The Use of Spatial Analysis in International Watershed Management

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Overview Paper

This paper and subsequent presentation aim to provide insight into various methods in which spatial analysis – geographic information system (GIS) and remote sensing – are used in international watershed management. Even though the applications are numerous there were two reoccurring applications of these spatial analysis technologies. Non point source pollution management and flood risk analysis and management were the two applications that dominated my research on this topic. Though I have left out some uses of spatial analysis in international watershed management, I believe these two topics were not only most dominant, but they are major concerns for almost all countries and a serious issue that can be addressed through the use of these technologies.

Firstly I will discuss non-point source pollution management. Non point source pollution is a never ending challenge for environmental managers and using modeling tools can be essential in the implementation of mitigation, prevention and policies. The analysis tools I encountered during my research were Integrated Watershed Management Model, Enhanced Stream Water Quality Model (QUAL2K), Erdas Imagine Process, and Agricultural Non Point Source Polluton Model (AGNPS) (Lin, 2010, Lai, 2010 and He, 2003). For the purpose of this presentation I chose to focus on one model that was applied most often; namely Enhanced Stream Water Quality Model (QUAL2K). QUAL2K allow for non point source pollution management through segmenting watersheds into unequally-spaced river reaches with multiple loadings and abstractions (USEPA, 2010). There are also several specific components of this model that allow it to successfully represent non point pollution within a watershed. The model calculates two forms of Carbonaceous Biological Oxygen Demand (CBOD) as a proxy measurement for organic carbon present within a system. These two forms are a slowly oxidizing CBOD and a rapidly oxidizing CBOD (Lin, 2010). It simulates detritus composition through the stoichiometry of particulate carbon, nitrogen and phosphorus.

The QUAL2K model is also able to analyze anoxic conditions through Redox reactions and denitrification is also computed through reactions that are produced at these anoxic conditions (Lin, 2010). Suspended solids can be obtained are also computed through a proxy measure – oxygen and nutrients through particulate organic matter settling and chemical reactions. In addition light penetration is calculated through algae, detritus and inorganic solids (USEPA, 2010). Besides using these proxy measures the model can precisely compute bottom algae levels. The pH of rivers within the watershed is computed by alkaline and total inorganic carbon quantities. This model can also simulate pathogen concentrations through water temperature, light and settling patterns. It is clear that the QUAL2K model is a very extensive watershed management tool, as it uses various factors that have significant roles in the accumulation, input and distribution of non point source pollutants within a study area.

The second focus of this paper is Flood Risk Analysis and Management. This is becoming an ever growing issue for a large number of cities worldwide. As most major cities tend to be located around fertile river basins and have high population density it is important for managers to understand the flood vulnerability of these marginalized areas (Adikari, 2010). The flood management model that I focused was the KINEROS model, as it is a very advanced tool and its components can be specified to a specific watershed and results in a very detailed analysis. The model details the interception, infiltration,
surface run-off and erosion after a specific rain event in agricultural and urban watersheds (Southwest Watershed Research Center, 2010). It works through by representing a watershed system as a cascade of planes and channels with formulas that calculate overland flow, channel flow, erosion and sediment transport. The model also allows for the additional natural parameters of rainfall, infiltration, runoff, and erosion parameters, as well as the anthropogenic parameters of urban developments, small detention reservoirs, or lined channels on flood hydrographs and sediment yield (Southwest Watershed Research Center, 2010 and Adikari, 2010). Other components of this model are including compound channels, watershed base flow, average rainfall and flow injection amounts.

The results of this type of analysis are very valuable as it can identify flood prone areas, simulate impact of land use change and impacts of potential flood control interventions (Norman, 2010). It is not only an important tool for environmental management but has serious implications for urban development and community planning. Both of these models have real significance and practical application for watershed management practices worldwide. They are useful tools that tackle issues that affect large populations, metropolis areas, important agricultural lands as well as many rural areas.

Works Cited


The Use of GIS in International Watershed Management

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In this paper Lin et al. investigate the main sources of point source pollution in the Houjing river watershed. In order to do this they integrated geographic information system (GIS) and Global positioning system (GPS) technologies to investigate land use throughout the study area. They utilized an integrated watershed management model (IWMM) and Enhanced Stream Water Quality Model (QUAL2K) which were used for the hydrology, water quality modeling, watershed management, and carrying capacity calculation. The results from these models showed the NH3-N carrying capacity of the Houjing River and it was used to develop remedial strategies to minimize the impacts of non-point source and point source pollution.


In this paper Lai et al. classify fourteen types of land use patterns along the Kaoping River watershed in Taiwan. The classification of these land use patterns were carried out by Erdas Imagine process and ArcView geographic information system. The results from the GIS identification and field verification show the major uses in the study area are agricultural uses. From this information they deduced that non point-source from these sources have significant contributions to the suspended solids that are inputted into the watershed. They then used an Integrated Watershed Management Model to simulate the water quality and evaluate non point source solution and suspended solids load to the river. The results of this model were able to indicate the best management practices for non point solution reduction.


This paper focuses on the flood vulnerability of several major cities throughout Asia. Because mega cities tend to be located around fertile river basins and have high population density it is important for managers to understand the vulnerability of these marginalized areas. The analysis of flood vulnerability incorporated factors such as; global changes, internal migration patterns, development patterns and government. GIS was used in this flood analysis through longitudinal and cross sectional profiles of each
of the six watersheds being investigated, and these were used in combination with inundation maps. These maps were then given attributes of the factors indicated above and flood vulnerability was determined.


This paper discusses the decisions related to mine management, as it pertains to dumped materials that cause environmental hazards to areas along the Erai watershed. Mining has direct effects on land use/land cover in the region and so it is important to identify and quantify the amount of mining to determine the effects on the watershed’s ecosystem. This study uses Landsat TM (1989), IRS LISS-3 (1999, 2007) and CARTOSTAT (2007) to study the extent of surface mines. These image processing techniques were used in conjunction with GIS to analyze flood scenarios, reasons for flooding and areas impacted. This study is able to spatially represent the areas that will be severely impacted due to floods and suggests methods that can be used to mitigate the situation.


In this paper Choi et al. examine the relationship between changes in GIS technology and watershed management spatial decision support systems (SDSS). The SDSS is a supporting model for spatial data manipulation in hydrologic model analyses. It discusses a web bases SDSS tool that may overcome the limitations of computer based modeling systems. This tool can be used in watershed delineation, map interfaces and hydrologic model for hydrologic/water impact analysis.


This paper uses satellite imagery from 1976, 1989 and 2003 to investigate land use change in the Pokhare watershed in Nepal and the subsequent effects on carbon dynamics in the area. Along with field data and Intergovernmental Panel on Climate Change tier one method Sherstha et al. used a temporal set of satellite images (1976-2003) as a tool to determine land use change on the mountainous study area. This data showed changes in land use, namely decreases in forested area and increase in cultivated lands throughout the watershed resulting in changes in the vegetated carbon amount in managed-dense forest and Schima-Castanopsis forest.

In this paper Norman et al. aim to investigate suitable land-use, watershed-management, and flood-attenuation policies the urban area of Ambos Nogales. The methods used in analyzing the watershed reaction to land-use change, both spatially and temporally, was the use of a hydrological models. The KINEROS2 model used along with the Automated Geospatial Watershed Assessment geographic information system interface analyze the watershed and assess flood vulnerability. This was done by computing volumes of runoff and peak flow for the watershed. The KINEROS2 model was able to identify flood-prone areas, simulate the impact of land-use change, and evaluate the impact of potential flood-control interventions in the Ambos Nogales watershed. This information can be used for the management of development suitable for this watershed.


In this paper Chansheng emphasizes the importance of simulation models as essential tools in support of watershed analysis and assessment of management scenarios at the watershed scale. The paper focuses on the integration of geographic information systems and agricultural nonpoint source pollution model (AGNPS) as a tool for analyzing the effects of land use change on nonpoint source pollution in a study watershed. The study uses ArcView nonpoint source pollution modeling (AGNPS), an interface between ArcView GIS and AGNPS has been used to facilitate agricultural watershed modeling. The AVNPS interface is comprised of six modules: a parameter generator, input file processor, model executor, output visualizer, statistical analyzer, and land use simulator. In order to successfully use this interface the researcher must input soil, climate, digital elevation model, land use/cover, hydrography, and management practices databases. The AVNPSM was applied to study the watershed and effects of land use change on runoff, sediment, and nutrient yields based on a 25-year storm event. The output of the analysis show that increases in urban development and proximity to water bodies are correlated to an increase in surface runoff, peak flow, and soil erosion throughout the watershed area.