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A GEOSPATIAL BASED APPROACH FOR SUSTAINABLE WATER MANAGEMENT UDAIPUR-DISTRCIT, RAJASTHAN: A LITERATURE REVIEW

Gara Megha Shyam*

*Centre for Climate Change and Water Research, Suresh Gyan Vihar University, Jaipur

Email id: gara.56457@mygyanvihar.com

ABSTRACT

In recent days, Remote Sensing Technology united with Geographic Information System (GIS) has become very important. Because these techniques are offer cheaper and faster results. Rainfall runoff is one of the dynamic hydrologic variables of Hydrologic Cycle. It is an ideal unit for the management of natural resources like water from rainfalls and for mitigation of the impact of natural disaster for achieving sustainable development. By using Remote Sensing Technology with Geographic Information System, Digital Elevation Model (DEM) is well-thought-out as utmost effective model, to delineate stream network with flow direction & watersheds and runoff is estimated by Rational & Lacy's model. This paper highlights the review of remote sensing & GIS techniques, methodologies and models use for precipitation runoff in various places. These techniques have provided a scientific approach to capture maximum possibility of precipitation runoff, planning of water conservation measures with ground water recharge structures and sustainably use the precipitation runoff in long term availability.

Key Words: Remote Sensing, GIS, DEM, Runoff, Rain Water Harvesting, Sustainable Water Management etc.

INTRODUCTION:

In India, the most of the watersheds are ungauged, without having historical records of calculated runoff, and accurate runoff data are hardly available (Sarangi et al., 2005). For the development of watershed and management programmes in India, need to be evaluate the rainfall runoff amounts in all catchments (Zade et al., 2005). Due to non-availability of rainfall runoff records in Indian watersheds, few techniques have been developed for estimation of surface runoff from basins (Chattopadhyay and Choudhury, 2006). Several rainfall-runoff methods have been evolved over the years, and a few of them were widely-used. All rainfall runoff methods have their own advantages and limitations; the Lacye's (Garg, 1976) & Rational (Raghunath, 2006) methods have received a great consideration and implementation due to easiness, easy applicability and consistency in obtaining results.

Haye and Youngs (2005) compared the design characteristics of observed hydrological data. For this purpose, they selected eight small catchments in central Virginia whose area ranges from 2.5 to 52.7 acres. Rational Method was used for estimation of peak discharge. Time of concentration and runoff coefficients were also used in this study. Zhan (2005) studied the temporal changes in spatial distribution of land cover, runoff coefficients, and runoff volume was estimated. A digital elevation model and runoff hydrograph was made for study area which based upon above mentioned data information. From the land cover pattern of the study area it was concluded that with the passage of time urban area increases and vegetation area decreases. Due to this change the runoff volume and peak flow increased. It was concluded that by increasing vegetation in catchment area floods can be reduced.

Norbiato (2009) compared a range of events and range of catchments by a single indicator and discuss event runoff coefficients available insight on basin response. To carry this study, he selected 14 catchments whose area ranges from 7.3 to 2608.4 km. All the catchments were mountainous. He analysis the effect of different factors e.g. flood type, geology, temperature, initial soil moisture conditions and land use on the distribution functions of the event runoff coefficients. Runoff coefficients were determined from hourly rainfall, and runoff data. Five hundred and thirty-five (535) events were from 1989-2004 and these events were analysed. The results of this study indicate that the correlation between spatial distributions of runoff coefficients with mean annual precipitation is approximately same. Mean annual rainfall well explained the spatial variability in average runoff coefficient value which ranges from 0.40 to 0.48.

Tedela (2009) studied the curve numbers determined from annual maximum series of observed rainfall and runoff indicate wide variability from average runoff conditions for a particular watershed and, hence, a unique curve number does not provide an adequate estimate of runoff volume. The curve numbers determined from annual maximum series of observed rainfall and runoff indicate wide variability from average runoff conditions for a particular watershed and, hence, a unique curve number does not provide an adequate estimate of runoff volume.

Sepaskhan and Fard (2010) have developed a daily runoff coefficient for micro catchment is 0.0737 which was same as the observed value of 0.080. Runoff was 6.5mm and the rainfall was 4.6mm in the micro catchment of Iran. They developed runoff-rainfall relationship of daily and annual data. The model was also designed for the micro catchment. The model was based on the developed rainfall runoff relationship.

Kadioglu and Zakai (2001) represented changes in monthly runoff coefficient within an annual period by using a simple polygon diagram. A simple polygon diagram was also made from monthly rainfall and runoff data. This method provides rainfall runoff coefficient variation and also provide rainfall-runoff translation pattern quantitatively. Zakai et al (2006) developed rainfall runoff relationship and used an average value of runoff coefficient for this study and he also ignores the antecedent condition for translation of rainfall into runoff. He also presented rainfall–runoff relationship into different statistical terms. In this model, the runoff coefficient does not appear explicitly, but the runoff estimations are achieved, on average, within the operationally acceptable relative error limits of less than 10%.

RS & GIS TECNIQIES:

The spatial and temporal changes of land use/land cover can be assessed using satellite imageries (Yu et al 2003; Geymen and Baz 2008; Kadiogullari and Baskent 2008; Solin et al 2011). Remote sensing (RS) techniques along with Geographic Information System (GIS) have been applied extensively in recent times and are recognized as powerful and effective tools for detecting land-use change, flood mapping and flood risk assessment (Sarma 1999; Islam and Sado 2000; Sanyal and Lu 2004; Dewan et al 2007).

Sanders (2007) examined the utility of several on-line digital elevation models (DEMs) with a set of steady and unsteady test problems. The differences between LIDAR, IfSAR, SRTM and NED were explained. DEMs based on airborne light detection and ranging (LIDAR) are preferred because of its horizontal resolution, vertical accuracy and its ability to separate built-up structures and vegetation. DEMs based on airborne Interferometric Synthetic Aperture Radar (IfSAR) have good horizontal resolution but gridded elevations affect built-up structures and vegetation. Therefore, it cannot permit flood modelling without processing. DEMs based on National Elevation Data (NED) overestimate the flood extent when compared with all other DEM. From his study, it was suggested that Shuttle Radar Topography Mission (SRTM) can be used as a global source of terrain data for flood modelling.

Lastra et al (2008) state that flood hazard mapping can be grouped as either geological geomorphological & hydrological hydraulic type. Sanyal and Lu (2004) considered the flood depth to be crucial for flood hazard mapping and the digital elevation model was considered to be the most effective means to estimate flood depth from remotely sensed or hydrological data. The recent developments on delineation of flooded areas and flood hazard mapping using remote sensing and GIS were presented. Flood risk maps based on the estimated depth of inundation were also prepared.

Shang and Wilson (2009) examined the effect of watershed urbanization on stream flow behavior. Stream gauge data, spatially distributed rainfall data, land use/land cover and census population data were used to quantify the change in flood behavior and urbanization in multiple watersheds. They used GIS based methods for quantifying spatially distributed rainfall and surface imperviousness. They concluded that both the frequent and rare floods were sensitive to urbanization and result in increased magnitude of floods with various recurrence intervals.

Prasad et al (2016) analyzed in this paper that There are many sources of flooding viz. river flooding, coastal flooding, surface water flooding, drain and sewer flooding, groundwater flooding etc. This study envisages identification of various flooding sources, estimation of maximum floods and their routing through drainage system for a proposed industrial site. The digital elevation model (DEM) is developed from DGPS points, 0.5 m interval contour and spot levels and contours extracted from survey of India topographical maps for the surrounding area. The L-moments based rainfall frequency analysis has been performed to estimate 1day maximum rainfall for various return periods. The synthetic unit hydrographs are derived from catchment characteristics and flood hydrographs for 10, 25, 50- and 100-year return periods are computed. The two major source of flooding are flow in the drain and rainfall induced catchment. It is observed that there is increase in both extent and duration of flooding for higher return period floods. Though there is variation in depths of flooding in upstream and downstream reaches, the duration of flooding are very identical. These computed parameters like flood extent, depth, level, duration and maximum flow velocity are used in designing safe grade levels for the industrial site to safe guard the flood hazard.

RAIN WATER HARVESTING:

Chiew et al (1992) estimated groundwater recharge using an integrated surface and groundwater modelling approach. The model was calibrated against streamflow and potentiometric head data, with recharge estimated as an output from the calibrated model. The model was applied to the Campaspe River Basin in North-Central Victoria and the results indicated that this modelling approach can estimate satisfactorily the spatial and temporal distribution of regional recharge rates resulting from rainfall and irrigation water. The simulations predicted by the integrated model were better than those predicted when the surface and groundwater models were used separately. Osterkamp et al (1995) reviewed the techniques of groundwater recharge estimates in arid and semi-arid areas with examples from Abu Dhabi.

In South Africa, Bredenkamp et al (1995) applied the Cumulative Rainfall Departure (CRD) method in dolomitic aquifers. Their approach is based on the premise that equilibrium conditions develop in an aquifer over time, i.e. average rate of losses equating to average rate of recharge of the system. They clearly showed that the natural groundwater level fluctuation is related to that of the departure of rainfall from the mean rainfall of the preceding time. If the departure is positive, the water level will rise and vise versa. However, it can be demonstrated that as long as there is a surplus of recharge over discharge of an aquifer, even though the departure is negative, the natural water level may continue to rise.

Finch (1998) used a simple water balance model to estimate the direct groundwater recharge. The results of varying the vegetation canopy parameters for forest in addition to varying the soil moisture model were discussed. There were significant differences between the land cover types but recharge estimates were relatively insensitive to the vegetation canopy parameters. Amitha (2000) reviewed various methods of estimating natural ground recharge such as soil water balance method, zero flux plane method, one-dimensional soil water flow model, inverse modeling technique. groundwater level fluctuation method, hybrid water fluctuation method, groundwater balance method and isotope & solute profile techniques.

Xianfeng Sun (2005) used a water balance approach to groundwater recharge estimation in Montagu area of the western Klein Karoo, South Africa. The water balance approach based on empirical evapotranspiration and runoff model was employed to analyze long-term average recharge. The long-term average recharge was modeled as a function of the regional interaction of the site conditions such as climate, soil, geology and topography. Modeling was performed according to the outlined procedure using long term climatic and physical data from the different rainfall period of different gauge stations and the actual evapotranspiration, direct runoff and recharge was quantified. It is found that the recharge varies from 0.1 mm/yr to 38.0 mm/yr in the study area. The total recharge volume in the study area was 63/yr. It was cautioned that the estimates based on the water balance model should be crosschecked before they are applied for management of groundwater resources. 54.2× 10^6 m^3/annum. It was cautioned that the estimates based on the water balance model should be crosschecked before they are applied for management of groundwater resources.

Artificial recharge (Jain, 2008) is the process by which rainwater is infiltered into groundwater system and ground water resources are augmented by altering natural conditions of replenishment. The storm water generated in industries with large catchment can be diverted to scientifically designed artificial recharge system based on runoff generated at peak rainfall intensity and recharge rate of sub-surface strata. There are several methods for artificial recharge depending upon the feasibility in different regions. In case of higher infiltration capacity of vadose & saturated zone, percolation pits with recharge shaft in the reservoir can be planned for increased surface water storage assimilation in to the aquifer. This serves as significant tool in storm water management and improvement of ground water regime through artificial recharge reservoir. Similarly, for recharging deep aquifer, injection wells can be planned through filtration chamber (CGWB, 2000). Hero Honda Motors had been facing problem due to storm water generation within the plant premises at Dharuhera, Haryana and Haridwar, Uttranchal due to improper drainage system & absence of any artificial recharge measure. The detailed studies were carried out in both the plants regarding the existing drainage system, hydrogeological conditions, climatic conditions & scope of implementation of recharge measures. An outcome of these studies, recommendations were given for drain design, new rainwater harvesting structures & artificial reservoirs. As a follow up, the Hero Honda Motors Ltd. After implementations, in last two rainy seasons, all the structures are working efficiently even at more than average rainfall of last five years and the problem due to storm water within the premises is completely solved.

SUSTAINALBE DEVELOPMENT:

Water constitutes a vitally important biological resource and is a critical component of any human development strategy. Consequently, sustainable water management is increasingly regarded as a necessity (Loucks, 2000; Richter et al., 2003; Mollinga, 2008; Schelwald-van der Kley and Reijerkerk, 2009; Flint, 2010; Grigg, 2011). Although 'sustainability' and 'sustainable management' are both vague and often politicized terms (Lant, 2004), particularly with regard to water, the basic concept – of guaranteeing sufficient water to support socio-economic and cultural activities from generation to generation – is undeniably important. Thus, organizations from global through national to sub-national scales have adopted the same normative goal of managing water resources to achieve sustainability (Koudstaal, et al., 1992; Rahaman and Varis, 2005; Molden et al., 2007; Allabadi, 2012).

Water plays a pivotal role in sustainable development, poverty reduction and maintaining healthy ecosystems (Flint, 2010; UN-Water, 2010). The use, abuse, and competition for increasingly scarce water resources has intensified dramatically over the past decade, reaching a point where water shortages are seriously affecting prospects for economic and social development, as well as political stability (UNDP, 2008; FAO, 2012). With water management now playing such an influential role in social development, domestic stability and international security, there have been increasing demands placed on governments to assume responsibility for, inter alia, determining appropriate forms of water management, interven in in water abstraction disputes among wter users, ensuring year-round access to water reducing conflict over 'water politics', and preserving ecosystem balance (Johnson and Handmer, 2002; Rogers and Hall, 2003; Petersen et al., 2009). Governments' assumption of these responsibilities is arguably most pressing in the developing world, where agriculture has a direct impact on socio-economic growth prospects (The World Bank, 2006; Namara et al., 2010, OECD, 2010).

Cheng and Wang (2002) focused on observing urban development in Taiwan's Wu–Tu watershed from the perspective of urban hydrology. The degree of change in runoff was arrived at using the available meteorological data. The mean rainfall was estimated using the Kriging method. Their study revealed that 30 years of urbanization within Wu–Tu watershed had increased the peak flow by 27%. Kibler et al (2007) measured the anthropogenic impact on the hydrology of watersheds in terms of the ratio: flood peak after development to flood peak before development over a range of return periods. The flood peak ratio depends on the impervious fraction and percent of basin sewered and these factors have been taken into account in an urban flood peak model. They concluded that the analysis of urbanization effects on flood frequency is a vexing problem because of lack of flood data in urban areas and also because of the dynamic nature of development process.

CONCLUSION:

Precipitation runoff is a natural phenomenon. is one of the dynamic hydrologic variables of Hydrologic Cycle. It is an ideal unit for the management of natural resources like water from rainfalls and for mitigation of the impact of natural disaster for achieving sustainable development. In India, most of the watersheds are ungauged, without having historical records of calculated runoff, and accurate runoff data are hardly available. For the development of watershed and management programmes in India, need to be evaluate the rainfall runoff amounts in all catchments by Rational & Lacy's model. By Digital Elevation Model (DEM), to delineate stream network with flow direction & watersheds. Then hydrogeological inputs, such as type of aquifers, depth to water level data, water quality etc. Finding the highest flood levels of the watershed. According to the flood levels the RWH structure has designed with suitable location. To evaluate total recharge potential, effect on ground water regime due to RWH. Then the evaluation of life of reserves of and it's sustainable long terms availability.

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