1.1 Introduction

Geomorphology is a scientific discipline of geography which is concerned with the study of landscapes. A detailed study of morphology of any area can provide a reliable base for its future development. In the present period, the anthropogenic activities are transforming the natural landscape which consequently alters the nature of geomorphology.

“Urban geomorphology”, a recent but more useful branch of applied geomorphology, studies the related process, materials and hazards, and the ways that are beneficial for planning, development and management of urbanized areas or areas where urban growth is expected (Cooke 1982). It primarily deals with lithology, geomorphic processes, hydrological conditions and topological characteristics of a specific area. Such factors are not only significant in determining the rate of urbanization, but also have a direct influence on the size of population and stability of ground surface of urbanized localities. In urban areas, the study of geography is primarily concerned with interpreting the patterns and interrelationships of the concerned parameters that exists within it. It is important to note that each city has its unique morphology from the geographical perspective, but the contemporary growth patterns result in the transition of its morphology.

In the developing countries, not much attention is paid towards understanding the geomorphological conditions in urban areas. Consequently, it results in uncontrolled growth of the settlement giving rise to shanty towns, which are observed in many deprived countries. This not only creates social problems but is also responsible for environmental problems (Cooke 1982). The transitions in the environment landscapes are inevitable if urbanization is considered to be a positive indicator of development.

The World Commission on Environment and Development in its report ‘Our Common Future’ stated that the environment and development are not separate challenges; they are linked. Development cannot subsist on a deteriorating resource
base; the environment cannot be protected when growth leaves out of account the costs of environmental destruction (WECD 1987).

1.2 Geomorphology

Geomorphology can be defined as a science which studies the genesis and the causes of evolution of land surfaces and their rate of change in relation to nature and human. Geomorphologic studies aim at describing the present nature of the topography and interpreting the causes of its formation. Much work in geomorphology is of great potential value to man in his use of the physical environment (Cook and Doornkamp 1974). In recent years, the application of geomorphological knowledge has increased in harmony with growing public and political awareness of environmental problems. Geomorphologist have emphasized on the practical application of the subject by establishing dynamic relationships between landforms, materials and contemporary processes. Now-a-days, geomorphology is influenced by one of the most advanced structure of human settlements in the form of cities, and its correlation with natural and environmental factors. Thus, the role of this discipline in establishment, site selection and physical development of cities especially arid and semi-arid cities is undeniable (Cooke 1982).

1.3 Geomorphic Processes and the Human Landscape

Over a period of few centuries, human activities have affected geomorphic processes on a scale that transcends natural impacts with an effect likened to a major global climate change (Knighton 1998). Deforestation reduces the rate of evapotranspiration and infiltration and increases runoff and sediment supply to water-courses. Farming involves tile drainage and water-course re-direction through ditches, which reduces stream length and alters the flow. It curtails the habitat potentiality of the area. Urban development typically results in the extensive compression and paving of land surfaces, which significantly reduces infiltration and dramatically increases runoff to watercourses unless extensive mitigation is applied. When changes in flow regime and sediment supply from land clearing and urbanization exceed the thresholds for self-regulation in affected water-courses, the dynamic equilibrium will be upset, causing the channel to become unstable. In such circumstances the water-
course adjusts with physical changes that occur more rapidly than the controlled adjustments of the natural dynamic equilibrium.

These changes are rapid, extensive and often catastrophic and may include severe bank erosion, a lowering of the bed level of the stream, or major changes to the path of the channel itself. Such changes can result in destruction of aquatic and riparian habitat, damage to infrastructure and property, and risks to public safety.

Research into the effects of urbanization on watercourses has indicated that the critical threshold, at which channel destabilization begins, typically corresponds to a total drainage basin imperviousness of three to five percent (Hammer 1972; Booth 1990). Significant enlargement of the channel cross-section begins once the drainage basin reaches five to ten percent imperviousness. It is estimated that the channel will continue to enlarge, in response to urbanization, for a period of 35 to 65 years after the end of development in the watershed.

Once adjustment of the channel to urbanization is complete, the cross-sectional area may be up to 6 times greater than that of the channel prior to disturbance (Hammer 1972). This enlargement can occur by erosion of the channel banks and incision of the channel bed, the degree of each being determined by their relative resistance to erosion. In addition to cross-section enlargement, urban water-courses also experience adjustment of their plan form as the channel attempts to evolve a new meander pattern that is compatible with the new hydrologic and sediment regime. This adjustment process is thought to take an order of magnitude longer than cross-section change, resulting in a total period of instability as a result of urbanization that may be measured in centuries. It is theorized that urban watercourses will eventually achieve a new form of dynamic equilibrium through these adjustments. Even if this should occur, experience suggests that the ultimate form of an urban water-course will bear little resemblance to a natural river or stream and will not possess the stability or structure required to support diverse aquatic ecosystems (Booth and Jackson 1997; Fuerstenberg 1997).
1.4 Urban Area

An urban area is characterized by high population density and vast human features in comparison to areas surrounding it. Urban areas may be cities, towns or conurbations, but the term is not commonly extended to rural settlements such as villages and hamlets. Urban areas are created and further developed by the process of urbanization. Measuring the extent of an urban area helps in analyzing population density and urban and rural population (Cubillas 2007).

Urbanization is the movement of population from rural to urban areas and the resulting increased proportion of a population that resides in urban rather than rural places. It is derived from the Latin word “Úrbs’a” used by the Romans to denote a city. Urbanization is two way process because not only does it involve movement from village to cities and change from agricultural occupation to business, trade, service, and profession but it also involves changes in the migrant attitude, belief, values and behavior patterns.

The criteria provided by the “Census of India” for identifying urbanization in a particular area are as follows:

- Population should be more than 5000
- The density should be over 400 persons per sq. km.
- 75 % of the male population should be engaged in non-agricultural occupation.
- Cities are urban areas with population more than one lakh.
- Metropolises are cities with population of more than one million.

1.5 Urban Geomorphology

In the urban environment, man is considered to be the creator of the landscape or "cityscape". Thus, urban geomorphology is concerned with the study of man as a physical process of change whereby he metamorphoses a more natural terrain to an anthropogenic cityscape. In such a context, urban geomorphology is the surface component of urban geology which is one of the important subfields of environmental geology (Coates, 1976).
Anthropogenic activities play an important role in the transformation of the Earth surface. Maximum distortion occurs, however, in urban areas where he has chosen to congregate and congest. The emphasis of urban geomorphology is on this unique geographic setting where man has thoroughly intruded some of the natural physical systems. The study of these aberrations, some of which are deliberate while others are by-products, constitutes one of the subfields of geomorphology (Coates, 1976).

The urban geomorphologist can use his expertise to predict the kind of destruction that will ensue from the anthropogenic activities when the type, degree, and magnitude of the environmental upsets are understood. It is not sufficient for the scientist to "merely know" what will happen, but he should become involved in decision-making matters. It is necessary to provide advice for those plans that seek alternate paths whereby man's activities can be consummated in a manner that will minimize environmental degradation (Coates, 1976).

Local and regional landforms have played a central role throughout history in the choice of sites for settlements and their further development has often been influenced by the regional geomorphology.

The erosion processes increase in urban areas where the building activities remove the soil cover and causes extensive wash denudation. The streams become overloaded with sediment as a result and their cross-sections change (Wolman 1967, Wolman and Schick 1967). As urban areas expand, impervious surfaces like buildings, streets, parking areas, industrial and commercial areas are built up. Such construction leads to the surface runoff flows into the sewage system. As a result of this Groundwater supplies are reduced causing increase in flood frequency and the peak flood height. (Leopold 1968, Graf 1975, Sala and Inbar 1992).

Human activities have increased the runoff maxima in many river basins, and this has been compensated by building of reservoirs which store the excess runoff and release it gradually. Reservoirs act as sediment traps for all the bed-load and part of the suspended load. Immediately below the dam, the stream is practically free of solid load so that it picks up new load and erodes its channel bed downstream from the reservoir. The bed-load is smaller than before because the high-water peaks are lower than before the dam was completed (Gregory and Park 1974, Gregory 1979).
Applied urban geomorphology is the study of landforms and their related processes, material and hazards, in ways that are beneficial to planning, development, and management of urbanized areas or areas where urban growth is expected. To prevent urban growth destroying or sterilizing valuable resources, especially aggregates; to identify and evaluate land and material resources required for development; to limit undesirable impact of urban development on geomorphological conditions; to predict the potential resources of ground surfaces to urban development; and to assess the potential impact of geomorphological hazards on the urban community (Cooke, 1982).

Along with the aerial photographs or other remote sensing imageries, the geomorphological mapping of the concerned area can assist in understanding, classifying and describing the terrain features. Analysis of process dynamics and landform change may be accomplished through historical records such as climate and hydrologic data, and the evidence of topographical maps, aerial photographs and satellite imagery. Less secure and less common, is to describe one, poorly known situation by analogy with another similar but better – documented situation elsewhere (Leopold, 1962).

Urban geomorphology combines the ambient geology, landforms, and geomorphological processes with the evaluation of impacts brought by urbanization. The practitioner of urban geomorphology tend to concentrate on alteration, using the physical environment as a baseline. A number of case studies from different parts of the world (dealing with topics such as slope instability, seismic hazards, increased flood problems, and land subsidence) have demonstrated the utility of urban geomorphology to engineers, city managers, and urban planners (Gupta and Ahmad 1999).

### 1.6 Effect on Urban Morphology

Various negative effects in terms of loss of agricultural land, surface and groundwater depletion, changes in geomorphic features, flooding, landslides, etc are experienced by the people of cityscapes and the surrounding areas. With the increase in population, it has become inevitable to adopt proper urban planning to attain sustainable environmental stability of an area.
Towns and cities have mostly expanded in accordance to the relief of the terrain and the relief changes as per the planning and needs of construction (Ahnert 1996). The other factors that have influenced the geomorphological process in the urban environment are the weathering of the building stones due to air pollution (Viles 1993). Ahnert (1996) was of the opinion that settlement geography is incomplete without taking into consideration the morphology and hydrology of an area. There is a need to understand the dynamic interaction between the different aspects of urban expansion as expansion of built-up area, construction activities over natural features which cause diversion and destruction of aquifers, and the specific geomorphic features of the urban area. (Wolman 1967).

The groundwater supply of the urbanized area also gets reduced and as a result drainage frequencies increase (Leopold 1968, Graf 1975, Inbar 1992). The local geomorphic features have played a crucial role by establishing and developing the kind of settlements in the history of civilization. The expansion of a city over the years and the construction activities gradually alter the topography of the area. These changes ultimately affect the rate of geomorphic process such as weathering and erosion (Viles 1993).

1.7 Urbanization and Watershed

Urbanization alters river ecology in and downstream of cities, harming aquatic systems thus prompting efforts to protect, rehabilitate, and even fully restore urban streams. Yet these efforts seldom succeed because of narrowly prescriptive solutions that do not take advantage of interdisciplinary knowledge in the physical, biological, and social sciences or because they do not treat the full range of urban change in streams (Karr and Rossano, 2001).

Several studies have shown that land clearing, poor agricultural practices and urbanization can change watershed hydrology and disrupt the physical behavior of channel systems (Graf 1975). This study sets up a conceptual framework for assessing stream degradation and uses it to recommend realistic improvements. Few urban streams can be entirely restored – that is, returned to a state that supports the full range of living things and ecological processes. Many urban streams can, however, be rehabilitated with their biological conditions. The framework used here explicitly links the human actions collectively termed “urbanization” with biological conditions,
the primary endpoint of concern. Urbanization does not itself cause biological decline; instead, it alters the landscape, inflicting stresses on stream biota. Successful stream rehabilitation requires understanding of stressors and their interactions, which link human actions to biotic changes (Grimm et al., 2000). This complexity demonstrates the futility of one-size-fits-all urban restoration.

1.8 Human Impact on Channels

Human-induced landuse changes can have a significant effect on streams morphology. Deforestation, urbanization, agricultural practices and wetland conversion can all contribute to stream channel degradation (Hammer 1972; Knox 1977; Hooke 1994). Impervious surfaces are one of the many human fabrications that disrupt the hydrological processes. Impervious surfaces are simply substances that halt the penetration of water into the soil. The result of this barrier is increased runoff, higher stream channel velocities and greater flooding (Chester L. Arnold and C. James Gibbons 1996; Wolman 1967).

Urbanization can also have a significant effect on channel characteristics within a watershed. The hydrology is vastly altered when vegetation is replaced with impervious surfaces like pavement and rooftops (Hammer’s, 1972).
Stream degradation caused by urbanization is not a single problem with a single solution, or even a well-defined set of problems with well-defined solutions. Rather, it results from a collection of individual decisions and actions that lead to specific urban landscapes and, in turn, to altered stream condition. “Urbanization” itself is multidimensional and has been defined in many different ways (McIntyre et al., 2000). It may constitute industrial, retail, or housing development; it may proceed quickly or gradually. It can be halted at an early stage by zoning or hastened by incentives that encourage development. An urbanized watershed may contain polluting or nonpolluting industries, dense road networks or only a few roads. The topography, soils, vegetation, and channel networks in an urban basin may be altered. Thus no single change defines urbanization; instead, the cumulative effect of the variety of human activities in urban basins profoundly influence urban streams (Booth et al., 2004)

Most of the key reasons for flooding of the Mithi River in Mumbai, Maharashtra, apart from tidal variations, flat gradients downstream and mud flats (in the eastern catchments, which cause excessive siltation), are the inappropriate levels of manmade outfalls, poor placement of drainage channels, loss of holding ponds due to land development over the years, increase in runoff coefficient due to widespread development and paving of open areas, dilapidated drains encroachments on drains, enhanced silting and choking of drains due to sewage inflows and garbage dumping in drains, obstruction due to crossing utility lines, poor structural conditions (NEERI 2011).

The recharge structures like lakes, tanks, ponds and other wetlands in the city have been ignored. All the wetlands of Chennai, Tamilnadu, became sites of waste disposal, housing, commercial and industrial purposes. Wetlands act as a sponge, soaking up rain water, playing vital role in floods. According to a report of leading daily, over 5,550 hectares of wetlands in that area have been developed into commercial real estate and only 10 percent of the original wetlands remain. Hence, rain water runoff has nowhere to go and settles instead onto roads, causing flooding. From past four decades the open and green areas are converted into urban area almost twenty times. The unplanned urbanization not only makes a city prone to urban flooding but also decreases its groundwater recharge. Chennai recorded 374
millimeters rainfall in 24 hours, which were highest record set after 190 millimeters. Because of this incidence almost 250 people have died (2015).

1.9 Man-made Environment

An environment made by humans results on the consumption of excessive amount of material and energy demanding core, supervision, management and often interferes with the natural environment. Industries, cities, town, crop fields, artificial lakes and dams are the major man-made environment. Environmental degradation might be caused by many factors such as intensification of agriculture, population growth, indiscriminate industrialization, rising energy use and transportation etc.

1.10 Literature Review

Fracassi C. (2013) Focus on several aspects like São Pedro, Brazil for urban sprawl with master plan zoning, bed rock soil map, environmental protection area, Area Steepness map, Urban Sprawl chart. The municipality of São Pedro presents a considerable potential of areas suitable for urban expansion intercalated with areas of intermediate and restricted potential. These limiting areas comprise a set of physical factors (geological and geomorphologic) with a high probability for the occurrence of erosion and mass movements, characterizing them as areas of environmental risk. Therefore, even in areas classified as suitable, urban expansion should be considered carefully, and it is essential that the guidelines for expansion take into account the natural conditioning factors. Hence, it is crucial for land use planning to be based on the quality and characteristics of the land in order to satisfy certain priorities and/or occupy any terrestrial space.

Siddhartha K. and Mukherjee S. (2012) emphasize on the social and physical system of urbanization and the interaction between them in term of spatial attributes, including dimensions, densities, scale relationships, associations and patterns. In their book, they have studied the layout, demographic characteristics and functions for structure of the Indian city. In the view of rural-urban fringe area they have explained important characteristics like changing pattern and land occupation, crop production, residential expansion, services & other public utility and speculative building.
Sarmah et al (2012) carried out a morphometric analysis of a highland micro-watershed WahUmbah area by using remote sensing and GIS techniques. Drainage map of the area was prepared from the high resolution satellite image and SOI topo-sheet. This map was updated using IRS-1D PAN sharpened LISS-III analog data. The relationship between geological setup and drainage pattern was analyzed. This study concludes that WahUmbah river micro-watershed is in the process of evolution as the basin is in the process of tilting. Their study well defends the rationale of remote sensing and GIS techniques to understand extent of geological controls on the morphology of watershed.

Kuldeep P. and Sanjay P. (2012) studied the geomorphological aspects for urban planning, which gives an idea about the variations in landscape and indirectly facilitates in evaluating the resources of an area. They studied the urban expansion from 1972 to 2011 for Sagar Town. For the study of urban mapping and urban expansion databases integrated, multi-scale, and multi-resolution catalogue, these deliver the baseline information for the planner and decision-makers to observer/monitor and predict the patterns and future trends of urbanization. Geomorphological and progressive urban maps have instant applications in monitoring of urban sprawl/urban expansion and predictive modeling techniques to better forecast future areas of urban growth.

Bhaskar (2012) studied the urbanization, development and changing green space in Pune city from 1857 to 1997. Land use planning describes the ongoing destruction and degradation in Pune city due to rapid and hazardous urbanization in development and making them more vulnerable to environmental change impacts. Hence, land use, land cover and green cover change monitoring becomes very crucial in decision making and conserving green spaces in Pune city.

Punithavathi J., Tamilenthi S. and Baskaran R. (2011) analyzed geomorphology and land use pattern of Thanjavur agriculture and urban area using IRS P6 data. The geomorphic units under structural landforms such as lineament, fault, and Pedi-plains; in fluvial landforms such as alluvial plain, flood plain, channel bar, and natural levee; in coastal landforms include beach ridge, brackish water, and mud flat, salt flat, upland and coastal plain area. Various categories of land (residential planned, and
unplanned, agricultural land, waste land and others) were studied under the Land use pattern.

**Kam Wing Chan and Man Wang (2008)** stressed on the urban geographical views in *Urban Geography*. Urban development in China from their origins to infrastructure and policies development shows systematic growth because of geographical view for city development. Transportation planning based on geographical landscape of particular area. On the other hand western development program design varies in Delta region in China on the basis of land characteristics.

**Duraiswami R. A., Dumale V and Shetty U (2009)** With the help of Remote Sensing and Geographic Information System, study suitable for rooftop rainwater harvesting by integrating traditional hydrogeological survey data is done. Development of SLUGGER-DQL program identified potential sites for rooftop rainwater harvesting and artificial recharge. Traditional hydrogeological surveys combined with modern techniques used for solving problems related to urban hydrogeology and town planning.

**Duraiswami R. A., Dumale V. and Shetty U. (2009)** Describing study of Geospatial Mapping of Potential Recharge Zones in Parts of Pune City while identifying areas suitable for rooftop rainwater harvesting by integrating traditional hydrogeological survey data with the help of Remote Sensing and Geographic Information System. Potential sites for rainwater harvesting and artificial recharge have been identified in the Pune University-Shivajinagar-Kothrud area by SLUGGER-DQL program. This study demonstrates the utility of traditional hydrogeological surveys combined with modern techniques in solving problems related to urban hydrogeology and town planning.

**Steve Kardinal Jusuf (2007)** Also used the remote sensing data and GIS to investigate and identify the impact of land use types on ambient temperature in Singapore. The study shows that there were different temperature orders within different urban land cover between daytime and night times. The above mentioned descriptive research established the parameters of study, but these urban/rural comparisons are at best only an approximation of the urban modification.
Cristiano P. and Henrique M. G. (2007) This paper on the greatest problems in Brazilian urban watersheds are concerned to the amount of solid residues, domestic sewerage and sediments that are disposed in the rivers and streams that drain those areas. The results suggest the occurrence of a high enrichment of the fluvial sediment by these metals. The concentrations of (Zn, Pb and Cr) elements vary temporally during storms due to the input of impervious area runoff containing high concentration of elements associated to vehicular traffic and other anthropogenic activities. The contamination of the urban watershed is reflected in the results obtained in the fluvial suspended sediments.

According to Chattopadhyay B. C. (2005), Metropolitan growth of India shows physical characteristics towards development, pattern of growth spreading horizontally as well as vertically.

Voogt J. (2002) mentions that anthropogenic heat contributes to atmospheric heat islands and refers to heat produced by human activities. It can come from a variety of sources and is estimated by totaling all the energy used for heating and cooling, running appliances, transportation, and industrial processes. Anthropogenic heat varies by urban activity and infrastructure, with more energy-intensive buildings and transportation producing more heat.

Mandal R. B. (2000) urban geography deals with urban land use, urban population, urban transport, industrial development etc. concept and theory framing regarding cities distribution, size, function and rate of growth. Urban geography gives the clue of cities in terms of their morphology besides origin, growth and function. Location and siting of town in an area shows latitudinal and longitudinal position and its significance and important. Location shows the importance of town and highlights the surrounding environment.

Dixit and Ahmed (1998) focused on the complexities related to flood control in the Himalayan watersheds, they considered that even partial flood control is an exercise that many be geopolitically, financially, and technically problematic at present. They are of the opinion that the hydrology of the Himalayan watershed is scantily studied, little understood and its potential for damage is often underestimated.
Oke, T. R. (1997) Many urban and suburban areas experience elevated temperatures compared to their outlying rural surroundings. This difference in temperature is what constitutes an urban heat island. The annual mean air temperature of a city with one million or more people can be 1.8 to 5.4°F (1 to 3°C) warmer than its surroundings.

Chengtai Diao (1995) Focused on geomorphic substance with various shapes and materials is an underlying surface for a city and an important factor to control the layout, regional structure and development of a city. Many

Huda Manirul (1990) Rate of growth of urbanization and its contributing factors such as demographic dynamics, growth and distribution of income, pattern of consumption, structure of industries as well as the cultural and educational aspects of the growing urbanization in Sibsagar town were studied. By arranging this data in a suitable manner and by the application of appropriate statistical technique, he has tried to deduce the significant trends in the urban economy of Sibsagar and their concomitant problems.

Harvey (1989) The place of urban politics in the geography of uneven capitalist development includes space, technology, structured coherence, physical and social infrastructures. The urban region shows Geopolitical unit in the uneven geographical development of capitalism. Urbanization modes Space of representation accessibility, political responses, knowing physical landscape of extraordinary complexity, etc. describing through example of America city of emphasis flexible accumulation through urbanization.

Zavoianu (1985) has authored a book on morphometry of drainage basins. His comprehensive work deals with historical developments in the field of measurement of forms i.e. morphometry. Besides, he has also elaborated on issues like stream classification, basin area, perimeter of drainage basins, basin shape, river length etc and various other principles and techniques related to drainage basins in a lucid manner. He has also devoted one chapter on relationships between morphometrical and hydrological features in the present series.

Diddee Jaymala (1984) explained the significance of central place theory that deals with temporal pattern of evolution, the spatial distribution and the functional organization of central places. Some methods deal with measuring centrality, the
determination of a hierarchical arrangement of central places service area relationship. Functional and locational factors growth characteristics of particular area.

Cooke R. U., Brunsden D., Doornkamp J. and Joines D. (1982) focus their attention on methods recording, analysis and presenting geomorphological information. Geomorphological mapping, morphological mapping and land system surveys have been used with success in many resource surveys prior to urban development. They specifically focus on geomorphological problems related to urban development in dry-land. Review of the nature of the problems posed by the presence of surface salt and saline wares in many areas of dry-land urban growth. One set of approaches to evaluating environmental data relevant to urban development in dry-land. The geomorphological perspective advocated in no way precludes equally valid approaches to the study of environmental problems in urban areas of dry-land adopted by geologists, ecologists, penologists, hydrologists and hydrologists.

Kumar and Pandey (1981) have studied the morphometry of some drainage basins of the Hazari-bagh plateau region. They indicated that “The present landscape is the combined output of the denudation processes operating since its earliest geological period”. They analyzed the morphometry of four catchment areas in terms of linear, areal and relief properties. The linear properties have studied using Strahler and Horton’s law of stream numbers. The study indicates the regional variations in the morphometric properties of four sample basins.

Singh and Singh (1979) have conducted a comparative study on morphometric evaluation of Himalaya and the peninsular uplands. The study is based on topographical maps, aerial photographs, and field observations in the region. They employed four principal methods i.e. relative relief, dissection index, drainage texture, and slope to identify morphological units. It is noted that these four principal morphometric attributes are significant enough in understanding the morphological character of both the terrain types.

Jackson (1972) describes urbanization as a process of growth and change, the expansion of government intervention in the affairs of the environment, the emerging consideration of interrelations between land use and transportation at the regional level of appreciation, and the minerals, atmospheric pollution, steep slope, height, tree
less environment, noise zone, etc are important for urban study towards morphological approach.
1.11 Background of the Study Area

1.11.1 Introduction: Pune

Pune is the seventh largest metropolis in India, the second largest in the state of Maharashtra after Mumbai and the largest city in the Western Ghats. Pune is the cultural capital of Maharashtra. Pune has many popular nicknames such as ‘Queen of Deccan’, ‘Pensioners Paradise’, ‘Cultural Capital of Maharashtra’, Cyber City’, etc. City is known for various cultural activities like music, spirituality, theatre, sports and literature and job opportunities attract migrants and students from all over India and abroad, which makes for a city of many communities and cultures. Pune’s culture reflects a blend of traditions with modernity. This City has more than a hundred educational institutes and nine universities. This results in a large student population, and a large number of quality academic and research institutes and has witnessed maximum floating population. As one of the largest cities in India and as a result of its many colleges and universities, Pune has emerged as a prominent location for IT and manufacturing companies to expand. It epitomizes the Marathi culture, which lays emphasis on education, arts and crafts, music and theatre. In recent times, Pune has emerged as a centre of modern architecture in India.

Pune’s is urbanizing at a phenomenal pace. The reason for such rapid development is the introduction of the IT sector in the city. The city is working on the three major sectors the educational sector at the core, the Industrial sector of Pimpri Chinchwad at one end and the IT sector of Hinjewadi and Aundh at the other. The improvisation in the transport connectivity by the introduction of BRT route and the upcoming metro within and in the periphery of the city is pushing the boundary of the municipal limit.

1.11.2 History of Pune

‘Punakka’ a tiny agricultural settlement in the 8th century, has grown into a megalopolis called Pune covering more than 700 sq. km. area and supporting a population of about 4 million. During the Mughal reign in the 11th century, this settlement of the 8th century developed into a small town ‘Kasbe’ Pune. During the mid-16th century, this settlement became the transitory residence of King Chatrapati
Shivaji Maharaj. From 1630 to 1647, King Shivaji Maharaj was crowned Chhatrapati (King) in 1649, he masterminded the further developments in Pune, including the planning and construction of the Guruwar, Somwar and Mangalwar Peths. Before the rise of the Peshwe, five other peths were built i.e. Shukrawar, Raviwar, Shaniwar, Bhavani, and Ghorpade Peth. During the 27-year-long conflict between the Marathas and the Mughals, the town was occupied by Aurangzeb from 1703 to 1705; during this time, the name of the town was changed to "Muhiyabad". Two years later, the Marathas recaptured Sinhagad fort and later Pune city from the Mughals.

The city rose to distinction when the Peshwas established the rule of Maratha’s empire here (1749 A.D.) During the Peshwa rule, the city expanded considerably. The 1761 defeat at Panipat by Abdali, affected the fate of the Maratha Empire and consequently that of the city. In 1818, the dynasty changed in trifling transition from Mughals to Marathas. The Maratha rule came to an end at Khadki near Pune, in 1871 when the British defeated them and the city and the surroundings came under the British rule. Pune became the ‘Monsoon Capital’ of the then Bombay Presidency, under the British rule. On the city’s outskirts the British established few army bases, which later transformed into the cantonments of Pune and Khadki.

In the 1850s Pune Municipality was established and Pune was connected to Mumbai by the railway in 1858. Pune became the home of many reputed educational institutes like: the Deccan College (one of the oldest in western India), Engineering College (second oldest in the Indian Subcontinent), Fergusson College (amongst ten most reputed in India), Agricultural College (one of the earliest in the country) to name a few. Pune is also the Headquarters of the Army Southern Command and has many other defense establishments.

Confined towards the north by the Mula-Mutha river, areas such as Deccan Gymkhana, Erandwane and Shivajinagar in the west; Camp, Bund Garden and Koregaon Park in the east; Swargate, Parvati Hill, Sahakarnagar, Mukund Nagar, Maharshi Nagar, Gultekdi and Salisbury Park to the south; were developed after post-independence era. Due to establishment of various educational institutes across Pune, areas such as Ganeshkhind, Kothrud, Sahakarnagar, Bibwewadi, Yerawada, Wadgaon Sheri (Kalyani Nagar, Viman Nagar and Shastri Nagar) Kharadi flourished.
The important events in the city's history, culture, its growth and development include the Peshwa era, progression of Peth areas, the development of Deccan Gymkhana and other colonies across the river in 1920's, the establishment of Pune Municipal Corporation in 1950, the establishment of an industrial estate in Pimpri-Chinchwad (1960), Panshet floods (1961). Development of educational and IT industries, and connection of Mumbai by expressway gave a unexpected boost to the growth of Pune.
1.12 Significance of Study

Local landforms or geomorphic features have played a crucial role in the establishment and development of settlements in the history of the civilization of Pune. The expansion of Pune city over the years and rising construction activities has gradually altered the topography of the entire area. These changes ultimately affect the rate of geomorphic processes such as weathering and erosion. Pune had the natural advantage of local topography and the hydrological conditions to flourish. Various negative effects in terms of physical environment such as loss of agricultural land, surface and groundwater depletion, changes in geomorphic features, flooding and landslides, etc have increased due to changes in the city’s environment.

The early geomorphological studies and design with respect to urban stream management have been mainly through classification schemes, which were based on the historical geomorphology developed by Davis in the first half of the twentieth century. This theory specifies evaluation of waterways, latitude and longitude profiles if the city is located in the vicinity of the flood river, one can calculate the channels present stability, past conditions and probable trend if left undisturbed. It is observed that many streams are overloaded due to ongoing construction activities and dumping of garbage causing their disappearance from Pune and its surroundings.

Pune has geographically ideal physiography for growth of human settlement. Massive unplanned urbanization happened post the 1961 floods in Pune city. Urban sprawl of Pune is spread in circular form due to the Sinhgad-Bhuleshwar range (towards south) and Mutha river (towards north) guiding development to grow in horizontal direction. Growth of settlement and change in land use is spreading towards southern and southern east area. Physical landforms such as hills and watershed streams have changed due to the enormously growing housing projects around Pune city. With the increase in population, it has become inevitable to adopt proper urban planning standards to attain a sustainable environmental stability of an area. It is necessary to understand the dynamic interaction between the different aspects of urban expansion like built-up area, construction activities over natural
features which cause diversion, destruction and change in geomorphology of Pune and surrounding area.

The reason behind selecting Pune and its surrounding areas as study area is its dynamic growth and topology. This study intends to learn slope, geomorphology, drainage and watershed analysis of Pune city. In this study, Remote Sensing data was extremely useful to understand change detection. It is important to study the change in slope in relation to sustainability of land and the role of dominant processes of degradation.

The morphometric characteristics of a watershed reveal information regarding its formation and development. It represents simple approach to describe the drainage basin geo-hydrological processes. This study is an attempt to comprehend geomorphic analysis with respect to the nature of the watershed and slope analysis to use it as an important tool for further planning. The study is limited to Pune city and 34 villages’ (Administrative boundaries) surrounding it topographically.