CHAPTER 1
INTRODUCTION

1.1 GENERAL

This chapter gives brief introduction of Land Use/ Land Cover (LULC), Remote Sensing (RS) and Geographic Information System (GIS), Urban Sprawl, Rainfall, Runoff, Use of RS & GIS in Land use/ Land Cover Mapping. Also, the objectives of the present study are described further.

1.2 INTRODUCTION

For any country, managing its water supplies has always been a big challenge. The development of water resources necessitates resolving the crucial challenges of storage, conservation, and ultimately utilisation of water. In order to develop a comprehensive management strategy for the efficient conservation and use of water resources, space technology plays a crucial role in managing country’s available water resources. To achieve the best planning and operation of water resources projects, systematic procedures incorporating the thoughtful blending of traditional ground measurements with remote sensing techniques are necessary. To track the development and effects of the aforementioned projects, the satellites' synoptic and repeated coverage can be a useful addition to the traditional data. In order to plan and track several water resources management initiatives, remote sensing imagery from polar orbiting satellites is a viable tool.

Over time, environmental changes have been brought about by human activity. The Earth's surface has undergone significant change as a result of urbanisation, agriculture, timber harvesting, mineral extraction, and other land uses. Ecological, environmental, and hydrologic systems and processes are significantly impacted by changes in land use and the resulting shift in land cover. For effective management, it is essential to have a grasp of past and current land-cover change as well as an analysis of anticipated future change; this necessitates the use of models. The different purposes of hydrologic models are hydrologic prediction and hydrologic process comprehension. In order to evaluate the effects of various land use/ land cover scenarios, hydrologic models now use technology-based tools like GIS. Future land use/ land cover can be projected using hydrologic models integrated with GIS to increase the clarity, probability, or likelihood of prospective effects on ecosystem services including biodiversity, water quality, and climate.
Despite the fact that the terms land use and land cover are frequently used synonymously, their true meanings are quite different.

Land Use

The term "land use" represents the purpose that a portion of land appears such as agriculture, wildlife habitat, or recreation. Since timely information is needed to determine what current quantity of land is in what sort of use and to identify the land use changes from year to year, land use applications require both baseline mapping and subsequent monitoring.

Land Cover

The term "land cover" describes everything that covers the surface of the ground, such as vegetation, urban infrastructure, water, bare soil, etc. For planning, resource management, and monitoring studies, it is crucial to identify, delineate, and map the land cover. The baseline for monitoring operations is established by the identification of the land cover.

Water resources are a major limiting element for ecosystems in arid and semi-arid regions that exhibit high sensitivity because they are significantly impacted by changes in land use/ land cover (LULC), and climate. Analysing how LULC and climate change may affect these regions' water resources is essential. It is hypothesized that LULC shift, which is predominantly brought on by profound human activities like converting farmland to forest and grassland, will affect runoff under conditions of climatic warming and dryness. In addition to different land uses, rainfall is the primary cause of runoff.

Rainfall

Rain is liquid water in the form of droplets that have formed after atmospheric water vapour condensed and precipitated, or developed so heavy that it could fall from the sky with the aid of gravity. Rain is a significant component of the water cycle and is responsible for depositing the bulk of the fresh water on Earth. It offers suitable conditions for a variety of ecosystems as well as water for irrigation of agriculture and hydroelectric power plants. As temperatures rise, evaporation also tends to increase, which may cause greater precipitation. Although patterns have varied greatly by place and by time, there hasn't been a statistically significant global trend in precipitation during the past century. Water that has been released from clouds as rain, freezing rain, sleet, snow, or hail is known as precipitation. It is the key link in the water cycle that ensures atmospheric water is delivered to the Earth. Rain makes up the majority of precipitation.

Rainfall is a significant component of the Indian economy. Even though the monsoons affect the majority of India, different regions see varying amounts of rain, from heavy to sparse. The distribution of rainfall varies significantly across regions and across time. The four wet months of June to September account for more than 80% of the annual precipitation.

When rain or snow falls on the ground, it doesn't just stay still; instead, it begins to move in accordance with the principles of gravity. The Earth's groundwater is replenished by a portion of the precipitation that seeps into the earth. Most of it runs off in a downward direction.

Total rainfall = Rainfall excess + losses

The term losses include interception, infiltration, evaporation, depression storage etc. Similarly, that portion of rainfall which produces direct runoff is called effective rainfall or rainfall excess.

Runoff

"Runoff" is the term usually employed to distinguish the flow of water running off the land's surface during and shortly after rainfall, from the longer-term flow of groundwater to rivers. This distinction is achieved by the analysis of flow data from perennial streams and rivers in humid climates, but in many agro-hydrological and water harvesting situations, groundwater contributions are not present, and all flow is runoff. This will almost certainly be the case in arid and semi-arid climates.

Runoff occurs when there is more water, than land can absorb. The excess liquid flows across the surface of the land and into nearby streams or ponds. Runoff results from either natural processes or human activity or both in general.

Snowmelt is a prevalent and known form of natural runoff. Mountains lacking water-absorbing capacity for large snowfalls generate runoff that transforms into streams, rivers, and lakes. Glaciers, snow, and rainfall all contribute to the natural runoff. Runoff is also a natural process that occurs as soil is degraded and transported to different water bodies. Toxic substances can infiltrate streams through natural mechanisms, including volcanic eruptions. Volcanic emissions of noxious gasses ultimately re-enter the hydrosphere or lithosphere as precipitation.

Runoff from human activity comes from two places: point sources and nonpoint sources. Point source is any source that empties directly into a waterway. This might include a pipe from specific sewage treatment plant, factory, or even a residential area. Regulations determine what type of runoff, and how much, industries are allowed to release. These regulations vary by region, state, and nation.

Nonpoint source is any source where runoff does not go directly into a waterway. Nonpoint sources of runoff can be large urban, suburban, or rural areas. In these areas, rainwater and irrigation water enter into local streams. Farms are a huge nonpoint source of runoff, as rainwater and irrigation drain into bodies of water.

Impervious surfaces, or surfaces that can't absorb water, increase runoff. Roads, sidewalks, parking lots, etc. are impervious surfaces. Runoff is crucial as it keeps rivers and lakes full of water at the same time it also erodes the soil, altering its appearance. Water in motion has incredible force and may erode canyons and move boulders.

Types of Runoff

Surface Runoff: It is the amount of water which is drained over the surface of the soil of watershed after saturation of micro- and macropores of soil, and under gravitational pull from a higher altitude to lower altitude having a much-defined rate of flow. The amount of runoff depends upon amount and intensity of rainfall, soil structure, texture, and porosity of soil and extent and degree of slope.

Sub-surface Runoff: When surface storage of soil in the watershed is completed (i.e., upper surface layer) and it becomes saturated water begins to flow in the surface of soil up to the depth of one meter from a higher altitude to lower altitude at the rate much less than surface runoff. It takes hours and even days to reach the stream. It is clear water and maintains the stream flowing after precipitation.

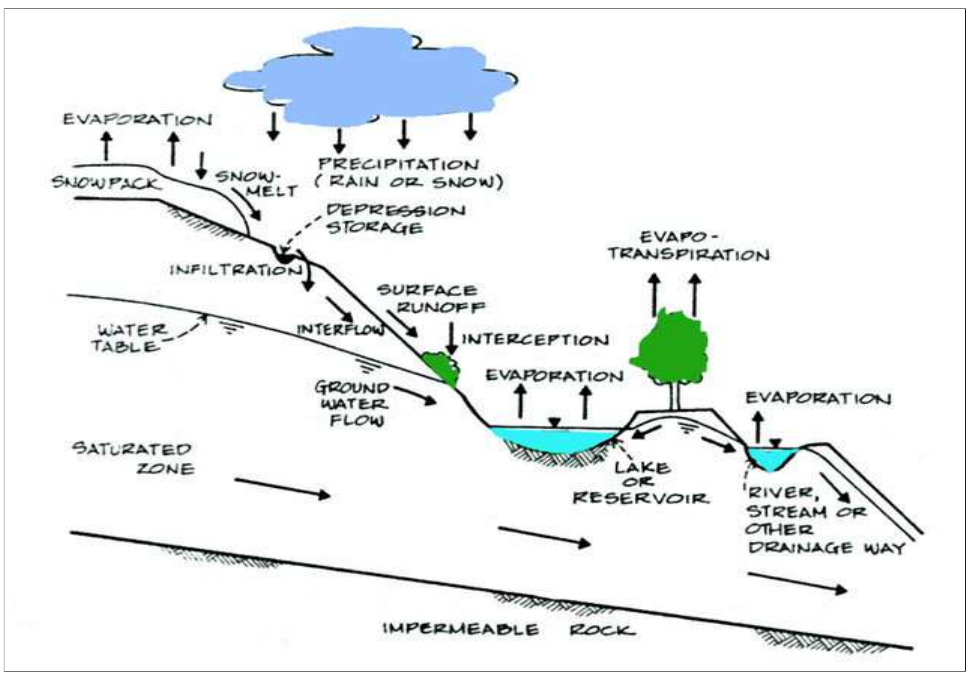


Figure 1.1: Overview of Components of Runoff

Fig. 1.1 gives an overview of components of Runoff. One component is the water visibly flowing across the ground surface. As water infiltrates, some water will flow just below the surface. This is called interflow, or subsurface flow. That portion of rainfall percolating to lower layers becomes part of the groundwater. Groundwater flow to a stream or river is termed base flow. It is base flow that supports streamflow during non–storm periods. The infiltrated water percolates through the soil and is stored there for a certain time. If it is not subjected by evapotranspiration, it can form a downslope flow above the groundwater table, which is called the interflow. Only a part of the infiltrated water percolates completely through the soil and reaches the groundwater table and forms the base flow. The storage effects in the soil and groundwater reservoirs are often modelled by cascades of linear stores.

1.3 FACTORS AFFECTING RUNOFF

Runoff is affected mainly by climatic and physiographic factors. There are a number of site (or catchment) specific factors which have a direct bearing on the occurrence and volume of runoff.

Rainfall Characteristics

If the rainfall is very heavy the consequent runoff will also be more. If the rainfall is just showery type with low intensity there may not be runoff at all as the rainwater is completely lost in infiltration, evaporation, etc. If the duration of rainfall is more the runoff will also be prolonged.

Rainfall is the most important factor, which affects runoff. The important characteristics of precipitation are duration, intensity and areal distribution.

Duration: Total runoff depends on the duration of rainstorm. For a given rainfall intensity and other conditions, a longer duration rainfall event will result in more runoff.

Intensity: Rainfall intensity influences both rate and volume of runoff. The runoff volume and also runoff rate will be greater for an intense rainfall event than for less intense event.

Areal Distribution: It also influences both the rate and volume of runoff. Generally, the maximum rate and volume of runoff occurs when the entire watershed contributes.

Soil Type

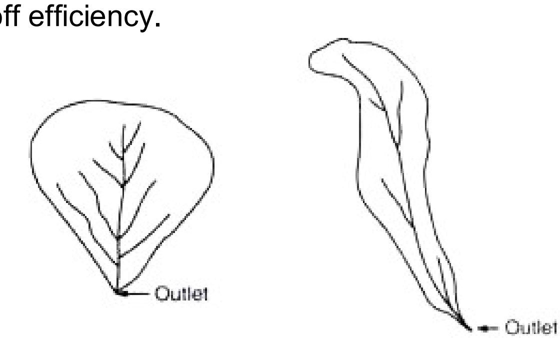
The infiltration capacity is primarily influenced by the porosity of the soil, which governs its water storage capacity and impacts the ability of water to penetrate into lower layers. The porosity of soil varies amongst different soil types. Loose, sandy soils exhibit the highest infiltration capacity, whereas heavy clay or loamy soils have significantly lower infiltration capacities.

Topography

Greater surface slope results in increased runoff, since water flows quickly over the surface before any losses occur. Local depressions in the catchment area can cause the accumulation of water, resulting in the formation of lakes, ponds, and other bodies of water. Furthermore, it has been noted that the amount of runoff reduced as the length of the slope increased. The primary reason for this is the reduced flow velocities, which therefore result in an extended time of concentration. The time of concentration is defined as the duration required for a water droplet to travel from the farthest point in a catchment to the outlet. Consequently, the water remains in contact with infiltration and evaporation processes for an extended period of time prior to reaching the designated measuring location.

Shape and Size of the Catchment

If the catchment area is large runoff will be more. If the catchment area is fan shaped runoff at outlet will be more as all the water contributes to the stream practically at the same time. If the catchment is fern shaped the runoff will be less. Fig. 1.2 shows the shape of catchment. The runoff efficiency (volume of runoff per unit of area) increases with the decreasing size of the catchment i.e., the larger the size of the catchment the larger the time of concentration and the smaller the runoff efficiency.



(a) Fan Shaped Catchment (b) Fern Shaped Catchment

Figure 1.2: Shape of Catchment

Vegetative Cover

If there is some sort of vegetal cover over the catchment, then evaporation loss will be reduced as sun rays cannot reach the ground surface. The amount of rain lost to interception storage on the foliage depends on the kind of vegetation and its growth stage. Values of interception are between 1 and 4 mm. A cereal crop, for example, has a smaller storage capacity than a dense grass cover. More significant is the effect the vegetation has on the infiltration capacity of the soil. A dense vegetation cover shields the soil from the raindrop impact and reduces the crusting effect. In addition, the root system as well as organic matter in the soil increases the soil porosity thus allowing more water to infiltrate. Vegetation also retards the surface flow particularly on gentle slopes, giving the water more time to infiltrate and to evaporate. In conclusion, an area densely covered with vegetation, yields less runoff than bare ground.

Geology of the Area

If there are fissures, cracks, fault zones present in the catchment then rainwater finds its way out through these openings. The water lost may find its way to some other catchment or to groundwater or in the sea.

Weather Conditions

Temperature of the region also affects the runoff to a great extent. If temperature is more, it renders surface dry and when rain occurs more water is absorbed by the ground surface. Evaporation rate will also be more if temperature is high.

1.4 COMPUTATION OF RUNOFF

The rate of runoff is required for the design of drains, canals and other channels, and for the prediction of water levels in streams and rivers. Quantity of runoff is required when storage is involved for irrigation, power generation, river transport etc. The collection of runoff data is very site and purpose-specific, both in terms of the kind of information that will be required and the manner in which it is best obtained. Runoff events are less frequent than rainfall events, in all climates. In areas of low rainfall, where agro-hydrological and water harvesting projects are usually located, the number of runoff events may be few. Certain projects will focus more on practical applications, and research may be coupled with farmer involvement and farming system implementation. The overall objectives of any project will determine the financial commitment that is placed on the measurement of runoff, but it is assumed for the purpose that in the field of either agricultural hydrology or water resources, runoff measurement is of very important.

[1] From Rainfall Records:

In this method consistent rainfall record for a sufficiently long period is taken and then average depth of rainfall over the catchment is determined. Then considering all the factors which affect run-off process, a coefficient is arrived at for that catchment. Now a simple equation can be used to find out the run-off over the catchment.

Run-off = Rainfall x Coefficient

[2] Empirical Formulae:

In this method an attempt is made to derive a direct relationship between the rainfall and subsequent run-off. For this purpose, some constants are established which give fairly accurate result for a specified region.

(a) Khosla's Formula:

$$\mathbf{R = P - 4.811\ T}$$

Where, R = Annual run-off in mm,
P = Annual rainfall in mm, and
T = Mean temperature in °C.

(b) Inglis Formulae for Hilly and Plan Areas of Maharashtra:

For Ghat Region:

R = 0.88*P – 304.8

For plain region,

$$\mathrm{R} = \frac{(P - 177.8) \times P}{2540}$$

(c) Lacey's Formula:

$$R = \frac{P}{1 + \frac{3084\ F}{PS}}$$

Where,
R = Monsoon run-off in mm,
P = Monsoon rainfall in mm,
S = Catchment area factor, and

F = Monsoon duration factor.

The values of S for various types of catchment are given below in Table1.1

Table 1.1: Values of S for various types of catchment

Type of catchment	*Vatue of S*
Flat, cultivated and black cotton soils	0.25
Flat, partly cultivated, various soils	0.6
Average catchment	1.00
Hills and places with little cultivation	1.70
Very hilly and steep, with hardly any cultivation	3.45
Values of F for various durations of monsoon are given below:	
Class of monsoon	*Value of F*
Very short	0.50
Standard length	1.00
Very long	1.50

Source: https://www.geographynotes.com/hydrology/measurement-of-run-off-functions-precipitation-geography/4297

[3] Runoff Curves and Tables:

Each region has its own catchment area and rainfall characteristics. Thus, formulae given above, and coefficients derived there in cannot be applied universally. However, for the same region the characteristics mostly remain unchanged.

Based on this fact the run-off coefficients are derived once for all. Then a graph is plotted in which one axis represents rainfall and the other run-off. The curves obtained are called run-off curves. Alternatively, a table can be prepared to give the run-off for a certain value of rainfall for a particular region.

[4] Discharge Observation Method:

By actual measurement of discharge at an outlet of a drainage basin run-off over a catchment can be computed. The complication in this method is that the discharge of the stream at the outlet comprises surface run-off as well as sub-surface flow. To find out the sub-surface run-off it is essential to separate the sub-surface flow from the total flow.

1.5 SCS – CN METHOD FOR COMPUTATION OF RUNOFF

The runoff curve number (CN) is an empirical parameter utilized in hydrology to forecast the amount of direct runoff or infiltration resulting from rainfall excess. The curve number approach was developed by the USDA Natural Resources Conservation Service, formerly known as the Soil Conservation Service or SCS. In the literature, this number is also referred to as the "SCS runoff curve number." The runoff curve number was derived by an empirical examination of runoff from minor catchments and hill slope plots that were monitored by the USDA. The method is extensively utilized and proves to be an effective means of estimating the estimated volume of direct runoff resulting from a certain rainfall event in a given region. The runoff curve number is determined by the hydrologic soil group, land use, treatment, and hydrologic state of the area. It is crucial to understand that the curve number approach is a calculation based on specific events and should not be applied to a single annual rainfall estimate. Doing so would inaccurately overlook the impact of previous moisture levels and the importance of an initial abstraction threshold.

1.6 URBAN SPRAWL

There are many definitions on urban sprawl. In oxford dictionary it has been defined as “the disorganized and unattractive expansion of an urban or industrial area into the adjoining countryside”.

Ewing (1997) experiences that the most crucial factors are inadequate accessibility and lack of usable open spaces.

Sierra club (1998) provided a definition of sprawl in their report titled "The Dark Side of the American Dream." They described it as a form of low-density development that extends beyond areas with essential services and job opportunities. This results in a separation between residential areas and places where people need to shop, work, engage in recreational activities, and receive education. As a consequence, the use of cars becomes necessary to travel between these different zones. Sprawl is said to be defined not just by its qualities, but also by its effects.

Pendall (1999) provided a definition of sprawl as the occurrence of unplanned, uncontrolled, and uncoordinated development that is limited to a single use and lacks a desirable and functional combination of uses. Additionally, this type of development is not functionally connected to the surrounding land uses and can manifest in various forms such as low density, ribbon on strip, scattered, leapfrog, or isolated development.

According to Downs (1999), sprawl refers to a specific type of growth characterized by unlimited expansion of development outward, low-density residential and commercial areas, discontinuous development, fragmentation of land use control among multiple small localities, heavy reliance on private vehicles for transportation, absence of centralized planning or control over land use, extensive strip commercial development, significant fiscal disparities among different areas, segregation of different types of land use in distinct zones, and dependence on the trickle-down or filtering process to provide housing for low-income households.

According to Brueckner (2000), urban sprawl is defined as the excessive expansion of cities in terms of physical space. According to **Gordon and Richardson (2000),** urban sprawl encompasses various negative consequences such as rising income inequality, job instability, decline of central cities, escalating housing expenses, lengthy commutes, environmental issues, extinction of species, depletion of farmland, and feelings of isolation, intolerance, psychological disorientation, and even homicide.

According to **Galster (2001),** sprawl is a metaphor that contains a significant amount of ambiguity. The concept of sprawl has faced criticism based on its aesthetic, efficiency, equity, and environmental implications, while also being supported based on the principles of choice, equality, and economic benefits. The eight aspects of sprawl encompass density, continuity, concentration, clustering, centralization, nuclearity, mixed usage, and closeness. Urban sprawl can be defined in several ways depending on different views. **Galster et al. (2001)** proposed alternative definitions for urban sprawl, including: (1) a model that focuses on specific land use patterns, (2) a framework that examines the process of land development, (3) an analysis of the factors influencing land use behaviours, and (4) an examination of the outcomes of urban land use behaviours. **Glaeser (2001)** established a correlation between urban sprawl and the level of employment decentralization.

In his study, **Kahn (2001)** examined a possible advantage of urban expansion, which is the rise in affordability of housing and the improvement in equal housing opportunities for people of different races. Sprawl is measured by the extent to which employment is dispersed in a metropolitan region, especially by the percentage of metropolitan employment that is situated more than 10 miles away from the central business district.

From **Fulton (2001)** viewpoint if land is consumed at a faster rate than population is growing, Sprawl is said to be increasing.

The **European Environment Agency (EEA)** (2006) defines sprawl as the spatial configuration characterized by the spread of metropolitan centers with low population density, primarily into the adjacent rural regions, driven by market forces. Sprawl is the forefront of urban expansion and indicates a lack of organized regulation over the partition of land. The development is characterized by irregularity, dispersion, and prolonged duration, often exhibiting a lack of continuity. It bypasses certain places, resulting in the formation of isolated agricultural regions.

Angle (2007) defined the characteristics of urban sprawl as follows: (a) The expansion of cities without clear boundaries, resulting in a vast and continuous urban area. (b) The continuous decrease in population density in urban areas and the growing use of land by city residents. (c) The ongoing trend of people moving to suburbs and a decreasing proportion of the population living and working in city centers. (d) The reduced connectedness of built-up areas within cities and the fragmentation of open spaces both within and around cities. (e) The filling in of gaps between different parts of a city, resulting in a more compact urban form. Furthermore, he emphasized the utility of assessing urban sprawl as a means to formulate effective strategies. The phenomenon of sprawl should be examined in terms of its underlying causes and resulting impacts, either as a pattern or as a process.

The concept of sprawl is exclusively tied to density. **Couch (2007)** conducted studies in Merseyside to examine urban sprawl. The research focused on three main aspects: variations in urban density at varying distances from the city center, the extent of expansion beyond the current urban region, and the transportation demand in terms of volume and mode.

Ewing (2008) has proposed four indicators of urban sprawl that may be quantified and examined: residential density; diversity of housing, employment, and services within neighbourhoods; vitality of activity centers and downtown areas; and the ease of navigating the street network.

Sprawl is the forefront of urban expansion and signifies a lack of organized regulation over the partition of land. The development is characterized by irregularity, dispersion, and prolonged duration, often exhibiting a lack of continuity. It bypasses certain regions, resulting in the formation of isolated agricultural communities.

Urban sprawl is a contemporary issue plaguing cities. In previous decades, cities have well-defined and distinct boundaries, but they have now exceeded their limits due to excessive expansion. Urban sprawl refers to a type of growth that exceeds the normal rate, distinguishing it from regular urban growth due to its excessive character. Urban areas typically experience growth until a predefined threshold is achieved, at which point there is a harmonious balance between urban expansion and the overall urban structure. However, if the rate of growth exceeds the norm, the resulting strain on the city's boundaries will give rise to significant new challenges.

Overview of Urban Sprawl

Urban sprawl is the process by which rural lands lose their rural features and fail to meet the requirements for being designated as urban. This indeterminate categorization leads to a variety of problems, such as unregulated growth of cities and the transformation of land for non-farming uses. Urban sprawl can be defined as the transitional area that lies between rural and urban zones. According to **Gordon and Richardson (1997)**, urban sprawl is characterized as the occurrence of leapfrog development.

Urban sprawl is largely characterized by the dispersed and fragmented arrangement of structures and the unpredictable fluctuations in population density. Sprawl not only has environmental and social impacts on urban and rural populations, but it also imposes a substantial financial burden on the state.

Several studies suggest that urban spread leads to a reduction in open space and amenities, an increase in the cost of public services and taxes, higher traffic density, urban flooding, and improved natural habitats and water quality. In addition, there are allegations that it contributes to obesity, asthma, indifference, and antisocial behaviours. However, several studies argue that urban sprawl has arisen as a result of individuals' inclination towards spacious residences and expansive surroundings, driven by their desires for comfort. This phenomenon has developed through a conventional market process involving the conversion of land from agricultural to urban usage.

Multiple studies have asserted that urban sprawl results in a decrease in available open space and amenities, an escalation in the cost of public services and taxes, more traffic congestion, urban flooding, and enhanced natural habitats and water quality. Furthermore, there are accusations that it has a role in the development of obesity, asthma, apathy, and antisocial conduct. However, other studies contend that urban sprawl has emerged due to individuals' preference for large homes and expansive environments, motivated by their desire for comfort. This issue has emerged as a result of a methodical market process that entails the transformation of agricultural land into urban areas.

Factors Contributing Urban Sprawl

As previously said, sprawl possesses distinct traits that set it apart from other forms of urban growth, and experts hold varying perspectives on its underlying causes. **Bruckner and Fansler (1983)** conducted a study in 40 urbanized areas across the United States. They surveyed many indicators, including agricultural land price, commuting expense, and income, to demonstrate that sprawl has progressively increased over time.

Miezkowski & Mills (1993) examined the relationship between urban sprawl and factors such as income and population growth, improvements in transportation systems, a wide range of choices for users, and competition for land. These are inherent signs. Central regions exhibit several characteristics, such as elevated taxation, crime rates, deteriorated infrastructures, and a significant number of educational facilities, which contribute to the expansion of urban sprawl. Another hypothesis for the potential increase in urban decentralization is rooted in the concept known as the "fiscalization of land use".

According to **Ewing (1997)**, urban sprawl is caused by four factors: consumer preference, technical innovation, subsidies, and public and quasi-public goods.

According to **Bruckner (2000)**, sprawl is caused by the simultaneous increase in income and population, as well as the decrease in commuting expenses. The growing population necessitates the demand for more space. From another perspective, when people' income increases, there is a tendency towards larger buildings. In response to this issue, there will be a construction of highways and infrastructures.

The factors contributing to urban sprawl differ based on the level of development of countries or the societal structure.

Habibi and Asadi (2011) concluded that urban sprawl is primarily driven by population and income growth, the availability of affordable land and housing, as well as the presence of advantageous factors such as affordable transportation systems, well-developed commuting networks, the establishment of job centers in suburbs, and the provision of infrastructure, subsidies, and public services. These variables will contribute to the development of utilities and incentivize residents to engage in urban sprawl. He categorised the factors causing sprawl as economic growth and increasing income, prices of land under the head of economic factors, population growth in demographic factors, More space per person and diversity of choice under housing factor , private car ownership, low commuting expenditure, transportation systems improvement, availability of roads under transportation factor causing sprawl and also categorised technological innovation, public facilities and infrastructures under other miscellaneous factors causing urban sprawl.

1.7 REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

Remote sensing is the acquisition of information about an object or phenomenon without being in physical contact with the object and thus in contrast to on-site observation.

A **Geographic Information System** or Geographical Information System (GIS) is a system designed to capture, store, manipulate, analyse, manage, and present all types of spatial or geographical data. Remote sensing in combination with the Global positioning system (GPS) and Geographical Information System (GIS) produces the terrain maps at the location accurately and containing detailed information of the variables under study. In India, satellite remote sensing technology is being used effectively in the areas of irrigation performance evaluation, snowmelt-runoff forecasts, reservoir sedimentation, watershed treatment, drought monitoring, flood mapping and management.

Usage of Remote Sensing AND GIS in LULC Mapping

LULC plays is crucial for comprehending the physical attributes of the Earth's surface, encompassing the arrangement of flora, water, soil, and other natural elements, as well as human-made features. Maps and data on land use and land cover are crucial for the strategic planning, conservation, management, and usage of land in various sectors such as agriculture, forestry, urban development, industry, environmental studies, and economic growth. Assessing and monitoring the earth’s surface is a key requirement for global change research. With the impending threat to environment, vegetation type/land use mapping is now given the highest priority. Classifying and mapping of vegetation is an important technical task for managing natural resources as vegetation provides a baseline for all living beings and plays an essential role in affecting global climate change e.g., influencing terrestrial CO_2.

Mapping is a crucial method for studying different types of vegetation, particularly when it comes to understanding their spatial distribution, changes over time, and the characterization of biodiversity at a larger scale. Currently, remote sensing and Geographic Information System (GIS) technologies can be utilized to accurately create and regularly update vegetation types/land use maps. Vegetation type/land use mapping is a crucial endeavour for the effective management of natural resources. The utilization of remote sensing and geographic information system plays a crucial role in promptly evaluating and monitoring land resources.

Urban sprawl refers to the conversion of rural areas into urban areas, resulting in changes to land use and land cover. This term has been used to characterize the urban environment since the mid-20th century. The combination of Remote Sensing (RS) and Geographical Information System (GIS) is a powerful method for identifying urban sprawl and creating models.

GIS provides diverse methods to create spatial planning scenario for decision making. Application of Remote Sensing technology have been identified and used as an important tool to monitor land use and surface changes. Since 1972, Landsat satellites have been steadily gathering imagery of the Earth's surface on a constant basis. This has given land managers, planners, and policymakers access to an unbroken data archive that helps them make better decisions regarding the environment and natural resources. Satellite remote sensing collects multispectral, multi resolution, multitemporal data providing valuable information for understanding and monitoring the process of urban land cover changes. As it is in the digital format, it can be brought into GIS, to provide a suitable platform for data analysis, update and retrieval. Land use can be captured both in terms of geographic location and absolute area. The growth profile obtained helps in formulation of development policies. LAND SAT, TM, ETM can be used for detecting the characteristics of land use change. ERDAS imagine, digital image processing software can be used for supervised classification. Further, ARC info can be used to prepare thematic maps and data base.

Moreover, our water supply is finite. From areas of abundance to places struck with drought, ensuring access to a clean, reliable source of water is critical. We can protect water supplies and their integrity by understanding how human behaviours impact the natural system. We can document water sources and quantify their capacity based on current and historic data, then share the story of the water system through engaging maps so everyone can see how today actions affect is tomorrow’s water system.

Modern life as we know it depends on our ability to match the supply and demand of water of appropriate quality to specific communities and users at specific times or rates. Our cities, farms, parks, and recreation areas all require water and their success (i.e., sustainability) relies on natural and human water delivery systems. Large amounts of time and effort are invested in learning more about the spatial and temporal patterns and characteristics of individual hydrologic processes so we can anticipate, manage, and modify system behaviour to sustain modern lifestyles and prevent shortages (droughts), surpluses (floods), and resource impairment (pollution).

1.8 NEED OF THE PRESENT STUDY

The Vadodara city is posing frequent problems of waterlogging/ flooding during the periods of high rainfall since last few years. It has also been observed in last few years that a lot of expansion has taken place. The areal extents of city have expanded, with a lot of construction activities taking place in the outskirts of the city. Vishwamitri river passes through the center of the Vadodara city and as it enters the city it becomes narrower. During heavy rainfall the areas near by the river are flooded. The flooding/waterlogging problems in the city are affecting the daily activities of people, damage to infrastructure and also impacting the livelihood.

Monitoring the ongoing process of land use/land cover pattern over time is necessary to ensure sustainable development. Authorities involved in urban development need these planning models in order to ensure that every available piece of land is used as rationally and optimally as possible, both to promote sustainable urban development and to prevent the haphazard growth of towns and cities. Information about the area's historical and current land use/ land cover is needed for this. LULC maps to further aid in the understanding of the changes taking place in our surroundings and ecosystem. Also, estimating the future land changes will help the urban planners to modify the land use patterns for further development. Land use/ land cover mapping is essential to identify its impact on the runoff. This study will help the water managers, to prepare strategies to utilize or divert or store the excess rainfall/ runoff, which is occurring.

1.9 OBJECTIVES OF THE PRESENT STUDY

1. To study the changes in Land Use/ Land Cover (LULC)/Urban Sprawl over a period, that influences the runoff characteristics of the study area.
2. To study and analyse the Rainfall over a number of decades in the study area.
3. To determine and analyse the runoff in the study area using quantitative techniques like Soil Conservation Services-Curve Number (SCS-CN) method using Remote Sensing and Geographic Information System (GIS).
4. To analyse the impact of Land Use/ Land Cover changes on Runoff in the study area.
5. To determine rainfall and runoff for various recurrence intervals i.e., for 2, 5, 10, 15, 20, 25, 50, 75 and 100 years return period.
6. To predict probable Land Use/ Land Cover changes in the study area.

Suggestive measures/ recommendations will be drawn out from the present study, to store/discharge the rainfall excess/runoff water so as to safely reduce the probable occurrences of flood peaks.