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Estimation of Runoff Using SCS-CN Method and GIS Techniques in East Godavari Dist., Andhra Pradesh, India

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Abstract
Development of accurate surface runoff estimation technique from gauged watersheds is relevant as finding temperature conditions in our country due to the availability of hydrological gauge stations. In the present study, for East Godavari Dist. Runoff Estimation is concluded by using Soil Conservation Service Curve Number (SCS-CN) method and application of Geographical Information System(GIS) using Landsat 8 series satellite images in 11 bands and developed various rasters through ARC GIS 10.5. The Runoff data is collected from the groundwater departments and also from National Institute of Hydrology in Kakinada of East Godavari Dist. The CN parameter values corresponding to various hydrologic soil group in land use and land cover management conditions can be selected from the Curve Number tables and it is preferable to estimate the CN value from measured rainfall which is 1815.99 for the years 2018 & 2019. There were fluctions in rainfall in mm nearly for every four to five years i.e., from 2010 to 2013 the rainfall in mm is recorded with decrease from 700 mm to 600 mm and with a slight changes in fractions of around 1077 mm from 2014 to 2017.The runoff is estimated from collected rainfall data for 64 mandals in East Godavari Dist. This study provided information of runoff potentially for all 64 mandals and it was found that in mandals Rangampeta, Gandepalli and partially Rajanagaram and few more are facing severe drought conditions.

Keywords: GIS, Runoff, Raster, SCS-CN

Introduction :
The assessment of excess precipitation gives a base for hydraulic structure plan and calculations of flood peak discharges. Characteristics like length, slope, land use and shape have significant impact on the run off generated. There are number of methods available for rainfall runoff modeling such as hydrological models, emperical equations and data driven techniques to correlate rainfall and runoff. The soil conservation service curve number (SCS-CN) model created by the U.S bureau of agricultural national resources conservation service (NRCS) formerly known as soil conservation service is the mainly prevalent, primogenital, simplest and broadly connected model for direct runoff estimation is used for the evalution of direct runoff for a given rainfall event. Land cover information is used in hydrological modeling to estimate the value of surface roughness or friction as it affects the velocity of the overland flow of water. It also be used to determine the amount of rainfall that will infiltrate into the soil. Soil data land use, antecedent

rainfall, strom duration and average annual tempreature are used to estimate surface runoff in SCS-CN method. The objective of the method is to determine the accurate curve number of the catchment of interest that difines the runoff potential. Hydrological soil group number, and use type, vegetation cover, soil conservation measures, antecedent soil moisture conditions are the basic catchment characteristics use or curve number caluculations.

East Godavari occupies an area of 12,805 square kilometres (4,944 sq mi), comparatively equivalent to Indonesia's Sumba Island. The district is bounded on north by Visakhapatnam District, Malkangiri District of Orissa on the northwest by Khammam District and Sukma district of Chhattisgarh, on the east and south by the Bay of Bengal and on the west by West Godavari. It has a coastline of 144 km (89 mi). The small enclave (30 km2 or 12 sq mi) of the Yanam district of Puducherry state lies within this district. The topography consists of hills in the north west and fertile plains in the central part and towards the east. The plains are drained by godavari river and its landscape is filled with evergreen paddy fields all along the delta. It is the largest producer of Paddy in whole of Andhra Pradesh. Papikondalu part of Eastern Ghats is the hilly terrain in located the north western part of this district, it consists of hills running on both the sides of river godavari till Bhadrachalam, Telangana. The temperature remains humid for most of the months as it is located in the coastal belt. This district is referred as the green belt of Andhra due to its greenary spread all around. There are abundant deciduous forests in the Northwest part near Maredumilli and to the east near Kakinada there are mangrove forests.

2. LITERATURE REVIEW:

There are numerous approaches to estimate runoff for ungauged watersheds. One approach utilizes precipitation data in conjunction with to pographic, soil, and vegetative conditions within catchment to arrive at an estimate of the likely runoff. One of the models falling within this group isSCS-CN model. This is frequently used for rainstorm events in ungauged basins (Muttharam et al 1997). The model was developed in 1954 by the U.S.Department of Agriculture (USDA) Soil Conservation Service (SCS), and is described in the Soil Conservation Service (SCS) National Engineering Handbook Section 4: Hydrology (NEH-4) (SCS 1985). In 1994, SCS became Natural Resources Conservation Service (NRCS), and therefore, the SCS-CN model is renamed as NRCS-CN model in the current literature.

This NRCS-CN (or SCS-CN) model is the product of more than 20years of studies of rainfall–runoff relationships from small rural watersheds. Based on annual flood data collected at a number of study watersheds with drainage areas of 1 sq. miles (2.6 sq. km) or less and with a uniform basin hydrologic soil–cover complex, the SCS developed the CN tables (Bales and Betson 1981). It is a simple procedure for estimating streamflow volume (exclusive of base flow) generated by large rainstorms. Further, this SCS-CN model is basically empirical, and provided a consistent basis for estimating the amount of runoff under varying land use and soil types.

To the origin of the SCS-CN

methodology, Sherman (1942, 1949)was the first to propose the plotting of direct runoff against storm rainfall. Later, Mockus (1949) proposed that the estimates of surface runoff for ungauged watersheds could be based on soil, landuse, antecedent rainfall, storm duration, and average annual temperature. He combined these factors into an empirical parameter 'b' characterizing the relationship between rainfall depth P and runoff depth Q (Rallison and Miller 1981) as:

Q = P (1-10-bP)

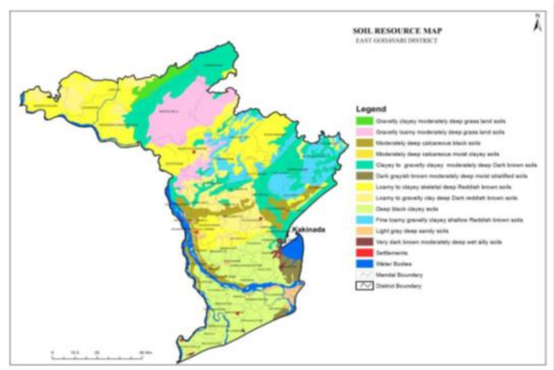
According to Mishra and Singh (1999b, 2003c), Equation (2.1)forms the basis of the development of the SCS-CN concept. In a separate attempt, Andrews (unpublished report, 1954) developed a graphical procedure for estimating runoff from rainfall utilizing in filtro meter data, and consequently, graphs were developed for several combinations of soil texture, type and amount of cover, and conservation practices, combined together referred as 'soil–cover complex'. Mockus empirical rainfall–runoff (P–Q) relationship and Andrew's soil–cover complex formed the basis of the conceptual rainfall–runoff relationship incorporated in NEH-4 (Ponce and Hawkins 1996).

3. METHODOLOGY:

Rainfall and runoff are significant constitute the sources of water for recharge of ground water in the watershed. Rainfall is a major the primary source of recharge into the ground water. Use of remote sensing and GIS technology can be useful to overcome the problem in conventional methods for estimating runoff. In this paper, modified Soil Conservation System (SCS) CN method is used for runoff estimation that considers parameter like slope, vegetation cover, area of watershed. The Land cover map developed for the study region was used in analyzing the runoff generated over the command area. Rainfall data and soil map for the region was acquired to calculate the antecedent moisture condition (AMC) and hydrological soil group (HSG) map respectively. SCS curve number model was employed to determine the runoff. The computation was carried out on a GIS platform to accommodate the spatial variability. Total runoff generated over the study region during the year 2007 was computed as 17.98 mm. The peak runoff was observed in the month of July which contributed 39.85% of the total**.**

NEH [9] developed ―SCS-CN method‖. The method requires numeric catchment characteristics which are the basis of catchment runoff determination. The objective of the method is to determine the accurate curve number of the catchment of interest that defines the runoff potential. Hydrologic soil group number, land use type, vegetation cover, soil conservation measures, antecedent soil moisture conditions are the basic catchment characteristics used for curve number calculations. Sharma et al. [10] studied the hydrologic response of a watershed to land use changes based on Geographical Information System (GIS) and Remote Sensing (RS) approach. Gangodagamage and Agarwal [11] carried out hydrological Modeling using remote sensing and GIS. Accurate modeling will require estimation of the spatial and temporal distribution of the water resources parameters. The present work aims to prioritize watershed of Sone canalbased on runoff generated, expressed as yield, due to existing land use conditions, and to evaluate the hydrologic response of these measures on runoff.

Runoff generated in a river basin contributes significantly to the river discharge [1,2]. River basin characteristic such as length, slope, land use and basin shape have significant impact on the runoff generated from the river basin [3]. There are number of methods available for rainfall runoff modeling such as hydrologic models, empirical equations and data driven techniques to correlate rainfall and runoff [4]. Soil Conservation Services and Curve Number (SCS– CN) technique isone of the primogenital and simplest method for rainfall runoff modelling. Land cover information is used in hydrologic modeling to estimate the value of surface roughness or friction as it affects the velocity of the overland flow of water [5,6]. It may also be used to determine the amount of rainfall that will infiltrate into the soil [7]. Mockus [8] used data on soil, land use, antecedent rainfall, storm duration, and average annual temperature to estimate surface runoff in ungagged catchments.



EXPERIMENTAL PROGRAMME:

This study is to determine the runoff deoth of the east godavri district by soil conservation service curve number (SCS-CN) method. The SCS-CN method is widely used for predecting direct runoff volume for a given rainfall event. The applicability of SCS-CN method and the runoff generation mechanisam were throughly analyzed in East godavari.
The aim of this project is to calculate the runoff depth of east godavri district for this purpose we collected the rainfall data from district water management authority (DWMA). They gave the data of rainfall for past 10 years.
By using engineering hydrology training series module 104- runoff curve number to computations to calculate the runoff.

The following characterstics are need to find the runoff, A) Soil Group Classification B) Hydrological Condition C) Antecedent Soil Moisture Condition (AMC) D) Curve Number Table

4.1 Soil group classification :

groupA: low runoff potentiall soils have high infiltration rates deep sand deep aggregated silts
groupB:moderate infiltration rates moderately deep sand shallow loss sandy loams
groupC:slow infiltration soils with a layer which impeds downward H20 movement moderately fine lectuarates clay loams, shallow sandy loams low organic content, with high clay

groupD:high runoff potential,slow infiltration , swells when wet clay pan / caly layer**4.2Hydrological Conditions :** poor-heavily graded or regularly burned less than 50% of ground surface is protected by plant cover bushes or tree conopyfair-moderate cover with 50%-75% the ground surface protected good-heavy or dense cover with more than 75% of the ground surface protected.

Antecedent Moisture Condition (AMC) of East Godavari Dist.

condition-I:soils are dry but not to wilting point satisfactory cultivation has been take place

condition-II:average condition

condition-III:heavy rainfall or light rainfall low temperature have occurred with in the last 5 days saturated soil **curve number tables** for a particular area the soil group classification hydrologic condition and antecedent moisture condition are collected from curve number tables.

Table 1. Curve Number

Mandal	Type of soil
Rayavaram	Clay
Kapileswaram	Clay
Pedapudi	Clay
Karapa	Clay
Pithapuram	Clay
Kajuluru	Clay
Ramachandrapuram	Clay
Sakhinetipalli	Clay

The above table refers the low rainfall areas in East Godavari district.

Soil group classification:-

Group-A:- Low runoff potential

Soils have high infiltration rates

Deep aggregated silts

Group-B:-Moderate infiltration rates

Moderately deep sands

Sandy loams

Group-C:-Slow infiltration

Moderately fine to fine textures

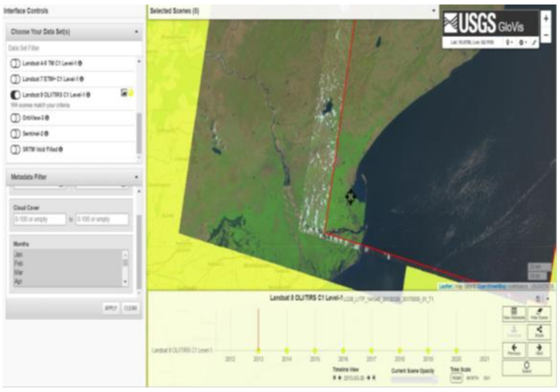
Clay loams

Group-D:-High runoff potential

Slow infiltration rates

4.3Applications of Remote Sensing and GIS

RS and GIS are the greate tools for researching in vast areas ranging for several hundreds and thousands of square kilometers of area. The satellites images of the study area are abtained from USGS GLOVIS website in which we have downloaded the landsat 8 images with these two sensors provided the seasonal coverage of the global landmass at a spatial resolution of 30 meters (visible, NIR, SWIR); 100 meters (thermal); and 15 meters (panchromatic). Landsat 8 was developed as a collaboration between NASA and the U.S. Geological Survey (USGS).



4.4. Results & Discussion:

Classified soil group , hydrological soil condition and antecedent moisture condition are applied to soil conservation

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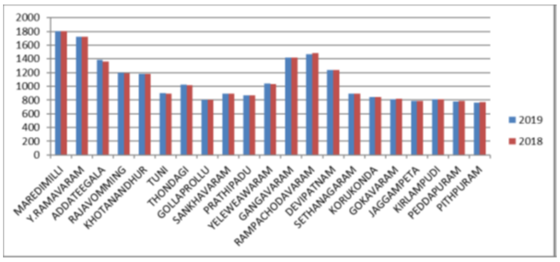
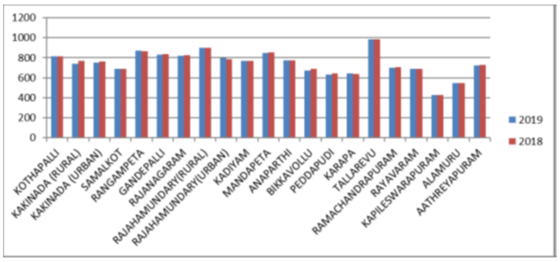
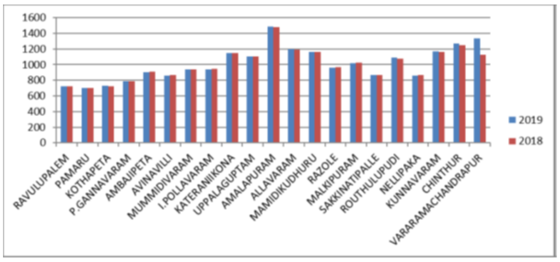
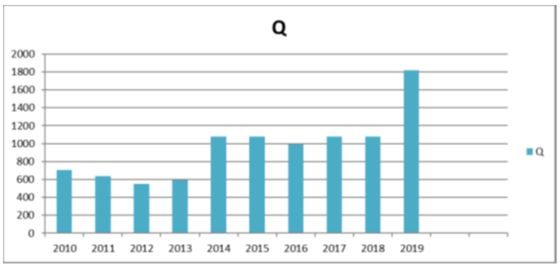
service curve number method to caluculate curve numbers of Andhra Pradesh curve numbers were calculated by means of engineering hydrology training series Module 104- runoff curve number computations

The following graphs shows the monthly and yearly output for the years 2010-2020 of Andhra Pradesh.









S.NO	YEAR	RUNOFF (mm)
1.	2010	705.14
2.	2011	635.42
3.	2012	551.77
4.	2013	595.10
5.	2014	1077.41
6.	2015	1077.41
7.	2016	1076.41
8.	2017	1076.41
9.	2018	1070.21
10.	2019	1815.99

5. CONCLUSION :

In this project show that sattelite images are very useful to determine runoff distribution of the andhra pradesh. There are several parameters effecting water level fluctuations such as climatic condition like rainfall and runoff. Water level of the andhra pradesh has been changed abruptly in recent years because of these parameters. Due to lack of the rainfall and runoff gauge stations it has not been able to understand hydrologic condition of Andhra pradesh. Thus it has become invertable to determine rainfall /runoff model by using remote sensing and GIS technology, so to achive the obtaining runoff depth of the basin area soil conservation model was used curve number is a model cofficient which was determined based on the factors based on land use cover from classified images and hydrological soil groups.

From the study area it is identified that the mandal – Gandepalli, Rangampeta, Peddapuram, amalkota and some parts of Rajanagarm are facing either draught condition or low yield of ground water and the extracted groundwater are saline too. From this study it is suggested to develop a surface recharge mound method (an Artificial Recharge method) by dregging the existing ponds, lakes in the villages of above mandals and to cover the surface of lake with HDPE (High Density Polyethylene) membrane which is a

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thermoplastic polymer produced from the monomer ethylene. It is sometimes called "alkathene" or "polythene" when used for HDPE pipes.[1] With a high strength-to-density ratio, HDPE is used in the production of plastic bottles, corrosion-resistant piping, geomembranes and plastic lumber. HDPE is commonly recycled, and has the number "2" as its resin identification code.

To control the rate of evaporation the surface of pond can be covered with the same HDPE balls by pouring them in to pond. Since the plastic ball float on the water they will reduce the passing of sunlight and rate of evaporation. It is also very much effective by growing of Garra rufa kind of fish in pond will reduce the growth of bacteria in the pond.

An Article published in allover the internet about dumping plastic ball in LA reservoir in USA.
https://en.wikipedia.org/wiki/Shade_balls
Starting in mid-2009, the Los Angeles Department of Water and Power (LADWP) put about 400,000 balls in the Ivanhoe reservoir with the main objective of preventing the formation of a carcinogenic chemical, bromate, which forms when naturally occurring bromine reacts with chlorine in sunlight. In the original release by the LADWP, there is no mention of water conservation as an objective and the project was planned for a five-year life span, until a Griffith Park project was 40

completed. The reduction in evaporation led to an estimated savings of about 1.1 billion liters (290 million gallons) of water in one year. In 2014 and 2015, the LADWP put 96 million shade balls onto its largest reservoir (Las Virgenes) in response to the United States Environmental Protection Agency's surface water treatment rule, which requires large reservoirs of treated water to be covered. The LADWP says that in addition to reducing evaporation, they also reduce UV radiation by-products and algae growth. The balls saved 1.7 million cubic metres of water from evaporating during their deployment from August 2015 to March 2017. However, they required 2.9 million cubic metres of water in their manufacture. Nevertheless, the balls have a lifespan of ten years, and the plastic may be reused after that.

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