

Chapter 1

INTRODUCTION



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1.1 General

The land use and land cover knowledge is important for any socio-economic development of a region. The term land use means the use of land for human activities like residential, commercial, etc. while the land cover term relates to the various types of features like agricultural fields, buildings, forests, road networks, etc present on the surface of the earth (Lillesand and Keifer, 1996). According to Gupta, (1991) Land Use/ Land Cover (LU/LC) information along with spatial distribution and its change is useful for the developmental planning and management of programs at various levels. The conversion of natural forests for industrial and agricultural activities is the common factor for the land use changes (Hammett, 1992). Although LU/LC changes are local and place specific, also contribute for environmental change. The changes in LU/LC include loss of forest and agricultural areas, increase of impermeable surfaces and urban built-up land, etc. The LU/LC study is useful for the city planners and policy makers (Abd El-Kawy *et al.*, 2011).

The multi-functional role and sustainability of environment are threatened due to the landscape changes in natural ecosystems (Narumalani *et al.*, 2004; Schulz *et al.*, 2010). LU/LC dynamics with its effects on hydrological and ecological process and on human livelihood is the major concern today. Thus the process of land use dynamics has been widely studied for finding mitigation strategies to reduce the impacts of climate changes (NRC, 2005). Urbanization is a metropolitan growth to the physical geography of an area due to economic, social, and political forces (Adegoke *et al.*, 2007). The study of urbanization used by experts like ecologists, urban planners, civil engineers, administrators and policy makers. Urban ecosystems are the present complex ecosystems arise mainly due to human settlements in to cities from villages. The world population has increased six times in the last 200 years; population of urban area has multiplied hundred times. In India, the unprecedented population growth along with unplanned developmental activities has resulted in urbanization with heavy pressure on land and the resources surrounding them, which has resulted in major environmental problems. The spreading of urban areas has also

resulted in loss of natural vegetation and loss of open spaces. Moreover greater infrastructure demand has arisen due to the ever increasing population. As a consequence, the planning and management process in growing urban areas has become more and more complex and difficult. A better understanding of the process of urban growth is very much required for an efficient planning and management of resources. Urbanisation is a form of metropolitan growth which includes - population growth, commercial activities, construction of industrial hubs, buildings, roads, parking slots, dump yards etc. This phenomena of rapid growth and urbanization lead to uncoordinated, uncontrolled and unplanned developments within the cities which impacts to loss of open space, loss of agriculture land, deficient in basic amenities, lack of waste management, underprovided transportation network etc. Coastal zones are most exploited geographic unit of the earth. It's easy access and resourcefulness has always attracted human activities (Anji Reddy, 2005). For ensuring sustainable development, it is necessary to monitor the continuous changes in LU/LC pattern over a period of time (Chaurasia *et al.*, 1996).

The population growth and socio-economic development results in a rapid increase of urban built up area results in the change of microclimate in urban areas. The increase of urban surface temperature compared with suburban areas is called heat island. One of the major implications of urbanization is increase of surface temperature and development of Urban Heat Island (UHI). Surface temperature is increased by anthropogenic heat discharges due to energy consumption with increased land surface coverage of artificial materials having high heat capacities and conductivities results in reduction of vegetation and water pervious surfaces which decrease the surface temperature through evapotranspiration.

Research in this area of environment is needed for effective plan and neighborhood-based heat island mitigation strategies, efforts to address summer time heat as a public health issue and the city planners must develop phase-in additional mechanisms and implement policies to support climate adaptive strategies in the built environment. Rapid urbanization has significant influence on different aspects of the quality of life and research in determining the patterns of urbanization and quantifying their impacts is the need of the hour. Unplanned urbanization will directly affect the LU/LC of the area. Understanding the distribution of Land Surface Temperature (LST) along with spatial extent will be helpful to

study the UHI and also to find out the solution for reduction of UHI. Cities located in forested regions have stronger heat islands (<http://www.nasa.gov>) than cities situated in other environments. It is the lack of cooling at night time rather than high day time temperature poses risk of health hazards. Thus there is an urgent need to study temperature variation of developing cities, so that a proper developmental planning in the formulation of policies could be implemented in future.

1.2 Geo-informatics

Geo-informatics is defined as the science and technology dealing with the spatial data, its capture, its classification, its storage, processing, analysis and dissemination, with the infrastructure necessary to secure optimal use of this information. These data are obtained from many sources such as earth orbiting satellites, air and space borne sensors and also ground-based instruments, which is processed and manipulated using information technology with computer software and hardware. It has applications in many disciplines, which depend on spatial data, including geology, engineering, agriculture, forestry, navigation, environmental studies, oceanography, land development and planning of natural resources. Thus, Geo-informatics has been an important tool in man's quest for knowledge, a motivating force for explorative spirit and an essential means for his commercial adventure. The growing demand for economic well-being and for better quality of life has put stress on the management of resources. Therefore, the resource management has to be supported by an effective decision support system, which in turn requires timely and high quality spatial information.

Geo-informatics encompasses a broad range of disciplines including Surveying, Remote Sensing (RS), Geographic Information System (GIS), Photogrammetry and the Global Positioning System (GPS). RS and GIS are considered extremely important technologies for addressing various issues related to the earth's environment. Remote sensing is mainly concerned with the measurement or acquisition of information about an object without being in physical contact with the object under study. Remotely sensed satellite data has advantages of providing synoptic view, repetivity and capability to study large and inaccessible areas on a regional scale. Thus it forms a vital tool in natural resources mapping and monitoring and helps to hasten the decision making process at

several stages of study. GIS involves the collection, integration and storage of diversified and complete information of a region in a computer system. GPS on the other hand allows us to locate our self on the ground by means of earth's longitude-latitude system. The altitude at any point with respect to mean sea level (MSL) is measured accurately with the help of GPS. It is universally accepted fact that RS and GIS tools play a major role in different types of infrastructure development. Most of the decision taken at various levels by different development agencies is dependent on the spatial analysis of different parameters obtainable through these systems. The maps are the most important aspects of spatial analysis. Remote sensing data provides accurate maps when used in GIS environment provides excellent tool for the planner.

1.3 Importance of the study

Satellite remote sensing techniques proved its capability in preparing accurate LU/LC maps and monitoring changes at regular intervals otherwise it is quite difficult with traditional method of surveying. Remote sensing techniques have proved their capability to study the change detection at global and regional scales with the availability of multi-sensor satellite data of high spatial, spectral and temporal resolutions. Thus it is now possible to prepare updated and accurate land-use/land-cover map at lower cost with better accuracy and in a short span of time (Jensen et al., 2001). Multi-resolution remote sensing data helps in the study of impacts of human induced changes and long term environmental changes in the land cover (Xu *et al.*, 2005; Berberoglu and Akin, 2009; Yu *et al.*, 2011). IRS-IC images are widely used to study the LU/LC features of the land surface (Ehlers *et al.*, 1990; Eastman and Fulk, 1993; Harris and Ventura, 1995; Dewan and Yamaguchi, 2009). Spatio-temporal data helps in mapping and monitoring changes in land cover process and to develop mitigation policies to minimize further degradation (Marcucci, 2000).

The study of processes of urban growth is essential for future planning and management of resources. In recent times Udupi city and its surroundings are experiencing unprecedented urbanization due to concentrated developmental activities resulted in the growth of population with consequent pressure on natural resources and infrastructure. Thus increase in built up area resulted in major environmental problems such as climate change, urban heat island effects, etc. The atmospheric changes mainly indicated by temperature.

Therefore in the present work an attempt is made to study the contribution of spatial extent of urbanization for the variation of temperature in and around Udupi taluk and also for the UHI effect. Keeping the above in view, the present work has been undertaken to prepare the multi-date land use/ land cover maps of Udupi taluk from multi-sensor satellite data and monitor the changes in various LU/LC classes using digital image processing techniques.

Thermal remote sensing operates in the thermal infrared (TIR) region of the electromagnetic (EM) spectrum mainly deals with the acquisition, processing and interpretation of the data acquired, which measures the emitted radiations from the surface of the target (Sabins, 1997). In the present research work an attempt has been made to study urbanization (LU/LC) using optical remote sensing data and surface temperature variation using thermal remote sensing data of Udupi taluk, Karnataka State, India.

UHI implication on local climate and on the natural resources necessitates appropriate strategies for the sustainable management. UHI study is possible using RS technology (Streutker, 2002). The phenomenon of UHI effect study using thermal infrared sensors data from satellites can be used to estimate LST. In this work satellite data of LANDSAT, IRS LISS-III data, hyper spectral data and stereo data of Cartosat-1 are used. In the present research work an attempt has been made to compare the urban growth of Udupi city and its surroundings with an effort to analyze urban growth contribution to temperature variation due to UHI effect. In addition, in order to understand heat island effect attempt is made to map LST variations across various land cover types. This study of process of urban growth is very much required for an efficient planning and management of resources.

This research focuses to analyze the contribution of the built up area growth due to change in land cover types of Udupi taluk during the years 2000, 2006, 2010 and 2014 to the UHI using GIS technology and also an attempt to locate the spatial extent of urban heat island areas using the temperature distribution maps based on Moderate-resolution Imaging Spectroradiometer (MODIS) data of the dates March 29 (2000), March 30 (2006), March 29 (2012) and March 30 (2014) and LANDSAT 7 of March 14 (2000), LANDSAT 8 of March 13 (2014) processed using IDRISI Software developed by Clark university lab. This is an attempt to map land surface temperatures across various land cover types to understand heat

island effect. This research aims to evaluate the use of various satellite data such as MODIS, LANDSAT for indicating temperature differences in urban areas, to analyze and compare the relationship between urban surface temperatures with land cover types using geoinformation technology.

1.4 Study area

The Udupi taluk lies in the coastal region of Karnataka state on the west coast of peninsular India. The taluk lies between 13°00' and 13°30' N latitude and 74°40' and 75°00' E longitude and covers an area of 939.40sq.km (Figure 1.1). The area is almost plain towards west and south with an undulating topography towards east and north. The elevation of the region is in the range 20-100m above MSL. Synoptic view of the study area, as viewed by the LISS III sensor of IRS 1C satellite, is shown in Figure 1.2.

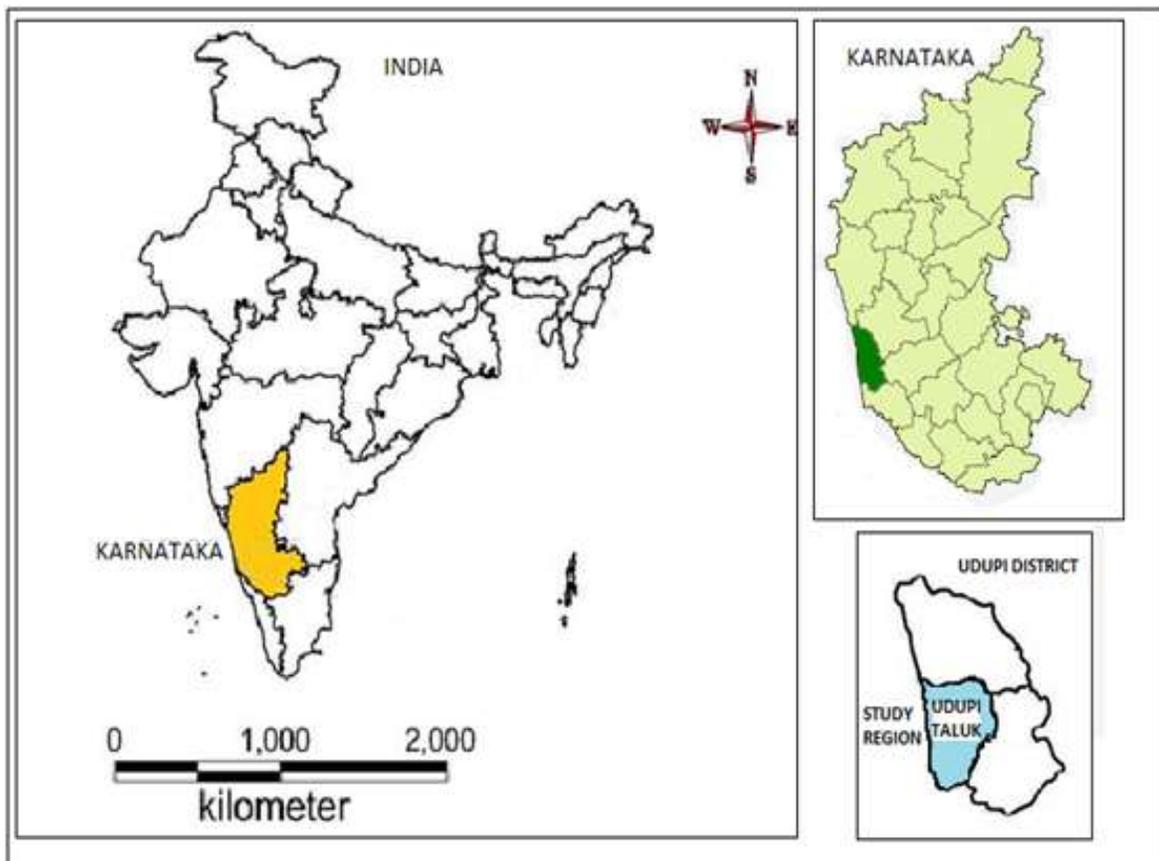


Figure 1.1: Location map of the study area (Udupi taluk)



Figure 1.2: Synoptic view of the study area as viewed by the LISS III sensor of IRS-1C satellite

As per provisional reports of Census India, Udupi taluk had a population of 5,29,225 while Udupi metropolitan population is 1,65,401 in 2011 with population density being 572/sq km. Present research work has been undertaken by observing the rapid growth of population which is in turn linked with built up area via urban growth of Udupi taluk. Agriculture is the major occupation of the people. Paddy is the dominant agricultural crop. In addition to this, sugarcane, mango, pineapple, jackfruit, pepper, beetle leaves, coconut, areca nut, cashew, etc., are grown in the region. Other occupations of the people include fishing, trade and commerce. Udupi taluk has made good progress in industrial development especially in small-scale industries, which include automobile, electrical, and electronics, chemical, glass and ceramics, paper and printing, wood and others. (Source: Directorate of Economics & Statistics). The area has an excellent transport communication system. National Highway (N.H)-66 and Konkan railway are passing through the area, almost parallel to the west coast. Villages and habitations are connected with metalled and unmetalled roads with a network of private and public transport systems.

1.4.1 Geology of the study area

Major part of the Udupi taluk is covered by gneisses and laterites. Enclaves of ancient supracrustals and granulites (mainly Charnockites) also occur in some parts of the taluk. Proterozoic younger dykes are scattered throughout the taluk. Laterite felsic volcanics and alluvium along beaches and river channels are major Phanerozoic formations in the

taluk. Charnockites and felsic volcanics such as dacites, rhyodacites, and granophyres are restricted to few places. The Figure 1.3 shows the geological/lithological thematic map depicting the various rock types of the study area.

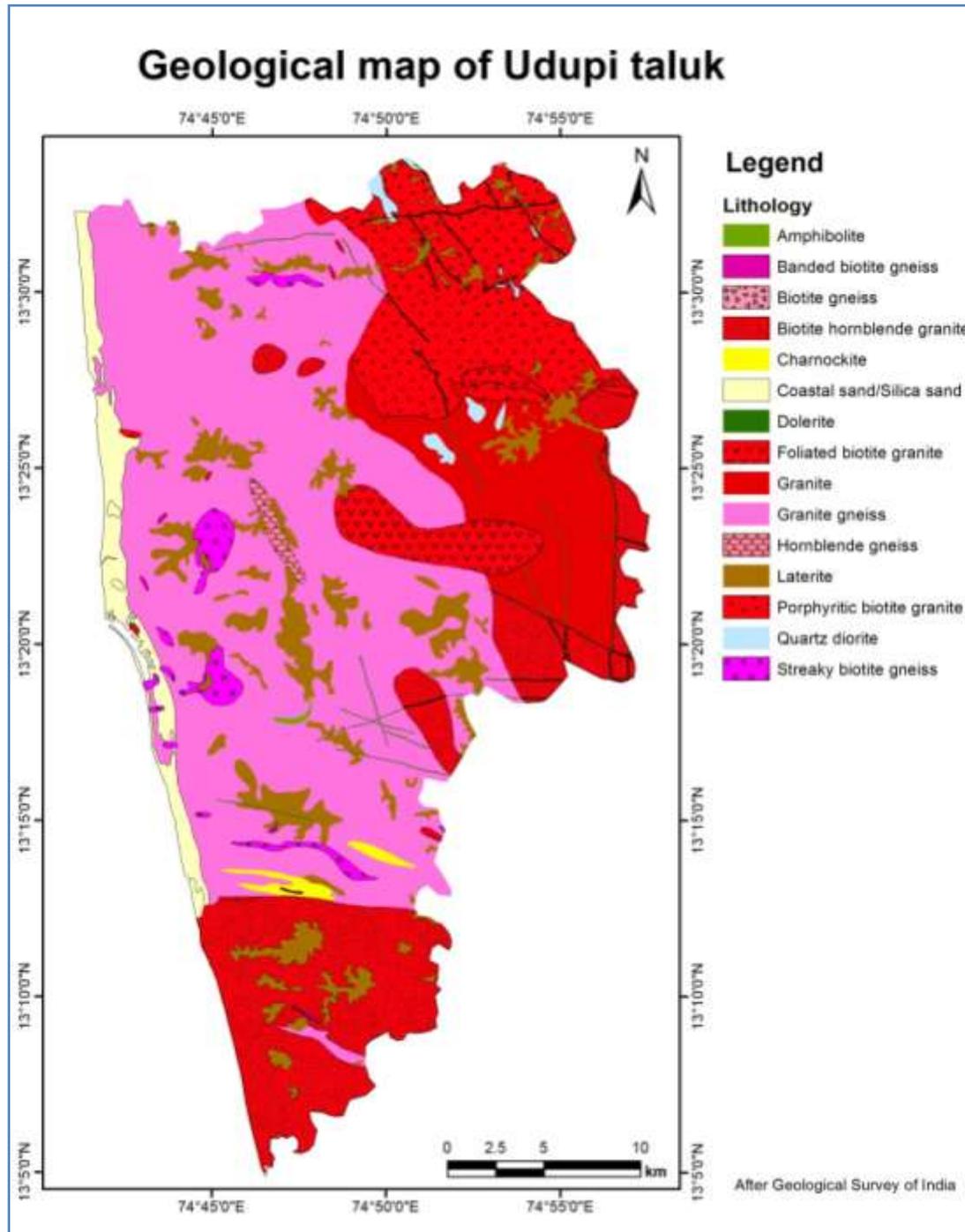


Figure 1.3 shows the geological/lithological thematic map depicting the various rock types of the study area

Three types of soils are found in the Udupi taluk namely sandy soil; yellow loamy soil and red lateritic soil. The narrow strip of the coast consists of sandy soils with width 100m to 1km range. Yellow loamy soils are found mostly along river banks and lower reaches of valleys. Most dominant soil type in this region is the red lateritic soil. The Karnataka coastal land can broadly be classified into three regions: lowland, mid-land and highland depending on the terrain features and their altitudes. Marine and estuarine geomorphic forms characterize the lowland or coastal plain region bordering the Arabian Sea. The rivers take a meandering course with wide channels and some landmasses in the centre. Such an island, a holm is locally called as kudru. These holms are fertile lands and are usually covered by coconut palms. The mid-land region is wide and has a large number of lateritic hillocks whose height ranges from 30 to 100m above the mean sea level and scrubs dominate the natural vegetation cover on them. The west-flowing rivers cut across this mid-land region and a number of wide valleys are formed. Shoulders of these valleys are used for coconut and arecanut plantations. Small mangrove formations occur within the backwaters of the rivers. The west flowing river basin covers parts of Swarna, Madisala, Sita, Haladi, Chakra sub basins. These rivers join Arabian Sea in the western coastal belt.

1.4.2 Meteorological conditions of Udupi taluk

The study area falls under tropical humid climatic conditions. Generally, the weather is hot and humid throughout the year. The coastal belt is hotter than the Western Ghats. The area is marked by heavy precipitation. The various climatic parameters like temperature, humidity and evaporation, wind and precipitation are briefly discussed in the forthcoming sections.

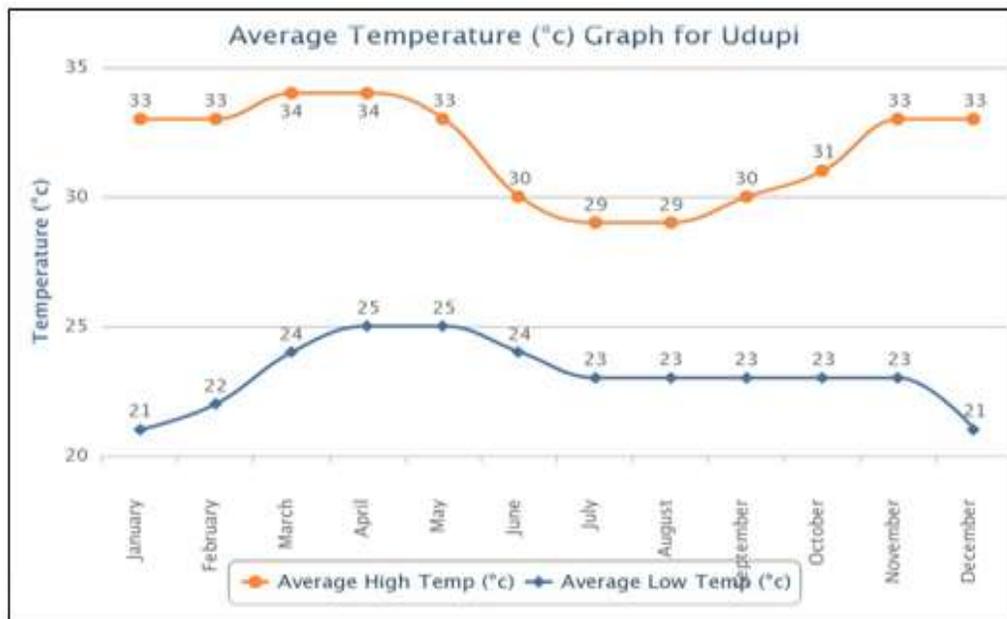
1.4.2.1 Temperature

The study region have maritime climate with an average temperature of 27.5°C. The hottest months of the year are March, April and May. In general, the temperature gets down with the onset of southwest (SW) monsoon (June) and increases with the retreat of monsoon (September, October). Average temperatures recorded during 2000-2014 are shown in Table 1.1 and its variations graph shown in Figure 1.4.

Table 1.1

Monthly average temperature during 2000-2012 at Udupi

| Month | Temperature (°C) (2000-2012) | | |
|-----------|---------------------------------|-----|---------|
| | High | Low | Average |
| January | 33 | 21 | 27 |
| February | 33 | 22 | 27.5 |
| March | 34 | 24 | 29 |
| April | 34 | 25 | 29.5 |
| May | 33 | 25 | 29 |
| June | 30 | 24 | 27 |
| July | 29 | 23 | 26 |
| August | 29 | 23 | 26 |
| September | 30 | 23 | 26.5 |
| October | 31 | 23 | 27 |
| November | 33 | 23 | 28 |
| December | 33 | 21 | 27 |



*Figure 1.4: Average temperature variations for Udupi during 2000-2012
(Source: <http://www.worldweatheronline.com>)*

1.4.2.2 Humidity and evaporation

Humidity reaches maximum during the SW monsoon (June-September) due to heavy precipitation and limited evaporation. Generally evaporation rate is very low during monsoon (July-August) and it gradually increases from October and reaches the maximum in May.

1.4.2.3 Wind

Wind speed in the study area varies from 10 to 18km/hour. During June and July (first half of SW monsoon) and in October, winds are strong (16km/hour to 17km/hour). Most of the time wind blows from S, SW and W directions between May and September. From October to January, it blows mainly from N, NE and E directions. While, between February and April, it blows from N, NE and E for about 50% of the time and from SW and W directions for the remaining 50% of the time. The land-sea breeze occasionally attains a speed as high as 20km/hour.

1.4.2.4 Clouds

Sky is densely clouded almost all the days during the southwest monsoon, which sets in the first or second week of June and continues till the end of September. The dense cloud setting usually starts in late April with the maximum cloud formation occurring in May/June. The number of heavily clouded days is only a few in the post-monsoon months of October and November. In the remaining months, sky is generally clear.

1.4.2.5 Precipitation

Precipitation greatly influences the physicochemical conditions and primary production of coastal waters by generating a large volume of water discharge into the sea. It is very crucial as it erodes and washes land and carries sufficient sediments into the sea along with inorganic nutrients and terrestrial organic load thus controlling the water quality. About 80-85% of the annual rainfall is received during the SW monsoon, about 10% during the post-monsoon season and the remainder during the pre-monsoon season (Figure 1.5). Western Ghats plays an important role in the distribution of rainfall and orographic precipitation. Compared to the coastal belt, the hill region of the Western Ghats usually receives more rainfall.

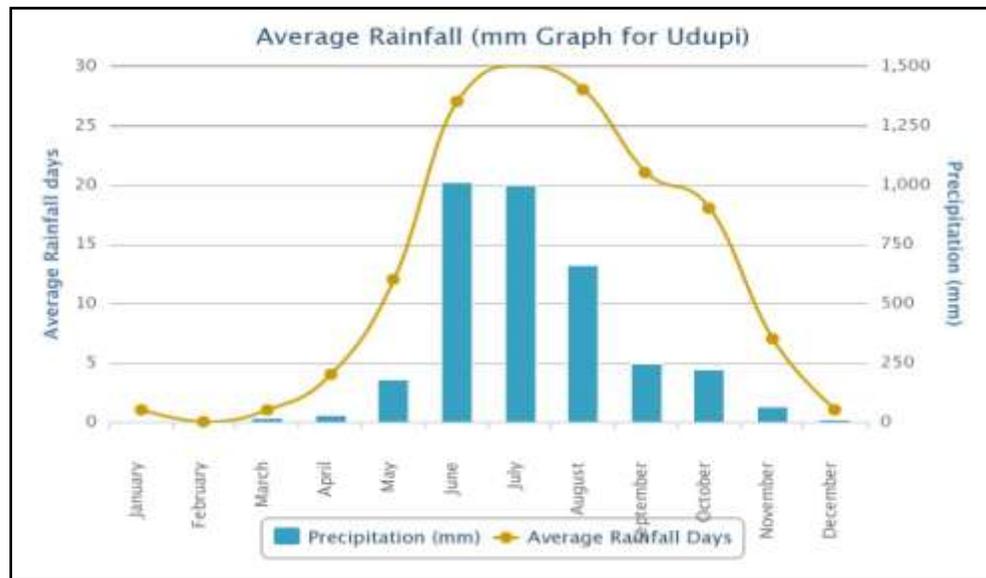


Figure 1.5: Graph showing monthly precipitation at Udupi during 2000-2012
(Source: <http://www.worldweatheronline.com>)

1.5 Specific objectives

The main objectives are:

- To generate spatial databases using topographic maps and various sensors of multi date satellite imageries of Terra/Aqua, LANDSAT and IRS.
- To generate the multi-date land use/ land cover maps of the study area from multi-sensor satellite data and to monitor the changes in various land-use/land-cover classes using digital image processing techniques.
- To generate land surface temperature spatial database using multi date thermal satellite imageries and retrieval of air temperature of the study area.
- To analyze the spatial pattern of the LST and surface urban heat island effect in order to correlate with urbanization and various land cover types using normalized difference vegetation index as a parameter.
- To develop mitigation strategies for urban heat island phenomenon based on integrated approach of RS and GIS techniques.