CHAPTER II

2. REVIEW OF LITERATURE

This chapter reviews and discusses the research that provides a context for the study. It is not meant to be an exhaustive review of the literature, but more an indication of the development of, and problems associated with characterizing surface form using satellite data and spatial modelling in Geographic Information System (GIS). Terrain heights together with clutter analysis have become necessary in most of the telecom related applications. As more and more sophisticated satellites are in orbit providing earth surface in oblique viewing with better spatial resolution, terrain modelling has become more research oriented and cumbersome process. Therefore, the literature survey is organised in three parts; (1) studies related to terrain modelling, (2) the studies related to mapping of thematic layers and, (3) spatial modelling in GIS.

2.1 Evolution of Digital terrain modelling

Terrain modelling, the study of ground-surface relief and pattern by numerical methods, has become integral to hydrology, tectonics, oceanography, climatology, and geohazard assessment. It is also important to such nongeophysical applications as land-use planning, civil engineering, and microwave communications. The field originated in 19th century work by Alexander von Humboldt and later German geographers. Modern terrain modelling is an amalgam of earth and computer sciences, mathematics, and engineering. It is commonly known as (quantitative) terrain analysis, (geo) morphometry, or quantitative geomorphology. The computer processing of square-grid arrays of terrain heights, digital elevation models (DEMs), has revolutionized the discipline's two chief functions of topographic analysis and display. Geographic information system (GIS) technology further enables terrain-modelling results to be combined with nontopographic data. The field has recently been reviewed by Moore [1991] and Pike [1995].
Edwards and Durkin (1969) were among the first to recommend a strategy for developing a regular grid digital elevation model (DEM) from contour maps, together with intervisibility and radio path loss algorithms; however, for such applications, inaccurate or misleading results can be counter-productive and expensive to remedy. Hence, radio planners are seeking to develop more accurate data models and algorithms to improve path loss predictions. Radio propagation between two unobstructed points is now well-understood and easily calculated. For these paths, differences between mathematical calculations and actual field measurements are quite small; however, when considering obstructed radio paths, which is quite common for urban radio planning, radio coverage is difficult to calculate. In fact, under these circumstances, coverage cannot be accurately determined, only predicted. Kidner (1991) considered the problems of estimating radio path loss with respect to different types of digital terrain models with different accuracies. But as geographical data capture becomes more precise at higher resolutions, it is hoped that these predictions can become more accurate.

Jehad Hijazi (2001) presented the elevation extraction from satellite data using PCI Geomatics. He mentioned about the DEM accuracy of various commercially available sensors evaluated through the PCI software. He briefly described the different types of stereo acquisition available through satellite data.

Dinesh Manandhar (2000) presented his work on Laser mapping and it's capability of providing information directly in three dimensions. However, the present laser mapping systems are either air-borne or ground-based (on a static platform). We cannot achieve detail information from air-borne system, though it has its own suitability for applications like DEM generation. Ground based static systems are not suitable for larger area mapping purpose. Hence he suggested for vehicle-borne laser mapping system (VLMS), which uses laser scanners for three dimensional data acquisition, CCD cameras for texture information, GPS, INS and odometer for positioning information. The data obtained by this system
could be a good resource for developing urban 3-D database, which has numerous applications in the field of virtual reality, car navigation, computer games, planning and management.

2.2 Remote sensing data analysis

Under FASAL project, area under principal crops like rice, wheat etc, is being estimated at district level in India, through remote sensing data analysis using the sampling approach. Single date digital data and supervised classification approach was adopted for wheat acreage estimation in Karnal district of Haryana (Dadwal and Parihar, 1985) and in Patiala tehsil, Punjab (Kalabarne and Mahey, 1986). Mahey et al., (1993) obtained wheat acreage estimates in Punjab, India using single date acquisition of IRS-1A LISS-1 data during 1988-89 seasons. The methodology consisted of stratified random sampling design, 10*10 kms sample segments, a 10% sample fraction and MXL supervised classification. The estimated wheat acreage which is mostly irrigated was in agreement with the estimates of government estimates. Data from Indian Remote Sensing Satellite IRS-1A, 1B have been used successfully to obtain the areas under rice and mustard crops in West Bengal (Panigray et al., 1993). Thus, numerous studies have concluded that remote sensing images can be potentially used for crop area inventory and delineating land use / land cover classes.

Sucharita Gopal (1998) worked on two neural networks to classify data and estimate unknown functions. Multi-Layer Perception (MLP) and fuzzy ARTMAP networks. The advantage of NN techniques were brought by her.

Road network is important information for this study as the placement of tower should exclude this network. Even though this information is available in maps, recent developed roads might not be available in map and have to be updated by ground based techniques or from satellite data. There are many researchers working on this field to derive road network automatically from satellite data. One such research was carried out by Jun Kumagai (2001) using high resolution data.
A pattern group of the roads were examined in search of histogram of the existent roads to see the characteristics of the roads. The part segments that match the histograms of the road pattern groups are extracted as roads from the image. He explored the possibilities of automating the process of the extraction of the road by assuming that the contrast in shade value between the road and surroundings is quite strong. The results were close to one prepared by manual methods.

An approach to achieve automated road network detection from high resolution digital image by mathematical morphology operation is discussed by Shunji Murai and Chunsun Zhang (1998). The approach proposed in that paper was to classify the image to find road network region, then morphological trivial opening is adopted to avoid noises. The developed method has been tested on the simulated image with 1 meter resolution. The result showed that mathematical morphological provides an effective tool for automated road network detection. They concluded that a combination of trivial opening and a new concept of granulometry can be effectively used to automatically detect road network with the wider width from high resolution image.

Thierry Geraud (2000) presented a fast method to extract road network in satellite images. A pre-processing stage relies on mathematical morphology to obtain a connected line which encloses road network. Then, he constructed a graph from this line and a Markovian Random Field is defined to perform road extraction.

The other method is to enhance visual interpretation and thereby manually extracting road network from the low spatial resolution multispectral data and high resolution panchromatic data. For this data fusion technique is used. The purpose of fusion process is synthesizing a new multispectral image whose bands coincide spectrally as much as possible with those of the original multispectral image, and having a spatial resolution comparable to the
panchromatic image. Therefore, because of its elevated geometric-thematic information, the merged image results very useful in digital cartography.

Generally any fusion process should not alter the basic radiometry of the multi spectral data. Recent advances in technology have provided data fusion near to multispectral data like one demonstrated by Kumar, A.S (2000). The use of cubic spline wavelets for merging high spatial content of panchromatic (PAN) data and spectral contents of multispectral (LISS-3) data of IRS-IC; ID spacecraft is discussed by them. It is shown that the method preserves the spatial content of the original PAN data and the spectral content of the LISS-3 better than many of the conventional approaches. It is also suggested that the spatial content of the merged data can further be enhanced by first correcting the PAN data for overall modulation transfer function (MTF) of the sensor. The overall MTF was realized with a piecewise linear model and using the sensor specified MTF at nyquist frequency.

Lau Wai Leung, Bruce King and Vijay Vohora (2001) worked on the assessment of image fusion by measuring the quantity of enhances information in fused images. Two measuring methods Entropy and Image Noise Index (INI) were employed. Entropy can measure the information content of the images but it has a limitation. It cannot distinguish between information and noise. A solution to this limitation is discussed and new method was proposed - the Image Noise Index (INI) using entropy. This method was applied on three commonly used image fusion techniques i.e. Intensity-Hue-Saturation (HIS), Principle Component Analysis (PCA) and High Pass Filter (HPF) to compare the technique, which gives better results.

Zhou.J(1998) proposed a wavelet transform method to merge the high spectral resolution Landsat TM and high spatial resolution SPOT PAN data. Both the data were decomposed into orthogonal wavelet representation at a given coarser resolution, which consisted of a low frequency approximation and a set of high
frequency, spatially oriented detail images. Inverse wavelet transform was performed using the approximation image from each TM band and detail from SPOT PAN. The spectral and spatial features were compared quantitatively with other fusion techniques and wavelet method was found to be good in preserving both.

Pierre Terrettaz (1998) evaluated the results of seven methods in the context of an urban and suburban area. A statistical and visual comparison was made for the overall area and for several zones that represent different land covers types including water, green area, forest, urban and semi urban. Mean and standard deviation of the XS bands were compared with the bands obtained after the merging process; the differences and the correlations between the XS and new bands were also calculated.

2.3 Spatial modelling in GIS
There are many actual and potential applications for spatial process modelling, and as such, research into the construction of generic process modelling tools and methods with maximum usability and flexibility are preferable. Parks (1993) recognised that the majority of recent spatial modelling research has focused on environmental issues. This appears to have resulted in a bias towards environmental modelling development as presented in the literature. It is argued here that much of the work reported has general application and thus no distinction is made.

There is great potential for modelling software that integrates the benefits of GIS with the process analysis capabilities of modelling software (Abel et al., 1997; Bennett, 1997). Parks (1993) argues that with appropriate planning, modelling and GIS technology may ‘...cross-fertilize and mutually reinforce each other’ (p31) and that both will be made more robust by ‘...their linkage and convolution’ (p33). According to Abel et al. (1997), this integration in the past has been technically difficult to achieve. Abel et al. (1997, p5) argues that many examples
of GIS and modelling systems integration ‘...are typically specific to the component subsystems and to the narrow application focus of the integrated system’.

Ball (1994, p346), defines a good model ‘...as one that is capable of reproducing the observed changes in a natural system, while producing insight into the dynamics of the system’. This implies that the model has two functions. First, to simulate and predict based on observed processes, and second, provide detailed understanding of the inter-relationships among variables and processes described by the model. Simulation modelling must ‘...describe, explain, and predict the behaviour of the real system’ (Hoover et al., 1989, p5) and ‘...requires that the model indicates the passage of time through the change in one or more variables as defined by the process description’ (Ball, 1994, p347). Ideally, in an integrated geographical modelling system (GMS), as described by Bennett (1997, p337), ‘...users should be able to visualize ongoing simulations and suspend the simulation process to query intermediate results, investigate key spatial/temporal relations, and even modify the underlying models used to simulate geographical processes’.

The limited development of these models in the past is according to Maxwell et al. (1995, p247) due to ‘...the large amount of input data required, the difficulty of even large mainframe serial computers in dealing with large spatial arrays, and the conceptual complexity involved in writing, debugging, and calibrating very large simulation programs’. An accepted method of reducing program complexity argues Maxwell et al. (1995, p251) involves ‘...structuring the model as set of distinct modules with well-defined interfaces.’

Maxwell (1995) suggested that the use of a modular hierarchical approach permits collaborative model research, and simpler design, testing, and implementation. Bennett (1997) and Maxwell et al. (1995) advocate the use of model base management systems to store, manipulate, and retrieve models.
Bennett (1997, p339) states that 'by managing models like data, model redundancy is reduced and model consistency is enhanced.'

Maxwell (1996) suggested that one way to develop simpler process model design tools is to construct suitable graphical interfaces for the display and manipulation of structure and dynamics. Albrecht et al. (1997, p158) suggest the use of a '...flow charting environment on top of existing standard GIS that allow the user to develop workflows visually.' In addition Bennett (1997) and Parks (1993) assert the need for artificial intelligence, expert systems, and agents to guide non-expert users in the appropriate handling of these tools and reduce the need for the writing of complex computer code.

Narushige Shiode (2001) worked on recent developments in the visualisation of urban landscapes. There is a growing interest in the construction of 3D models of urban and built environment for which a host of digital mapping and rendering techniques are being developed. He identified the range of data and techniques adopted for the development of 3D contents and how they could contribute to geographical analysis and planning of urban environment. He also focused on the effectiveness of GIS and its related methods for their capacity to accommodate the demands for visual representation of urban environment as well as the basis for analysis and simulation.

Young-Hoon Kim and Graham Clarke (2000) in their work on 'Integration of spatial models into GIS for health care facility site planning' in the context of spatial modelling methodologies such as maximising patients accessibility to their hospitals and minimising accessibility costs, or reducing the uncertainty of patients travel behaviours. They brought out the site selection problem through integrated spatial model by combining spatial interaction and location-allocation modelling methodologies. To improve spatial analysis performance, they have used Avenue scripts to enhance the coupling strategy and data interaction process between the model and the GIS system.
Gary and D. Phillip (1996) had explained ancient settlement strategies using GIS on environmental models. This study applied to one such approach, visibility analysis, to data from the Umayri regional survey. The results suggested that visible communication played an important role in local settlement strategies throughout antiquity.

Radio communications planning has been a prominent application area of digital terrain modelling for the last 30 years. In addition, the range of radio communication modelling scenarios (and associated variables), coupled with the higher resolution terrain and topographic data sets now available, make radio path and network planning a very computationally demanding process. David Kidner (1999) presented the issues for developing a distributed GIS for radio propagation modelling and presented a domain decomposition strategy that optimises performance over hilly terrain. The results are extremely encouraging, suggesting that speed-up performance can be increased by a factor of 19 or more using only 20 PCs. The strategy can also be extended to urban landscapes with the integration of 3-D data models for representing surface features such as buildings and vegetation.

Bruce Bayne (2000) in their work on cellular phone tower siting used the location allocation analysis. The different parameters considered for study are population of cell users covered under one cell tower, cost of system, environmental impacts, aesthetic impacts and population density for assessing the future growth. Demand points considered based on population, land use suitability, cell tower height and cell tower coverage radius of 1-30 km. Evaluation with in this article given that location allocation model provided a useful modelling technique to determine demand centres for towers. This type of studies may not tend to give the most needed coverage along the roads where most of the use or maximum usage will be there. Visibility tool was used to analyzing the tower inter visibility for coverage calculation.
André (2000) worked on the Vulnerability of the Cellular Telecommunication Network. An understanding of the vulnerability of the cellular communications network is crucial in hazard prediction and response management efforts. He modelled the cellular network involving several stages and using the scripting language of Arc View and simulated the networks response to a natural hazard. Telecommunication companies are beginning to realize the potential use of GIS for modelling their network. For example, Vodafone Ltd. used GIS to plan their cellular phone networks by overlaying their cell network with demographic information. (Fry, 1999)