developed to provide systematic and periodic information to the planners, decision-makers and developmental agencies. The animal and plant genetic resources of India are of great global importance. These resources need proper evaluation that can be done through interactive interpretation in a relational database system. Also, digitizing socio-economic database along with biophysical factors is important to objectively monitor and evaluate the current and future agricultural growth and development.

Many agencies have developed various information systems, which include databases on different resources. Space Application Center (SAC) has developed Natural Resources Information System (NRIS). The database covers information on various soil types and water bodies of the entire country. It includes both the spatial and non-spatial databases. Department of Science and Technology (DST) has developed a Natural Resources Data Management System (NRDMS) with the aim of developing and demonstrating the use of spatial decision support for integrated planning and management of resources for micro level planning. Under NRDMS they have also developed a user-friendly Geographic Information System (GIS) package viz. Geo Referenced Area Management (GRAM) for entry, storage, manipulation, analysis and display of spatial data on a low cost computer configuration.

Thus, the development of a data warehouse on soil, water, climate, animal, fisheries, crops and cropping system along with socio-economic and geographical features on a single platform, and to evolve methodologies to interpret the inter-linked data through the Central Data Warehouse (CDW) for planning and development purposes. Therefore a nationwide project named Integrated National Agricultural Resources Information System (INARIS) has been initiated at Indian Agricultural Statistics Research Institute (IASRI), Indian Council of Agriculture Research (ICAR) funded through National Agriculture Technology Mission (NATP). In this project various existing databases developed or being developed at various centers will be integrated and
database on critical data gaps of various fields will be designed for important parameters in respective field and an operational and flexible warehouse for agricultural resources so that it can be expanded further, in future as per requirements.

Thus the development of CDW under Integrated National Agricultural Resources Information System (INARIS) project will improve the quality of research and planning, reduce the duplication of research efforts, encourage dissemination of research findings, and facilitate qualitative research supported by agricultural databases. Besides this it will help in the development of Decision Support Systems (DSSs) which in turn can be used as effective tools for agricultural research and education planning. Further, it will also help in developing effective linkages with other national and international organizations in sustainable development [57].

Dairy Development plays a vital role in bringing out significant changes in socio-economic structure of rural economy. The main objectives of Dairy Developments in India is to increase production and availability of milk through integrated policy of cattle cum Dairy Development, eliminating the middlemen, through formation of co-operatives and self supporting dairy enterprise. The advent of Geographical Information System (GIS) has added new vistas in the field of Dairy Farm and Management. It also helps in integrating the whole Dairy Farm in a more precise way to get correct information about the various factors related with the whole dairy farm.

Use of remote sensing and GIS technology is very useful in the preparation of groundwater prospective areas mapping and management plan of the dairy farm in a scientific basis. Use of GIS and Remote Sensing technology is very useful for the preparation of the ground water prospective areas mapping & Dairy-Farm Management Plan on scientific basis. The information generated on Integrated Farm and Dairy Management prospects; quality and depth in a single map will help the decision makers for devising sound and feasible development plan [58].

Today the gathering information, which is synthetic and systemic, is possible from social activities to natural environment based on divers spatial information technology such as GIS and remote sensing. It, therefore, is processing not only the forecast of meteorological environment in the whole scale of the earth, but also the study about the local area, being possible to get the input datum which need that relative meteorological models have been developed with remote sensing for the decades.
Some study have been done for the development of the Ansung-watershed area of Korea by the urbanization of the agricultural area interprets more reasonably influencing the area of meteorological environment characteristic, fractionating both the diverse civilization and the environmental information of the nature around the basin of Ansung-watershed area based on population distribution information in addition to the observation of AWS (Automatic Weather Station) around the basin, and also analyzes systemically the pattern of the landcover change, surface temperature as well as NDVI distribution in the agricultural area, applying the technique of GIS spatial analysis and the multi-temporal of Landsat TM satellite image [59].

Since agriculture resources are among the most important renewable, dynamic natural resources, Comprehensive, reliable and timely information on agricultural resources is very much necessary for a country like India whose mainstay of the economy is agriculture. Agriculture survey are presently conducted throughout the nation in order to gather information and associated statistics on crops, rangeland, livestock and other related agricultural resources. These information of data are most importance for the implementation of effective management decisions at local, panchayat and district levels. In fact, agricultural survey is a backbone of planning and allocation of the limited resources to different sectors of the economy.

With increasing population pressure throughout the nation and the concomitant need for increased agricultural production (food and fiber crops as well as livestock) there is a definite need for improved management of the nation agricultural resources. In order to accomplish this, it is first necessary to obtain reliable data on not only the types, but also the quality, quantity and location of these resources. The remote sensing techniques have been and it will continue to, a very important factor in the improvement of the present systems of acquiring and generating agricultural data [60].

Precision farming revolves around the idea that any agricultural land can contain wide spatial variations in soil types, nutrient availability, and other important factors and not taking these variations into account can result in a loss of productivity. Precision farming, as such, is a method of farming that allows the farmer to produce more efficiently, thereby realizing gains through economical use of resources. In practical terms, precision farming involves studying and managing variations within fields that can affect crop yield [61].

Precision farming in many developing countries including India is in its infancy but there are numerous opportunities for adoption. Progressive Indian farmers, with guidance from the public
and private sectors, and agricultural associations, will adopt it in a limited scale as the technology shows potential for raising yields and economic returns on fields with significant variability, and for minimizing environmental degradation. Although it is recognized that agriculture is a major polluter of the environment in many developing countries, farmers will not adopt precision farming unless it brings in more or at least similar profit as compared to traditional practice. The support from governments and the private sector during the initial stages of adoption is, therefore vital. It must be remembered that not all elements of precision farming are relevant for each and every farm. For instance, introduction of variable rate applicators is not always necessary or the most appropriate level of spatial management in Indian farms. Likewise, not all farms are suitable to implement precision farming. Some growers are likely to adopt it partially, adopting certain elements but not others. Precision farming cannot be convincing if only environmental benefits are emphasized. On the other hand, its adoption would be improved if it can be shown to reduce the risk. The adoption of precision farming also depends on product reliability, the support provided by manufacturers and the ability to show the benefits. Effective coordination among the public and private sectors and growers is, therefore, essential for implementing new strategies to achieve fruitful success [62].

In India watershed-based development has been the strategy for growth and sustainability of agriculture in the vast semi-arid and dry sub-humid regions popularly called rain-fed regions. Watershed Development Projects have been undertaken to enhance agricultural production, conserve natural resources base and ensure rural livelihood since 1980s. Initially soil and water conservation was the primary objective of the program which attracted large public investments in the last 25 years. Subsequently, egalitarian principles of equity and enhancing rural livelihood were given prominence; more recently the principle of sustainable development with emphasis on tenets of development economics like cost of degradation of fragile land and economic ecology like valuation of ecological services have gained emphasis. Large investments have been assigned for watershed based development in the National Five-Year Plans since 1990s and more investments have been earmarked till 2025. The rain-fed regions of India span across several agro-climatic and ecological regions which warrant location-specific approaches to watershed development and management. Besides this three major ministries of the Govt. of India, development agencies and NGOs are involved in implementation of the projects. As a result, notwithstanding, the common guidelines for
implementation, the projects have yielded little by way of lopsided development and impact assessment has been rendered impractical. In view of the huge investments already made and the necessity for effective implementation of watershed development projects in rain-fed areas of India, the tools of Geomatics were employed to evaluate the impact of various aspects of the program on agricultural sustainability, natural resource base and rural livelihood in selected villages. The present paper elucidates the multi-disciplinary approach of using satellite data, GPS and GIS along with conventional methods of field survey, transect walk, PRA, soil sampling and physico-chemical analysis and socio-economic survey for evaluation and monitoring these developmental activities for initiating corrective measures in order to increase their efficiency [63].

Palm oil plantations are a major commodity producer with Indonesia currently being the world’s second-largest producer of crude palm oil (CPO) after Malaysia. Together these two countries account for 84% of total world production and 88% of global exports (Guerin 2006). The demand for palm oil is increasing significantly, both locally and for export resulting in further land clearing and conversion of existing plantations over extensive areas of Sumatra and Kalimantan. Typically, palm oil plantations include production areas requiring supporting infrastructure such as buildings, roads and services. To better control the associated resources and assets, GIS is considered to be an essential tool for effective management. The implementation of this technology is only slowly emerging in the Indonesian plantation industry. Information requirements for plantation management, and GIS integration including mapping, infrastructure, production planning, and control analysis for several plantations at various stages are performed by the researchers for the several plantation projects in Sumatra, Indonesia.

When GPS and GIS technologies were applied, information was accurate, reliable and repeatable. These technologies were welcomed by plantation management, as GIS technology established a dependable basis on which to make decisions [64].

Horticultural crops cover a large number of fruits, vegetables, flowers which are highly perishable in nature. Post harvest losses estimated to be in the range of 20-40 per cent. Hence, emphasis is given to develop post harvest infra-structure like cold storage, food processing, packaging, market outlets etc. during the current plan period. Most of the cold storages are concentrated in and around the consuming markets. Thus, very little facility exists to cater to the marginal farmer’s requirement during the harvesting season. Potato is one of the most important
vegetable crop. Though 90 per cent cold storage facilities of the country is for potato crop and located in the potato growing regions, still it falls far below the requirement. The National Co-operative Development Corporation is trying to promote the setting up of such storage facility in the co-operative sector. Thus, a scientific approach to evolve a methodology to locate sites for cold stores which would be optimally utilized by the growers is required. A pilot study was taken up to analyze the demand and supply situation and evolve an optimum plan to locate cold stores using satellite remote sensing (RS) data and Geographic Information System (GIS). Some studies were done for potato crop in Bardhman district of West Bengal, a leading potato growing area.

The studies shows that remote sensing and GIS can be used to develop a scientific approach to draw an integrated plan for cold storage, food processing, packaging sites etc. for fruit and vegetable crops [65].

Traditional decision support systems based on crop simulation models are normally site-specific. In policy formulation, however, spatial variability of crop production often needs to be evaluated due to different soil conditions, weather conditions and agricultural practices within a target-region. The researchers developed methods to generate fine resolution data from coarse resolution data which are usually available at regional or national level. In addition, since the original EPIC (Erosion Productivity Impact Calculator) crop management practices are static in nature, dynamic adaptation loop also added to evaluate the impacts of agricultural practice changes over temporal scale. Validation of the spatial EPIC was conducted at different spatial scales, i.e. National scale (approx. 50km cell-size) and regional scale (approx. 10km cell-size) in India. Results showed that at both resolutions level crop yield varied significantly as a function of seasonal climatic variation, soil water holding characteristics and applied crop management strategies. Also, the study of researchers successfully demonstrated model applicability in evaluating an impact of climate changes over major cereal crops productivity at national level taking spatial variability into account. The model were applied for Indian State Bihar, at national level it was applied to India and then for the entire globe for the major cereal crops. Using the methodologies of the researchers a region/nation can be modeled for any crop productivity, which help researchers and decision-makers understand the status and extent of climate, soils and crop cum field management effects on global processes such as rice, wheat and maize production. The “Spatial-EPIC” possesses immense potential as a farm management tool [66].
Up-to-date and reliable information is vital for managerial purposes and take efficient planning decisions. Researchers, policy makers as well as estate managing companies may wish to integrate socio-economic, spatial and temporal data in order to make Sustainable Strategic Development Plans (SSDP).

Remote Sensing and GIS is widely accepted as a tool for the establishment of integrating spatial and attribute data. In recent years the development of Geographical Information system (GIS) makes timely accessible of spatial and temporal data (Burrough, 1986). Moreover, its capability of spatial analysis and presentation makes it useful tool for studying land use change and developing sustainable land use plans. Up-to-date and reliable information is vital for managerial purposes and take efficient decisions. Geographical Information System (GIS) and Remote Sensing (RS) technology can be used as tools for update estate information. In addition developing land use planning system-using SSDP can be used for estates for maximizing their profits and optimizing lands [67].

The potential risk of pest and disease damage to rice cops was studied at the Province level using a Geographic Information System (GIS) to monitor the relationship between environmental and climatic variables.

Cantho City Province, Vietnam, was selected as the study area due to the occurrence of favorable conditions for potential outbreak hotspots of the Brown Backed Rice Plant Hopper, BBRP Hopper, (Nivaparvata lugens). Findings from this research investigated the need for village level surveillance of BBRP Hopper outbreaks, the level at which outbreaks are acknowledged to occur, as opposed to district level surveillance. A Global Positioning System (GPS) was used to record the spatial location of the data. Geostatistical software and a GIS were respectively used to analyze and interpolate, and then plotted the data. Climatic evidence suggests that rainfall, maximum and minimum temperature, and relative humidity are causal aspects in the prevalence of the BBRP Hopper. Biological evidence supports the observed effects of climate; such as increased rainfall and higher humidity, resulting in a higher incidence, and thus frequency, of the BBRP Hopper. Rice plant factors, such as number of leaves and the stage of grain maturity, also influence the density of the BBRP Hopper. The density of BBRP Hopper was observed to change with the different stages and seasons for rice growth. The geostatistical analysis showed that the density of the BBRP Hopper was closely correlated with the environmental factors. However, obtaining the climatic data at field or village scale can
sometimes be difficult to lack of monitoring equipment. The use of interpolated climatic data is of great value of that instance. The use of GIS and other spatial analysis methods are extremely valuable for modeling the relationships in biological problems as has been demonstrated with the BBRP Hopper and contributing environmental factors. Crop-pest interactions will change significantly with climate change leading to an impact on pest distribution and crop losses. Given a significant population base of disease and insects within an area, increases in temperature and humidity create favorable conditions for population growth and thus substantial rice yield losses [68].

Fire blight is the most dangerous disease on apple in the north-west of Iran (Azerbaijan province). Weather-based fire blight risk maps of the east Azerbaijanan province were made by Geographic Information System (GIS) with the use of 20 years data from 10 weather stations using the MARYBLYT model. The long term meteorological data was assessed using STATISTICA software for calculating conditional probability of occurring a day with suitable thermal and humidity conditions which fire Erwinia need for flower infection and outbreak in the province. Then, by using Geographical Information System (GIS) and preparing the digital elevation model (DEM) of province the map of fire blight risk was prepared by the model of the researcher. The results of the study showed that regions of west and north-west of province are of high fire blight risk.

Geographic Information Systems/Science (GIS) seem to be a natural fit for epidemiology, the study of the origin and transmission of disease. Epidemiology attempts to integrate a vast array of risk factors such as temperature, moisture, vegetation type/percent cover, the presence and density of disease vectors (i.e. mosquitoes, ticks, etc.), the presence and density of susceptible hosts, pathogen transmission rates- even the molecular, cellular, reproductive and behavioral biology of the host(s)- in an orderly way. The information was used to identify which factors are necessary for disease, the areas that support disease vectors, and the risk of disease transmission and outbreak. A GIS provides with the ability to overlay many of the larger-scale risk factors and spatially analyze the data in an attempt to better understand which factors are essential, or how the factors influence each other, to increase or decrease the occurrence of a particular disease. The articles of the researchers provide an introduction to some epidemiological studies which have utilized GIS technology Fire blight, caused by the bacterium Erwinia amylovora, affects over 130 plant species in the rose family. In the east Azerbaijan province Fire blight was a
destructive bacterial disease of apples and pears that kills blossoms, shoots, limbs, and, sometimes, entire trees. Once the first few open blossoms are colonized by the bacteria, pollinating insects rapidly move the pathogen to other flowers, initiating more blossom blight. Those colonized flowers were subject to infection within minutes after any wetting event caused by rain or heavy dew when the average daily temperatures were equal to or greater than 60 F (16 °C) while the flower petals were intact. Although mature shoot and limb tissues are generally resistant to infection by E. amylovora, injuries caused by hail, late frosts of 28 F (-2 °C) or lower, and high winds that damage the foliage can create a trauma blight situation in which the normal defense mechanisms in mature tissues are breached and infections occurred. As the infection progresses the leaves on the same spur turn dark brown or black as thought scorched by fire. The dark, shriveled leaves hang downward and usually cling to blighted twigs. Infected shoots, twigs, and suckers turn brown to black and often bend in a characteristic shepherd's-crook. Infected immature fruit turns dark, shrivels, mummifies, and rots. Mummified fruit may cling to the tree for several months. A canker is formed when an infection progresses into larger branches [69].

Agriculture has always been India's most important economic sector. Large area yield forecasting prior to harvest is of interest to government agencies, commodity firms and producers. Timely monitoring during the growing season provides opportunities to mitigate any detected challenges. The current methods used in India provide neither sufficient nor timely cost effective spatial information. The developments of an Agricultural GeoCapacity Centre Network to overcome those problems were provided a sustainable, long term solution have been done. The presentation describes the functionalities of AGCN, the requirements, the design and the implementation AGCN is a complex system where several independent modules are integrated and cooperate to reach the final objective. It is based on a multi-tier architecture model. These modules are implemented as one or several applications; for crop monitoring, yield forecasting, weather forecast, etc. The applications were built around services provided by the GIS core, like Image Processing, Map Generation, Web System, and Database Connection. The GIS core provides application programming interface to build custom applications, integrates external application and access to the database management system.

The AGCN for the implementation of an Agriculture Information system is based on the Geo-Capacity Information System (GCIS) concept and is conceived with the aim of developing methods to produce timely statistics on land use, planted area and production volumes for
various crops within India, of applying remote sensing and ground surveys to estimate the planted area, as well as providing weather information and water management service applications and tools. Real-time image processing tools, proven methods to relate satellite imagery to quantitative crop yields, weather, soil and crop information to feed crop growth monitoring and water models, information technology required to build an open and multi-tier architecture are presently available, such that implementation and deployment of an AGCN system is not beyond the reach [70].

Remote sensing plays an important role to estimate agronomic parameters and yield. To study the relationship between spectral indices and agronomic variables, yield attribute and yield of cotton (Gossypium sps.) species, field experiment was conducted at Punjab Agricultural University, Ludhiana, India. The spectral reflectance were taken in the two spectral bands, red (R) band (625-689 nm) and Near Infrared (NIR) band (760-897 nm) from the crop canopy to calculate spectral indices, Radiance Ratio (RR=NIR/R) and Normalized Difference Vegetation Index [NDVI=(NIR-R)/(NIR+R)]. The correlation studies were discussed between the agronomic variables i.e., plant height, leaf area index, chlorophyll content, total and dry matter partitioning with the spectral indices viz., RR and NDVI. To see the best regression equation, data were run in three models i.e. linear model, quadratic model and multiple linear model, in which independent variable ‘days after sowing’ was added in linear model. Similarly the correlation between yields attributes and spectral indices were calculated from the linear model under different date of sowing and nitrogen levels. The results were also presented of correlation between seed cotton yield and the spectral indices of different date of observations from the linear and quadratic models. The results showed that plant growth parameters, yield attributes and seed cotton yield can be estimated from RR and/or NDVI.

The agronomic variables are highly correlated with both spectral indices viz., RR and NDVI under American and Desi cotton. The LAI can be predicted by RR by simple linear model while plant height, stem, leaf, total dry matter with NDVI by quadratic model. Number of flower, open boll, total bolls and boll weight per plant are significantly linearly correlated with RR and NDVI and depend on the sowing dates. Timely sown American seed cotton yield can be estimated by RR in quadratic model from maximum vegetative growth period (95 DAS) and in early vegetative growth period for late sown. Plant growth parameters, yield attributes and seed cotton yield can be estimated from RR or NDVI of cotton species [71].
The growing world population needs more food, with less water available for agriculture. This situation can only improve if water is managed more effectively leading to increased crop yield per unit of water consumed. Crop yield is the ultimate indicator for describing agricultural response to water resources management (Molden and Sakthivadivel). Most of the research for estimation of rice yield have been carried out with vegetation indices namely Normalized Difference Vegetation Index NDVI which is calculated through the reflectance of red and infrared bands. But the assessment of rice yield with NDVI method has overestimated the actual yield by approximately 30%. Researchers shows that the feasibility of applying remote sensing techniques to assess the near real time yield of rice crops using biomass production in large irrigation systems leading proper decisions towards the crop productivity. A major advantage in the measurement of biomass through the remote sensing methods is that it captures the spatial heterogeneity. Since the MODIS images have daily images, it captures the spatio-temporal distribution of biomass development. In the research, the time series of MODIS images were used for the determination of biomass production [72].

Agricultural sustainability has the highest priority in all countries, whether developed or developing. Cropping System Analysis is essential for studying the sustainability of agriculture. Crop rotation is stated as growing one crop after another on the same piece of land in different timings (seasons) without impairing the soil fertility. A cropping system can be defined as the cropping patterns and their management to derive maximum benefits from a given resource base under specific environmental conditions. Multiplicity of cropping system has been one of the main feature of Indian agriculture and is attributed to rained agriculture and prevailing socio-economic situations of farming community. It has been estimated that more than 250 double cropping systems are followed throughout the country. Thirty important cropping systems have been identified based on rationale spread of crops in each district in the country. It is well known that one of the main advantages of remote sensing satellites is the synoptic and repeated collection of data which facilitate to map multi-year cropping patterns and crop rotations. In the work of Sharma, M. P., Yadav, M, et al., 2011, crop rotation and long term changes monitoring in cropping pattern along other spatial and non-spatial collateral data have been done with the help of satellite data at block level of Kurukshetra district of Haryana. Multi-date IRS LISS-III data of different seasons for the year 2007-08 have been used for the study. Cropping pattern maps of Rabi, Kharif and Summer season have been understood to know the spatial distribution.
and associations between crops or crops and uncultivated land in the same fields (although not in a particular order of sequence). The findings of the study may be used by Department of Agriculture, Haryana for planning of agricultural strategies in the district and for planning agricultural research and extension activities for crop diversification.

The study introduced a method for analysis of cropping systems for main crops, other crops and fallow land of the year 2007-08 of the Kurukshetra district and its development blocks. Using unsupervised classification of multi-date satellite images of LISS III, cropping pattern and crop rotation maps are generated. The method identifies main crops of Kharif, Rabi and Summer Seasons shown in the study area. Although, the study shows crop rotations as such, it allows spatial relationships between main crops, and other crops at a specific location to be mapped during the study period. An advantage of the method is that it may show some spatial relationships between crops, which could reveal certain specific location of some rotations. For example, in the study area of Kurukshetra district the spatial relationship between Rice, Wheat and Sunflower which are seasonal crop in Kharif, Rabi and summer shows the specific location of typical distribution areas. An additional possibility of multi-year cropping pattern map was its use in future spatial crop distribution prediction, since it contains expert knowledge about spatial relationships between crops in the study area and implicit probabilities of changes [73].

The proposal of Goswami and Saxena, et al., 2012, highlights on application of Remote Sensing (RS) and Geographical Information System (GIS) technologies for the wheat acreage estimation for Indore District, Madhya Pradesh, India. Wheat acreage estimation is one of the most important parameter, if area has a strong inter-annual variability while yield remains relatively stable. Single date, cloud free Resourcesat -1 LISS- III digital data coinciding with flowering stage of wheat crop was used for acreage estimation. The administrative boundary of the study area (Indore District) is overlaid on the image to extract all pixels belonging to study district. ERDAS IMAGINE 9.1 image analysis software and Arc GIS 9.2 software were used for data processing and analysis. The refined training statistics generated using the multi-bands data were used for supervised classification using maximum likelihood. Remote sensing & GIS technologies based district level wheat acreage estimation has been done and found that deviated from the (Land record Commissioner) LRC by +19.

The paper reveals the results of one year (2010-11) Remote Sensing based district level wheat acreage estimates. Single date Remote Sensing digital data from resource sat P-6 LISS III
Sensor, coinciding with flowering to grain filling stage of wheat crop was analyzed for acreage estimation using maximum likelihood (MXL) supervised classification and ground truth (GT) information.

The performance of wheat acreage estimates was evaluated by comparing relative deviations (RD %) with Land Record Commissioner’s (LRC) estimates since wheat is dominant crop in the district and the gram is second competitive crop grown in the district. The RD% about 19 has been found when the Remote Sensing estimates compared with Land Record Commissioners estimates [74].

2.3 Application of GIS and Remote Sensing in Irrigation

Satellite remote sensing (SRS) and geographic information (GIS) techniques are used for the improvement of water management in canal irrigation schemes. The Bhadra command area was brought under NWMP (National water management project) to improve agricultural productivity and farm income through a predictable, equitable and reliable irrigation service. Satellite remote sensing technique has been applied to historic and 1995 Rabi season data by National Remote Sensing Agency to generate primary data on irrigated area, cropping pattern and crop yield at disaggregated level and to access the improvement in agricultural productivity and water management after MWMP implementation. The GIS technique helps in integration of satellite and ground information to evaluate the system performance and to diagnose the inequality in the performance to aid in improving the water management.

The primary objective is to diagnose the factors for poor performance of selected distributaries using satellite data and ground data collected by specially designed sample survey and to improve performance by prescribing corrective measures. The distributaries 9A, 12 and 15 of Malabennur division of Bhadra project in Karnataka state covering about 2350 ha area, is considered for the study of the researcher. The performance of 12th distributory is good whereas the other two were poor performing. Hence to find the causative factors for poor performance were studied in comparison with a good performing area.

The physical and socio-economic data were interpolated with different considerations and methods and analyzed. A Conjunctive analysis of remote sensing-derived, irrigation, agricultural and socio-economic data was attempted. Various causative factors pertaining to all the activities were identified, ranging from poor physical condition, improper fertilizer consumption to poor
interaction between the officials and the farmers. The GIS served as a platform to analyze the effect of each component of the system based on the results [75].

Agriculture resource planning in Bangladesh carried out without adequate knowledge and information of the specific area. Since, with small amount of irrigated land to feed the overly populated people of the country, precise planning is necessary. This leads to step forward towards a system with updated and enlarged data. The technology, Geographical Information System (GIS) can play an active role by ameliorating the existing system and finding the required information.

The work was for the application of GIS in minor irrigation projects for assessing the status of irrigation equipment and their irrigated area in context of arsenic and ground water level. Study area includes division wise coverage of the whole Bangladesh. It presented findings generated through the GIS software and documents-based research that indicate arsenic contamination and ground water level has a major impact on minor irrigation. Declination of the Static Water Level observed due to extensive use of mechanized equipments. The researchers suggest further developmental study detailing the impact on agricultural environment in order to formulate proper planning and the development of minor irrigation.

Based on the findings by applying GIS on minor irrigation it was observed that there is a trend of enlarging area by minor irrigation mostly in Rajshahi and Dhaka division than others. The major factor contributing to the expansion is the static water level; arsenic level also has its impact too. However, excessive withdrawn of water from these area causing lowering of the static water level creating a negative impact on the environment. In Chittagong division irrigation coverage is low due to higher arsenic contamination in region nearer the Meghna River; though the later part of the Chittagong division might be useful for minor irrigation activity. Besides this, mechanized equipment is playing a significant role in the development of minor irrigation. There is a tendency of increasing both LLP and STW in comparison to manually operated equipment. Increased no of STW was found in Rajshahi division followed by Dhaka and Khulna division but very poor in Barisal division. Again, in Chittagong division the use of LLP is higher, using extensively the surface water source. Higher use of this mechanized equipment has lead to increase in power consumption. STW run by diesel is the top most consumers in the whole Bangladesh and STW run by electricity is the next. Those run by diesel creating harmful effect on the environment by air pollution so as noise pollution.
Evidence from the report also shows that minor irrigation plays both positive and negative role in national economy development through agriculture. Positive in a sense that it is taking the place of Major irrigation covering most of the irrigated area with less investment but it is negative in a sense that it is using more of the mechanized equipment and extracting more of the ground water creating pressure on the natural resource as well as on environment. GIS application to minor irrigation makes assessment of the trend and nature of irrigation in faster and precise way comprising both socioeconomic and environmental factors [76].

Land suitability provides a rational basis to analyze various soil, nutrient and land parameters to arrive at an optimum solution for various problems of natural resources. It includes land capability classification, land irrigability assessment, soil suitability for crops, suitability to plantation/trees/aquaculture, etc. Remote sensing has shown great potential in land suitability model mapping and monitoring due to its advantages over the traditional procedures in terms of cost and time effectiveness in the availability of information over larger areas. Hence, it is proposed to use remote sensing data for the mapping of natural resources. Nevertheless, the surface reflectance spectra over a wide range of objects and conditions should be identified and interpreted into meaningful outputs prior to decision making and applications. Satellite remote sensing images, such as IRS P6 LISS IV MX have been used. Geographic Information System (GIS) has become an important tool because it enables the integration of complex decisions to be taken under multi-variant situations of the resource base and their dynamics. Survey of literature reveals that GIS techniques have been employed for development of land suitability model for irrigation management [77].

Bastawesy and Ali (2011) investigate the interplay of the hydro geological characteristics, soil properties and recent land reclamation projects on the distribution of water logging and salinisation within the Farafra Oasis. The multi-temporal remote sensing data and field observations show that new reclaimed areas have been recently cultivated in distant areas from the old agricultural land. These new cultivations have developed widespread water logging, seepage channels and soil salinisation. Analysis of the Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM) showed that both old and new agricultural areas are located within same closed drainage basin. The fluvial channels of these catchments, which were developed during wet climatic pluvial have largely, been obliterated by the prevailing aridity and often buried under aeolian deposits. However, the new cultivations have been developed on the
fingertips of these fluvial channels, while the old fields occupy the low level playas. The soil of
the new cultivated areas are mainly lithic with a high calcium carbonate content, thus limiting the
downward percolation of excess irrigation water and therefore develop perched water table and
seepage through the paleo-channels. The automatically extract drainage networks from DEM are
resembling fluvial patterns and coincide with the seepage channels slowly heading toward old
cultivation. The inactive alluvial channels and landforms have to be considered when planning
for new cultivation in dryland catchments to better control water logging and salinisation hazard.
It is highly recommended that newly developed seepage-channels have to be detected and
intercepted before reaching old agriculture areas. Therefore, the “dry-drainage” concept can be
implemented as the seepage water can be conveyed into a nearby playas reserved for
evaporation.

Water logging and soil salinisation is the major threat facing inhabitation and development in the
Saharan areas. Extensive water logging hazard has occurred as the geomorphologic setting was
not considered when developing new agricultural areas. The playas and buried channels of
closed drainage basins are the most vulnerable areas for water logging, particularly when the soil
of higher surrounding areas is cultivated. It is recommended by the researchers that constructed
open drainage networks should coincide with the natural drainage system delineated using
remote sensing and DEM analyses [78].

Development of irrigation infrastructure and its efficient management is the primary concern for
sustainable food production. The assessment of irrigation infrastructure creation, its utilization,
diagnostic evaluation of the various performance indices (monitoring) are important to measure
the efficiency. Benchmarking of Irrigation Systems (BIS) is for the diagnostic analysis of
irrigation performance indicators comprising of Irrigation Infrastructure System (IIS),
Agricultural System (AS) and Water Delivery Dynamics (WDD). Since, the performance of an
irrigation command varies with space and time, utilization of spatial information technologies
viz. Remote Sensing (RS), Geographical Information Systems (GIS), and Global Positioning
Systems (GPS) useful to provide spatial information on several indices in the process of
benchmarking (BM). Information requirements for BIS at different stages, utilization of spatial
information technologies to derive irrigation performance indicators was discussed with suitable
examples and demonstrated in this study. The studies carried out indicates that the geospatial
approach for BIS enabled the improvements in data collection methods, diagnostic analysis,
spatio-temporal visualization of BM indicators at disaggregated canal level which would be useful for decision support during the corrective management measures. The conjunctive use of multi-date (medium resolution) satellite data, high spatial resolution data, field data on water deliveries was found to be an alternative to the conventional non-spatial approaches for BIS and thereby better water resources planning and management. Geospatial approach for benchmarking of irrigation systems was found to be very much useful to evaluate the performance of irrigation command and to know how the performance is varying across the disaggregated units within the command and identify the problem pockets and offers scope to look into the for the alternatives for corrective management. Utilization of satellite data helps to know the existence of crops, cropping pattern, sowing progress at disaggregated level in an irrigation command/ regional-river basin/district/state/country level in spatial domain because of the synoptic coverage and multi-date satellite data acquisition from various satellites/sensors. High resolution satellite data was found to be very much useful for inventory of irrigation infrastructure viz. entire canal network including primary, secondary & tertiary canal networks, outlets, cross drainage structures, other infrastructure etc. The methods suggested by Babu and Shanker et al. (2012) proved to be the alternative for monitoring the status of ongoing projects or verification of existing projects and to identify the infrastructural gaps/requirement in the existing projects. Finally, the methods discussed with suitable examples, flow charts provided will enhance the scope guide the researchers to take up an irrigation command and analyze and use in operational mode [79].

2.4 Application of GIS and Remote Sensing in Soil Management
Timely information on the content and distribution of key soil nutrients is vital to support precision agriculture. The work carried out by Daniel and Tripathi, et al., 2002, describes the newly developed approach, “Spectral Band Cloning” (here after, SBC). The purpose was to enhance the IRS satellite data for soil nutrient estimation, which otherwise was unattainable. The idea emanated from sensors integration, where the intraspectral relationships of spectrometer channels are mimicked by the corresponding IRS bands. New and synthetic bands were generated, which are competent to estimate soil organic matter (SOM). Forty-two samples from topmost soil layer, collected during a satellite-synchronized field survey in Lop Buri, Thailand, were analyzed chemically and spectrally in a laboratory. From raw spectrometer-driven spectra,
SOM was successfully modeled from bands R410, R460, and R480 ($R^2 = 0.85$), which were unobtainable in IRS. The SBC enabled decent modeling of SOM from synthetic IRS bands ($R^2 = 0.72$). The model was implemented and verified on a GIS platform and generated a predicted SOM surface with a reasonable degree of accuracy. SBC is a promising to estimate other indiscernible biophysical parameters, which enhance precision farming, and could be employed to other satellite sensors.

Very few soil nutrients are identifiable (mappable) from satellite sensors. Satellites with very good spatial resolutions are usually composed of few and broad spectral bands, which significantly limits the identification of soil nutrients. Integrating satellite and spectrometers are the current practices for mapping indiscernible earth’s objects. The relationship between surface reflectance values and SOM constituents of samples representative of Lop Buri district, Thailand, were analyzed at cross-platforms.

That research was applied quite the inverse approach with the most currently employed methods from AVIRIS data. Due to the high number of spectral bands in AVIRIS, researches (Hoffbeck and Landgrebe, 1996, Palacios-Orueta and Ustin, 1998, Price 1998, Galvao et al., 2001) employed a mechanism to find out the few, but information-rich bands for nutrient modeling. However, in that study, the approach focused to maximize the existing few spectral bands to the level of adequate prediction of soil nutrients.

The research followed an empirical approach, which involves the derivation of quantified relationship between the remotely sensed data (through synthetic bands) and a measured SOM at laboratory (conventionally). The result does not provide the physics or surface interaction mechanisms. However, the developed method emanated from the knowledge and theory that the chemical components of soils behave differently at certain wavelengths. The study might have the limitation that the derived SBS models are for specific conditions at the time the measurements were obtained [80].

Multi Scanning Microwave Radiometer (MSMR) provides data for Brightness Temperature (TB) at four different frequencies 6.6 GHz, 10.65 GHz, 18 GHz and 21 GHz, at Vertical and Horizontal Polarizations. From the studies there are various models provided for estimating soil moisture, vegetation water content, surface roughness, etc. Due to the complexity of equations used, it is a tedious task to obtain these parameters with better accuracy. In the work carried out by Narvekar, 2003, with a 50 by 50 Km area at Bikaner Rajasthan, India was considered and the
TB data of MSMR of IRS P4, SMMR of Nimbus 7 and theoretical calculations were compared. Plots of TB v/s frequency shows an unexpected fall in TB values at 18 GHz frequency of IRS P4 indicating some problem at 18 GHz of IRS P4. Thus the measurements at 6.6 GHz, 10.65 GHz and 21 GHz were considered.

The results obtained by the research using the technique closer resemblance with the actual ground values of surface parameters. Thus using satellite data it is possible to get idea of the nature of the surface and vegetation presence, which can be used effectively weather forecasting, hydrologists, agriculturist, etc. It has been seen that, microwave polarization difference gives more accurate estimation of vegetation water content and soil moisture [81].

A watershed is the area covering all the land that contributes runoff water to a common point. It is a natural physiographic or ecological unit composed of interrelated parts and functions. In India, the availability of accurate information on runoff is scarcely available in few selected sites. However, quickening of the watershed management programme for conservation and development of natural resources management has necessitated the runoff information. Advances in computational power and the growing availability of spatial data have made it possible to accurately predict the runoff. The possibility of rapidly combining data of different types in a Geographic Information System (GIS) has led to significant increase in its use in hydrological applications. The curve number method (SCS, 1972), also known as the hydrologic soil cover complex method, is a versatile and widely used procedure for runoff estimation. The method of Pandey and Dabral et al., 2003, includes several important properties of the watershed namely soil's permeability, land use and antecedent soil water conditions which were taken into consideration. In that study, the runoff from SCS (Soil Conservation Services) Curve Number model modified for Indian conditions had been used by using conventional database and GIS for Karso watershed (Hazaribagh, India). In that study the methodology for determination of Runoff for Karso watershed using GIS and SCS model was described [82].

With the development of economic activities in the world, the construction activities have also increased manifold. In order to assess the general suitability of the site and to prepare an adequate and economic safe design for the work of Rajesh and Sankaragururaman et al., 2003, proper sub surface investigation was made. The primary objective of subsoil investigation in civil engineering is to determine stratiagraphy and pertinent properties of soil underlying the site. The sub-soil stratum below the ground is always complex. Traditional method of soil
investigation includes boring (or) drilling, test pits, plate/ footing load test, sounding/ probing, dynamic soil test, analysis chemical and engineering parameters of soil or rock sample in laboratory and so forth. Later with the introduction of various indirect methods (involving geophysical investigation such as electrical conductivity test, seismic refraction and magnetic methods) and expansive application of remote sensing techniques in the soil mapping, now more synoptic coverage could be obtained. With the introduction of Geographic Information System (GIS) at present, not only the missing spatial data could be generated to cope with existing geographically referenced data and the corresponding attribute information, but modeling and simulation for specific requirement and fore costing can also be carried out.

The use of GIS in geotechnical investigation has been rather recent in comparison to its own applications such as water resources, agriculture, geology, metrology etc. As for as geotechnical engineering is concerned inclusion of the spatial attributes of the data is itself a significant advance over common practice, where the spatial component of these data is often ignored through the averaging of multiple data values from different location and application of a safety factor to account for variability among other factors. The soil as a whole is a complex material, it is always heterogeneous and non-isotropic because of which profile of soil will be entirely different from place to place.

The research work of the upper said researchers aiming the suitability of shallow foundation using GIS/ LIS for the southern part of Chennai, India will be very useful for all Civil engineers, Geotechnical Engineers, Design Engineers, Planners and even the local inhabitant for any future developmental activities in the area concerned. In fact, for any specific location, with suitable queries, the allowable load intensity of soil and the suitable foundation can be obtained, which is found to be close to the actual findings at this location. Another advantage with the work is its flexibility with respect to adding data as well as adding few non-spatial parameters like depth of water table, surface drainage pattern, soil permeability and infiltration capacity and so forth [83].

Nowadays, the degradation of renewable natural resources is one of the most important problems of human. Soil is one of the most important natural resources and the degradation of that is caused, the decline of fertility, weakening of plant cover and at last aggravation of desertification specially in the arid and semi-arid regions. In accordance with the estimation of FAO, in excess of 75 billion tons soil in the whole earth is eroded. In the neighborhood of 76 percent of Iran exposed to the erosion. In Iran, the climate variation and topographic conditions
have important role on the increasing of erosion. The study area (of Tajbakhsh and Memarian, 2003) has located in the northeast of Taibad town (Khorasan province, Iran, between 60° 00' to 60° 30' E and 34° 30' to 35° 00' N). This area locates into Qareqoom basin. With due attention to the suitable compatibility of MPSIAC model to arid and semiarid conditions of Iran in the erosion and sediment studies of these watershed was applied. In that study newest GIS softwares to obtain a good and accurate result at the least time were used [84].

Soil erosion is one of the most critical environmental hazards of recent times. A large area suffers from soil erosion, which in turn, reduces productivity. Methods such as the Universal Soil Loss Equation or Revised Universal Soil Loss Equation are widely used for the estimation of soil erosion from catchments areas. The proposal of Biswas, S., 2012, deals with the estimation of soil erosion using Universal Soil Loss Equation in a GIS environment and prioritization of catchments on that basis. Upper Kangsabati catchment in West Bengal, India was taken as the study area. Satellite Images of IRS P6 LISS III have been georeferenced with respect to SOI toposheets(1:50,000 scale). The drainage network and the catchment have been identified from the mosaiced toposheet and updated from satellite imagery. Landuse, soil and slope maps were prepared from Survey of India maps and NBSS & LUP maps and integrated into GIS database. Soil erosion of each of the subcatchment was estimated from the integrated map. The subcatchments were prioritized based on the estimation of erosion. From the study it can be inferred that soil erosion estimation using Remote Sensing and GIS technique can be effectively used for prioritization of catchments and this helps in the way the catchments can be taken for treatment for conservation measures [85].

2.5 Application of GIS and Remote Sensing in Geology

Data generated from the modern day exploration campaign are not only diverse but voluminous also. Sophisticated geological, geochemical, remote sensing and geophysical techniques combined with high-resolution ground and air-borne geophysical surveys are not only making mineral exploration more laboratory oriented but also makes the task difficult for interpretation. Many sophisticated techniques like stable and radiometric isotope analysis, fluid inclusion study and litho-geochemistry are introduced in exploration campaign for proper understanding the process of mineralization and in turn also used for generation of genetic/exploration model for that commodity. Hence, the positive result of modern day exploration lies in the effective
analysis of the datasets, the extraction of only the exploration relevant factors and integration of these factors to a single prospectivity map (Knox-Robinson, 2000). Visualization and integration of these high volumes of data require an analytical system viz. GIS, which has been designed for effectively store, interrogate and integrate diverse spatial and non-spatial data to generate prospectivity map depending on a hypothesis. Over the past decade, a number of techniques have been evolved to make use of exploration dataset and construct maps that illustrate how mineralisation potential or prospectivity changes over an area (Knox-Robinson and Wyborn, 1997). The GIS modeling methodologies in prospectivity mapping of a commodity can be categorized either as knowledge driven or data driven. There are several knowledge driven modeling approaches are available and which can be effectively transformed into GIS analytical environment: some of which can be summarized as Boolean logic, Index Overlay, Fuzzy Inference analysis and Vector Fuzzy modeling [86].

The study area (of Ranjbar and Shahriari et al, 2003) is located in the southern part of Central Iranian Volcanic Belt has a great potential as far as porphyry copper mineralization is concerned. Darrehzar and Sar Cheshmeh porphyry copper deposits are presently mined for Cu, and Mo in the area. The area has a semi-arid type of climate and has a mountainous topography. Vegetation cover is substantially poor in the area. Porphyry type deposits are associated with hydrothermal alterations such as phyllic, argillic, potassic and propylitic. Hydroxyl minerals are abundant in the phyllic, argillic and potassic zones. At the same time, an oxide zone is developing over many of the porphyry bodies, which are rich in iron oxide minerals. These alteration minerals can be detected by remote sensing techniques. Hydroxyl and iron oxide minerals can be identified through remote sensing techniques (e.g. Rutz-Armenta and Prol-Ledesma, 1998; Tangestani and Moore, 2001). Landsat data has been used for a number of years in arid and semi-arid environments to locate areas of iron oxides and/or hydrous minerals which might be associated with hydrothermal alteration zones. ASTER sensor onboard Terra platform has more capability in terms of spatial and spectral resolution than Landsat. Theoretically, the SWIR bands of ASTER have more capability than the landsat for recognition of areas with hydrothermal alteration. The study of the researcher aims at evaluating ASTER and ETM+ data for enhancing the areas with hydrothermal alteration.

Comparison of Landsat and ASTER data over known altered areas shows that ASTER data has more capability than Landsat data for enhancing areas with hydrothermal alteration [87].
The Neyriz ophiolite occurs along the Zagros suture zone, SW Iran, and is part of a 3000-km abduction belt that was thrust over the edge of the Arabian continent during the Late Cretaceous. This complex lithologically consists of ultramafic unit, layered and massive gabbros, sheeted dykes, and pillow lavas, surrounded by radiolarites and limestone. The TIR and VNIR+SWIR datasets of Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER) instrument were used for enhancing the rock units. The VNIR-SWIR spectra of field samples were measured and implemented as the potential spectral end-members, as well as the published spectra of the USGS library. ASTER matched-filter and spectral angle mapper (SAM) algorithms as well as minimum noise fraction (MNF) and principal components analysis (PCA) processing were used for lithologic mapping. Output images were compared and evaluated with the field evidences in order to evaluate the capability of each dataset in mapping the lithological units. Results obtained by the researchers showed that TIR dataset enhances the ophiolite units more efficiently and discriminates the ultramafic, pillow lavas and sheeted dykes as well as the radiolarites and marbles; while the VNIR-SWIR dataset enhances different Cretaceous rock units, northeastern Zagros suture zone.

The recent development of truly multi-spectral remote sensing systems such as the ASTER instrument potentially offers geologists a cost-effective solution to expensive and time-consuming regional mineral exploration and geological mapping. Subtle spectral reflectance differences recorded in both the VNIR and SWIR wavelength regions are an important basis for identifying specific individual minerals and mineral groups and is a significant advancement over earlier sensors.

Digital image processing techniques such as PCA, spectral angle mapping, and matched filtering were implemented by the researchers on both VNIR-SWIR and TIR datasets of ASTER using the spectral characteristics of rock units exposed at the Neyriz ophiolite zone. The PCA technique is very effective for discriminating rock units where spectral information is not available and/or ground truth is limited. Performing PCA approach on SWIR dataset enhances marbles, basic alluviums and gabbros. A RGB color composite image generated from PCA outputs of thermal bands 10, 12, and 13 discriminates most various rock types in different colors. Examining the output Rule images, derived from performing spectral angle mapping on dunite, gabbros, pillow lavas and marble spectra showed that the enhanced areas were coincided on the relevant rock exposures in geological map and as observed in field. Although main rock types
are showed in a RGB color composite generated from components 1, 2, and 3, of minimum noise fraction algorithm, gabbros are not discriminated from peridotites in the same colored image. Performing matched filtering on SWIR and TIR datasets using the spectra of marbles, dunites, pillow lavas and gabbros results in enhancement of these rock types. The results obtained from the work on the ASTER data of Neyriz ophiolite zone and adjacent outcrops showed that the main lithologies can be mapped using the compositional information derived from spectral characteristics of the samples. Although using VNIR-SWIR data enhances some of the ophiolitic units, but spectral similarities between rock units prevents the mapping of all the lithologies, however, the datasets show the carbonate units at the northeastern and southern the study area. The researchers suggested that the TIR data of ASTER could successfully discriminate mafic-ultramafic rock units as well as radiolarites, the main lithological units of the ophiolite zone [88].

Principal component analysis is a well known method of orthogonalizing data. It converges very fast and the theoretical method is well understood. Basically image processing is used for extraction of required information. The study (of Mirzavand and Mirzavand, 2006) begins with remote sensing techniques and PCA applying on enhance thematic mapper (ETM+) satellite image dated 2002 for central of Iran, west Esfahan city. The study of the researchers presents two methods of enhancing igneous body consists of amphibolites and volcanic using optimum index factor (OIF) and Crosta. The optimum index factor allows using the multi-spectral data for understanding the best false color composite (FCC) image. It is also highlighted the required spectral range (bands) for classification of image to enhance the igneous bodies. The Crosta technique is based on PCA using eigenvector enhanced the spectral behavior of minerals. The objects on the image are enhanced in terms of black and white with respect to eigenvector loading. 27 FCC images were produced and analyzed using OIF. It was shown that the classification on FCC images for bands 741 and 541 of Infra-red and FCC images for band 654 and 641 of Thermal infra-red are the most accurate composite color images to enhance igneous body, amphibole and clay minerals. The study of the researchers reveals that the PC3 is increasing the enhancement for reorganization of amphibole minerals in orthoamphibolite rocks. It was also shown that PC5 has suitable enhancement to identify the clay minerals in granite rocks. However that study also indicated the use of optimum index factor for identification of spectral bands to give more information about minerals on the image using classification.
techniques in arid and semi-arid environment where vegetation cover is scanty. That study also represents the use of remote sensing techniques for exploration [89].

Combinations of reflectance spectroscopy and various constituents matching algorithms have been successfully used to classify and to detect geomaterials in field of remote sensing. Measuring reflectance spectra on the rock surface can be applied to assess degradation of rock surface as a new non-destructive inspection method. In the proposal of Hyun and Park, 2006, the spectral reflectance of weathered granite specimens of Mt. Gwanak were measured by using field spectrometer and spectral characteristics of reference minerals were used to identify rock-forming minerals of the granite from the spectral reflectances obtained using field spectrometer. Granite is mainly composed of quartz, feldspar and mica. Hardness and durability of quartz are greater than other granite forming minerals and quartz has no diagnostic peak in spectral reflectance curves, but feldspar and mica produce clay minerals, such as illite and kaolinite, according to weathering processes. The comparison of the amount of the clay minerals using absorption peak in the spectral reflectance curves among differently weathered granite specimens could result in newly designed weathering indices against rock surface mineral composition [90].

Nigeria is endowed with varieties of solid minerals in addition to the abundant oil and gas reserves that have been driving the country’s economy since the mid-70s. About 35 minerals of proven reserves abound in the country. Due to the vastness of these resources, there is the need to establish a database that would enhance and optimize their exploration and exploitation with the aim of deriving maximum benefits from such venture.

The study area of Anifowose and Bamisaye et al., 2006, Igarra, is located in Edo State, southwestern Nigeria. While the northern part is underlain by crystalline rocks of Precambrian age, the southern part is covered by Cretaceous to Tertiary sedimentary rocks. Landsat-7 ETM imagery was utilized in ILWIS® environment to delineate lithological boundaries in the study area. Field observations were carried out at 37 localities in order to evaluate the rock/mineral type and mining activity at each locality.

A Geographic Information System database of the mineral resources of the study area was established, and utilized to carry out a digital update of the existing geological map. That is expected to contribute accurate and up-to-date metadata to Nigeria’s National Geospatial Data Infrastructure (NGDI) which is at its formative stage.
The study has revealed that there is improvement in mineral resources data management in the study area compared with the conventional resource management technique. With the creation of a GIS database of the mineral resources in the study area, accurate representation of locations of mineral deposits and their characteristics can be provided and can be easily updated over time. Also, with the eventual legislation of Nigeria’s Geospatial Data Infrastructure policy, the country will be in a good stead to tackle the problems generally associated with data collection and access for planning purposes and decision making [91].

Different types of asbestos have been mined in South Africa for more than ninety years. However, the mines have been decommissioned because of the negative social health impacts and environmental degradation associated with asbestos mining. A majority of the mines have been rehabilitated over the years since they were decommissioned. Despite the rehabilitation process, field evidence shows that traces of different asbestos minerals appear scattered even on the rehabilitated environments. The study of Petja and Twumasi, et al., 2006, investigates the feasibility of using remote sensing to differentiate different types of asbestos minerals. An ability to separate different types of asbestos will play a significant role in developing spectrally based mapping methods to detect the spread of asbestos. Analytical Spectral Devices (ASD) Field Spectrometer was used to collect spectra of asbestos minerals that occur in South Africa. Spectra of soil and water samples were also collected from the rehabilitated environments to determine the presence of asbestos minerals. The collected spectra of asbestos minerals will be used to discern the possibility of using asbestos spectral library to map distribution of asbestos minerals in the post mining environment for effective monitoring of environmental pollution.

The study demonstrated the separability of different asbestos minerals using field based reflectance spectroscopy. The potential for detecting the presence of asbestos minerals in water bodies was also examined using the remote sensing techniques. The information derived can be used as a valuable input to carry out spectrally derived mapping of minerals and pollution in the mining environment. However, cost and accessibility of hyperspectral images may become a limiting factor [92].

2.6 Application of GIS and Remote Sensing in Geomorphology

A remote sensing study of structural (tectonic assemblage) and network drainage systems of the South American continent was made. The researchers used SAC - C raw scenes and composed
free mosaickings” of Landsat TM 5 images which were released by the Geological Survey of the United States (USGS) in the servers. They assembled the SAC-C images in graphic design programs. The LANDSAT TM 5 satellite series, which were nine scenes assembled per each digital archive were handled by means of digital image processing software. They determined the main structural lineaments, geological regional units and the principal drainage systems, including Amazonas, Orinoco, Del Plata, Paraguay, Uruguay and Paraná rivers catchments. Both visual and digital interpretations were made always helped by field works. Continental and regional studies are largely improved by using satellite images of these kinds which carry medium spatial resolution sensors. It is very useful for make preliminary structural and drainage interpretations helping land-use and land-management projects due to relative low cost and rapid peer review of the relief and structural framework [93].

Three kinds of approach was attempted to identify the changes of coastal and off-shore morphology of the Gulf of Mannar. Survey of India (SOI) topographic map (1969) and IRS LISS-III (1998) satellite data were used for shore line change and coastal land form mapping. Multi-date bathymetry data (1975 and 1999) were used for bathymetry mapping and identify the seafloor change. The multi-date shoreline date analysis indicates that 23.49 km$^2$ and 4.34 km$^2$ of the mainland coast and 3.3 km$^2$ and 4.10 km$^2$ of island coast have been accreted and eroded over a period of 30 years (1969-1998). The multi-date bathymetry data analysis indicates that the 0.51m sea floor depth have been decreased all along self region of the Gulf of Mannar. Seaward migration of shoreline, newly formed spits, swales, beach ridges, mudflat, strandlines and reduction of seafloor depth indicates that the Gulf of Mannar sea floor have been rising by tectonic movement.

Remote sensing and GIS techniques are most useful for coastal landform, shore line change and bathymetry mapping. Interpretation of IRS LISS-III imagery aids in demarcating various coastal geomorphologic features like beach, spit, beach ridges, swales, mudflat, back swamp, dune complex, teri sand, natural levee, flood plain, deltaic plain, flood plain, strandline, etc. All the coastal geomorphologic features such as shoreline changes, bathymetry changes and coastal landform, in particular, spit, beach ridges, strandlines, swales and backwater system, back swamp, mud flat etc. indicate that the Gulf of Mannar coast is going on emerging [94].

The Gulf Coast is a major source of oil and gas for the United States. In Texas, an oil field over a salt dome known as Spindletop started the Texas Oil Boom. Salt domes are great traps because
they are mostly impermeable and create an upward structure for oil and gas to accumulate. Several salt domes have been documented in and around the Houston area such as Pierce Junction, Mykawa, and Webster to name a few. The diapirism of the salt domes can be attributed to regional extension and sedimentation. Monitoring the topographical changes directly above salt domes can give insight to subsurface movements of the salt. Geographic Information System (GIS) and remote sensing techniques are used to quantify surface movements of the salt domes in the Houston area. Data collected by Light Detection and Ranging (LiDAR) and Global Positioning System (GPS) allow detection of surface changes on a centimeter to millimeter scale. Preliminary statistical analysis of Digital Elevation Models (DEM) over a span of 12 years (1996, 2001, and 2008) showed increased surface changes over some salt dome locations. GPS studies from Engelkemeir (2008) and the Harris-Galveston Subsidence District (HGSD) show most of Houston is subsiding. Areas that are not subsiding or rising are mostly over known salt dome locations. Gravity surveys will be conducted over these areas to ensure that it is salt under these areas. Areas over salt domes should have a significantly different reading compared to areas without a salt dome. Quantitatively tracking surface movements of salt domes can be an easier and cheaper alternative to subsurface monitoring. Variations or abnormal movements may signify regional tectonic activity.

GPS, LiDAR, and gravity are all powerful tools. The GPS data documented substantial subsidence and uplift in the Houston area. These surface deformations may suggest continued salt withdrawal and salt diapirism. DEM derived from LiDAR documented elevation changes between areas within the salt domes and their surroundings. This could suggest salt movement, possibly the result of secondary salt withdrawal during diapirism. The changes in the gravity measurements could be another indicator of subsurface salt movements. Although salt withdrawal and salt diapirism could cause all the observed results another large factor comes into question, groundwater. Groundwater withdrawals have been targeted as one of the main causes of subsidence in the Houston area for decades. This extremely impactful anthropogenic factor may skew most if not all natural surface deformation in the greater Houston area. Natural factors that may influence subsidence such as salt withdrawal may be largely overshadowed by groundwater withdrawals [95].
2.7 Application of GIS and Remote Sensing in Land Information System

Geographical Information System (GIS) technology provides municipal governments with extraordinary quantitative and qualitative benefits. In fact, the technology can be the basis for revolutionizing how government processes work. Some of these benefits and changes can be achieved fairly early in the GIS development process; while others take much longer to realize. A GIS may take several months to develop and the full benefits are experienced after many years. The time requirement is only partly what is required to build a database and procure a system. Technology transfer and capacity building for effective utilization of the system, and perhaps more importantly, synergizing existing work processes can be as complicated as the development of the system itself.

A comprehensive municipal GIS should provide a common platform for data collection, storage, authorized and secure access to spatial and a spatial data harmonize the work flow of respective departments and disseminate information for the benefit of public at large. Municipal GIS will largely address the needs of various local government departments such as Local Administration, Public Works & Engineering department, Public Health Department, Water supply, Town and Country planning Department, Public Safety, Land records, Tourism Department etc.

The proposal of Padaki, et al., 2003, enumerate the need for a municipal GIS solution for various departments, suggested approach for implementing a system, Enterprise GIS approach to municipal GIS, successful case studies implemented by Magnasoft for municipal GIS, hurdles for making municipal GIS a success and the future road map for municipal GIS in India [96].

In India land records are maintained by district administration for deciding ownership and boundaries of land or property. The process of defining and determining land in favor of an owner is called registry of land. Municipal Corporation also uses the ownership information for tax collection. Land records maintained on paper or cloth has preservation, updating and retrieval problems. Computerization is natural solution for all these problems. The government of India has already taken initiatives to computerize land records in the country. According to computerization scheme was started in 1988-89 and extended further in phased manner throughout the country. At present (2003) the scheme is implemented in 544 districts leaving only those districts where there are no land records. So far the progress is concerned only five districts have completed computerization and Records of Right (ROR) are being issued to
landowners. According to TV (television channel DD1) news Karnataka state has completed computerization of all land records in the state. Jain & Singh, et al., 2003, designed and implemented Land Record System (LRS) by taking specific case of district Hamirpur of Himachal Pradesh. The design of LRS was extended to convert it into nationwide LRS and nationwide information system. Case study of LRS for district Hamirpur (HP) is implemented successfully. All queries implemented were working properly. Map of a plot is represented as an image using OLE data type. In order to make uniformity in management of land records throughout the country, that nationwide LRS was very useful. The system was suggested for further extension to include information like population, literacy, soil type, crop, sex ratio, rain fall, school, hospital, bank, post office etc. The extended system can be termed as Nationwide Information System to satisfy the needs of district administration, state and central government. The researchers suggested that the consistent structure of information can be made with the consultation of district, state and central govt. concerned officials. The system could help to the district administration to have a close watch on balance development of the district. The nationwide latest data will help the governments to make macro level planning for balance development of the country. The accessibility of the system through Internet will solve a number of land disputes generally take place in rural areas of Bihar and Uttar Pradesh. It will also provide transparency in government functioning. According to the opinion of the researchers the system can also be converted for on line sale and purchase of land through Internet. There is need to have cooperation among various departments of government at different levels to take initiatives for developing Nationwide LRS / Information System [97].

Global environment is a dynamic feature influenced by natural phenomena as well as human activities. Industrial development considerably accelerates the rate and speed of such changes. Agriculture lands are due to significant changes in different aspects. Land use changes are the result of several factors. Population increase requires more need for food thus more lands are needed to go under cultivation. Land use changes are influenced by several factors and some complicated processes are involved in this concern. Dividing agriculture lands into small sizes according to Islamic heritage law, urban and industrial development or any other improper land use changes are all factors which may affect the case. Updated cadastre maps are needed to show these changes particularly in rural area for efficient management of agriculture lands. Cadastre
maps as well as its application have already been discussed, but temporal changes of different land use have not yet been considered. The study of Ahadnejad-e-Reveshti, 2003, focused on annual changes of cadastre maps from several points of view. The results of the research disclosed that agriculture lands are due to annual changes. Precise updated maps are required to study and monitor all these changes. Therefore high-resolution satellite data as Ikonos and Quick Bird are needed to monitor the trend of changes. It will be time consuming and expensive if such study is conducted in small scale. Besides a continuous monitoring possibility satellite imageries will also reduce the time as well as expenses in these types of studies. Besides that land Information systems (LIS) is needed for better management of agriculture lands in rural area [98].

It is a general misunderstanding that a high land price real estate market must have an accurate land boundary system. Being an internationally well-known and expensive land market, Hong Kong adopts only an approximate land boundary system which attaches to the deeds registration for all land grants from 1842. Land boundary conflicts are daily matters for land surveyors but court dispute cases surface only few times in a year. Using different epochs of land grants, the proposal of Tang and Yau, 2006, classifies the general accuracies and problems in land boundaries in Hong Kong. The typical boundary accuracy and serious boundary problems of each epoch are described. The types and trends of the boundary problems are thus grouped and analyzed.

To upgrade and provide secure rights on the extent of a property is certainly the duty of a government. In the coming era of e-government, spatial data infrastructure would necessarily be built on accurate property boundary layer, otherwise, cost and responsibilities cannot readily be estimated at the land parcel level, and developments are unnecessarily retarded. Opposite voices are always based on the huge cost of survey, which is untrue and there are successful cost-effective cadastral reform examples. We need a willing and able government to take the lead to break the inertia. It is difficult, so there are always rooms for improvement [99].

The purpose of the research of Miin and Wei, et al., 2006, is to explore a new procedure on a class basis approach to extract several land cover types. Kuala Lumpur City Centre, which is a dense urban area, has been chosen as the study area of the research. Multispectral QUICKBIRD imagery and high resolution LiDAR (Light Detection and Ranging) data were used in that study. LiDAR data enabled the identification of buildings and other elevated features from non-elevated
urban features like roads and vacant lands. It was very complex to differentiate between roads and some of the vacant lands from VHR (Very High Resolution) imagery accurately especially using traditional classification methods due to the similarity of the reflectance of spectral and spatial characteristics. The eCognition software was used in the study to implement the fuzzy classification according to the shape feature of the image objects. Fuzzy classification is a simple technique, which basically translates feature values of arbitrary range into fuzzy values between 0 and 1, indicating the degree of membership to a specific class. The compactness feature had been used to distinguish the road and vacant lands. Accuracy assessment and visual interpretation proved that class-basis classification approach was providing a promising result [100].

Recently, high-spatial resolution imagery has widely been used for environmental assessment and mapping in Indonesia. However, most of these studies made use of visual interpretation instead of digital classification for generating land-cover/land-use information from such imagery. On the other hand, digital classification was usually applied to deliver land-cover information or mixed information between land-cover and land-use with relatively general categorization, so that the results were not adequate to support planning. Danoedoro, P., 2006, tried to extract land-use information related to socio-economic function by combining spectral classification, image segmentation and visual interpretation of Quickbird imagery covering Semarang area, Indonesia. For that work, a multi-spectral classification was run to derive detailed spectral-related land-cover classes. Image segmentation and visual interpretation were also carried out to generate spatial pattern of the land-cover features. A classification scheme under the versatile land-use classification system (VLUIS) was used as a reference. Integration of the spectral-related land-cover and spatial pattern maps was controlled using a knowledge-based approach, by formalizing knowledge about spatial relationship between land-cover, socio-economic function, spatial pattern and their ecological context into a set of GIS rules. The result showed that Quickbird imagery could be used for generating socio-economic function of land-use at 83.63% accuracy (Kappa=0.821). In addition, several limitations related to the methods used and inaccurately mapped categories were identified by the researchers [101].

Applications of cartography in rural mapping are age old and this art has taken various turns since from its existence till today. The new trends in cartographic development has endeavor this art with digital techniques. The making and use of computer based systems for the
cartography is added advantage in reproduction and multidisciplinary use and analysis of thematic mapping in the rural development activities. In fact this transition to "computer cartography" started long time ago. It is worth noting, however, that the pace of change towards an electronic future is variable across the world. Digital cadastral maps are being produces as cartographic maps, which provide an overview of some of the major trends and concerns in digital cartography. The proposal of Singh, 2006, was attributed the contribution of applications of CAD (Computer Aided Drafting) in digital cartography in addition to Geographical Information Systems applications for thematic mapping through digital analysis. Digital cadastral maps were used as a media for generating and preparation query cell for rural planning as well.

Every activity needs proper planning, reporting and monitoring. A well-formed information base is most essential for support during these processes. The graphical form of data is most easily understood at any level of functionary and is most properly interpreted, and useful actions can be followed. As far as storage and processing of information is concerned, computers are already quite accepted tool. Computers mainly help in storing information in the form of maps and help the user in performing complex tasks in such simplified way. Sketchy maps and illustrations used to record land ownership and revenue information in India, later gave rise to cadastral maps. Assessment of crop yield and fixing the governmental share became a major activity of revenue administration. Scale alteration and superimposition are hard exercises if one is working with printed maps (on paper), but the same are easily performed through digital maps.

Beginning in the 1970's, many mapping experts adopted a communications model for cartography, understanding maps as tools for the communication of information from cartographer to map user. With the rapid progress in computer technology afforded by the ubiquitous personal computer, in the last decade a number of cartographic researchers, led by Alan MacEachren, 1995, have suggested a new way of understanding how maps work. Rather than attempting to make a best map, modern computer technology can allow for the preparation of multiple representations of a phenomenon that can be used to answer different questions. High-resolution digital data (satellite image / aerial photographs) can be used for capturing the individual land holdings. It also aids in easy retrieval and manipulation of data, to update new land parcels to enable periodic report generation and its changing pattern. Based on the requirement of different departments and NGOs and approval of authorities extensibility of
digital cadastral mapping can be provided to make the Land Records easy to use. Thus, creating a transparent administrative environment, most State Land Records Departments could use the methodology to make it usual practice [102].

In India, the “concentration of scheduled caste and scheduled tribe population”, is a commonly used surrogate indicator for measuring economic backwardness. The researchers undertook a poverty mapping study in the state of Sikkim using scientific economic criteria, to identify the poor households. This extensive household census covering all the 905 villages and 93,463 rural households, identified 19,235 poor households (2010). The village poverty rate showed a large variation from 0 to 72% (20.58+ 13.85%). No significant correlation (r = – 0.05%, n = 905) could be found between the village poverty rate and the percentage of scheduled population. Hence the researchers propose using a scientific economic criteria rather than a caste based criteria to measure poverty.

Concerns have been raised on the ‘invisibility’ of mountain states in national policy, possibly because they are considered as an insignificant part of the total territory, or seen as too sparsely populated to be of political importance (Browne et al. 2004). Based on the findings of the study, the researchers propose that firstly, the economically backward 122 villages should be targeted in the ongoing developmental programs; secondly the criteria and indicators used for measuring backwardness should be regionally customized, to ensure a more universal applicability especially for mountain states. Also along with proxy indicators, possibilities of using scientific, economic criteria for measuring poverty and backwardness should also be explored. Resource allocation of poverty alleviation programs which use a scientific economic criteria rather than a caste based criteria for defining poverty and backwardness will be more effective. Thirdly instead of selecting district as the planning unit for social sector programs, targeting smaller areas i.e. blocks or villages, will help in an increased coverage of the poor, and reducing leakage to the non poor. Further studies are needed to identify the determinants of poverty, which will aid in the scientific designing of poverty alleviation programs [103].

Numerous and diverse stakeholders need to work commonly to meet the issues of the urban governance and management. Today two technologies – 3D and virtual reality – are able to answer the requirements by enabling decision-makers to understand and explain in 3D the large urbanism and architecture projects, to analyze and validate a master plan, to assess territory risks, to communicate about the city and to let people discovering it by Internet, to supply data to the
GIS applications, to have at your disposal data relevant for civil security, to create a urban database for consultancy of developers, town planners, architects. Moreover, the set of the business linked to the urban management creates a multiplication of data. So it is essential that all data are interoperable within SDI for all applications and businesses. Expert in 3D virtual environment and supplier of 3D georeferenced databases, the Group Vectuel will share its experience and knowledge on how these technologies can help you to optimize your urban governance and management [104].

The need for effective planning and disaster prevention is the main reason for real time data generation provided by Remote Sensing and GIS. Zaria is fast becoming more unplanned due to increase in population and the consequent human influence leading to high rate of land use-land cover change. The study of Abbas and Arigbede, 2011, looks into changes in land use-land cover between 1985 and 2005 with a view to providing database for future planning. Landsat, spot and digital globe imageries for 1985, 1995 and 2005 respectively were used for the analysis. The result shows that built-up areas increased from 2.3% in 1985 to 36.4% in 2005, water body decreased from 22.5% in 1985 to 6.5% in 2005 while cultivation decreased from 44% in 1995 to 40% in 2005 sending a bad signal of imminent food crisis if not checked. The process has led to elimination of the crop, forest and scrub land mostly towards the eastern and southern outer limits of the city. The growth of built-up areas is mainly towards the east-west route in a linear pattern.

Land evaluation helps to know how the different landuse landcover classes have performed (decrease or increase) over time. With this in mind, sustainable land planning and management can be done to cater for the causes of the changes especially population influx. Indeed, between the period of 1995 and 2005, there has been significant increase in the spatial expansion of Zaria compared to the period between 1985 and 1995. There is a possibility of continual increase in this region in the near future. The study therefore suggests that the city has increased in producing functions that attracted migration into the area. After the initial increase in farm land between 1985 and 1995, the city witnessed a steady drop in this land use and in deed, may continue in this trend if not checked. In view of this, the study shows the importance of Remote Sensing and Geographic Information System techniques in change detection and land uses monitoring. If the land change pattern and trend of a place is known, then sustainable land planning can be embarked upon to have sustainable land management and development that is
eco-friendly. It is suggested here that a deliberate attempt should be made by the local government to reverse this trend since this could lead to major food insecurity in the future [105].

2.8 Application of GIS and Remote Sensing in Natural Hazard Management
Since the earthquake disaster that struck Yogyakarta and Central Java, Indonesia on 27 May 2006, the issue of Geospatial infrastructure has become central. From the disaster event, it has been observed that the lack of geospatial data availability and access has caused inefficient and uncoordinated disaster response to the disaster conducted by agencies and community. That condition had motivated the research of Santosa and Heliani, et al., 2007, to develop a local collaborative geospatial data infrastructure (CGeoSDI) which would be accessible by related agencies, referred to as collaborators, and effective in facilitating coordination in response to a disaster. The paper of the upper said researchers examines and evaluates aspects and existing condition contribute to the process of developing the system. Examination and evaluation was based on five components i.e. people, access network, policy, standards, and data. Results showed that there are some impediments in developing that system. Issues related to these components need to be taken into account in developing the system, and some improvements need to be conducted to them in order to be able to successfully develop and employ the system for real actions.

A Collaborative GeoSpatial Data Infrastructure (CGeoSDI) design system has been developed in that research. This system was designed based on the principle of efficient and effective use of geospatial data for collaborative works between parties/agencies in disaster management activities in Yogyakarta. Several aspects necessarily considered in developing the system include: people, data, access network, standards, and policy. Existing condition evaluation to these components showed that the development of such a CGeoSDI in Yogyakarta had been hindered by technical and non-technical obstacles. Some strategies had to be defined to overcome those obstacles in order to be able to develop as well as to implement the system. That was not trivial task since the impediments to overcome were too broad and complicated. However, the development of CGeoSDI which was part of disaster management program was urgently needed. It would not to wait until the next disaster event to occur to start developing and implementing such a system. It should learn from the past deadly disaster events [106].
Esfandiar Zebardast, PhD Associate Professor and Associate Dean for Research School of Urban and Regional Planning University of Tehran, Iran E-mail: zebardst@ut.ac.ir Mohammad Javad Koohsari Graduate Student Abstract Iran has experienced many destructive earthquakes in the last few decades. These earthquakes have resulted in the death of thousands of people and destruction of many villages and cities. Tehran City, the capital of Iran, with a current population of about 7.6 million is located at the foot of the southern slopes of the Alborz Mountain Range that form part of the Alps-Himalayan tectonic zone. This zone is one of high seismic potential with many peculiar active faults. Seismologists believe a strong earthquake will strike Tehran in the near future. While natural hazards will continue to occur, their capacity to become a disaster or merely a manageable event depends on many factors, including the magnitude of the hazard, the vulnerability of people and their communities, and the built environment. In the work of Zebardast, 2007, a methodology for assessing social vulnerability of individuals within households to risk from earthquake hazards was developed, using AHP and GIS, and applied in Zone 6 of Tehran City. The methodology started by selecting social vulnerability indicators from the literature and then collected the relevant data needed for the analysis. AHP was used to identify how those indicators contribute to the vulnerability of a person within a household, and GIS was used to map the social vulnerability of the individuals in zone 6 of the Tehran City. Although there is no consensus about social vulnerability or its correlates, using the proposed model of vulnerability, the researchers suggested that social vulnerability is a multidimensional concept that helps identify those characteristics and experiences of individuals and communities that enable them to respond to and recover from earthquake hazards. By using the social vulnerability index, mitigation efforts can be targeted at the most vulnerable groups or census blocks level. The development and integration of social, built environment, and natural hazard indicators and models will definitely improve our hazard assessments as well as mitigation efforts [107].

Temporal sheltering is a very important issue in disaster management, since optimum temporal settlement of people in predefined safe areas may decreases the number of victims who would faces with post earthquake disasters. For an optimum sheltering, several factors should be considered including minimal movement of people and homogeneous distribution of victims in safe areas with respect to their. In the context of research project, RS and GIS techniques were utilized for optimization of temporal settlement in three steps. First, determination of safe areas,
second, determination of optimum path between building blocks and safe areas, and finally grouping of building blocks relating to each safe area [108].

Over the last decades, the world has become increasingly vulnerable to natural disasters. Population growth and the increased concentration of physical assets in high risk areas are leading to increased exposures to adverse natural events. Unplanned and unregulated land use, lack of environmental controls, and the poor application of building standards contribute significantly to asset losses in the region. The trend toward increased vulnerability is likely to continue and when coupled with increased climatic variability, resulting from global climate change and future losses from natural disasters like earthquakes are expected to rise.

The acceptance of disaster-preparedness, where international financial institutions, national governments and large development agencies see mitigation strategies as an important part of their work, is now recognized as crucial by experts on disaster-risk reduction. GIS provides an opportunity to civilian authorities and international agencies to enhance their preparedness for coping with natural disasters in general and earthquakes in particular. Poor people in developing countries are particularly vulnerable to disasters because of where they live. Research shows that they are more likely to occupy dangerous locations, such as flood plains, river banks, steep slopes, reclaimed land and highly populated settlements of flimsy shanty homes.

The earthquake that devastated Bam in Iran in December of 2003 killed more than 40,000 people mainly because their housing was not designed to handle a major tremor. The availability of a probabilistic risk assessment tool may have better prepared the government to handle the situation. It is the mixture of available GIS technologies like ESRI ArcGIS and accurate data capture on the ground and probabilistic risk assessment that can help the preparedness for such events. Tangri and Jena, et al., 2008, described how the use of GIS technologies and probabilistic risk assessment can better prepare us for handling and responding to earthquake risk in the world [109].

Seismologists have not yet found a reliable earthquake precursor. In order to look for a reliable earthquake precursor a remote sensing based thermal technique has been employed recently based on the concept that stress accumulated in rocks in tectonically active regions may be manifested as temperature variation through a process of energy transformation. Rise in land surface temperature (LST) before an impending earthquake has been detected for 23 earthquakes using pre- and post-earthquake datasets of thermal sensors such as NOAA-AVHRR, Terra/Aqua-
MODIS and SSM/I for the different parts of India and the world. Analysis revealed a transient short-term thermal rise in LST ranging from 2-12° C around epicentral areas of different earthquakes. In the studied earthquakes, pre-earthquake thermal anomalies generally started developing about 1-10 days prior to the main event depending upon the magnitude and focal depth, and then disappeared just before the main shock. This temperature increment prior to an impending earthquake can also be attributed to degassing from rocks under stress and/or to p-hole activation in stressed rock volume and their further recombination at the rock-air interface. A precise correlation of LST maps of Bam (26 Dec 2003, Iran) and Zarand (22 Feb 2005, Iran) with InSAR generated deformation maps; published by other workers (Stramondo et al., 2005, Parsons, 2005); also provides evidence that the thermal anomaly is ground related phenomena, not an atmospheric one [110].

Timely information about the onset of drought, extent, intensity, duration and impacts can limit drought-related losses of life, human suffering and decrease damage to economy and environment. The work of Rabab, U., 2004, has been carried out with the aim to integrate SRS and GIS for the identification of drought vulnerable areas in Sindh and major part of Balochistan. Arid and extremely arid conditions prevail in these areas and the amount of rainfall varies with time and space. This departure of rainfall results in the emergence of drought condition. The vegetation cover is directly linked with water availability and a decrease in vegetation cover can be alarming. NOAA AVHRR derived NDVI can be used to obtain vegetation status on regular basis. Although spatial resolution of NOAA is coarse, yet, the onset of drought conditions for a large area in a given year can be predicted by comparative analysis of trend of derived NDVI of that year relative to the trend in a normal year. It is better to develop a multi date NDVI composite for the study area and consider it as a normal for comparison. Thus, for a developing country like Pakistan, regular monitoring of the vegetation status (application of NOAA derived NDVI data) along with the other layers including climate, soil type, hydrology and socioeconomic condition of people is needed to delineate the areas that are drought vulnerable. This multidisciplinary information can be effectively and accurately handled with GIS. Spatial analysis in GIS can lead to a decision support system for the concerned government departments, NGO’s and others to help drought vulnerable people and others living in potential drought areas [111].
After the tragic events of large scale flooding due to torrential rains in Mumbai on 26th –28th August 2005, which resulted in the death of more than 1000 persons and an estimated loss to the economy of more than 1000 crores, it was imperative to prepare a ‘flooding potential zonation map ’ for Mumbai.

About 40% of the total land in Mumbai city is low lying marshland that has been reclaimed in the last 200 years. The reclamation has been done without regard to the natural topography and drainage (stream network) of the city. The pattern of infrastructure development in Mumbai is also without regard to the geomorphology. This has resulted in the occurrence of intensive localized monsoonal flooding in more than 30 areas in the metropolitan city. The flooding is further aggravated due to tidal surge in the creeks if rainfall duration and intensity coincides with the rainfall duration. The cause of such localized flooding with regard to the type of human activity and the natural topographic factors has been investigated. The monsoonal flooding was studied by integrating multi-thematic data in a GIS environment. The maps depicting the geology, geomorphology, drainage network, drainage density, slope, and land use were overlaid on the map depicting the flooding locations and the observations were used in a semi-quantitative analysis for generating a flooding potential map for Mumbai and the neighboring Navi-Mumbai area. The weightages for the different factors were calculated using prior probabilities of flooding, and a flooding potential map was generated. This map can be used for exercising precautions right at the stage of land development and also to plan the flood water disposal systems for the present as well as prospective problematic areas [112].

Tsunamis are a threat to life and property to anyone living near the oceanfront. The most affected are those living along coastal areas whose livelihood entirely depends on fishing. Many rehabilitation organizations (relief agencies) have played their role well and even now they are continuing their activities in slowly improving the socio-economic condition of the affected sector.

Priyadharshini and Saranya, et al., 2008, had taken an area along the Cuddalore coast for assessing the pre- and post- tsunami conditions with respect to socio-economical conditions of the affected population. GIS proves to be an effective tool for that assessment. The base maps of the place before and after tsunami were obtained. The demographic information of the area was obtained from the DHAN foundation. Those are incorporated using GIS. The status of the socio-economic condition of fishermen was studied. The relative distribution of the effect of the input
efforts (shelter, health, education, alternate livelihoods etc.) were found and analyzed for corrective administrative decision [113].

During the past five decades, natural hazards such as floods, earthquakes, severe storms and tropical cyclones, droughts, wild land fires, and also manmade disasters such as Nuclear disaster, oil spills, and terrorist attacks have caused major loss of human lives and livelihoods, the destruction of economic and social infrastructure, as well as environmental damages. Disaster reduction is both an issue for consideration in sustainable development agenda and a cross cutting issue relating to social, economic, environmental and humanitarian sectors. These important features have to analyze and there is a need to study. Though, in recent years the Open GIS technology standards have been developed by several agencies, which provide the basis for utilization of geographic information services, also gives an opportunity for data interoperability, data integration and data sharing between different emergency management agencies, However finding suitable services and visualization of geospatial information for decision makers is still a crucial task. Objective of the proposal of Vijayaraghavan and Thirumalaivasan, et al., 2012, was to assess the state of art literature review in different methodologies of utilizing geospatial technology in managing both natural and manmade disasters dedicated by different authors and also to find new direction in this important area.

In the paper a general review of disaster management for both natural and manmade disasters using Geospatial technology and Geographical Information system (GIS) was presented. From this literature review it has been concluded the most of the authors worked on the unique three phases of disaster management such as Pre disaster management, on disaster management and Post disaster management. The paper also concludes that using Geospatial technology the disaster could not be able to completely mitigate but to some extent the administrators could use this technique for planning preventive measures before disaster and to react during emergences situation. It is also appropriate to review the work so far accomplished in different fields of various disasters and to identify the necessary directions for future research [114].

2.9 Application of GIS and Remote Sensing in Urban Planning

It takes a leap of faith for many Boards to jump onto the GIS Bandwagon. It takes forward thinking leadership to move favorably on a project that has no end and continually need updates and maintenance. For the health and longevity of GIS projects, there needs to be numerous quick
wins to demonstrate cost benefits. These need to be more than just charts showing man-hours saved, better decisions being made or number of maps created. They need to be tangible real-world solutions to problems that communities face. Olivenhain Municipal Water District’s use of GIS moved the District from being reactive to problems to being proactive and finding solutions that helped prevent problems from happening. The proposal of Samuel, 2007 would detail some of the early and current GIS projects that led, some unexpectedly, to tremendous cost benefits not only for the District, but also for the Community and the environment at large. Nobel Systems hosts the entire GIS data of the District on its secure web servers in California, and provides an easy to use viewer called GeoViewer Online for all district staff to use. In addition, the District has linked their billing information, SCADA, real time vehicle location tracking, scans of the as-built record drawings and easements, and leak information. The district also uses a software called GeoViewer Onsight, which allows internal views of the facilities, such as pumpstations, tanks and reservoirs to be linked to the GIS in addition to maintenance manuals, 3D views of features and operation and safety notes [115].

The development of any country depends on the infrastructural facilities available therein. Good road network facilities plays major role. The developed countries have good road infrastructure not because of the fact that they are wealthy; instead they become developed because of good road infrastructure. Realizing this fact an ambitious and biggest ever infrastructure development project in India (expected cost of $26 billion) named as Pradhan Mantri Gram Sadak Yojna (PMGSY) under ministry of Rural Development was conceptualized and launched on 25th December, 2000. The objective was to provide basic access by way of all weather roads to the all habitations having population “250 or above in desert and tribal areas” and “500 or above for the rest of habitations” by year 2007 in phased manner.

The role of Rural Roads is very important in a country like India where majority of the population resides in rural areas and the main source of their earning is based on agriculture products. Rural roads provide the access to basic amenities and means of transporting agricultural products to nearest market centers. The Rural Roads can be classified as Other District Roads (ODR) and Village Roads (VR). ODR are those roads which connects the rural areas to market centers, Block, tehsil/taluka HQ or main roads while VR are those roads which connects villages and group of villages and each other or to the market place or with the nearest road of higher category (Operation Manual, 2005). PMGSY scheme is becoming very popular.
among rural areas because of the specifications and quality aspect adopted for construction of roads. Although it is a Rural Road Connectivity Project but it has well designed working system, clear guidelines and streamlined efficient monitoring and execution strategy.

The effective planning, monitoring and decision making of any developmental activity mainly depends on the reliable, updated and relevant information system. The GIS overcame the drawback of time consuming and tedious traditional methods of planning. Incorporation of Geo-informatics into planning, implementation and monitoring process of PMGSY scheme is changing the whole concept of execution of rural road plan. An authentic database for Rural Road developed using GIS which immensely helped in the planning and monitoring process by maintaining the information in an effective and easily updatable manner. Database prepared this way will also allow the data sharing among different government department which will reduce the cost of duplication. Considering all these aspects and potential of Geo-informatics, this technology is being used for monitoring, management and implementation of PMGSY scheme in India. The performance of Rajasthan state in implementing PMGSY scheme has proved it. Future applications of GIS are beyond imagination and almost all development projects will use this technology [116].

Urban Planning in India has gathered momentum in the last decade. 30% more area is now under urbanization, as compared to last decade. With growth of urban areas, the need and demand for physical and social infrastructure has also increased tremendously. The onus of providing these facilities lies with the Local Authorities and Urban Development Authorities. In most cases, the Development Plans are prepared as per stipulated norms. However, market forces determine the location of different landuse. Social facilities, such as educational, health, socio-cultural, institutional purposes, are hence often consigned to inappropriate locations. Thus, their purpose of catering to the targeted population judiciously and efficiently is not met. A logical and objective-oriented approach, therefore, needs to be adopted for allocating appropriate locations to these social facilities. An attempt was made to allocate judicious locations by using Geographic Information System (GIS) techniques. Map preparation, cleaning, building and analysis of the coverages (themes) were carried out by use of different software such as ARC/Info, Arc View, and AutoCAD Map etc [117].

As a measure of accessibility, road density is an important indicator of urbanization. Areas that are highly accessible are those with high percentage of road density. However, providing
respectable level of road density requires considerable planning as well as large amount of financial resources. Therefore, it is critical that only adequate road density required to guarantee continued growth is provided, nothing more. Realizing this fact, the Highway Planning Unit of the Malaysian Ministry of Works has awarded a contract research to the University Technology Malaysia to study the relationship between the transportation (road density) and land uses with an expectation that a generalized empirical model can easily be used as a guide in road planning. In accomplishing the modeling tasks, Geographical Information System (GIS) has been identified as a tool in preparing land use datasets required to test and run the model – in the process of determining the significant parameters that contribute to road density. Furthermore, GIS is also used as a graphical display tool in demonstrating the variation of existing and forecasted road density of the study sites.

Based on the study, it is clear that GIS can play important roles in supporting modeling process. This can be made possible either as an integral part of a software package used or coupled with other external modeling packages – as applied in this study. Requirement of geospatial data as an input to develop and establish a model, such as land use – road density model, can be fulfilled by selecting appropriate GIS functions once the geospatial database is available. This is proven to be much more handy and efficient especially when a required data has to be extracted from various sources and via complex processes such as map overlay and neighborhood analysis. Furthermore, analytical tool such as distance and area measurement, coupled with the ability to do a quick computation of a certain quantity that is purely based on the stored data on the database gives a great advantage of using GIS for variety of works such as related to spatial modeling [11].

Delhi as the seat of power has been the focus of attention for administrators and planners. It’s fast growing population, natural and manmade disaster proneness, changing security perceptions and pressure for maximum utilization of space call for exploring newer avenues for development. Sky scrappers as well as the sophisticated underground living and working space are the features of inevitable future. Subsurface maps of Delhi, emerged as an outcome of a research project undertaken by Central Building Research Institute, are the essential prerequisite of further urban growth of the mega city. Whether it is new development of any uninhabited area, delineation of earthquake prone localities, building up a failsafe corridors creating strategically sensitive space, subsurface maps are one of the best required tools.
Pandey and Dharmaraju, 2000, discussed about the methodology used for preparation of subsurface maps as well as their results. The study has been undertaken by CBRI as an in-house R & D project, and the authors could produce the above subsurface map with the help of limited sets of data and surfer software. As more and more detailed layer wise borehole data were being collected and processed, more realistic and reliable subsurface maps may be prepared in near future. GIS may also be used for producing better results. Seismic microzonation of big cities of the world have been taken up by groups of research workers, and such subsurface maps may serve as powerful tools for seismic microzonation of Delhi in near future, if need be [119].

Solid Waste Management (SWM) is a major urban challenge in Malaysia. Increases in the waste generation rate from economic development coupled with the increasing complexity of waste characteristics demand a more responsive management strategy from the authority to ensure that public health and the environment are protected. A holistic and strategic monitoring plan for SWM is by far the most complex to execute when compared to other urban utilities such as sewage or water supply, where the actual flow of material is transported in sewers and pipes. Solid waste however is collected by vehicles that run on countless possible routes with different destinations. This requires comprehensive and reliable data and information for planning and monitoring purposes.

Currently, the availability of solid waste related data is limited to data managed by individual local authorities and waste contractors. The lack of readily available data hinders decision making as well as monitoring of performance. With the introduction of the new Solid Waste Management & Public Cleansing Act and the ambitious plan of federalizing SWM in the country, there is an urgent need to establish a centralized, comprehensive solid waste data management system. Ping, 2007, presented the on-going efforts in developing an integrated data management system to cater for increasing data and information needs. The paper emphasized on how the integration of GIS with the GeoEnviron Database System can be used to meet the tasks and requirements of integrated SWM in Malaysia.

The federalization of SWM in Malaysia will require a robust and reliable information management system to provide the extensive data and information required for sound decision making and for daily management. Data management for SWM involves extensive data from many different stakeholders, therefore requiring a centralized, integrated system. Integrating GIS
with a powerful database such as GeoEnviron is a strength critically needed to enhance further the user’s capability in SWM. The integration allows instant retrieval of data simultaneously across two different platforms. The integration allows not only effective data queries and the retrieval of data but it will also present opportunities to develop advanced data reporting and modeling for SWM in the future [120].

Spatial Data play an effective role in different applications especially urban applications. GIS databases are used to manage the collected spatial data. Using these systems brings us benefits such as security, accuracy and possibility of data integration. It is struggled to use GIS databases and integrate them with spatial data acquisition systems especially photogrammetric systems that are important and reliable spatial data sources. Integration of photogrammetric systems and GIS databases makes it possible to control data quality, update and improvement of existing data and map production in various scales. Currently, various systems in different levels of integration have been introduced to the market. So it is necessary to evaluate integration approaches and different kinds of integrated systems in order to use them in our applications. After evaluating spatial databases and photogrammetric systems, integration systems were compared in various aspects such as efficiency, data quality and connection type. Hosseinian and Ebadi, et al., 2008, presented the results of the comparison with considering their integration level. It was shown that by increasing the level of integration, the efficiency and data quality of the system was increased. Finally, with considering the results of the evaluation and the requirements of urban applications that were mentioned in the paper, it was recommended a new approach of integrating these systems for urban management.

In the paper, after studying spatial database management systems and photogrammetric systems, considering importance of integration of these two systems, integration methods were evaluated and popular existing integrated systems were studied. Each of the presented methods for integration had characteristics that should be considered for selecting a suitable method for the needs. In the first method of integration, internal link that was explained, the researchers used system facilities provided by photogrammetric and database system providers for integration but this had some restrictions and may not match to the application requirements. By using the second method of integration, external link, that was explained, requirements of the application were considered but in that way it was needed to develop a new link between systems with respect to requirements and that may not be so easy. Using the method it is possible to choose
desired photogrammetric and database systems with considering the requirements of the application [121].

Urbanization is an index of transformation from traditional rural economies to modern industrial one. It is a progressive concentration of population in urban unit. At the moment, India is one among the country of low level of urbanization. In the last fifty years the population of India has grown two-and-a-half times, but urban India has grown nearly five times. In 2001, 306.9 million Indians (30.5%) were living in nearly 3700 towns and cities spread across the country, and it is expected to increase to over 400 million and 533 million by 2011 and 2021 respectively. At the moment, India is among the counties of low level of urbanization. As a result, most urban settlements are characterized by shortfalls in housing and water supply, urban encroachments in fringe area, inadequate sewerage, traffic congestion, pollution, poverty and social unrest making urban governance a difficult task. The high rate of urban population growth is a cause of concern among India’s urban and town planners for efficient urban planning. For this, the government of India has taken an important initiative to strengthen municipal governance, is the enactment of the Constitution (74thAmendment) Act (CAA), 1992. Through this initiative, an attempt is being made to improve the performance ability of municipalities/urban local bodies, so that they would be able to discharge their duties efficiently in the planning and development of urban areas. However, most studies undertaken to assess the functioning of municipalities in India, point out that the municipalities are confronted with a number of problems, such as non-availability of data, ineffective participation in the decision-making process despite adoption of the policy of reservation, delays in the transfer of funds to the municipalities despite constitution of State Finance Commissions, poor recovery from various tax and non-tax sources despite devolution of power etc. Therefore, there is an urgent need to adopt modern technology of remote sensing which includes both aerial as well as satellite based systems, allow us to collect lot of physical data rather easily, with speed and on repetitive basis, and together with GIS helps us to analyze the data spatially, offering possibilities of generating various options (modeling), thereby optimizing the whole planning process. These information systems also offer interpretation of physical (spatial) data with other socio-economic data, and thereby provide an important linkage in the total planning process and making it more effective and meaningful. Planning and managing cities in the new era of globalization and economic liberalization would be a demanding task calling for new skills and approach. Indian cities will have to compete with
others to attract investments and, therefore, issues like quality of infrastructure, energy efficient services provision and environmental conditions in a city besides economic stability would play a significant part in such competition. Urban planning profession in general will have to address these issues and respond rapidly. It is worthwhile noting that spatial dynamics of cities is complex to fathom and urban theory is still static. In other words, the urban planning authorities and agencies in every parts of the country should adopt new technologies like remote sensing and GIS. These have capability to provide necessary physical input and intelligence for preparation of base maps, for planning proposals and act as monitoring tool during implementation phase(s). Satellite remote sensing with repetitive and synoptic viewing capabilities, as well as multi spectral capabilities, is a powerful tool for mapping and monitoring the ecological changes in the urban core and in the peripheral land-use planning, will help to reduce unplanned urban sprawl and the associated loss of natural surrounding and biodiversity. On the other hand, moving further, interfacing of urban planning models with GIS should now receive due attention. Incorporation of land-use transportation models, water distribution network analysis, simulation of urban activities to evaluate different urban development alternatives in the GIS framework needs to be explored for added advantage [122].

Along with the population growth, changes occur in the physical aspects of cities. Indeed, this population increase is characterized by various consequences; one of the most important is the urban spread: this is a phenomenon of development of urban areas at the periphery of cities, which generates mobility issues, finance and planning issues and so on. In environmental terms, there is an impact on the natural landscape and ecosystems. The purpose of the work of Barry and Garouani et al., 2012, was to use the possibilities offered by new technologies, including Geographic Information Systems (GIS) and remote sensing to analyze the evolution of urban sprawl of Fez (Morocco) over the last fifteen years. On a temporal dimension, based on multi-sources documents set at different times and sufficiently spaced in time, it could be clearly highlighted the changes that occurred. This included satellite imagery, digital maps, files restitution, etc. Spatially, the researchers studied the variations in the extent of urbanized areas, and precisely we tried to find out how changed the various influences on the ground depending on their nature and use: vegetation, water bodies, urban networks, commercial and industrial areas etc. The spatio-temporal analysis will help to understand and anticipate the trends of urban spread in Fez, by identifying the causes: so their economic, social and environmental effects can
be kept under control. Finally, the study of the researchers will serve as a tool for decision support that stakeholders and decision makers, in order to make efficient choices, to better protect the heritage of Fez and to plan its future development.

The study shows that urban sprawl is a reality in Fez. Yet urban development represents a major challenge for Morocco. Urban management, respect for heritage and respect for the national environment ensuring the creation of wealth and offer a pleasant living environment (F. Ouzzine, 2006). Sprawl is preferentially towards the south of the town towards the Plain of Saiss. This spread has accelerated in recent years due to a housing boom. Nevertheless, the situation is not yet alarming: the administrative boundaries of the city are not yet obsolete, there is still room for the valuation of such spaces on the banks of Oued Fez and in the east and west areas of the city.

In the work, the prospective dimension will be dealt through the integration of more precise data: high precision satellite images, demographic data, and so on. All controlled by a multifunction GIS, integrating the best techniques for image processing. Thus, the city of Fez has at its disposal a tool for analysis and monitoring of urbanization, which will contribute to its economic and social development [123].

2.10 Application of GIS and Remote Sensing in Environment

Musinguzi and Bax et al., 2006, highlighted the opportunities for improved wetland assessment and the need for Spatial Data Infrastructures (SDI) as supporting frameworks. For a long time, the society view of wetlands as wastelands led to their continued conversion for agricultural use or for industrial development. Limited knowledge on the benefits of wetlands and their associated functions and values resulted into wetland reclamation in many countries, and the impact of their loss is being realized in different forms. Wetland functions are natural processes that occur in wetlands with or without the knowledge of humankind while values are benefits that society attaches to wetlands. With increased knowledge and appreciation of wetland benefits over the last few decades, wetland assessment and management are becoming very serious concerns for governments and the international community. The initial attempt to protect wetlands has been an “either or” scenario (either you are in a wetland and therefore no permit or you are on a dry land and you get a permit). The approach of the researchers was slowly giving way to the concept of “wise use” as adopted in Uganda or “No net loss in functions and values” as applied in the US. In both policies, wetland resources are used without impacting on the
functions that they perform and the values attached to them. To support such policies, impact assessments are required to ensure that developments carried out in wetlands do not impact negatively on the functions and values from the wetlands.

Wetland assessment includes wetland-related data gathering, data analysis and the presentation of resulting information to decision makers. It provides information upon which decisions on different management options and mitigation measures for specific wetlands or sections of wetlands are made.

Researchers and scientists in the field of wetland assessment have for a long time been involved in developing models and techniques for rapidly assessing wetland functions and values. While developing the techniques, the guiding principle has been to provide a solution that is cheap and affordable to evaluate a number of functions for many wetlands while ensuring that the activity is accomplished in a short time. Techniques for rapid assessment of wetland have improved over time from those that evaluated a single site for a single function or problem, to more complicated models that combine variables and parameters to assign functional indices to various wetlands in a watershed. The latest generation of models incorporates wetland measurements and landscape characteristics to evaluate the capacity of wetlands to perform a number of functions. These models recognize the role of biotic and abiotic factors for contributing to the capacity of a wetland to perform its functions.

Because of the enormous data involved, the models utilize the capabilities of Geographical Information Systems (GIS) to integrate, analyze and display multi-thematic data. The Hydro-geomorphic techniques (HGM) are one of those latest techniques that require collection of field data about wetland characteristics and analyzing it with existing spatial data. This study of the researchers applied SWAMP, one of the HGM based models for the wetlands in Lake Kyoga basin of Uganda, with a view of identifying the various issues for its applicability for wetlands in Uganda. SWAMP is a GIS based model developed by NOAA Coastal Services Centre for assessing functional capacities for wetlands in the Ashepoo-Combahee-Edisto (ACE) river basin of South Carolina, but can be used in other areas as long as there is local knowledge of wetland systems. The model required input of the following datasets: Soils, Landuse, Landover, wetland boundaries, Hydrography, roads and watershed boundaries. In addition a digital elevation model and administrative boundaries were found to be desirable. While attempting to test the models, it was identified that lack of infrastructures to access existing data presents more challenges to
wetland assessment than lack of assessment tools. Apart from institutional bottlenecks, the technical issues included variations in data formats, semantics, variations in scale and scarcity. The effort and time taken to locate a spatial dataset, determine its quality and fitness for use, resolve issues of semantics and finally acquire it, is so enormous that its defeats the whole purpose of wetland assessment models. As scientists in developed countries continue to improve on the existing models for wetland assessment, their counterparts in developing countries need to first and foremost, address the issue of data accessibility and interoperability since it is key to wetland assessment using GIS as a platform. With a lot of donor support for data capture of environmental data and mainly in the Sub-Saharan African region, the major challenge in the next few years will shift from availability of data to issues of accessibility, semantics and interoperability. Development of relevant and coordinated Spatial Data Infrastructures at various levels is therefore seen as the future for the implementation of wetland assessment models. The SDI will provide a basis for spatial data discovery, evaluation, accessibility and application, and hence shorten the complexities for wetland assessment [124].

Wetland assessment and management techniques utilizing Geographical Information System tools have been developed in the last decade. Wetland spatial databases from local to national scales are being maintained in many countries to serve the interests of multiple stakeholders in wetland management. For a wetland database to serve the interests of wetland planners, scientists, politicians, law enforcement agents and other users, there is need to develop a code for uniquely identifying an instance of a wetland entity from numerous wetland features in a database. The concept of a wetland code is analogous to a parcel identification Number that is used to identify parcels in a land information system, but differs from a wetland code assigned for classification of wetlands. In decentralized or federal governments where wetland management is a decentralized function, such a code should enable users to determine the hydrological linkages of wetland systems at a glance. Wetlands in many countries stretch beyond administrative boundaries and their management at a local level should take the wider system management options into perspective. Musinguzi and Bax, et al., 2006, presented a methodology for developing a multipurpose unique identifier for a wetland in a national wetlands database. The wetland code was developed and tested in the Uganda National Wetlands Database and provides information about the positions of wetlands in the nine hydrological basins in the country [125].
Rajaji National Park lies in foothill of Shiwalik, and is comprised of Deciduous and Sal forest, and famous for the favorable habitat of Asian elephant. It is facing the problem of deforestation and habitat loss in recent years. Sanguri and Mishra, et al., 2007, discussed in detail, threats faced by wild Asian Elephant in the sub Himalayan region of Rajaji national park. The very existence of this biggest terrestrial animal is now under threat for various reasons such as persecution for its ivory and blockage of migratory route due to constructions of many development works in and around national park, ultimately resulting in human-elephant conflict, confrontation among herd and accidental death. The proposal of the upper said researchers discussed in detail threats faced by elephants. The proposal examines the disastrous effect of incompatible design and construction of crossing on the age-old migration track and existing linear development and how they could be rectified in an animal friendly way. It also suggests practical solution to reduce the threat to the elephant and their habitat using geo-spatial technique [126].

The National Park consists of natural resources that highly contribute to the ecology. These environments make a pleasant place with its own unique to admire, which may be scenic, water fall, cave, mountain and floral including wildlife. However, without any appropriate management, the scenic of this will be fallen down and end finally. Our children will no longer see these anymore. Hence, any national park ought to be scrutinized, coupling with a good manage in order to keep the nature as long as it should be. The objective of the study of Sukawattanavijit, C., 2007, was to develop GIS database for zoning of Mae Yom National Park in Lampang and Phrae provinces. The management zoning was developed using remote sensing data and GIS. The environmental factors used for analysis were slope, landuse, elevation, and distance from office, distance from community, distance from roads and distance from river/streams. The results of environment factors for ranking the score of each factor by overlay technique and weighting-rating score. The management zones were classified into 5 zones; service zone, recreation zone, primitive zone, strict nature reserve zone and recovery zone. The five management zone maps were overlaid, the score of each management zone was then ranked regarding to the objectives of National Park Management, and the final map of management zone was then produced. The areas of management zone in Mae Yom National Park were 12.3%, 11.35%, 26.53%, 53.86% and 31.72% for service zone, recreation zone, primitive zone, strict nature reserve zone and recovery zone, respectively. The result will be the input of the managing
of the Park, to preserve the natural resource and high degree of futility, which enhance the completeness of the ecology in a sustainable form.

The zoning of area management is one of the tool in national park management. The environmental factors used for analysis were slope, landuse, elevation, distance from office, distance from roads, distance from river/streams, and distance from the community. The Mae Yom National Park Management by applying the RS and GIS in the study. With the environment 7 factors, it has been classified and ranked, according to the priority. Then the factor being formed into model in zoning. From that, the five management zone maps were service zone, recreation zone, primitive zone, strict nature reserve zone and recovery zone which the percentage are of the Mae Yom National Park as follows 12.3%, 11.35%, 26.53%, 53.86% and 31.72% respectively [127].

The study of Maleknia, R., 2007, was conducted to investigate the effective factors on distribution of coppice stands and high stands in traditional forest management in central Zagros in costum properties of Cheshme Khazane village. In order to attain the goal, separate forest types based on canopy cover, diameter, height and origin and understory farming lands were surveyed by GPS. Then gathered data were used as inputs for GIS. By digitizing the paper map (scale: 1:5000) of the region, the slope, aspect, elevation, proximity to population centers, road maps were created. Maps of forest types overlaid on these maps. Results showed that most of coppice stand occur in gentle slopes, low elevations, north and east aspects and proximity to population centers. High stand occurred in high elevations, steep slopes, far from population centers and west and south aspects.

In zagros forests, non irrigated farming in understory is common. The manner result in decline in canopy cover and reduce the species of forest. The most effective factors in site selection of coppice and high stands are slope, aspect and elevation. Most of coppice stands are limited in gentle slope but some of them occur in step slope. In low elevation, north aspect due to better soil and water condition these stands are more. But high stand occur more in west and south aspects, higher elevation and steep slope [128].

The proposal of Idrus and Shah, et al., 2006, examines the question of vulnerability that results from rapid environmental change experienced in the Langat Basin, Malaysia. The Langat Basin, the region adjacent to central development hub of Klang Valley in Malaysia, has experienced tremendous economic growth in the past few years. Rapid growth has often been linked to
vulnerability, and thus unsustainability. An understanding about vulnerability is a beginning
towards paving the sustainability development path currently sought upon by many countries.
The research, focused on socio-economic development, the environment and the relationship
with the vulnerability of those residing in the Langat Basin. The study attempted to analyze the
sustainability of development efforts in the basin and increased vulnerability is always a
possibility in the face of rapid development. Vulnerability is deemed to require a critical realist
approach, being a condition layered by effects at several scales by various agents. Findings in
this study, not only look at those directly impacted – the people, but also the drivers of
development, the industries, as well as the support mechanisms, that of the commercial sector.
GIS application had been used to see the environmental change as well as the region of
vulnerability [129].
The major aim of the work of Bac–Bronowicz, 2007, was to present GIS as a useful tool for data
verification, analysis and the presentation of spatial distribution, for example of climate
parameters which depend on topographic conditions, over medium scale areas and a relatively
long period of time. The reliability of the model of phenomena parameters’ distribution,
established on the basis of measurements in points, is the one that was obtained for the least
reliable parameter put into the model’s creation. It concerns both the location of the
measurement’s place and parameter’s value. Subjective experience of an author may influence
the modeling on the basis of insufficient number of points. Lack of knowledge on that fact may
lead to drawing wrong conclusions when it comes to phenomenon distribution and to elaborating
incorrect forecasts. Describing the probability of information transfer, while creating a model on
the basis of insufficient number of points, may increase the reliability of that model.
Accuracy of information accepted from the model of distribution which was constructed on the
grounds of point database of spatial information system, will also depend on the size of the
reference unit (natural or geometric) on the basis of which it was created. Those constructions
are more complicated when the network of measuring points does not represent majority of units
which were separated by factors’ distribution, for example topographic conditions (Kondracki,
2000). Determinations of regions’ borders and reliability zones of transferred information of
continuous features measured in point are introduced as an important part of geographic
analyzes. Location of stations measuring various parameters (whose distribution depends on
topographic conditions) is required especially in rivers valleys, uplands and mountains, because
of very strong influence of relief. The elaborations of elements’ distribution, mainly in the areas without the sufficient number of measuring stations, are still being discussed and examined. Each of the mentioned above features (and more) has influence on information obtained from the model of precipitation distribution. Even the most correct model can be a cause of wrong decisions if the proper explanation data are not taken into account. In GIS elaborations, the sources, accuracy, topicality and complexity of data should be given carefully to avoid exposing users to inaccurate results of their work.

Contemporary needs of users require interpretation of many years’ average in order to assess thoroughly climatic conditions, especially in smaller areas. Local authorities should also put emphasis on the use of values of characteristics of environmental conditions when formulating characteristics of administrative units. Such approach may be helpful in the decisions about the ways to stimulate the economic progress. That’s why the researcher pays attention to the need to correct assessment of climatic data obtained from climatic stations in order to compare them and improve utilization of data. Because nowadays information about climatic conditions serves to load not only the database of environmental and natural conditions, it should be clear and precise. The information about the reliability of information transfer may be very useful for advanced users. The climatic database should contain information about sources and the way of interpolation of continuous features on the basis of point information. The identification of precipitation regions in the tested area typical for Lower Silesia region is an important part of a research project, being sponsored by the State Committee for Scientific Research for the years 2001-2004 (The modeling spatial climate data in GIS no. 8 T12E 042 21) [130].

The healthy living of citizens depends upon the successful and optimal exploitation of the natural resources; however a slight imbalance in any equilibrium is bound to manifest itself in the form of what we call as environmental hazard. Understanding the natural occurrence of any hazardous materials, its chemical and mineral forms in the surface environment is of paramount importance in assessing the sources and pathways contributing to human exposure. Arsenic is one such element within Group Vb of the Periodic Table, but is often incorrectly referred to as a metal. It is ubiquitous in the environment, usually being present in small amounts in all rocks, soil, dust, water, air and biological tissues. Though the various effects of arsenic on human body are understood, but the knowledge of its source, hydro geochemistry and pathway is still under research and study. The work carried out by Basu and Sil, 2003, was aimed at mapping the
arsenic presence, the contour of its concentration and the depth of its presence in the district of North 24 Parganas in West Bengal, India. For the purpose, Geographical Information system and Satellite Image Processing was used to identify, locate, map and analyze the existing data on the district for modeling the hazard zones in the district. Though arsenic mapping requires a broad zonal understanding of the whole dynamics to achieve a strategic mapping and remediation, yet the present study at block level for a single district can act as a precursor to the whole process to initiate and set a strategic model subsequently. Satellite image IRS 1C (LISS) had been used along with the block map from district and planning series of NATMO, for preparing the base map. That work was a unique example of applying GIS and Remote Sensing for environmental mapping [131].

2.11 Application of GIS and Remote Sensing in Health

Human service organizations ultimately aim at evaluating, producing or delivering some type of goods or services to people in the community (Chisholm, 1995). Allocating human service resources to needy communities and populations in fast changing multi-cultural urban regions is becoming a major challenge for both public and private sector human service organizations. In order to achieve this objective of effective production and distribution of goods and services, it is necessary to have a detailed picture of the target population and access to appropriate and timely demographic and socio-economic data pertaining to that population. With this information, public and private sector human service organizations can make decisions in the best interests of the citizens/communities they serve. Health and human service agencies today are faced with tough challenges in raising funds for program planning and service delivery. This is reflected in terms of government’s increasing focus on performance and outcome management requiring agencies to produce measurable program improvements, and in some cases even making a tangible change in the lives of their clients. Funding organizations and service beneficiaries increasingly require that policy decisions be backed by information indicating that such decisions result in efficient and effective distribution of human service resources. Human service agencies are beginning to realize that better fundraising and well-informed policy decisions on health and human service needs of communities are possible through better information management that help them collect, analyze and display evidence of the need for resources in the community. Mapping communities is an
important information management strategy, which results in a geographical organization of resources and assets of the community while being sensitive to the community’s needs as identified by agency exercises such as needs assessment.

Mandayam, 2002, discussed the utility of GIS technology for the human service profession. A demonstration project on the use of GIS software, ArcView 3.2a, for assessing the social service needs of elderly individuals residing in Maricopa County, Arizona, was described as an example of the practical application of GIS technology for planning human services [132].

In a developing country like India where 73% of the population resides in rural area and 27% in urban areas, we need a very structured planning procedure such that the development activities and infrastructure facilities are available at both urban and rural area. However, in such a condition where majority of people leave in rural area and are provided with the least infrastructure facilities, creates a regional imbalance in development, causing shift in population from rural to urban areas. Hence administrators or decision-makers require an efficient GIS based tool which will assist them to get the updated scenario of the region. Recently after the creation of Jharkhand as 28th state, it faces a number of challenges in the path of development. One of the main causes is absence of accurate digital data in the form of maps. The data generated by various state government departments such as Education, Health, PWD etc. are enormous but poorly maintained; particularly the spatial data shows the maximum inaccuracy.

The study of Ghosh and Lal, et al., 2002, emphasizes the power of GIS technology which would help the state government of Jharkhand to better understand and evaluate spatial data by creating graphic displays using information stored in the database. As GIS does more than just display the data; it enables the user to dynamically analyze and update the information linked to those locations spatially and can further strengthen the e-governance. Ranchi district was taken as a case study covering all the 20 blocks with 2154 villages. The administrative maps were digitized and non-spatial attribute data, prepared on MS-Excel, were incorporated to each of the villages in spatial data. In the study of the researchers two prime parameter – health end education were taken as a model to demonstrate the GIS based e-governance. Similarly other amenities can also be linked and a holistic analysis of the regional development can be found out. The purpose of the study was to locate existing health and education facilities and indicate upgradation /new creation of such facilities require as per the norms. An interface was customized where the user can query on the datasets to retrieve tabular and spatial information. ArcInfo8.01 software was
used for creating maps (to the scale) and Arcview3.2a for creating the GIS based information system. Provision is made for hosting the maps on the Internet in such a way clients can view the information query using Arcexplorer. The researchers concluded that a state like Jharkhand which has immense potential of development and has maximum tribal population residing in rural area urgently needs a GIS based e-governance system such that it will help the government in planning, implementation and monitoring of various projects for development in different fields at much faster rate which in turn will make the state technologically more developed.

The newly created state Jharkhand, whose capital is Ranchi (study area), is tribal dominated state having immense potential for developmental activities. For overall development, first have to concentrate in providing the basic amenities such as health, drinking water, electricity and primary education. Hence the SDSS is effective and satisfies the stated objective in the field of health and education. The village and block level maps showing several demographic related data, along with current status of health and education will help the state government for better governance. If all or most of the state departments join hands in a combined effort to implement GIS based system, then it will be a big leap towards e-governance for a new state like Jharkhand. However the SDSS can be amplified much more by incorporating Remote Sensing and GPS technology. Also to make it more comprehensive, more and more data from all the government departments where computerization is in progress can be integrated at village / block level [133].

The Pattani Provincial Public Health Office (PPHO) received financial support from the United Nations Population Fund AID (UNPFA) to launch a pilot project on application of Geographic Information System (GIS) for analyzing and planning of Reproductive Health (RH) services in 2001. The project had both short-and long-term objectives. The short-term objective was to introduce a GIS technology in RH application in analyzing and seeking clusters of houses of pregnant women who use TBAs services for delivery. The long-term objective was to apply the GIS technology and the experience gained during the implementation of the system prototype development phase for developing the health plans in RH and other health concerns such as STD/HIV/AIDS protection, family planning, adolescent reproductive health, health education and epidemiology for common and rare disease control. More importantly, the project aimed to build up the capacity of the Information Technology and related GIS technologies to health personnel of Pattani PPHO so that they can further develop and apply the GIS knowledge in other public health areas after completion of the pilot project. It was expected that the model
used in the pilot project would be applied in the extension of the project to cover public health services in Pattani over a broader area.

In launching the pilot project, the GIS database was created. These spatial data were derived from aerial photograph interpretation and verified by ground truth survey. The spatial data were linked with the available health database called HcPro which was the household based data stored in dBASE file format. A social survey was also conducted in almost every households in the selected villages using questionnaires to collect primary data on pregnancy and ANC, involvement of husbands during pregnancy period, family planning and using TBAs’ services. From the study, it was found that most pregnant women in all villages practiced modern way of family planning. Oral contraceptive was the most popular method used. Most pregnant women delivered in government hospitals or sub-district health centers.

From the analysis, it showed that distances from TBAs and health centre had some influence on pregnant women. It was found that those who lived near the Khok Pho community hospital would go to the hospital when delivered. Using TBAs’ services was found more in Muslim village and majority of them used their services in delivery. Almost all of them found TBAs' services satisfactory. It also showed that Islamic pregnant women who used the TBA’s services received lower education and were attached to agricultural sector. From the pilot study, it was recommended that the Pattani PPHO should consider about raising awareness on RH to these Muslim women and mobilizing them to use government services [134].

An infection process is the interaction of a pathogenic microorganism with a macro organism under certain environmental and social conditions. Microorganisms causing infectious diseases parasites on host and persist due to continuous reproduction of new generation which change their properties in accordance with evolution of the environment conditions. Living inside its host, the microorganism persists for a definite period of time then moves to another host via a corresponding transmission mechanism. Hence, three obligatory factors are necessary for the onset and continuous course of an epidemic process: source of pathogenic microorganism, the mechanism of their transmission, and microorganisms susceptible to infection. Basic concepts in disease emergence are: Emergence of infectious diseases is complex; Infectious diseases are dynamic; Most new infections are not caused by genuinely new pathogens; Agents involved in new and emergent infections cross taxonomic lines to include viruses, bacteria, fungi, protozoa, and helminthes; The concept of the microbe as the cause of disease is inadequate and
incomplete; Human activities are the most potent factors driving disease emergence; Main factors are: Social, economic, political, climatic, technologic, environmental factors, shape, disease patterns and influence emergence; Understanding and responding to disease emergence require a global perspective, conceptually and geographically. In designing prospective studies careful consideration needs to be given to the following factors: Range of pathogens is potentially unlimited so microbial indicators need to be selected; Health outcomes are uncommon; Participant selection: general population, susceptible groups such as children or immuno-compromised, a representative sample; Case definition and ascertainment; Exposure assessment; Data analysis.

In this ever increasingly complex world, it is no surprise that the problems that face public health researches are becoming more and more intricate to solve. A cross-disciplinary approach may be one of the ways to discover new methods. Recently, GIS has emerged as an important component of many projects in public health and epidemiology. Epidemiologists have traditionally used maps when analyzing associations between location, environment, and disease. GIS has been used in the surveillance and monitoring of vector-borne diseases, water-borne diseases, in environmental health, analysis of disease policy and planning, health situation in an area, generation and analysis of research hypotheses, identification of high-risk health groups, planning and programming of activities, and monitoring and evaluation of interventions. GIS enabled researchers to locate high prevalence areas and populations at risk, identify areas in need of resources, and make decisions on resource allocation. Good epidemiology science and good geographic information science go hand in hand. Many development agencies and government institutions are exploring Health GIS in India. However, the sheer size of our country, varied life styles, climatic zones and environmental conditions make it all the more important for India to have a health GIS.

GIS is an effective tool to monitor and control the various infectious diseases. A number of papers discuss the applications of GIS in controlling, monitoring, and surveillance of infectious diseases. However, no research covers a wide number of contagious diseases with a common methodology with special treatment to a disease with respect to GIS application. The proposal of Gupta and Jay et al, 2003 was a step towards to find a common methodology to identify the vulnerable area of infectious disease using GIS. However, in some cases the method may not be very effective due to the need of high accurate data [135].
The USAID-funded Partners for Health Reform plus Project (PHRplus) is assisting five underserved and remote governorates in Yemen to improve their health care systems using evidence-based GIS decision tools based on accurate health and spatial information. Several health GIS applications have been developed to optimize the best available demographics, cleaned and enhanced GIS base map data layers, health facility survey results, and accurate health statistics and household health survey information. These customized GIS tools are improving the capacity of Ministry of Public Health and Population and governorate health office officials to visualize, understand, and make decisions more easily. Integration of these data into a relational database with a GIS interface facilitates efficient use of limited resources for improving health care in the predominately rural areas of Yemen. Four state-of-the-art health GIS applications will be described and demonstrated, namely: (1) health facility viewer: combining a map and health statistics for a health facility with digital images of exterior and interior conditions; (2) health facility targeting: using GIS to screen and/or target health care program interventions based on selection criteria; (3) health care accessibility: determining appropriate access to health facilities based on mode of transportation, road and trail conditions, terrain, and distance; and (4) health risk index: locating populations at risk to waterborne and communicable diseases associated with poor access to clean water and inadequate sanitation systems. These GIS applications demonstrate sophisticated use of health information to enhance facility utilization, improve distribution of preventive and curative care, and provide evidence-based rationale for targeted assistance and service delivery. Additionally, the health GIS may advance decentralization of selected aspects of decision-making and health reform authority.

Use of GIS in Yemen by the MoPHP and other decision-making organizations in the past has involved mostly preparation of maps to show the locations of specific features. However, the underlying data has not been reliable and inconsistent across the Yemen GIS user community. The PHRplus Project cleaned and enhanced GIS base map data layers to form the underpinnings for developing health-based decision tools and applications. The PHRplus Project has been maximizing the use of accurate health data and spatial information to improve the health system in Yemen. The tools and applications described in this paper highlight the important role spatial considerations can play when analyzed in combination with a comprehensive health facility database, demographic and population data, health information systems, and summary statistics. The four tools and applications specifically demonstrate sophisticated use of a health GIS to
enhance facility utilization, improve distribution of preventive and curative care, and provide evidence-based rationale for targeted assistance and service delivery. Easy-to-use health GIS tools are being designed to assist governorate- and district-level officials with local health care decisions in support of the Yemen health sector strategy to promote health system decentralization [136].

Imbalance in the distribution of human resources for health, eventually leading to inequities in health services delivery and population health outcomes, is an issue of social and political concern in many countries. Public Health Mapping is one of the best options for making better analysis of Health services especially in case of developing countries such as India to overcome this problem. Thus in order to properly plan, manage and monitor any public health programme, it is vital that up-to-date, relevant information is available to decision-makers at all levels of the public health system. That must be done with best available data and taking into consideration of demographics, availability of and accessibility to existing health and social services as well as other geographic and environmental features. GIS technology (Oracle Spatial) provides ideal platforms for the convergence of disease specific information and their analyses in relation to population settlements, surrounding social and health services and the natural environment. Public Health Mapping is basically a thematic mapping process, which can be done by a specific method that is commonly used such as Choropleth mapping. It can be created by shading a bounded area with a color corresponding to a particular value that is associated with it. The technology used for the mapping is Oracle spatial that is advantageous over other softwares currently available in market, which uses SDO_GEOMETRY objects for fast retrieval of data and can be accessed by open source softwares. Based on the study the Public Health map for districts of Tamil Nadu is created [137].

After the Second War World, most cities had gone through a transformation from a specialization by sector to a specialization by function. In modern urban systems, the economic growth of cities is largely motivated by services. While specialization continues to be a main highlight of the urban system of Malaysia, cities are increasingly distinguished by their serviceable specialization rather than by their sectoral specialization. This transformation of urban structure has thus far been unremarkable.

Striking evidence is presented of a previously unremarkable transformation of urban structure from mainly sectors to functional specialization and this transformation is inextricably unified
with changes in firms’ organization. A greater variety of business services for headquarters and of sector-specific intermediates for production plants within a city reduces costs. Cities change from specializing by sector, with integrated headquarters and plants to specializing mainly by function, with headquarters and business services clustered in larger cities, and plants clustered in smaller cities.

The agglomeration of private hospitals in Penang Island has not only provided a platform for knowledge-based activities but also enhanced the specialization of urban services particularly the medical sector. Collaborations between private hospitals, medical laboratories, and research based companies have contributed greatly to the application of advance technology in health facilities and services. Strong financial supports and investment provide avenues for further medical research and development. New medical products are marketed and quality of services is improved.

The physical location of a private hospital is heavily influenced by accessibility and the catchment areas. The market for medical services is greater in areas occupied by residential and commercial types of land uses with close proximity to major arterial roads and public transportation. Such locational criteria have instrumented the agglomeration of private hospitals, thus turning medical into one of the latest specialized urban services in Penang Island [138].

Malaria has been found in the vast areas in different regions of the world. Particularly many people in the tropical and subtropical regions suffer from this disease. 40 percent of the earth’s population lives in zones where malaria exists. In Iran, Malaria is one of the main public health concerns mostly in south and southeast regions of the country. Malaria outbreak is profoundly correlates with the environmental and climatic conditions of a region. Due to the vastness of the potential area, Remote Sensing is a useful tool for detection of the conditions appropriate for malaria outbreaks and consequently helping managing it. This could be done through estimation of environmental information and climate parameters using satellite imageries. Thus, it can be used for organizing a controlling system for malaria outbreaks.

In the study of Marj and Mobasher et al., 2008, a methodology was suggested in which at the first step, based on the biology of the insect, the minimum requirements of the environmental and climatological parameters for the incidence of this phenomenon will be determined. The study showed that some parameters such as air temperature, relative humidity, vegetation cover and lagoons and basins are the most influential parameters in creation of potential for of
epidemic outbreaks. In the modeling section, different methods in extraction of environmental parameter were thoroughly studied. Comparison of different methods leaded to identification of the most appropriate strategy for each parameter extraction using Landsat images. Then, high risk regions were located for each parameter. In the next step, the selected regions were imported in to a GIS (Geographical Information System) environment as independent layers. Weighted overlay method was implemented and finally, high risk regions were determined. Also, for model evaluation, some ground truth data has been collected and the work has so far shown good applicability.

As shown in the paper of the researchers, Malaria incidence depends on the environmental parameters. Air Temperature, Relative Humidity, Vegetation cover and basins are discussed as the most influential parameters. By using satellite data, these parameters could be extracted, assessed and by GIS's analysis, the high risk regions could be recognized. Therefore, a comprehensive model could be developed to produce an output to recognize the high risk regions of malaria incidence. Due to 15 degree centigrade temperature difference and 25 percent relative humidity difference, the uncertainties due to the remote sensing technique could be considered acceptable [139].

2.12 Application of GIS and Remote Sensing in Natural Resource Management

Remote sensing technology offers a wide variety of digital imagery that makes it extremely interesting to develop monitoring systems capable of regularly updating land-cover maps. The objective of the study of Sim, 2009, was to access the capability of Advanced Land Observation Satellite (ALOS) Phase Array L-type Synthetic Aperture Radar (PALSAR) data on land cover mapping over Penang Island, Malaysia. The paper presented the basic information of the project, the status of the research and preliminary result including data acquisitions, data processing and data analysis. ASF MapReady programs from Alaska satellite Facility Geographical Institute at the University of Alaska Fairbanks was used for the preprocessing of ALOS-PALSAR data. Standard supervised classification techniques such as the maximum likelihood, minimum distance-tomean, and parallelepiped were applied using the same training areas derived from high resolution optical satellite imagery.

Filtering and enhancement methods had to be applied in order to reduce speckle noise and to contrast the images. Composite color images were produced for visual interpretation and field
surveys. After investigation of the ground truth, representative areas of each land cover type were identified and allocated to the images. The ALOS-PALSAR data of training areas were choose and selected based on the high resolution optical satellite imagery and was classified using supervised classification methods. The land cover information was extracted from the digital data (HH and HV Polarization) bands using PCI Geomatica 10.1 software package. An accuracy assessment was also carried out in this study. High overall accuracy 82.5% and Kappa coefficient 0.70 was achieved by the Maximum Likelihood classifier (HH+HV Polarization) in the study. Finally maximum likelihood classifier (HH+HV Polarization) was used to classify the land features into a land cover map. The study indicated that the land cover of Penang Island, Malaysia can be mapped accurately using ALOS-PALSAR data. The result of the preliminary study showed that analyzing the accuracies of the single band input data in comparison to the multi-mode data. The researchers clearly detected the use of multimode data indicate an increase accuracy in land cover identification. As the result of the study the Maximum Likelihood classifier (HH+HV Polarization) produced the highest degree of accuracy [140].

Forest resources are either altered by natural or by human-induced factors; however, human-interventions are more aggressive and have influenced forest depletion in a variety of ways. Panta and Kim, et al., 2009, used ancillary data sources, GIS and simple statistics to assess the socioeconomic impact in forest degradation process. Pearson’s correlation coefficient significantly showed (? = - 0.750 and - 0.788 at p = 0.01) a negative association between population and forest area lost for 1958 and 1978 respectively. Moreover, forest area lost and arable land growth has showed a strong negative correlation association significant (? = -.745 at p = 0.01) for 1958-1996 while association also negatively correlated and significant (? = -.485 at p = 0.05) for 1958-2001. Forest area lost and food insufficiency in 2001 also showed a strong negative association significant at (? = - .492, p = 0.05). Similarly, pressure on forest significantly increased from 2.4 people/ha to 17 people/ha during the same period. This shows the Terai forest is undoubtedly susceptible with certain socioeconomic factors. This information could be useful and preliminary source to course of action for further probing of socioeconomic collision in deforestation and forest degradation processes in Nepal. As Brink and Eva (2008) emphasized the effect of population growth in agricultural expansion, the researchers also found that population has influenced on both forest degradation and
agriculture land expansion. However, contradictly Sire´n and Brondizio (2009) found that deforestation rates neither correlated with indigenous population nor with external populations. As Namaalwa et al. (2007) concluded, the researchers also realized that such types of study is useful for policy makers interested in designing alternative intervention programs for ensuring sustainable forest resources use while simultaneously promoting food access and agricultural production. The lack of spatio-temporal information at regional level makes it difficult to further analyze the impacts of various socioeconomic factors and population increase on the potential of future forest cover losses. Although, remotely sensed data sets provided over the past three decades for land cover studies and deforestation estimation (Boyd et al. 2002; Eva and Fritz, 2003). Due to limited capacity for purchasing and interpretation of remote sensing data, however, is sophisticated and expensive (Eva and Fritz, 2003), and uses of such data in developing country is still fewer. Moreover, availability of research grant and data assemble/purchase are still a major constrains. Confronted with this, optimal utilization of ancillary data sources is further warranted in the countries like Nepal where investigations are still limited and updated information is urgent, decisive and exigent. The information provided here could be preliminary source, imperative and advantageous to the planning and decision-making level for sustainable forest resource management process [141].

So long as the earth preserves her forests and wildlife, man's progeny will continue to exist. This is the Hindu approach towards conservation of ecology (Upanishads). Human beings use natural resources available on earth such as land, water, vegetation, minerals and many others to make a living and to shape their culture. In doing so they changed the earth surface enormously. Proper management of available natural resources is vital in today's world where overexploitation by the growing population is taking place at a very fast pace. This overexploitation of natural resources is responsible for all kinds of pollution viz. air, water as well as declining biodiversity and falling water tables. It is quite shocking to know that about 50% of the world's forest has shrunk due to logging. About 65% of the cropped land experienced significant impact on the soil quality (World Resources, 2000-2001). India being one of the most densely populated nations of the world suffers from a variety of environmental problems. Therefore, it requires a multidisciplinary approach involving inputs from various fields for proper risk assessment to check the problem of environmental degradation at its earliest.
Patanjali and Joshi, et al., 2003 had demonstrated that the area is vulnerable to various kinds of hazards. For sustainable development of the area the researchers need to identify the hazards and make proper strategies so that there is a balance between development and destruction. Sustainable management of natural resources of land water and vegetation is essential in providing food and feed for human and livestock and also for environmental security. This type of study has significance in terms of natural resource management on a sustained basis. The study also emphasized the role of Remote Sensing and GIS in sustainability studies. Geo-spatial technology is immensely helpful in the assessment of natural resources in the watershed and their effective management. For example, the digital terrain model (DTM) created in the GIS environment can be used for the identification of potential areas for the construction of water harvesting structures. The study of the upper said researchers clearly showed that in Huinyal watershed the resource utilization and distribution pattern are responsible to the degradation of the natural resources available in the area. The vulnerability assessment is important because it is the indicator of the sustainability of the ecosystem and the socio economic status of a watershed. The identification of critical and vulnerable areas using geo-spatial techniques is strong inputs for the policy planning and proper management aimed at sustainable development of a watershed. The actual vulnerable area in the study has been estimated to be 25%. Local villagers can play a very important role in preventing the degradation of their immediate environment. There is a need to make people aware of their negligence towards forest fires. They should be made aware of the deadly consequences of degradation of the forests. The deforestation of slopes impairs the water regime in the surface layers and thus contributes in slope failure and landslides [142].

The objective of catchment management is to maximize the net socio-economic benefit of land use activities in the catchment area. In Malaysia, catchment management problems are associated with river pollution from untreated industrial wastes in urban areas (Low, 1993), with water shortages due to the uneven distribution of rainfall throughout the country and with high erosion rates due to deforestation for agricultural and urban expansion (JICA, 1982). The objective of the research of Hadi, 2006 was to produce a digital map of land use/cover for Perlis using the spatial analysis technique of remote sensing and the geographical information system (GIS).

In the preliminary study, the results suggested that the main factor controlling landuse/cover distribution on the area is topography. Low areas are dominated by paddy fields, sugarcane and
urban settlement, hills and hill slopes are covered by rubber, and higher grounds are occupied by reserved forest. These preliminary results clearly suggested that the spectral and spatial characteristics of Landsat TM data could serve to identify and map landuse/cover types in the northern of Perlis. The results also suggested that a raster-based GIS can facilitate the necessary digital analysis and manipulation. That includes data integration, geocorrections and handling the classification. In conclusion, satellite remote sensing and GIS can be used to generate the necessary dynamic information for surveying and monitoring landuse/cover in northern Perlis [143].

Groundwater forms part of the natural water cycle and is present within underground strata. Water supply for irrigation and domestic use in Perlis state, at the most northern tip of Malaysia, is mainly supplied from surface waters, with groundwater supplementing this supply for localized uses. The geology of Perlis consists of mainly alluvium soil, granite and limestone hard rock formation. The pilot study of Ahmad Kamal b. Md. Issa, 2007, was to investigate the use of remote sensing data from SPOT satellite image, and other ancillary data. The analysis of these data using GIS has produced different thematic maps such as landuse, geology, rivers and drainage, land administration areas or ‘mukim’, boreholes, wells, soil types, and rainfall gauges. These maps later will be used to predict characteristics of groundwater potential zones in the study area. Groundwater potential is based on the modified DRASTIC model.

Preliminary results suggested that the spectral and spatial characteristics of SPOT satellite data can serve groundwater monitoring. The results also suggested that a raster-based GIS can facilitate the necessary digital analysis and manipulations, including data integration, geocorrections, and handling classification. It is foreseen that some of the recommended refinements for future advancement of the study may include addition of other data (e.g. recharge, soil suction, pore pressures, temperature changes) as thematic GIS layers, determining the criteria/ constraint factors, processing of thematic maps using supervised classification, assigning weightage to data layers based on accepted engineering principles to reflect their characteristics and relative importance. In conclusion, satellite remote sensing and GIS can be used to generate the necessary dynamic information for groundwater monitoring in Perlis state [144].

Any changes in sea floor may be the result of sea-level variation or to a change in the elevation of land surface. Changes in absolute water-surface levels are worldwide due to the
interconnectivity of the oceans and are termed eustatic changes. Changes in the absolute level of the land are localized. They may be due to tectonic adjustments or due to adjustments caused by their distribution of weight on the land surface. As and when sedimentation or ice build-up occurs, such changes are known as isostatic. A rise in the sea level or down warping of land would involve the opposite movements of sea and land. Synonymous with positive and negative changes are the forms of sea-level transgression and regression, although in many cases these terms also refer to the horizontal movement of the shoreline associated with vertical changes of sea level. Indian shore has experienced submergence and emergence due to global as well as local oscillations of the sea level by multivariate tectonic, fluvial and marine geomorphic processes. The repeated emergence and submergency of coast have been instrumental in shaping the morphological expressions of the continental shelves in general and shoreline in particular (Jayaprakash et al., 2002). Thanikachalam and Ramachandran, 2002, proved that the coast is going on emerging by tectonic movement. There is a remarkable difference in the extent of continental shelf of the east coast of India when compared to west coast of India. The shelf on the west coast is broad with thin layer of sediment, while the eastern shelf is narrow with thick layer of sediment (Agarwal 1990). The main objective of the proposal of Thanikachalam and Ramachandran, 2003 was to generate the bathymetry maps using multi date bathymetry data and identify the morphology of sea floor and its changes.

Geographic Information System and ERDAS imagine softwares are very much useful for bathymetry mapping. Various shelf morphological features like channels, continental raise and islands, and their slopes and extents were identified. The study suggested that in the study area sea floor has been gradually rising due to tectonic upliftment [145].

Seaweed farming becomes one of the coastal and marine prospects for improving the national economy. Identification of coastal areas suitable for this aqua culture is highly needed. The proposal of Pramono and Dewi, et al., 2007, explained the process of performing suitability analysis in Tarakan, east Kalimantan, Indonesia. The analysis was based on the physical properties of coastal water which was directly surveyed such as water depth, dissolved oxygen, salinity, temperature, clarity and pH.

The Geographic Information System (GIS) was used to do the analysis. The comparison of matching and scoring approaches showed relatively similar results. However, scoring method predicts wider areas which are suitable for weed farming.
The study of the researcher showed that the geographic information system (GIS) is able to perform suitability analysis of seaweed farming in Tarakan, east Kalimantan province. The suitable and conditionally suitable areas were identified near the coast. The scoring approach predicts more areas with suitable level. The results of the study should be verified by trying to farm seaweed in the suitable areas. Further study would be to identify the appropriateness of the used parameters, whether by removing certain parameter or adding other parameters. The weight and minimum suitable values should also be evaluated to achieve an optimum suitability analysis [146].

Alor is an island that located at the border between Indonesia and Timor Leste. The area has high prospect in coastal and marine resources, especially for coral reef. However, the potentiality of this island is still under usage. It seems such assessment has to be employed for the future of local economic growth. Dealing with this, a research was employed in order to achieve the optimal used of coral reef area, especially for eco-tourism. Sea weed culture nearby the coral reef area was also being considered as the other coastal economic prospect. Remote Sensing (RS) and GIS approach were being used for the study. RS was used for mapping the coral reef distribution area. Meanwhile, spatial analysis would be used for classify the suitable location for sea weed culture and marine eco-tourism. Beside that, economic analysis was also being employed for both marine eco-tourism and sea weed culture. The economic analyses were employed based on productivity approach and travel cost method (TCM). Scenarios were carried out in order to get optimal ecologically and economically used of coral reef area. The result of the research would become an input for local and national decision maker for coastal resource management of Alor Island [147].

Coastline changes are the most important and common processes in coastal zone. These changes were occurred in coastline of Kouhestak- Karian area in the Persian Gulf coasts in which terrestrial processes directly affect oceanic processes and vice versa. Coastline changes in Karian area contain sedimentary and geomorphologic unit’s transformation, subversion, erosion and substitutions to each other, sedimentation and occurrence of other ones. The main scopes of the work of Choopani and Pour et al., 2006, were the determination of the rate of coastline changes in short period (26 years) and long period (quaternary) and determination of effective factors in these phenomena. The research was based on GIS investigations, field operations and laboratory Studies, Preparation of orthophotos for two periods of aerial photo (1967, 1993), GIS studies.
Initial recognition of coastal features, investigation of maps exactness, and sampling of fossils from pale shorelines were done by field operations. Fossil samples were tested by 14C method at Jaber-Ebn-Hian laboratory in Iran. The main achievements were as follow:

1- Sedimentary unit’s polygon maps
2- Coastal landform unit’s polygon maps
3- Erosion and sedimentation maps
4- Pale shorelines maps
5- Superficial and vertical coastal changes rates and amounts
6- Effective factors in coastline changes.

Other achievements of the research were obtaining the best method for investigation of coastline changes in the Iran coastal zones, and late Quaternary history of coastal Makran zone and coastal Zagros folded zone and areas of Karain area, which need coastal protection. Important results of sea level changes are formation of coastal sedimentary sequences in Quaternary time. Coastal sedimentary sequences in the study area were shown retrogressive coastline and respectively from base to up including Pliopleistocene conglomerates, high and low level alluvium terraces, sand ridge that are components of wave dominate deltas, tidal flat, supra tidal, river alluvial deposits considered: river channel deposits, river bar deposits and flood plains and evaporate deposits (sabkha) [148].

The impacts of two hurricanes (Katrina and Wilma) were assessed on 44,390 ha of protected mangroves in southwest Florida using a series of 20m multispectral SPOT and 1-km MODIS images. Established empirical relationships between mangrove leaf area index (LAI) and the normalized difference vegetation index (NDVI) were used to generate four different LAI maps before and after the hurricanes. These maps were compared to gridded LAI data (MOD15A2) derived from the Moderate Resolution Imaging Spectrometer (MODIS) on board the Terra satellite. A semi-empirical approach based on the GeoSAIL radiative transfer model was also developed to estimate both pre- and post-Hurricane LAI based on SPOT band 2 (red). The results indicated modest agreement ($r = 0.53$) between one empirical formula and MODIS LAI pre-hurricane; while the GeoSAIL approach produced good agreement between post-hurricane MODIS LAI and SPOT LAI ($r = 0.69$) among the different methods employed. The results suggested that in the absence of detailed field data a relatively simple radiative transfer model linked to multispectral satellite imagery may provide an effective way to monitor the damage and subsequent recovery of mangrove ecosystems following major disturbances such as tropical cyclones.

Linear fits applied to scatter plots indicated modest agreement ($r = 0.53$) between one empirical formula (Green et al., 1997) and pre-hurricane MODIS LAI; while the GeoSAIL approach
produced the best agreement between post-hurricane MODIS LAI and SPOT LAI ($r = 0.69$) among the different methods employed. The results suggested that in the absence of detailed field data, the GeoSAIL model combined with 20m multispectral satellite imagery provide an effective way to monitor LAI changes associated with the damage and subsequent recovery of mangrove canopies following tropical cyclones. Moreover, while further refinement of the GeoSAIL-based approach was needed, LAI estimates derived from 20m SPOT imagery possess clear advantages over 1km MODIS products, which mask local variation and spatial detail that might otherwise be revealed in SPOT 20m multispectral imagery [149].

Remote Sensing Technology in combination with Geographic Information System can render reliable information on land use dynamics. The study of Akingbogun and Kosoko, et al., 2012, examined the integration of Remote Sensing and Geographic Information System (RS/GIS) for application in urban growth effects on the Eleyele Forest Reserve in Ibadan, Oyo State. The 1972, 1984 and 2000 Landsat TM satellite Remote Sensing data was used to identify and classify Eleyele Forest Reserve. A GIS database of land use categories and their location within 28 years (1972-2000) was generated and analyzed with the aid of GIS analytical functions. These include Area calculation, overlay, image differencing, Markov operation, and cross tabulation. The result showed that population growth (anthropogenic factors) among communities around the forest imposes a lot of pressure on the forest plantation. Forest reserve has suffered seriously and if the present trend of deforestation continues; it is just a matter of time when the whole reserve would have been converted to a bare ground. The 1972, 1984, 2000 TM satellite remote sensing data were used to identify, classify assess and interpret Eleyele Forest Reserve Plantation Degradation in North West Local Government of Ibadan in Oyo State of Nigeria. A GIS database of land use / land cover categories and their changes within 28 years (1972-2000) was generated and analyzed. The result showed that in general the forest plantation was retreating due to several anthropogenic activities of man such as illegal felling of wood, farming activities. The rates at which the reserve is been degraded have made the area a shadow of their former selves. The local communities show that at the rate at which the degradation of the reserve is going on, the conversion of the forest plantation to a bare ground is just a matter of time. From the study, Land Sat TM data are important sources of imagery data for mapping and monitoring the dynamics of land use / land cover in tropical rain forest [150].