CHAPTER 5

DISCUSSIONS

(5.0) Discussions:

(5.1) Thematic Map generation:

Today in this urbanizing world eco-city concept should be guiding means, representing the public interest, protecting the health of the environment and for carrying out construction in line with the surrounding environment. Hence, for upgrading and adjusting the concept of ecological planning in the city's overall planning, thematic planning has become imperative. Thematic maps are indispensable tools in any development and planning programme both at the national and regional levels (**Olomo *et al.*, 1998**). In case of Vadodara city, these maps have provided baseline information for further updation of various resources required for implementation of planning strategy of the city (**Anonymous, 2010**). RS-GIS approach has aided in improving these maps. The cost effective, quick and repetitive characteristics of spatial data have already been proved by **Xu Zhenhua (2005)**. RS- GIS approach together helped in analyzing the spatial and non-spatial attribute, offering possibilities of generating various options (modeling), thereby optimizing the whole planning process. **Verma *et al.* (2009)** has shown how this approach facilitates updating of base maps wherever changes have taken place in terms of land development, etc. by superimposition of two maps of different scales or by insertion of fresh survey or modified maps into existing base maps. Digital information also aided in understanding land use change, providing inputs for urban green space suitability analysis for Vadodara city and finally providing the Eco-city maps for selected wards of the city. To be precise, integration of spatial data with other information provided an important linkage in the total planning process, making it more

effective and meaningful. Thematic map generation also aids in the land use change analysis of the study area.

(5.2) Land use change analysis:

Human beings are the most progressive creatures on the earth. For their progress they have made several changes on this earth through industrialization, urbanization and many others. In this competitive world they have migrated from rural area to urban cities. As a result growing cities are creating an alarming situation in all countries of the world. This process is very rapid and explosive in developing world (**Klaus and Jose, 2002**). These rapidly growing cities are constantly demanding land for making new settlement and sprawl which are the two major drivers for the land use changes **(Oluseyi, 2006)**. These land use have important impacts on the water and energy balance, directly affecting the climatic condition of the urban areas.

Similar situation also exists in Vadodara city. The extent of the city is increasing rapidly due to a huge increase in population density and demand for dwelling places. Poor urban planning and housing development has led to construction of informal settlements that lack access to basic infrastructure and provide poor living conditions. As pointed by **Zeug and Eckert (2010)** this type of situation, increased unregulated traffic, noise, and underdeveloped sewage and waste management causing further environmental degradation. The overall rise in the population in the city resulted into increase in travel times due to congestion of the road network. Consequently length of the road network increased several folds catering the demand of increasing traffic. This resulted into the huge increment in the growth rate of the city as a consequences, the city has expanded its boundary several times from the year 1880 to 2009 to accommodate

increasing population. This type of expansion has evolved by addition of built-up pockets to already existing urban development zones. Similar results were observed by **Ji (2008)** for Kansas city of USA. In addition, the upcoming chemical, Engineering and other industries in the city led to an increased sprawl in northern and southern part of the city. This has not only reduced the agricultural land, but also raised the traffic volumes with increased pressure on the environment. Such factors have created unsustainable surroundings in the city **(Wong and Yuen, 2011)**. The current spatial and physical planning focus of the planning system does not provide an effective means to achieve resource management planning at local level as already proved in China **(Yip, 2008)**. As a result, sustainability of cities is under pressure. This is seen as a threat in the developing country like India **(Reiner, 2005)**. At this point, an immediate solution for sustainable development of urban land is required which can be achieved by sustainable land use planning. According to **Lavalle *et al.* (2001),** understanding of land use change is a prerequisite for this type of planning. In this view, Land use change analysis in this study was carried out using the integrated approach of Remote sensing and Geographical information system (GIS) which gave a key input in Eco-city planning.

Remote sensing and GIS provided a fast and efficient method to carry out a land-use inventory and detect changes. These changes in the city over a period of time cannot be neglected but require proper monitoring and assessment so that no further deteriorative step are taken unknowingly. As such remote sensing data are capable of detecting and measuring a variety of elements related to the morphology of cities, such as the amount, shape, density, textural form and spread of urban areas **(Webster, 1995; Mesev *et al.* 1995).** The spatial technology along with GIS act as an ideal tool to identify, locate and map various types of lands associated with different landform units

(Dhinwa *et al.*, 1992; Palaniyandi and Nagarathinam, 1997; Murthy and Venkateswara, 1997). The GIS technology provided a platform for integration of various data sets which helped in identifying the problem areas and in suggesting conservation measures. This required the planning process to be carried using spatial information along with other non-spatial information which is linked with the development of the city. Accordingly RS-GIS tool employed for understanding the land use changes in Vadodara city over a period of 129 years have proved to be fast, effective and cost-effective method. Change detection carried out for the city on two levels, i.e. VUDA level and VMSS level has shown a notable decrease in the area under classes like water body, vegetation, and agriculture with a parallel increase in built-up and industrial area. The whole city experienced a vast expansion of urban areas at the expense of agricultural land. It decreased very rapidly from the year 1880 to 2009. This was due to the conversion of agriculture land in other land use classes like built-up, industrial area, etc. As observed by **Brown (1995)**, this high rate of conversion of the agriculture land has threatened the food security, also. Due to high rate of urbanization, the extent of natural land uses like, water bodies also decreased very rapidly during the study period converting them in other land uses. This fact indicated that if the same trend will continue unchecked then there will be water crisis as already experienced in some parts of the city.

Conversion of natural land uses like water bodies, vegetation, etc. made it crucial to determine the rate and direction of urban sprawl for which several parameters were estimated. It aided in the understanding of the causes and effects of urbanization processes. Shannon's Entropy gave the distribution of the loss of these natural land uses to the built-up. It played very significant role in identifying, measuring and monitoring

the spatial distribution of urban sprawl **(Jat *et al.*, 2008)**. Same approach was applied by **Punia and Singh (2011)** for Jaipur city of India. Entropy calculation for Vadodara city showed that the value was low in the year 1880 which increased by 0.29 during the span of 129 years indicating the high rate of urbanization. In addition, high value of entropy also indicated dispersed type of developmental pattern of the Vadodara city. Estimation of the U.S.I. showed high values between the years 1960 to 1980 while it decreased during the recent time due to more compact development. Land Consumption Rate a function of increased urban land use which increased with increasing population density. Parallely, Land absorption Coefficient (L.A.C.) also showed a rapid consumption of land during years 1960 to 1980 due to industrialization.

Land use change and associated parameters played a major role in strategic planning of urban green space. It also helped in proposing new buildings with vegetation in gaps of existing structures which helped in harmonizing its built and natural environments. It also aided in generating the eco-ward plan of selected wards.

(5.3) Urban green space Analysis:

Urban Green spaces are a part of nature and play a key role in improving the environmental quality, livability, and sustainability of cities. They provide many environmental and social services that contribute to the quality of life in cities and play social, planning, economic and ecological functions. Factors such as the size, shape, accessibility, diversity and distribution of green spaces within a city as well as the design and management of the green spaces play a decisive role in defining these functions of them. Despite of these functions provided by urban green spaces, they are not properly managed in the Vadodara city. Urban sprawl is leading towards the loss and increased

fragmentation of them, thereby diminishing their positive functions **(Wang and Moskovits, 2001)**. These urban green spaces are getting converted to other land uses due to expansion of the city. As a consequence, UGS is becoming a scarce source in the city due to their loss over a period of time. This makes it essential to map the location and quantify amount of green space areas in the city. This allows the urban planners to identify existing green space areas to protect from urban development, or to target certain areas of conversion into new green space areas, e.g., vacant lots into city parks, or unused rail lines into greenways, etc. Moreover, there is a deficiency of information about the quality of these spaces of the city. Not only that but, the available information is incomplete and fragmented and needs improvement. Because of such lacuna of information, some of the wards of the city have high amount of vegetation while some of them have least or negligible vegetation. The reason for such unbalanced distribution is lack of application of advanced technology for planning and mapping of urban green spaces. Most of the planners are still designing urban green spaces based on subjective judgments, that is, the accumulation of knowledge, inspiration, insight, imagination and even speculation **(Shen *et al.*, 2011)**. Therefore, in this study, suitability analysis using advanced technique of Remote sensing and GIS approach was applied for identifying suitable sites for UGS development to ensure their roles and functions **(Gilbert, 1989)**.

With the help of remote sensing and GIS the database generation for suitability analysis became fast and reliable **(Sathish and Niranjana, 2010)**. Remote Sensing and GIS helped in mapping different themes related to physical and social factors utilized for suitability analysis. The use of remote sensing techniques helped in describing a variety of satellite-derived data sets and their application to understand changes in the landscape **(Kouchoukos, 2001)**. GIS offered a flexible and powerful tool to manage all these data.

It provided a tool for integrating and analyzing of land resources to determine the suitability for urban green spaces. It played a significant role in spatial display of different biophysical and socio-economical parameters depending on the location of housing property. It provided a means of taking large volumes of different kinds of data sets and manipulating and combining them into new data sets which was displayed in the form of thematic maps **(Foote and M, 1996; Marble and Amundson, 1988).** This helped in determining to what extent the urban land can be used for green space development which is the main objective for suitability analysis **(Kerkstra and Vrijlandt, 1990).**

One of the various themes utilized for the suitability analysis was the vegetation and related parameters. This theme was analyzed using satellite derived NDVI index which played a very important role in analyzing present status of urban green space of the city. The results revealed that there was rapid decrease in the urban green space from the year 2000 to 2009. Per capita vegetation also showed decreasing trend due to increase in population density. This implied that existing green spaces in Vadodara city are far from satisfactory according to the quantity. The spatial dispersion of urban green spaces is also unbalanced. Various socioeconomic variables in combination with biophysical variables like land use, slope, presence of water body, transport, location of Greenbelt and gardens also influenced the suitability of UGS. Land use was found to be a dominant factor affecting the tree cover and hence, played a key role in suitability analysis. The results revealed majority area of the wards was not suitable for the development of the UGS. However, certain areas found to be highly suitable for development of UGS because of their attributes like medium slope, proximity to the road

and water bodies. From the management perspective it was interesting to note that the majority of the suitable sites are either under the ownership of public and government.

These urban green spaces in the form of suitable sites not only provide opportunities for people, they also improve social and economic life, and contribute to the ecological and planning system, and as a whole the urban quality of life. Therefore, the analysis of market demand of the urban green spaces is an important factor for their development. However, there is no real market for urban green spaces and thus it is hard to determine the market demand of urban green spaces and therefore, it is also difficult to determine the extent of supply and development of urban green spaces **(Goede *et al.*, 2001)**. The value of urban green spaces is related to the value of nature. Many studies have shown that presence of public green spaces parks, natural areas and golf courses in near vicinity raise the property price **(Bolitzer and Netuzil, 2009; Marancho, 2003 and Kong *et al.*, 2007)**. Many real estate professionals agree that houses with mature trees are preferred to comparable houses without mature trees **(Dombrow *et al.*, 2000)**. City dwellers prefer to live closer to the green spaces. **Burgess *et al.* (1988); Coles and Bussey (2000) and Grahn and Stigsdotter (2003)** stated that green spaces will be more often visited if they are closer to the dwellings. Therefore, value of green space in residential areas was estimated for the city. The results obtained showed that there is a positive correlation between house prices and the existence of green spaces. **Similar** results were obtained by **Altunkasa and Uslu (2004)** for development area of Adana (Turkey). This study also demonstrated the importance of spatially retrieved parameters in understanding the economic valuation of area in urban cities to mark out importance of UGS. Modeling of cost through integration technique like PCA based on biophysical

and socioeconomic data demonstrated the significance of NDVI, LST, and Population density on green space availability.

Above results revealed that urban green spaces are not evaluated effectively in the Vadodara city according to the potentials and dynamics of sustainable urban development. The existing green space has to be preserved and numbers of usages of these areas and their functions should be diversified so that more people can benefit from them in the city. Therefore, there is a need of a process of suitability analysis to be put into planning, designing and management of green spaces for the city by taking into consideration the ecological, scientific, and technical criteria. This will also aid in Eco-ward plan generation of selected wards.

(5.4) Eco-ward plan generation:

The urban areas of the country are facing problems of deteriorating environmental and socio-economic conditions. There are several reasons creating these problems such as, population migration, environmental consideration not adequately being incorporated into master plans of cities, uncoordinated and haphazard development, weak implementation of plans and laws and inadequate institutional competences. One of the major issues is resource crunch. There is severe lacking of infrastructure facilities. Urban sprawl onto cheaper land is the major driver of urbanization. Waste stemming from energy consumption tends to affect areas beyond their administrative boundaries **(Ryser and Franchini, 2009)**.

Application of non-conventional solution of Eco-city development is imperative after bring into the above facts. Such city is vital to have the valuable trend of city planning, construction and development in the modern world as it is based on the reformation and rebuilding the city's ecosystem with structural integrity and explicit

function on the basis of human beings' activities. It is necessary road to realize city's sustainable development; it reflects the radical distinctions between the new and traditional strategies of development about "comprehensive construction of a well-off society" **(Hildebrand, 1999)**. The Eco-city development should consider the scientific theories of modern ecology and sustain by scientific regulation of ecosystem. An Eco-city, as a civic human residence model, is built for many reasons as follows: it utilizes material, energy and information very effectively; it provides a perfect harmony of city population, resources and environment, it leads to coordinated growth of society, economy and nature **(Fazeng and Shengnan, 2007)**. Such non-conventional solution has been applied to Vadodara city.

The physical development of the Vadodara city has exacerbated their environmental deficit over recent times. The existing space in Vadodara built-up areas is not enough to bear the weight of more and more population followed by the future urbanization, and the support in the promotion of city status. This situation is worse in the old city zone. Hence, transformation of old city zone was the main aim of this study. Therefore, the three wards comprising the core of the city were selected. This task for Vadodara city was carried out by performing the Land suitability analysis using Arcinfo 7.2 based USAP module for selected wards. It played a non-substitution role in the preparing the Eco-city plan for selected wards. This module examined the combined effects of selected set of parameters such as slope, Land use, road buffer, water buffer, etc. by overlaying in the GIS environment. It allowed the construction of models from which a new thematic map (e.g. land suitability map) was produced from a set of thematic maps **(Harasheh, 1994)**. Suitability map generated based on the model four gave precise output for further development. Suggestions of participants were also

incorporated for proposing the Eco-ward plan. Different land uses were allocated considering current potentials of land. The most suitable land was used first for urban development. Care was taken to protect natural sources for the next generations. Same practice was performed by **Tuncay *et al.*, 2011**. This ensured the proper utilization of existing space of the city. New built-up areas were proposed on the open space present in highly suitable category.

New gardens and green belts were proposed on the open spaces present on the land which was non-suitable for construction. These urban green spaces will form the main component of ecological environment in city ecological system **(Wang, 1997; Tang, 2002)**. Air pollution tolerance index (APTI) of various plants present in the wards was estimated to analyze their tolerance to pollution. The tolerance of these plants differed drastically based on the response of their biophysical and biochemical parameters. Polluted environmental condition was responsible for the higher level of leaf extract pH which imparted them the tolerance to the air pollutants **(Kuddus *et al.*, 2011).** The leaf pH decline was greater in sensitive plant than the tolerant plant **(Scholz and Reck, 1977).** Plants with the higher ascorbic acid level under polluted condition indicated that these plants were tolerant to air pollutants (**Senthilkumar and Paulsamy, 2011**). Several researchers have proved that pollution stress decreases the chlorophyll level in plants as the chloroplast is the primary site of attack **(Speading and Thomas, 1973, Santhoskumar and Paulsamy, 2006).** Similar results were obtained for the plants of all the wards. Tolerance level of the plants was estimated based on the APTI values of all the plants of particular ward. Results revealed that plants having high APTI values were tolerant to pollution. It was observed that plats like, *Ficus bengalensis* L., *Ficus religiosa* L., *Mangifera indica* L., etc. were found to be most tolerant plants and was

recommended for planting the green belts and gardens. This type of planning will help in improving the microclimatic conditions of the Eco-wards.

For conversion the existing situation into more sustainable form, more compact, space-saving and mixed use settlement structures interrelated with an environmentally compatible transport system convenient for pedestrians, cyclists and public transport was suggested. The buildings must make best use of the sun, wind and rainfall to help supply the energy and water needs of occupants. Further, the buildings should be multi-storey to maximize the land available for green space. Nearby wards should be threaded with natural habitat corridors to foster biodiversity and to give residents access to nature for recreation. It was recommended that the settlement structures should serve as a framework for sustainable development across all sectors, such as energy (including solar architecture), water supply and management, social and economic development and sewage and waste management.

This type of planning practice will help in directing urban development towards minimizing the use of land, energy and materials, and impairment of the natural environment while maximizing human well being and quality of life.