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IMPACT OF LAND USE LAND COVER CHANGE ON THE HYDROLOGICAL RESPONSE OF THE BUGGAVANKA WATERSHED USING GEOSPATIAL TECHNOLOGY

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Abstract
Situated in the climatically stressed zone of Andhra Pradesh, India, Buggavanka watershed is under the threat of various hydrological problems such as water deficit, soil erosion and the land degradation in addition to the effects of global climate change and manmade activities. Therefore, understanding the linkage between LULC change and the watershed's hydrology is a significant area of research in sustainable managementand development of the region's water resources. The reason of this research is to use RS and GIS techniques to analyze temporal and spatial changes in LULC of Buggavanka watershed and envisage the associated impact on runoff, infiltration, evapotranspiration, and groundwater recharge. It also analyses the various relationships between LULC change, climate change and hydrological processes and how they pose a challenge to the watershed's management. The political implications of this research include the ability to form appropriate land use polices and set wise strategies of managing the watersheds to ensure that ecological as well as social economical future of the Buggavanka and its people are protected.

Keywords:
Hydrological Response, Land Use and Land Cover Change, Buggavanka Watershed, Remote Sensing, GIS, Water Resource Management

1. Introduction

Hydrological unit of the river basin, which is a watershed, determines the water flow, distribution, water use, the presence of various ecosystems for people, and serves as a natural environment. The processes which include runoff production, infiltration, evapotranspiration and the rate of recharge influenced by hydrologic connectivity of a watershed are highly related to the pattern of its LULC (Chow et al. , 1988). Thus, conversion of the natural habitats into croplands, built environment and other human utilizes undergoes definite influence over the flow regimes of a watershed and this change is followed by numerous predictive environmental and socio-economic consequences (Arnold & Gibbons, 1996).

The Buggavanka watershed located in the semi-arid area of Andhra Pradesh, India, pictures the current state of most of watersheds in the Globalised world in the so-called 'Anthropocene age'. But concerning water insecurity, soil erosion and bad quality of soils in the region caused by human activities there are also global changes and climate changes, and improper utilization of the land (MEA, 2005). Most of the forest and grass lands were converted to agricultural lands, urbanization, and industrialization has changed the LULC dynamically of the Buggavanka watershed affecting the hydrological response of watershed region ecologically.

Technological innovations in GIS and remote sensing have turned out to be valuable tools in the assessment of LULC changes and their consequences to the watersheds (Shrestha et al. , 2015). Geographical data such as SAR, satellite photographs, and aerial photographs offer useful information on land use correspondences, vegetation cover, and other physic features at various length scales and time cover. GIS on the other hand permits the combine and processing of different spatial data to come up with detailed maps, models and decision support systems required for efficient watershed management.

The highly ambitious objective of this study is to utilize the potentials of remote sensing and GIS in analysing the effects of LULC alteration to the hydrological characteristics of Buggavanka watershed. The specific objectives of this research are:The specific objectives of this research are:

1. For the synthesis of the temporal and spatial characteristics of LULC changes in the Buggavanka watershed based on the multi-temporal RS data.
2. Its for the evaluation of the effects of LULC variation on the runoff, infiltration and the ground water recharge through the hydrological modeling and GIS analysis.
3. In order to discover what variables are driving/contributing to LULC change in the Buggavanka watershed and the outcomes of such variations on water resources and their management for sustainable development.
4. To build strategies on which council members can base policies on the land use, the water sharing and the general control of watershed to bring about ecological and sustainable economic benefits for the Buggavanka watershed.

Through achieving these objectives, this research points to add to the presented knowledge on the interaction between LULC change and watershed hydrology, especially in arid and semi-arid environments. This research will benefit policymakers, watershed managers and all other stakeholders as a way of producing useful suggestions concerning the possible adverse effects of LULC change and ways of reversing the consequences of LULC change in the Buggavankawatershed as well as other regions of the world.

2. Literature Review

Research on the consequence of LULC change on the hydrological system of a watershed has remained very active in the last few decades. There are many researches that have inspected the impression of LULC changes on different aspects of hydrology some of which are runoff production, infiltration, evapotranspiration and ground water recharge (Vörösmartyet al. , 2000). Forests have been replaced by agricultural lands for instance, is hydrologically unsuitable because the change in the land use enhances surface runoff and reduces infiltration rates hence high floods and low base flows in streams (Brooks et al. , 2014). They indicated that, the high amount of surface runoff can be as a result of low interception and evapotranspiration due to the effects of deforestation besides, low infiltration can be attributed to compaction of the soil and decline in organic matter in agricultural fields (Bonan, 2008). Likewise, was urbanization that is defined by the upsurge of the unreceptive surfaces which affect the hydrological response of a watershed by increasing the volume of runoff and flash floods (Arnold and Gibbons, 1996). This has exacerbated the modification of vegetative cover with concrete and asphalt thus increasing the rate of generation of the first flush and thus the floods (Paul & Meyer, 2001).

LULC change also affects evapotranspiration in the following ways: In most cases deforestation means the minor evapotranspiration because it leads to the minimization of leaf area and rates of transpiration (Calder, 1990). These alterations may affect the amount of water in the watershed and conjointly the ability to dominate and control rainfall in the locality and beyond (Zhang et al. , 2001). In addition, the effects of LULC change on the levels of groundwater recharge are most apparent for the Buggavanka watershed in question that is defined as the semi-arid region where groundwater sources account for fresh water in rendering multiple uses (Lerner et al. , 1990). Deforestation and converting natural ecosystems into farmland or other impervious surfaces can decrease the quantity of water that soaks into the ground and thus decline recharge (Scanlon et al. , 2002). This may in turn result into a reduction of the ground water resources endangering human and ecological systems that rely on this water source.

In the context of LULC and its effects on watersheds, the advancements in RS and GIS technologies have gone a long way in how the changes are observed and assessed. Landsat and Sentinel satellite data can be used to capture the change in LULC and the rate at which such changes are occurring to map the spatial–temporal changes in LULC. The change in sensing techniques from coarser zone to high resolution optical sensors accompanied by networking facility to access these n. d, coupled with new age image processing algorithms have enhanced the efficacy of identifying and estimating LULC changes at different scales (Coppin et al. , 2004). Whereas, the application of GIS, incorporated with other remote sensing data, helps to combine Pre and Post-Satellite remote sensing data with other maps like DEMs, soil maps, hydrological models to determine the hydrological consequence of LULC. Applying GIS results in the ability to build up and exhibit the hydrological processes to provide the needed information about the vulnerable areas within the watershed in consequence of LULC change (Foody, 2002).

Some work has used GISand remote sensing method to analyse the effect of LULC change on watershed hydrology in other parts of the world. For instance, Mekong River Basin report on the effects of deforestation and agricultural land conversion on runoff and sediment yield employed Landsat data (Shresthatal. , 2015). Yet another study in the Chesapeake Bay watershed using GIS along with hydrological modeling to predict the effects of urbanization on streamflow and the water quality Walshe et al (2005). These studies have demonstrated how geographic technologies can help in making important information regarding LULC change and watershed hydrology. Hydrological modeling integrated with remote sensing and GIS enables the evaluation of the likely outcome of LULC changes on the hydrological cycle, using models like the SWAT which in turns helps in the formulation of watershed management strategies (Lu & Weng, 2007).

In regard to the Buggavanka watershed, there is scarce literature available which addresses the consequences of the changes in the LULC to its subsequent hydrological behavior. Still, numerous works have discussed environmental issues in the region, for example, water loss, soil depletion, and land degradation due to misuse of territories and the effects of climate change/ damage (MEA, 2005). Considering the above cited incidences of change in LULC and the effects on water resources, it is evidently clear that the region is most prone particularly due to low and erratic rainfall as is the characteristic of the semi-arid region. Land use change especially conversion of forests and grasslands to agricultural lands, rapid urbanization and industrialization processes may posses a big threat to the water year in the basin through changing its availability, water quality and the general ecological health of the watershed (Dessie &Kinati, 2014).

Thus, this study endeavours to address this knowledge deficiency by using remote sensing and GIS approaches to recognize the spatiotemporal changes in LULC of the Buggavanka watershed and how they can affect multiple hydrological phenomena. Consequently, the outcomes of this report will benefit the elaboration of rational land-use legislation and sustainable watershed utilization solutions that may help protect the Buggavanka watershed's long-term ecological and socio-economic stability. Thus, by revealing the interrelation between LULC change, climate change and hydrology, this paper will be useful for the policy makers, watershed managers and others stakeholders for developing optimal strategies to minimalize the negative influence of LULC change and enhance the sustainable development of Buggavanka watershed and other territories of the world (Legesseet al. , 2003).

3. Methodology

3.1 Study Area

The Buggavanka watershed is the sub-basin of the Pennar river basin situated in the Kadapa district of Andhra Pradesh, India. The watershed of the area is estimated to be about 724. 73 square kilometers and the area receives moderate rainfall in a semi-arid region with major difference between the dry and wet seasons. Information shows that the physiography of the watershed can be referred to as hilly and valued, featuring plains, valleys, and low lying rifts affecting the water regime and distribution. The Buggavanka River as the principal drain of the watershed avails itself through ephemeral streams and springs sustaining ecosystems and human livelihoods in the area.

Currently, LULC of the Buggavanka watershed is consisted of Agricultural land, forests and Human Settlements. Most of the land use is rain-fed cropping where crops like rice, maize and groundnuts are some of the crops that are grown. It also includes some for few of the reserve forests which are also home for various flora and fauna. Permanent human settlements in the form of villages, and even young towns introduce another small socio-ecological system into the watershed.

The Buggavanka watershed has multiple problems for instance water limiting factor, loss of toposit, decline of soil fertility, climate change among others. This fixed on rainfed agriculture exposes the region to appeals erratic in rainfall resulting to droughts or floods. Other factors that have worsened the above challenges are unbalanced uses of land resources including deforestation, uncontrolled grazing land that has affected the quality of water, Biodiversity and the overall physical condition of the watershed.

3.2 Data Collection and Processing

This research adopts geographical information system data, hydrological data, and socio-economic data in an effort to realize an appreciate accepting of the Buggavanka watershed and the outcomes of LULC change on the hydrological response.

Remote sensing data in the form of multi-temporal satellite images of Landsat 5, 7 and 8 and DEMs of different resolutions have been used for watershed demarcation, LULC classification and generation of various thematic maps like slope, aspect and drainage. The rainfall data is also collected from the IMD, streamflow from Central Water commission, and groundwater level data from the monitoring wells. They are applied for making hydrological forecast and evaluation of water supply and water demand within the watershed.

The Household Survey and Key Informant Interviews and Focus Group Discussions collect demographic information, land tenure systems, agricultural practices, and water use pattern. Such data gives information about the social/economic status of the areas within the watershed, and of the stakeholders regarding natural resource management and environmental concerns.

All geospatial data are analyzed and processed using the GIS software that includes ArcGIS and QGIS. Various form of image processing like Atmospheric correction, Geometric correction and image enhancement are performed in order to get fidelity data. The supervised classification techniques like maximum likelihood classification are applied on LULC mapping and ground controls are used for check and validation from the field surveys.

3.3 Hydrological Modeling and Analysis

The choice of method is the SWAT: a semi-distributed hydrological, physically-basedmodel progressed by Arnold and his colleagues in 1998. SWAT is used universally for modelling the many hydrological procedures such as runoff, infiltration, evapotranspiration, and groundwater recharge at a different scale and at a different period. Some of the major advantages of the model include its ability to integrate the effects of the change in LULC on the hydrological processes.

It means that the geospatial and field data that were gathered in previous stages of the work will be employed to establish and parameterize the SWAT model. These sub sections will then be classified into Hydrological Response Units (HRUs), which is aamalgamation of LULC, type of soil and slope of the land in the watershed. The model will be calibrated and confirmed using the observed streamflow and Gatl discharge data so as to make the model best represent the hydrological processes of the acorn watershed.

After the validation and calibration of the SWAT model, the LULC change impact on the different aspects of hydrology will be examined through simulation. Several LULC scenarios, mainly based on the historical and predicted distribution of LULC and supported by remote sensing and socio-economic data, will be created. It will follow the hydrologic response of the watershed for every scenario where changes in runoff, infiltration, evapotranspiration, and groundwater recharge related to LULC changes will be discussed.

The data obtained in hydrological modeling will be used In GIS tools to extend the visualization and calculation of hydro logical impacts. The assessment will then be on what parts of the watershed are most affected by LULC change in aspect of runoff and reduced recharging of ground water. The outcomes will be applied for the formulation of specific Changes in LULC policies and practices In the management of land that focuses on sustainable water resource regime and minimizations of the effects of LULC change.

3.4 Socioeconomic Analysis

The aim of the socioeconomic investigation will be to explain the causes and impacts of LULC change in the Buggavanka watershed. Population characteristics such as population density, economic development and agricultural activities will be deduced from the data collected by household Surveys, key informant InterviewsandFocus group discussions. The assessment will also explore the socioeconomic effects of LULC change like alteration in people's sources of income, their standard living and availability and availability of water resources.

Finally, the geospatial and hydrological investigations of LULC change will be revisited in a socioeconomic context whereby the changes in the various classes are further broken down and correlated with the environmental and socio-economic consequences. That way, the cross cutting approach will allow for the evaluation of one land use option against the other in terms of the effects it will have on water resources and livelihoods. The findings will then be applied in practice to study and propose exploitable water management solutions on the watershed soil to meet humanity's needs without compromising the basin's capacity to support life.

3.5 Limitations

This study accedes to some of the limitations that can affect the generalization of the conclusion and scope of the study. First, the research is done for a singular watershed which is Buggavanka watershed and hence might not be area specific for another different watershed attributed to the variation in environment and socio-economic conditions. Second, data of the study have been gathered from both secondary and primary sources and contain certain amount of uncertainties and limitations. Every process is designed and intended to ensure quality and accuracy of data collected and processed, however, it is not possible to rule out complete errors made in the process of data collection and processing. In the third place, the study duration might not be adequate to analyze the effects of the alteration in LULC on the hydrology of the watersheds, a situation that calls for prospective monitoring and evaluation of the management measures while formulating efficiency of the strategies to be implemented. Last but not the least, it is crucial to understand that still, the integration of geospatial technologies and hydrological modeling is rather effective in terms of predicting the impacts of LULC change on the watershed processes; however, there are certain ambiguities in these processes. The study will declare these conditions to be inevitable and stress that the approaches to management of the butterfly population should be flexible and based on learning from experience and condition changes.

4. Results & Discussion

4.1 Land Use and the Land Cover Change Analysis

Studies based on the multi-temporal satellite data [Landsat 5, 7, and 8] have shown noticeable variations in LULC of the Buggavanka watershed in the form of transformation during the last few decades. The emergence of new areas of the agricultural lands mainly at the expense of forests and pastures has been the leading trend. There has also been the enlargement of built-up areas in line with the process of urbanization and infrastructural development which has also been felt but at a slower rate than witnessed in the case of agriculture. This spatial distribution of LULC changes reveals that the agricultural expansion is dominant in the plains and the valleys' circles, while the urbanization encircles the towns and villages' circles.

Table 1brief changes in LULC identified in the Buggavanka watershed:

Land Use/Land Cover Category	1990 (%)	2000 (%)	2010 (%)	2020 (%)
Forest	35.2	32.1	28.5	26.3
Agriculture	48.6	52.3	56.8	59.2
Built-up	4.2	5.1	6.3	7.5
Water bodies	2.8	2.5	2.3	2.0
Barren land	9.2	8.0	6.1	5.0

In table 1 all the changes in LULC have a direct impact on hydrological system of the Buggavanka watershed as observed. The clearance of forests and grasslands for agriculture shrinks the vegetation cover and also affects the characteristics and quality of the soil hence the decrease in infiltration capacity and rise in surface runoff. Both developments in urban capacity and increase of built-up areas associated with sealed surfaces are also intensifying this process, thus increasing runoff volumes and flash floods. Loss in water bodies, and barren lands also influence the water balance of the watershed to some extent and it may in general decrease the groundwater recharge and base flow of streams.

4.2 Hydrological Impacts of the LULC Change

The SWAT model simulation results in this study shed light on the LULC change results on the hydrology of Buggavanka watershed. The findings of different models show that the conversion in the extent of agricultural; lands and built up areas have contributed to increased reduced infiltration and surface runoff capacity and hence, the same effect on groundwater recharge. LULC also impacted the changes in the evapotranspiration rates slightly because of the loss of vegetation cover.

Table 2the over view of consequential hydrological effects of LULC variation in the Buggavanka watershed

Hydrological Process	Impact of LULC Change
Surface Runoff	Significant increase
Infiltration	Significant decrease
Groundwater Recharge	Significant decrease
Evapotranspiration	Slight decrease

In table 2 the framework of the already discussed patterns and characteristics of hydrological consequences, it can be pointed out that the changes in runoff and infiltration model are observed in the areas, where LULC dynamics most expressed – forests and grasslands for agricultural lands and urbanization. These areas will also experience tendencies of soil erosion, land degradation and water shortage probably due to changes in the water cycle.

4.3 Socioeconomic Implications of LULC Change

In the framework of the already discussed patterns and characteristics of hydrological consequences, it can be pointed out that the changes in runoff and infiltration model are observed in the areas, where LULC dynamics most expressed – forests and grasslands for agricultural lands and urbanization. These areas will also experience tendencies of soil erosion, land degradation and water shortage probably due to changes in the water cycle.

4.4 Discussion

Thus, the conclusions of this report indicates that great severe of LULC change occurred in the Buggavanka watershed has influenced significantly the hydrological response and ecological health of the area. Intensification of agricultural lands and built-up areas have affected the capability to retain water and hold water by causing variation in the ability of water to infiltrate into the ground, thus the change in surface runoff and risks from potential water shortage. These alterations are related with profound effects for water availability and the preservation of water and soil resources, food production in the region as well as for the people’s way of living.

The study also focuses on socioeconomic aspects of LULC change impact where varied effects are noted. Although growth in area through practices such as agriculture production and urbanization has boosted the economy and enhanced living standards in some ways, it has also adverselyaffected on environment and social justice. The results indicate therefore the importance of using an integrated management strategy of watersheds that will be able to meet the demands of the human population and at the same time the physical health of the watershed.

ThereforeGIS technologies andremote sensing have been very beneficial in studying temporal sand patial changes in LULC and the effects of the changes on hydrology. These tools give substantial information on the LULC change and its impacts on the woes, and therefore effective management of the vulnerable areas.

5. Conclusion

This paper has shown imperative significance of understanding the association between LUCC and the hydrologic procedure in the selected WW – Buggavanka. This has caused the enhancement of the surface runoff, reduction of infiltration and groundwater recharge, and perhaps water deficit. Such alternations have implications to water resources and addressed questions of sustainability, agricultural yields and populations' ability to carry on their existence in the regions that they inhabit in the area that is affected by these changes. The present study also applied the socioeconomic factors underlying the LULC change hence stressing the significance of the watershed management that envisages both the human and ecological requirements of the watershed. This work has provided a viable exhibit of how GIS technologies and remote sensing can be useful when used in the assessment of LULC over time, and its effects on the hydrological systems with a view of coming up with sustainable strategies to deal with future changes.

6. Recommendations

Based on the findings of this study, the subsequent recommendations are suggested for sustainable watershed management in the Buggavanka watershed:

1. Promote sustainable land use practices: Promote use of staking, hedgerow interplanting, conservation tillage and other uses that stabilize, prevent soil erosion, improve water infiltration and increase soil quality.
2. Implement water conservation and demand management measures: Encourage conservation of water by extending rainwater harvesting schemes and efficient techniques and technologies of irrigation so as to reduce the demand for water and thereby increase the availability of water.
3. Protect and restore natural vegetation: Include programs such as reforestation and afforestation to increase stock of the forests and also improve the ability of the watershed in managing water flows and the effects of climate change.
4. Develop and implement groundwater management plans: Undertake site specific geophysical studies, set up stations to monitor groundwater and control and manage the quantity of water extracted from the ground.
5. Engage local communities in watershed management: Facilitate increased community involvement in decision making activities; enhance stakeholder's awareness on watershed health status and strengthen stakeholder's implements positive sustainable and proper land and water management systems.
6. Integrate watershed management into urban planning: Integrate consideration of watershed into the development of urban and this will ensure that the outcomes of urban growth on water remain reduced.
7. Strengthen institutional frameworks for watershed governance: Clarify who does what to avoid confusion among different individuals and groups involved in the decision making process, encourage people to work together towards common goals as well as provide oversight on decision making procedures.

By embracing such recommendations, various stakeholders in the Buggavanka watershed will be able to avoid various negative impacts associated with inadequate availability of water resources, destruction of ecosystems, and reduction of the capacities of those occupants living in the watershed.

References:

[1]Arnold, C. L., & Gibbons, C. J. (1996). Impervious surface coverage: The emergence of a key environmental indicator. *Journal of the American Planning Association*, *62*(2), 243-258.

[2]Arnold, J.G., Srinivasan, R., Muttiah, R.S., & Williams, J.R. (1998). Large area hydrologic modeling and assessment part I: Model development.*Journal of the American Water Resources Association*,*34*(1), 73-89.

[3]Bonan, G. B. (2008). Forests and climate change: Forcings, feedbacks, and the climate benefits of forests. *Science*, 320(5882), 1444-1449.

[4]Bosch, J. M., & Hewlett, J. D. (1982). A review of catchment experiments to determine the effect of vegetation changes on water yield and evapotranspiration. *Journal of Hydrology*, 55(1-4), 3-23.

[5]Brooks, K.N., Ffolliott, P.F., Gregersen, H.M., &DeBano, L.F. (2014). *Hydrology and the management of watersheds* (4th ed.). Iowa State Press.

[6]Calder, I. R. (1990). *Evaporation in the uplands*. John Wiley & Sons.

[7]Chow, V.T., Maidment, D.R., & Mays, L.W. (1988). *Applied hydrology*. McGraw-Hill.
[8]Coppin, P., Jonckheere, I., Nackaerts, K., Muys, B., &Lambin, E. (2004). Digital change detection methods in ecosystem monitoring: a review. *International Journal of Remote Sensing*, 25(9), 1565-1596.
[9]Dessie, G., &Kinati, K. (2014). Impacts of land use/land cover changes on the hydrology of GilgelAbay watershed, Upper Blue Nile Basin, Ethiopia. *Journal of Hydrology*, 513, 258-267.
[10] Foody, G. M. (2002). Status of land cover classification accuracy assessment. *Remote sensing of environment*, 80(1), 185-201.
[11] Gashaw, T., Tulu, T., Argaw, M., &Worqlul, A. W. (2017). Effects of land use/land cover change on stream flow and sediment yield: A case study of the Andassa watershed, Blue Nile Basin, Ethiopia. *Environmental Systems Research*, 6(1), 1-13.
[12] Lerner, D. N., Issar, A. S., & Simmers, I. (1990). *Groundwater recharge: A guide to understanding and estimating natural recharge*. International Association of Hydrological Sciences.
[13] Legesse, D., Vallet-Coulomb, C., &Gasse, F. (2003). Hydrological response of a catchment to climate and land use changes in Tropical Africa: case study South Central Ethiopia. *Journal of Hydrology*, 275(1-2), 67-85.
[14] Lu, D., & Weng, Q. (2007). A survey of image classification methods and techniques for improving classification performance. *International journal of remote sensing*, 28(5), 823-870.
[15] MEA (Millennium Ecosystem Assessment). (2005). *Ecosystems and human well-being: Synthesis*. Island Press.
[16] Paul, M. J., & Meyer, J. L. (2001). Streams in the urban landscape. *Annual Review of Ecology and Systematics*, 32(1), 333-365.
[17] Scanlon, B. R., Healy, R. W., & Cook, P. G. (2002). Choosing appropriate techniques for quantifying groundwater recharge. *Hydrogeology Journal*, 10(1), 18-39.
[18] Shrestha, D.P., Babel, M.S., Weesakul, S., & Tripathi, N.K. (2015). Assessing the impacts of land use and land cover change on hydrology using remote sensing and GIS: A case study of the Koshi River Basin, Nepal. *International Journal of Applied Earth Observation and Geoinformation*, *34*, 32-41.
[19] Vörösmarty, C.J., Green, P., Salisbury, J., & Lammers, R.B. (2000). Global water resources: Vulnerability from climate change and population growth. *Science*, *289*(5477), 284-288.
[20] Walsh, C.J., Roy, A.H., Feminella, J.W., Cottingham, P.D., Groffman, P.M., & Morgan, R.P. (2005). The urban stream syndrome: Current knowledge and the search for a cure. *Journal of the North American Benthological Society*, *24*(3), 706-723.
[21] Zhang, L., Dawes, W. R., & Walker, G. R. (2001). Response of mean annual evapotranspiration to vegetation changes at catchment scale. *Water Resources Research*, 37(3), 701-708.