Review on the Role of Geographic Information System and Remote Sensing for Watershed Management

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ABSTRACT

The objective of many water resource and watershed studies include irrigation performance, ground water management, rain fall estimation, run off for casting evaluating, waste disposal, disaster monitoring, watershed segmentation, infiltration monitoring characterizing of terrain slop and aspect ,catchments configuration and routing of the flow of water , wet land management . Concerning these variables has been difficult to do from paper maps and aerial photographs. GIS and remote sensing technologies are different strengths bring to water resource and watershed monitoring GIS allows for improved data base organization and storage. GIS and RS have thus become important tools for evaluation of the physical attributes of water and land recourse in many parts of the world and provides an unique opportunity towards comprehensive monitoring of water resource and watershed dynamics characteristic. There are different case studies on rainfall estimation, run off fore casting, irrigation potential evolution, surface and ground water management, wasted disposal, disaster monitoring, wet land monitoring and watershed management have proved beyond doubt that integration of remote sensing and conventional approaches significantly decrease the cost and time involved as well as improve the steadfastness.

Keywords : Decision Support System, Geographical Information Systems, Global

I. INTRODUCTION

Watersheds are described as an important source of water, energy and biological diversity. Furthermore, they are a source of such key resources as forests, agricultural products and of recreation. As a key ecosystem representing the complex and interrelated ecology of our planet, watershed environments are essential the survival of global. To further put the role of watersheds in a context as noted by (Heal, 2000) requires a further digression towards the attributes and the importance of watersheds from a global perspective. In line with the goal of protecting the Earth's basic riparian resources and environmental systems, the conservation of watersheds is of great importance, in part because they are significant in their own right, but also because they cover many regions of the world in the form of as forests, which contribute genetic diversity. Additionally, conservation of watersheds enhances the protection of many habitats that are essential to other life support systems of the planet. To demonstrate this point, the world's 106 biggest watersheds cover 53 percent of the Earth's surface. Close to 3 billion people representing 50l ecosystem while human impact on the environment has intensified, considerable attention has been directed towards the search for a means to preserve existing biodiversity and management of large watersheds (UNEP 1999, Revenga and Murray 1998). In the process, the question of watershed management in a tropical ecosystem continues to substantial interests from researchers. Increasingly, in the past decades, Nigeria's River Niger Delta has been under intense pressure because of the threat posed by multiple factors. The Niger Delta region has suffered all forms of pollution and degradation originating from oil and gas exploitation. This includes a decrease in agricultural productivity and loss of vegetation. Other prevailing problems in the region consist of rising concentrations of airborne pollutants, acidification of soil and rainwater, loss of marine organisms and fish population (Ologunorisa 2001).

Compounding the problems are the lack of efficient, inventorying and mapping of precise data to sustainably manage the watershed. Notwithstanding the gravity of these trends, there has not been any major effort by resource managers aimed at examining these issues in watershed management within the Niger Delta Region of Southern Nigeria. This calls for the need to find appropriate tools to aid the management of the river. Perhaps the most important element in the efforts to manage the Niger Delta is the need to provide a baseline data based on integrated GIS and remote sensing approach about the ecology and forest cover to form the basis of future management (Merem and Twumasi 2005). This approach is quite effective in monitoring the impacts of human activities on watershed environments in international development (Shultz and Saena 1998). In light of this, many authors view the widespread applications of GIS and remote sensing techniques in watershed management as a major step towards sustainability and resource conservation (Malczewski, 2003 and Tyson 2004).

Effective watershed management requires the integration of knowledge, data, simulation models, and expert judgment to solve practical problems and provide a scientific basis for decision-making at the watershed scale. The GIS technologies nowadays occupy a prominent place among the modern computer tools and constitute an invaluable support in the decision making of problems with a spatial dimension. The Automated Geospatial Watershed Assessment (AGWA) tool was developed jointly by the USDA Agricultural Research Service, the U.S. Environmental Protection Agency, the University of Arizona, and the Univ. of Wyoming to conduct hydrologic modeling and watershed assessments at multiple time and space scales (Miller et al., 2002, Goodrich et al., 2006).

Objective

To review on the role of geographic information system and remote sensing for watershed management.

Management of Natural Resources on Watershed Basis

Soil, water and vegetation are the most vital natural resources for sustainable development and management, and hence should be handled and managed effectively, collectively and simultaneously. Managing the natural resource with sustainable approach is a rational phenomenon in its natural region. In this approach, the natural regions are invented to be in terms of the flow of water, which influences almost all fields of the environment, where the regions are diversified as basin, catchment, sub-catchment, macro watershed ([50,000 ha), sub-watershed (10,000–50,000 ha), milli-watershed (1,000–10,000 ha), micro watershed (100–1,000 ha), mini watershed (1–100 ha) (Nair 2009).

Decision Support System in Watershed Management

Decision Support System (DSS) are a model-based set of procedures for processing data and judgments to assist a manager in his/her decision (Little 1970). Adelman (1992) has defined DSS as interactive computer programs that utilize analytical methods, such as decision analysis, optimization algorithms, program scheduling routines, and so on, for developing models to help decision makers to formulate alternatives, analyze their impacts, and interpret and select appropriate options for implementation. DSS is a computer based system of integration of database, models and user interface which are programmed for easily interpretable results to aid the decision makers (Walsh 1993).DSS is a computer-based and is a comprehensive support system than other traditional techniques of decision-making for watershed management community who deal with semi-structured watershed problems such as surface/sub-surface water source long-term availability, hydrological, socio-economic and water quality issues. It is used for development of watershed management plans and operating rules for sustainable environment through policy making. Integration of GIS into spatial DSS system (SDSS) has given the researchers advantage for spatial analysis 20 P. D. Aher et al. and visualization (Enache 1994). The ITC Netherlands had developed the first Integrated Land and Water Information System (ILWIS) in 1990s with the integration of GIS which is extremely helpful in spatial modeling. Adinarayana et al. (2006) designed a spatial decision support system for rural land use planning (SDSS/ LUP) to support decision making on area selection for different watershed management schemes for conservation planning by providing suggestions and hazard warnings for land use sustainability. The recent technologies such as Geospatial Information Communication Technology (GeoICT) and Wireless Sensor Network (WSN) were integrated to formulate Geo-Sense, a wed-based DSS to facilitate precision agriculture services (Sudharsan et al. 2012). Many tools for watershed analysis and management are being developed for integrated planning. The modern technology and thinking offered by the advent of the stand-alone or web-based DSS is highly complementary to assure the goals of watershed analysis through solving the complex decision-making process.

II. Infiltration monitoring

Traditional storm water management practices mainly rely on conveyance to route storm water runoff from urban impervious surfaces towards the nearby natural water bodies. Dedicated facilities are designed to mitigate the effects of the increased runoff peaks, volumes, and velocity. More recent concepts in urban storm water management, such as Sustainable Urban Drainage Systems (SUDS), Low-Impact Development (LID) technologies or Water Sensitive Urban Design (WSUD), aim at restoring the critical components of natural flow regimes. In particular, such techniques are designed to capture, temporarily retain and infiltrate storm water (e.g. rain barrels, bio filtration swales, pervious pavements, green roofs), promote evapo-transpiration and harvest water at the source, encouraging in general evaporation, evapo-transpiration, groundwater recharge and the re-use of storm water (Villareal et al., 2004).

The volume retention is mainly affected by the thickness of the stratigraphy, the hydraulic properties of the green roof components and partially by the vegetation typology and density. From data published in the literature it is evident that a green roof system is able to significantly reduce the generation of storm water runoff, with volume retention scores in the order of 40-80% of the total rainfall volume (Bengtsson, 2005; Monterusso et al., 2004; and Woert et al., 2005). The magnitude of peak attenuation mainly depends on the rainfall intensity, rainfall duration and the antecedent soil moisture conditions. However the detention capacity can be increased with increasing the substrate depth, with lowering the slope and selecting optimal technical solutions. It has been shown (Getter et al., 2007) that a decrease of 60%-80% in storm water runoff peak rates is to be expected from a green roof.

III. Drainage area analysis

Drainage patterns of stream network from the basin have been observed as mainly dendritic type which indicates the homogeneity in texture and lack of structural control. This pattern is characterized by a tree like or fernlike pattern with branches that intersect primarily at acute angles. While in some parts of the basin represent parallel and radial pattern types indicating that the topographical features are dipping, folded and highly jointed in the hilly terrains. A parallel drainage pattern consists of tributaries that flow nearly parallel to one another and all the tributaries join the main channel at approximately the same angle. Parallel drainage suggest that the area has a gentle, uniform slopes and with less resistant bed rock. A radial drainage pattern forms when water flows downward or outward from a hill or dome. The radial drainage pattern of channels produced can be linked to a wheel consisting of a circular network of parallel channels flowing away from a central high point (Jensen, 2006). The properties of the stream networks are very important to study the landform making process (Strahler and Strahler, 2002).

Morphometric analysis will help to quantify and understand the hydrological characters and the results will be useful input for a comprehensive water resource management plan (Jawahar et al., 1998; Kumaraswami et al., 1998 and Sreedevi et al., 2001).
The catchments area of each grid cell is determined using the method the flow vectors are used to follow the path of steepest descent from each cell to the edge of the DEM, and the catchments area of each cell along this path is incremented by one. After a path has been initiated from each cell, the catchments area value accumulated at each cell gives the number of upstream cells which contribute over land flow to that the cell. The boundary of the water shed to be analyzed is also determined from the flow vectors. The users specifies the location of the grid cell at water shed out let, and all grid cells which contribute over land flow to the out late cell are identified. This provides a mask of the water shed that is used for subsequent operation (Lyon 2003).

Watershed Degree Segmentation

Watershed transformation is one of the most powerful tools for image segmentation. Starting from a gradient, the classical paradigm of watershed segmentation consists in determining markers for each region of interest. The markers avoid the over-segmentation (a region is associated to each minimum of the function) and moreover, the watershed is relatively robust to marker position (Beucher and Meyer, 1992).

The morphological connected alters suppress details but preserve the con- tours of the remaining objects. Leveling are a subclass of symmetric connected operators which are very useful to simplify an image before segmentation by watershed transformation (Meyer, 2004).Strahierr 1957 Cited by Lyon (2003) the degree of water shed segmentation and drainage network density are a function of the value given to the critical sources area parameter (CSA). The CSA is the minimum drainage area that is required to initiate of first order channel. Any area smaller than the threshold value does not produce enough run off to form and maintain channel. The threshold CSA value depends upon among other things, terrain scope characteristics, soil properties, land use and climatic condition. It can was small as of reaction of hector or as large as ten hectares, depending on the land scope characteristic under consideration. Often the CSA value is also used to represent different degrees of water shed segmentation and drainage network densities to address scaling issues. At a small scale, one would choose a small value to represent the smallest channels and hill slopes. As the result, a high degree of partitioning, many sub catchments and dense drainage networks are obtained. In case of large scale applications, only the major streams in the water shed may be needed. A large CSA value would result in the desired low degree of water shed segmentation, few sub catchments and only large streams (Lyon2003)

IV. CONCLUSION

Using GIS and RS for water resource and watershed management has been widely recognized to day in irrigation evaluation, water quality assessment, rain fall estimation, run off forecasting, and ground water monitoring, in wasted disposal monitoring, water related disaster fore casting, and watershed approach. The role of GIS can be play in mitigation, observation, integration of multi-source data and efficient dissemination of knowledge to concerned people during the time of natural and human water related disasters that cause a wide spread loss of life and property. It provides a common frame work spatial location for watershed data and watershed biophysical process have spatial dimensions. GIS and RS technology bring to generate basic information on various natural resources namely water, forest, soil, land coverage and subsequent integration of such information with slope and socio economic data in a GIS to generate local specific prescription for sustainable development of land and water resources development on the waters shed.

V. Future Line of Work

GIS technology has played critical roles in all aspects of watershed and water resources management. From assessing watershed and water resources conditions through modeling impacts of human activities on water quality and to visualizing impacts of alternative constant management activities. Because there is highly complex nature of human and natural systems, the ability to understand them and project future conditions using a watershed and water resources approach has increasingly taken a geographic direction. Finally I recommend that the importance of RS and GIS application to national and regional watershed resources management needs to be more easily understood to government and the stakeholders, the continued support for RS to maintain the performance of existing Programs and the transfer techniques and the need to be established between users of RS and GIS technology and research institutes projects.

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