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# Assessment of Climate Change Effect on Water Harvesting Structures in Rainfed Regions: Geospatial Data Mining Approach

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# ASSESSMENT OF CLIMATE CHANGE EFFECT ON WATER HARVESTING STRUCTURES IN RAINFED REGIONS: GEOSPATIAL DATA MINING APPROACH

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**ABSTRACT**

Advances in the Information and Technologies (ICT) may assist researchers in the assessment of watershed development programmes by developing better visualization understanding of their impacts. GIS based research studies utilizing remote sensing images can facilitate in identifying the potential zones for watershed development and enable improved ground water resources. Effective watershed management is dependent on a number of factors such as demography, climate, soil, land use and topography and these are affected by changing climatic conditions. For example, changes in rainfall intensity and volume in rain fed areas can influence the effectiveness of the placement of watershed structures. Existing methods of impact assessment of watershed development, which are based on farmers' interviews and traditional statistical analysis may explain the impact to a certain extent—the influences of drought or high rainfall conditions.

However, with changing rainfall patterns and temperature regimes the effect of infiltration and evaporation of these watersheds needs further analysis. Novel geospatial data mining techniques could help in knowledge discovery and unknown pattern identification of the effects of these changes in rainfall and temperature patterns on the placement of watershed structures. An approach by utilizing these methods to simulate watershed development conditions in different climate conditions will help watershed management officials to make efficient and timely investments for placement of water harvesting structures using a more scientific assessment. Techniques such as spatial trend analysis help to visualize the changes in the ground water level, land use pattern at different rainfall situations. This approach could also help in studying the temporal changes at smaller intervals and with different intensities of rainfall in monsoonal and non-monsoon situations.

***Keywords:*** *Climate Change, Watershed, Geospatial, Data Mining, Impact Assessment.*

## 1. INTRODUCTION

The advancements of Information and Communication Technology (ICT), in the field of Remote Sensing and Geographical Information System (RS/GIS) helped researchers to enhance visualization of spatial patterns with more accuracy. Application of these techniques has been used in different field of studies such as business intelligence, urban structure dynamics (Jiang and Yao, 2010) and demographic studies. Geospatial analysis is being used in connecting potential business metrics to different geographical locations for optimal resources investment and better yields (Kent, 2010). The application of these techniques in the agriculture domains has geared up recently and successfully applied in the fields of pest management, crop management, drought management and livestock management (Mucherino, *et al.*, 2009) for better results.

The rainfed regions in India often experiences either drought situations or erratic rainfall conditions (Wani, *et al.*, 2009). Though the annual amount of rainfall may be normal, the actual occurrence of the rainfall during the agricultural operations is changing. The changes in the intensity of rainfall and prolonged hydrological drought during monsoon season could be some of the reasons which can be attributed to climate change effects, either no runoff or excess runoff (Simvonic, 2010). A greater understanding of the dry and wet spells during the monsoon will help in efficient agricultural operations (Singh and Ranade, 2009). Watershed program in the rainfed regions has developed many water harvesting structures which are exclusively developed to store the rainwater for improving ground water table (Garg., *et al.,* 2011). The criteria used for development of watershed should improve the agricultural and water productivity (Bhalla *et al*., 2011). The investments made by the Government of India through watershed programmes in constructing several water harvesting structures, yet, failed to give optimum results due to improper location of these structures (Action for Social Advancement, 2008). The impact assessments based on several socio-economic surveys haven't looked into impact of water harvesting structures and the hydrological changes after watershed development. This is crucial and challenging area which needs to be further investigated. The hydrological impact cannot be assessed as it could be due to change in the rainfall pattern and may not be necessarily from watershed development (Reddy and Soussan, 2004). Geospatial analysis utilizing data such as daily rainfall, ground water levels, soil properties and watershed development at different time scales could help in understating climate change impact and hydrological changes in the watershed before and after the development of water harvesting structures. This paper discusses the literature based

on application of geospatial data mining techniques to different agricultural datasets and how this can be used to describe watershed development impact assessment in the light of climate change.

## 2. GEOSPATIAL DATA MINING ANALYSIS

Availability of huge amount of spatial data and advances in GIS led to knowledge discovery processes from the spatial databases. Spatial data mining is the process of different technical approaches to identify unknown patterns in the spatial data. These approaches include clustering, classification, correlation and association of the similar entities in a geographical space have been reported as being used previously (Tripathy *et al.*, 2009). The geo spatial data mining applications are being used with agriculture datasets (Mucherino *et al.*, 2009) for enhanced assessment of patterns in the datasets. A spatial analysis with the existing spatial data is required to understand the effects of the watershed structures as well to support the concerned departments for a successful implementation of such programs. For example, Sharma (2006) applied spatial data mining techniques for drought monitoring studies. Similarly, Bhalla *et al.* (2011) has assessed the evaluation and design of watershed guidelines using geospatial data sets. These studies utilized the GIS and remote sensing techniques to compare and contrast the watershed guidelines. Other studies by Hsiao *et al.* (2006) applied co-location pattern mining to find the associations between spatial features.

A number of techniques have been used to evaluate watershed management. For examples, studies include the investigation of patterns in the weather with the effect of North Atlantic Oscillation (NAO) using Independent Component Analysis (ICA) techniques by mining spatial and temporal data (Basak *et al.*, 2004). The use of Artificial Neural Networks (ANN) combined with GIS for estimation of rainfall-runoff in the watershed has also been reported (Chiari, *et al.*, 2000). In addition, rainfall-runoff modeling studies using geospatial methods to identify inlet and outlet responses in a watershed was carried out by Ramasankaran *et al.* (2012). This study used physical based models to simulate temporal and spatial distribution of runoff in the watersheds. Studies have reported that single scan clustering in spatial clustering can identify the neighborhood of a geographical object. Spatial association rules, spatial characterization rules allow identifying the association between a geographic object and non-spatial object or between geographical objects (Ester, *et al.*, 2000). Utilization of such techniques helps to assess the land use changes and climate change effect. These techniques are more cost effective and will give promising results as compared to manual methods (Shanwad, *et al.*, 2008).

## 3. METHODOLOGY

Water harvesting structures in the watershed includes check dams, percolation tanks, rock fill dams and bunds (Figure 1). These structures will impact the local hydrology based on the rainfall intensity and volume. Consider a check dam in a watershed area which is usually built on a first or second order streams to regulate the flood flow during the monsoon season. The main purpose of the check dam is to store the water for a while to infiltrate into the ground and thus improve the water table in the surrounding open wells or bore wells. Depending on the soil water holding capacity, the infiltration rate differs from location to location. The impact assessment survey including focus group discussions, sample surveys reveal that the impact of the structures is good during the rainy season and has a positive effect on the local water bodies. The improper placement of such structures will have negative impact on the local hydrology and will have negative consequences (Bhalla, *et al.*, 2011). Since a large investment has been made into the construction of these structures, critical analysis is required for the actual impact of these structures. As per the Common guidelines given by the Government of India, the utilization of novel GIS and Remote Sensing techniques in watershed development and impact assessment has been suggested (India, 2008). An attempt has been made to understand the impact of water harvesting structures in different rainfall situations using GIS and data mining techniques. Due to the climate change effects, the annual volume of the rainfall doesn't have much differences but the intensity of the rainfall is changing (Singh and Ranade, 2009). The data on daily rainfall, evaporation, soil properties such as soil type, water holding capacity, infiltration rate and fortnightly ground water levels, GPS (latitude and longitude) of the water harvesting structures (check dams) could be appropriate to understand the spread of these structures across the watershed. Spatial data for these parameters can be utilized for pattern recognition of the existing development and can see the trend at different spatial and temporal scales.

The proposed framework for the geospatial data mining is given in Figure 2. The basic data from watersheds will be made into mega data file for feeding into the data mining software. The results will be reviewed with the other established techniques and will be validated accordingly. The water holding capacity at the watershed structures will be examined in relation to rainfall intensity, volume and changes in the ground water levels. The close examination of these parameters with the combination of other spatial data on soil properties, water harvesting structures may give a trend to understand the erratic rainfall pattern. The data can be simulated with low, normal and high rainfall parameters to examine the

hydrological changes in the watershed. This study will help the researchers to understand the level of saturation of the watershed development and help in further management for getting optimum results.


**Fig. 1:** Different Water Harvesting Structures

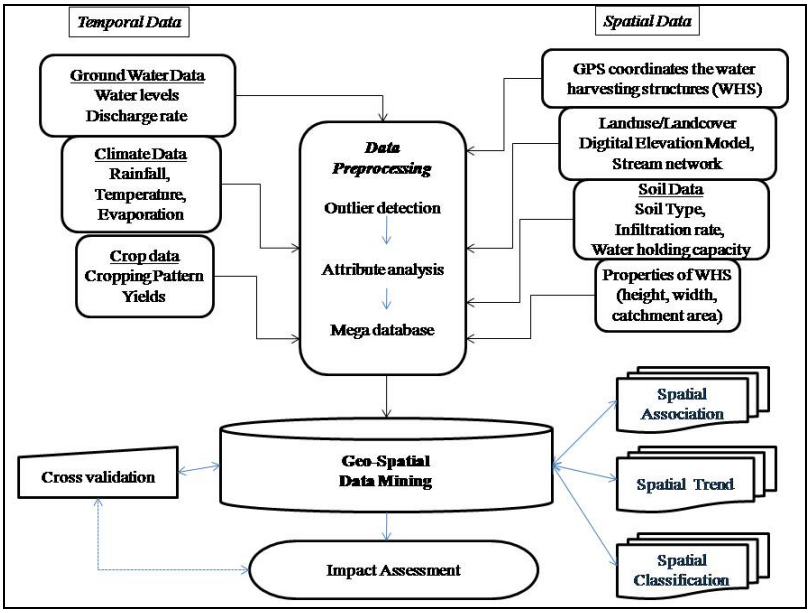


**Fig. 2:** Geospatial Data Mining Framework for Watershed Assessment

## 4. DISCUSSION AND CONCLUSIONS

With the prediction of climate change resulting in such as erratic rainfall in rainfed regions has highlighted the need for better water management practices (Garg *et al.*, 2011). The investments made in to the watershed development need to be assessed thoroughly to understand the actual impact and and necessary management (Joshi, *et al.*, 2004). The water harvesting structures constructed in the watershed, check dams require great financial investments and have more benefits as compared to other water harvesting structures. These check dams not only help in controlling the flood water, but also helps in stopping soil erosion (Rao and Bhaumik, 2008). The location of the check dam construction is normally in the lower order streams and based on the engineering guidelines given by the government. Though the guidelines are available, there is no proper understanding at the grassroot level for proper placement. The location of the

structure can affect the hydrological changes both in the upstream as well to the downstream. It is very much necessary to understand the spatial pattern of the stream and the watershed geography before constructing the structures. In many cases, the construction is based on the available resources looking within the watershed and didn't consider the upstream or downstream of the watershed. This may arise some abnormalities in the hydrological regime of the area. In order to understand the effects of the development of the structures, spatial analysis is required.

Application of novel algorithms enhances the quality of the output as compared to existing indigenous techniques. Geospatial data mining in the field of agriculture related domains and in particular to watershed impact assessment is a current challenge. The data mining requires crucial data to understand the impacts at a micro scale. The effect of climate change at micro level watershed scale is difficult to understand but the impact can be experienced indirectly. The rainfall data at an hourly rate and the infiltration rate at different check dam structures and the levels of ground water at a less interval during rainy season can provide greater accuracy. Sparsity of yearwise water harvesting structures data with its location specific coordinates, also may hinder this type of spatial analysis. However, with the revolution in the software and hardware availability and the ease of optimal storages can give more options for collection of micro level data sets for a crucial study using geospatial data mining techniques.

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