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# An Investigation of Storm Water Runoff Using GIS and Remote Sensing

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**ABSTRACT:** Stormwater is the water flow generated from rainfall. Rainfall that flows over the ground surface is created when rain falls on paved surfaces like road, parking lot rooftop and other concrete surface like road, parking lot, rooftop and other concrete surface that don't allow water to soak into the bottom. This research focuses on high intensity rainfall or storm rainfall and runoff in the Yewalewadi, Pune. The problem is due to lack of proper drainage mixes in various solid wastes, human and other domestic wastes. Such lack of cleanliness can result health disorders. In the modern era, the development is inclined towards population growth, urbanization, climate change and urban stormwater management are the major concerns in the development. In urban areas sequential flooding has become major concern to the city planners and modelers. The role of stormwater model in GIS vital to check flash floods and issues related to the quality and quantity of stormwater. IPA SWMM has proven an effective tool for particularly in urban watersheds to effective management, design and analysis of drainage system network. This study presents a stormwater modeling with flooding in urbanized watersheds using EPASWMM 5.1 approach in the concern model. Pune urban, the cultural capital of Maharashtra State is considered as study area model development using critical rainfall event in the past. GIS approach is engaged in data handling and preparation. The simulation results show that the available drainage is not capable to handle the extreme rainfall intensities and overwhelm with a splash rainfall. Thus, the model suggests in increasing the drain size or provides alternate arrangement to carry the excessive flows.

**KEYWORDS:** Runoff, Water logging, Paved surfaces, Land use, Urban flooding, Geographical research, GIS, Mountain landscape, Digital database, Remote sensing, Mapping techniques.

## I. INTRODUCTION

Surface water in abnormal quantity resulting from heavy falls of rain or snow. Stormwater, also spelled storm water, is water that originates from rain, including snow and ice melt. Stormwater can soak into the soil (infiltrate), be stored on the land surface in ponds and puddles, evaporate, or contribute to surface runoff. Most runoff is conveyed directly to nearby streams, rivers, or other water bodies (surface water) without treatment. Urban runoff entering a storm draining natural landscapes, such as forests, soil absorbs much of the stormwater. Plants also reduce stormwater by improving infiltration, intercepting precipitation as it falls, and by taking up water through their roots. In developed environments, such as cities, unmanaged stormwater can create two major issues: one related to the volume and timing of runoff (flooding) and the other related to potential contaminants the water is carrying (water pollution). In addition to the pollutants carried in stormwater runoff, urban runoff is being recognized as a cause of pollution in its own right stormwater is also an important resource as human population and demand for water grow, particularly in arid and drought-prone climates. Stormwater harvesting techniques and purification could potentially make some urban environments self-sustaining in terms of water.

Stormwater management

Stormwater filtration system for urban runoff managing the quantity and quality of stormwater is termed, "Stormwater Management. The term Best Management Practice (BMP) or stormwater control measure (SCM) is often used to refer to both structural or engineered control devices and systems (e.g. retention ponds) to treat or store polluted stormwater, as well as operational or procedural practices (e.g. streets weeping). Stormwater management includes both technical and institutional aspects



#### Technical aspects

Control of flooding and erosion;

Control of hazardous materials to prevent release of pollutants into the environment (source control); planning and construction of stormwater systems like retention basins, buried vaults with various kinds of media filters, and vortex separators to remove coarse solids before they pollute surface waters or groundwater resources; acquisition and protection of natural waterways or rehabilitation; building nature-based solutions such as ponds, swales, constructed wetlands or green infrastructure solutions to work with existing or "hard" drainage structures, such as pipes and concrete channels (constructed wetlands built for stormwater treatment can also serve as habitat for plants, amphibians and fish) .

#### Institutional and policy aspects

Development of funding approaches to stormwater programs potentially including stormwater user fees and the creation of a stormwater utility; development of long-term asset management programs to repair and replace aging infrastructure; revision of current stormwater regulations to address comprehensive stormwater needs; enhancement and enforcement of existing ordinances to make sure property owners consider the effects of stormwater before, during and after development of their land; education of a community about how its actions affect water quality, and about what it can do to improve water quality. Remote sensing technology in recent years has proved to be of great importance in acquiring data for effective resources management and hence could even be applied to coastal environment monitoring Remote Sensing and Geographical data system (GIS) and Its Application in Various Fields and management especially, GIS and remote sensing technologies together offer the skills of rapidly collecting data, processing and integrating data and knowledge, and displaying leads to geographic referenced maps and reports.[1]

The satellite remote sensing may be a timely technological development in sight of great pressures on our natural habitat. it's wont to interpret the pictures or numerical values obtained from a distance so as to accumulate meaningful information of particular features on earth. For the last couple of decades, the appliance of remote sensing isn't only revolutionized the way data are collected but also significantly improved the standard and accessibility of important spatial information for conservation and management of natural resources. The parallel advance within the reliability of GIS has permitted the interpretation of huge quantity of knowledge generated through remote sensing to deal with different environmental problems. [2]

When rain water runs off the land—it is called storm water. Storm water flows across land and through the elaborate series of pipes, ditches, culverts, and catch basins that make up our storm water system, ending up in our streams, estuaries, lakes, rivers, and eventually, the ocean. As the storm water flows on, it picks up and carries many substances that pollute it. These pollutants include sediment, fertilizers, pesticides, motor oil, debris, pet and animal waste, soap and fuels. Storm water runoff is not treated in any way, so these pollutants end up in our environment and our water supply. Urbanization increases storm water discharges and the capacity to transport contaminants from watershed to the streams it feeds. Therefore, storm water discharges need to be managed to meet the regulatory requirements. Development of the modern city often results in an increased demand for water due to population growth, while at the same time altered runoff predicted by climate change has the potential to increase the volume of storm water that can contribute to drainage and flooding problems. Effective storm water management offers a multitude of possible benefits, including protection of wetlands and aquatic ecosystems, improved quality of receiving water bodies, conversion of water resources and flood control. [3]

Pune as a major city located within the state of Maharashtra, India. Pune city central is that the district headquarters of the district. The district population was 10,089,916 census 2020. It is the 4th most populous city of India. The Urban population is 58.76% of the total which nearly is 6 lakhs. The population projection of Pune is 8.59 million within the year 2041. It is one of the most industrialized cities of India. In the past we want to study only the river flood but because the population goes on increasing day by day the paved area increased which increases runoff and decreases the infiltration capacity of soil. Urbanization creates lots of pressure on land use which may result in urban flooding. An urban flood may be a situation that happens when water overflows the sewer and takes the direction to the road and into the building parking. Due to torrential or sudden rainfalls nowadays water overflow condition in storm water drainage system occurs quite frequently. It clearly shows the need to increase the size and maintenance of not only the provided drainage system but also think of an innovative way to dispose of the sudden water. In this paper we shall find out the proper need of such a method. The project area is near the Kondhawa side. Its boundaries to eastern side are Pisoli, Southern side boundary is Undari and Bivari and west side boundary is Katraj. Population of Yewalewadi is 24919 out of which 13468 are males and 11451 are females. Stormwater management is that the effort to scale back runoff of rainwater or melted snow into streets, lawns and other sited and the improvement of water quality, consistent with the us Environmental Protection Agency (EPA). When stormwater is absorbed into the soil, it's filtered and



ultimately replenishes aquifers or flows into streams and rivers. However, when heavy rainwater hits, ground saturated by water creates excess moisture that runs across the surface and into storm sewers and road ditches. This water often carries debris, chemicals, bacteria, eroded soil, and other pollutants, and carries them into streams, rivers, lakes, wetlands etc. Stormwater management is the effort to reduce runoff of rainwater or melted snow into streets, lawns and other sites and therefore the improvement of water quality, according to the United States Environmental Protection Agency.[4].

## II. METHODOLOGY

### Input Data

The maps used are:

Canals, streams and other water bodies' location, contour map, drainage basin map, road network map from survey of India, top sheets and the concerned departments.

Land use map and soil map from higher resolution satellite imagery.

Rainfall intensity, past rainfall data and rainfall distribution from Indian Meteorological (IM) stations.

Population distribution—duration frequency curves and other related maps.

### Computational Facilities

The work was carried out using ARC/INFO and Earth Resources Data Analysis Systems (ERDAS), Imagine Software running under UNIX Operating System.

### Development of GIS Data Base

The following coverages are prepared using ARC/GIS:

Polygon coverage depicting the boundary of the area selected

Polygon coverage showing the location of probable sites for detention basins

Polygon coverage showing the population distribution and population density

Arc coverage showing the network of the area

Arc coverage showing the storm sewers designed in the drainage network

Fused data coverage for Land Use (IRS1D, PAN + LISS III) classification is to be carried out to classify the LISS III image for the Land use/Land cover classification

### GIS Data Sources

A heightened awareness of environmental problems developed over the past several decades, which spurred a need for reliable geospatial data to enable better understanding of the environmental processes and their impacts [10]. Environmental models have also undergone changes creating new requirements for geospatial data. In view of the critical role played by the data in any kind of spatial modelling, emphasis is given to new information gathering initiations for remotely sensed data and to advancements in integrating data for different sources with GIS.

A GIS is any system that captures, stores, analyses, manages, and presents data linked to a location. GIS is a system that includes mapping software and its application to RS, land surveying, aerial photography, mathematics, photogrammetry and geography.

GIS and environmental models function with a broad spectrum of geospatial data used for spatial analysis and modelling of environment related problems at different scales [11]. These data generally come in different formats and from various sources and measurements [12]. The examination and organization of data into a useful form produces information content, which is compatible to GIS, enabling appropriate analysis and modelling of urban environment.

### GIS Data Types

Basically all the GIS data used in this study are classified as

Topographical data;

Thematic data; and

Collateral data.

In stormwater management on urban watersheds many decentralized systems are experimented with around the world along with the best management practices and the methodologies of their planning and design [10]. From the aspect of promoting the decentralized approach to stormwater management on urban watersheds and the integration of this approach in spatial and city planning plans is precise interesting methodology of sensitive design of stormwater system, which is applied on the Molenbek watershed within the Brussels Region in Belgium, with the world of 13.5 km<sup>2</sup> and encompassing the 8% of the Brussels region.

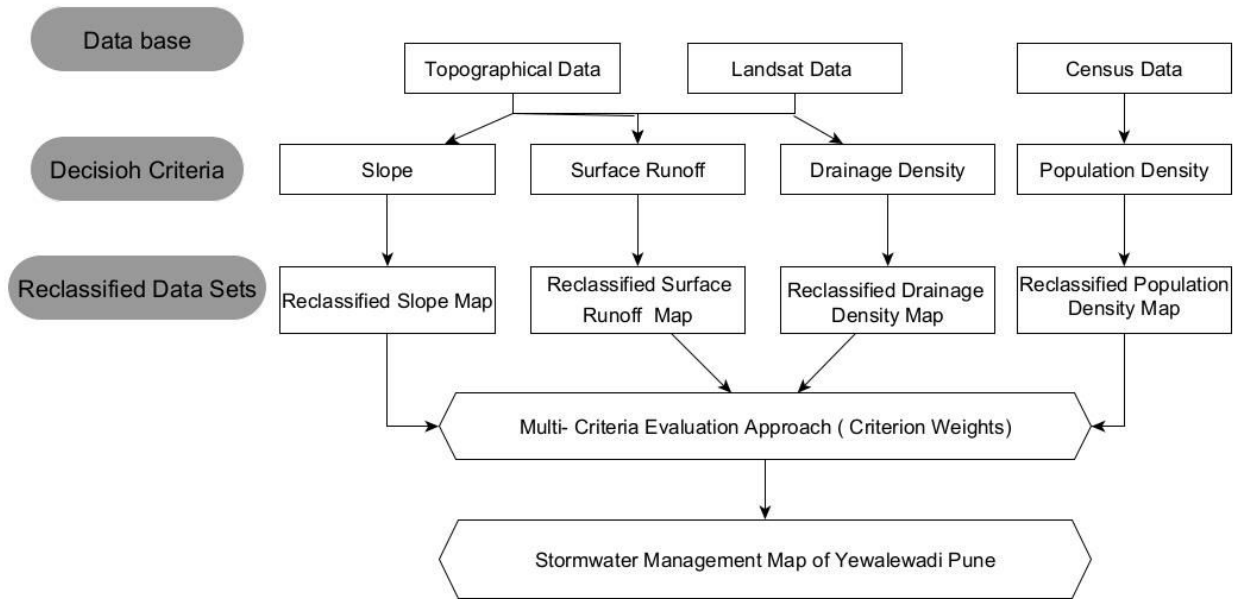


Fig.1 Flow Chart of Methodology

Decision Criteria for Stormwater Management –

The indicated criteria can form the base for choosing the most favourable stormwater operation system for both large and civic catchments and individual installations. Thanks to the considerable inflexibility of the advanced decision problem structure, its wide operation can contribute to perfecting the effectiveness of stormwater operation systems.

Surface Runoff –

Runoff is defined as the portion of the precipitation that makes its way towards rivers or ocean as the surface or surface flow phenomenon of infiltration and other losses from the precipitation, the excess rainfall flows out through the small channels on the surface to the main drainage channels. Runoff can be estimated by rational method [13]. The rational equation is the simplest method to determine peak discharge from drainage basin runoff.

Table 1 Ground Level and Runoff Coefficient

Ground Cover	Runoff Coefficient, C
Lawns	0.05-0.35
Forest	0.05-0.25
Cultivated Land	0.08-0.41
Meadow	0.1-0.5
Parks, Cemeteries	0.1-0.25
Unimproved areas	0.1-0.3
Pasture	0.12-0.62
Residential areas	0.3-0.75
Business areas	0.5-0.95
Industrial areas	0.5-0.9
Asphalt streets	0.7-0.95
Brick streets	0.7-0.85
Roofs	0.75-0.95
Concrete streets	0.7-0.95



Slope –

Slope is another indicator used for collecting storm water at one place which is taken into consideration. The slope function determines the maximum rate of change between each cell and its neighbours, for ex. The steepest downhill descent for the cell.

Slope map is generated based on contour line in QGIS and ARC GIS platforms.

Population Density –

Yewalewadi is a growing area in district of Pune, Maharashtra. As per year 2020 the total population of Yewalewadi is 24919 of which 13468 are males while 11451 are females.

Drainage Density –

Drainage density is measure of stream spacing. Drainage density reflects basins geology and climate.

The drainage pattern of area to be worked out carefully based on the contours before proposing any development or detail design of public service like water supply or sewage system.

Drainage density = (Total length of streams within a catchment/ watershed(sq.km) )/(Total area of the catchment/watershed(sq.km))

A high value of drainage density indicates a relatively high density of streams and thus rapid storm process.

### III. EXPECTED OUTCOME

Stormwater runoff management gives conservation of water resources, protection of public health and flood control. Through GIS studies on a slope and land utilization patterns can be used to predict whether water in a given area is secure. Due to the ability of GIS to handle huge amount of data sets operated, stored as well as reports will generated.

Through this project we will find saturation area and preventive measures of stormwater.

We have implemented an automatic text detection technique from an image for In painting. Our algorithm successfully detects the text region from the image which consists of mixed text-picture-graphic regions. We have applied our algorithm on many images and found that it successfully detect the text region.

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