CLIMATE CHANGE AND LAND USE DYNAMICS; PERSPECTIVE ON SOIL EROSION AND SEDIMENTATION PROBLEM IN PHEWA LAKE WATERSHED AREA OF NEPAL

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KEY WORDS: Climate change, soil erosion and sedimentation, watershed, Geographic information system

ABSTRACT:

Phewa watershed area is in a fragile physiographic region, which intense monsoon rainfall one of highest rainfall receiving watershed of Nepal. The Phewa lake watershed covers the area of $118.19\,km^2$ and lies on Western Development Region of the country. The objective of this study is to find the land use dynamics and climate change effects on soil erosion and sedimentation problem in the watershed. The Phewa lake watershed is located in a steep slope terrain of the Himalaya mountain range as high. The precipitation plays the important role for the soil erosion and sedimentation. 30 years data of rainfall is analyze and see the scenario of change in climate of the watershed and the change in land use in watershed area. Phewa lake watershed area has significant marked of land use change and analyzed by using GIS technique. The land use change is due to the opening of the roads in the hilly areas connecting to the Pokhara valley. Most of the land use changes are found in all categories of the land cover. The effect of land use change directly shown to the soil erosion and sedimentation in the Phewa Lake. Direct observation survey also shows the tremendous effect in soil erosion and sedimentation. Barren land is completely disappearing changing to other land use. The rate of change of land use agriculture decrease (0.49% per annum), forest decrease (0.12% per annum) and built-up area increase (0.135%) per annum. Most of the changes are in settlement, agricultural land, and forest and build up area in the watershed. Adaptation and management of the settlement policy for the environmental perspective is the way of minimize the effects of climate change and land use dynamics with respect to soil erosion and sedimentation. Lake conservation can play the important role for minimizing the soil erosion and sedimentation problem in Phewa Lake. The study shows that the land use change is continuous process from one aspect to another aspect; man and nature are its major agents for change of the landscapes in the watershed area of the Phewa Lake.

1. Introduction

Pokhara is one of the most rapidly growing cities due to tourism destination in Nepal. It has natural beauty and spectacular views of Annapurna range and fishtail peak standing much closed by 28 Km.; these scenes with Phewa Lake made the Pokhara one of the popular tourist destination. The tourism destination is one of the causes of change in land use pattern of the watershed. Increase in number of hotels and lodge at lakeside and changes in land use affected the lake environment and its watershed. Estimating temporal land-use and land-cover changes is essential which can show the problems and cause of the changes (Lambin, 1997). Land-use and land-cover changes have important environmental consequences through their impacts on soil and water quality, biodiversity, microclimate, methane emission and reduced Co_2 absorption and, hence, contribute to watershed degradation (Lambin et al., 2000; Schneider and Pontius, 2001). Increased consciousness of these impacts enhanced their estimating, forecasting and modeling at the global, regional or watershed scales (Chen et al., 2001). Numerous developing countries including Nepal face serious environmental degradation and soil erosion induced by large-scale deforestation. The severe degradation of the middle mountains of the Nepal (Ives and Messerli, 1989) has recently been quantified and mapped through the considerable efforts of the Nepalese Government and international agencies. A total of 103 968 ha of forest in Siwaliks hills and plains were cleared under the government's resettlement programme from the 1950s to the mid-1980s (MPFS, 1988). Comparison of the 1978–1979 maps with those of 1994–

1996, showed that the annual deforestation rate is 0.5 per cent nationwide, where as it is 1.7 per cent for southern Terai (plain areas) and 2.3 percent for middle mountain regions, respectively (FRI, 1999),Which shows the middle mountain have more problem and affects for the soil erosion. However, introduction of community forestry and leasehold forestry programmes during the 1980s and 1990s has resulted in increase in forest cover in the middle mountain area (Gilmore and Nurse, 1991). The destabilization of fragile mountain slopes through deforestation, agricultural expansion, excessive grazing and expansion of the road network has increased land degradation and soil erosion rates (Ives and Messerli, 1989; Thapa, 1990). Soil erosion rates have been estimated as high as 15.3 Mg /ha for degraded forest and as high as 213 Mg /ha for uncontrolled grazing lands (Pahari, 1993). Agriculture was extended at the cost of forest/shrub, marginal, and sub marginal areas with very steep slopes without due consideration for the suitability of these lands for cultivation (Tiwari, 2000). Interpretation of aerial photographs taken at different intervals provides valuable information of physical features such as land use, soils, vegetation, stream networks, and landforms at different time scales (Borrough and McDonnell, 1998).Geomorphometric characteristics such as hypsometric curves, hypsometric integrals (HI), drainage density and length of overland flow are important indicators of watershed conditions (Ritter, 1986). These parameters are important indicators for assessing the watershed health in the fragile watersheds in the Himalayan region. Drainage density is closely associated with erosion processes, lithology, relief and vegetation. It relates morphology to soil properties and climate (Berger and Entekhabi, 2001; Roth and La Barbara, 1997) and plays an important role in shaping the watershed through erosion, deposition and sediment transport processes (Tucker et al., 2001). Significant important of these environmental variables, our knowledge of land-cover dynamics and influence of geomorphometric characteristics on watershed quality is poorly studied in Nepal. In conjunction with land-use and land-cover changes, investigation of relevant geomorphometric characteristics serves as a more holistic indicator of watershed status. The objective of this study is to find the land use dynamics and climate change effects on soil erosion and sedimentation problem in the watershed and the land use policy.

2. Study Area

The Phewa lake watershed area is located in the south-west corner of the pokhara valley ($28^0 7'$ N to $28^0 12'$ N latitude and $84^0 4'$E to $84^0 10'$ E Longitude) which lies on a relative subsidence zone between the greater Himalaya and Mahabharat range. This watershed is spread fully or partially of six VDCs (Sarangkot ,Kaski Kot ,Dhikurpokhari ,Bhadaure Tamagi ,Chapakot and Pumdi Bhumdi) and the south western part of the Pokhara sub- metropolitan city of Kaski district. It covers an area of approximately 123 km^2 and the length and width of the east–west oriented watershed is about 17 and 7 Km respectively. The surface area of the Phewa Lake is 4.43 km^2 and depth from 8.6m to 19 m. The watershed height varies from lower part from sea level 793m to the upper part 2508m.

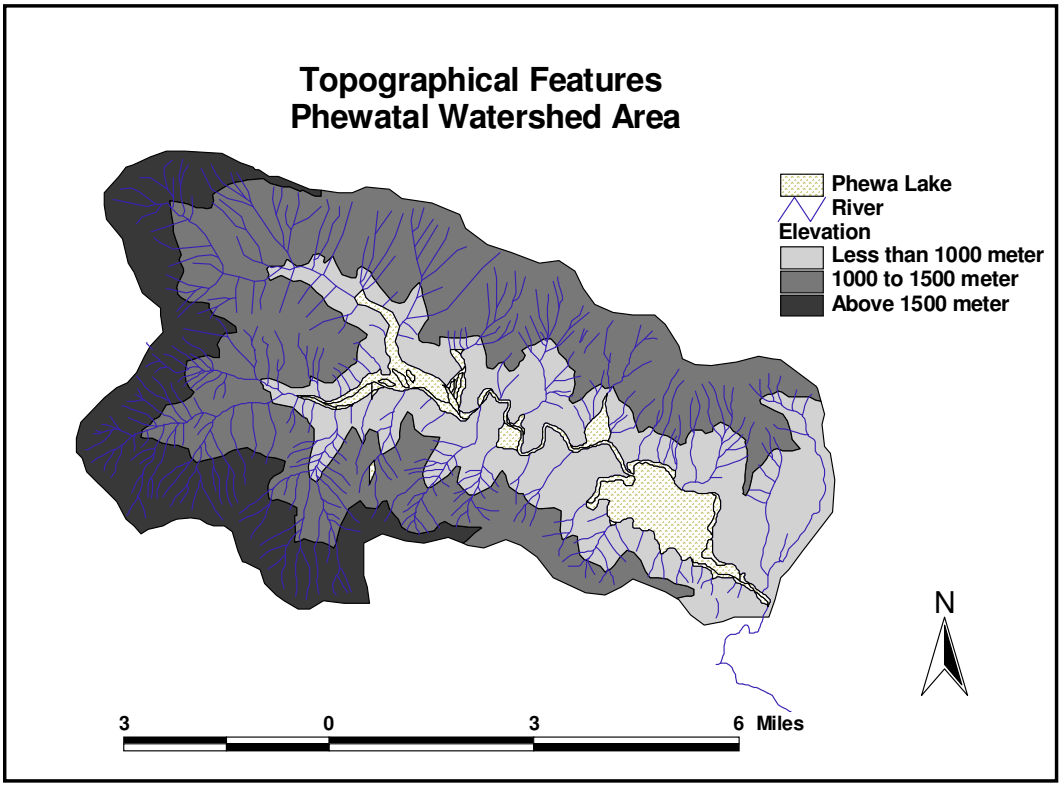

Figure 1 Topological features of Phewa Lake watershed area

Source: Aerial photo and Toposheets, 1978.

3. Data used

The following data have been used in this study:
Aerial photos from 1954 (obtained from Forest Statistics and Survey Division), 1972, 1978, and 1998 (obtained from Department of Survey)
Medium resolution satellite data: Land sat TM from 1991 and 1999
High-resolution satellite data: Quick Bird image from November 2004, other data: Digital topographic data, population data, personal photographs from old times, etc.

4. Methodology

The present study involves both primary and secondary information focusing on the land use change dynamics of the Phewa lake watershed from 1978 to 1998 aerial photos (scale 1:50,000) and land use map (1:50,000) prepared by the Land Resource Mapping Projects (LRMP) in 1986.

4.1 Classification for land use/cover

Classification was made for different land use and cover from aerial photos and topographic map. Different land use categories have been taken as the categories classified by the department of survey during the preparation of the topographic map viz. agriculture, forest, built–up area, water bodies, landslide, and bush/shrub, sand/sedimentation and fallow/grazing. Present study of the data layers are the land use map of 1978 and 1998. Roads, rivers settlement and contours have been converted into digital form through manual digitizing using Arc GIS 9.2 software. Land use change in each category between 1978 and 1998 are analyzed by spatial analysis methods using Arc GIS 9.3 software.

4.2 Change analysis

A change analysis was made to study the change in land use and cover, such as in the change in water bodies, built up areas, etc. This was then related with other data such as digital elevation data, population etc, to related the environmental change with socioeconomic changes. Population is dynamic factors that can change the natural environment into socio-cultural environment, which affects the soil erosion. Due to climate change temperature raises, more precipitation, and drought, which make the environmental change, affects in soil erosion.

4.3 Major Land Use /Land Cover Change: 1978-1998

The agriculture land was changed into forest, sand/sediment, built up area, bush/shrub, fallow/grazing, water bodies, and landslide by 2.46% in 20 years. The highest change from agriculture into forest is 1.61% and lowest change into bush and shrubs is .0012%. The forestland was changed into agriculture, sand/sediment, built up area, bush/shrub, fallow/grazing, water bodies, and landslide by 2.172 % in 20 years. The highest change from forest into agriculture is 2.04% and lowest change into built up area is .00005%. Barren land was changed into agriculture, forest, fallow/grazing by 0.314%. Built up area was changed into agriculture by .0009% and water bodies was changed into agriculture build up area and forest by 0.039%.

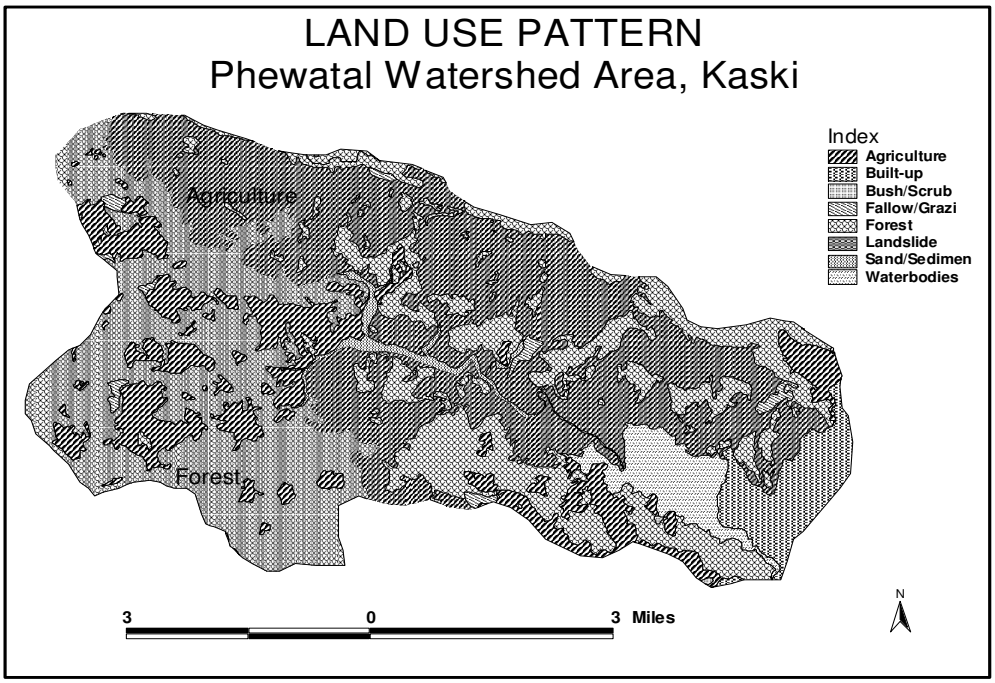

Figure 2 Land use pattern of Phewa lake watershed Area , Pokhara, Kaski

Source: Land use /land cover changes: 1978-1998

5. Result and Discussion

The agriculture followed by the forest cover is decreasing percent is higher than increasing percent. However, in case of barren land, the whole land cover is changed into agriculture, forest and fallow /grazing. The trend land use land cover in built up area, sand/sediments, fallow/grazing and bush/shrub are increasing. The barren land is totally converted into another landform. Besides forest and agriculture, land other lands such as built up area, water bodies, landslide, sedimentation fallow/grazing and bush/shrub highly change into new form of land. The built up area and water bodies change into

trend of positive change. The rate of change of increasing ratio is high in the built up areas (2.7%) within the 20 years It indicates the urbanization rate is high.

6. Conclusion

The effect of land use change directly shown to the soil erosion and sedimentation in the Phewa Lake. Direct observation survey also shows the tremendous effect in soil erosion and sedimentation. Barren land is completely disappearing changing to other land use. The rate of change of land use agriculture decrease (0.49% per annum), forest decrease (0.12% per annum) and built-up area increase (0.135%) per annum. Most of the changes are in settlement, agricultural land, and forest and build up area in the watershed. Adaptation and management of the settlement policy for the environmental perspective is the way of minimize the effects of climate change and land use dynamics with respect to soil erosion and sedimentation. Lake conservation can play the important role for minimizing the soil erosion and sedimentation problem in Phewa Lake. The study shows that the land use change is continuous process from one aspect to another aspect; man and nature are its major agents for change of the landscapes in the watershed area of the Phewa Lake.

Reference:

Berger KP, Entekhabi D., 2001. Basin hydrologic response in relation to distributed physiographic descriptors and climate. Journal of Hydrology 247: 169–182**.**

Borrough PA, McDonnell RA., 1998. Principles of Geographical Information System. Oxford University Press: Oxford.

Chen L, Wang J, Fu B, Qiu Y., 2001. Land-use change in small catchment of northern Loess plateau, China. Agriculture, Ecosystems and Environment 86: 63–172.

FRI., 1999. Forest resources inventory. Ministry of Forest and Soil Conservation, His Majesty's Government of Nepal: Kathmandu.

Gilmore D.A, Nurse MC., 1991. Farmer initiatives in increasing the tree cover in central Nepal. Mountain Research and Development 11: 2329–2337.

Ives JD., Messerli B., 1989. The Theory of Himalayan Environmental Degradation. What is the Nature of the Perceived Crisis? The Himalayan Dilemma Reconciling Development and Conservation. Rutledge: New York**.**

Lambin EF., 1997. Modeling and monitoring land-cover change processes in tropical region. Progress in Physical Geography 21: 375–393.

Lambin EF, Rounsevell MDA, Geist HJ., 2000. Are current agriculture land use models able to predict changes in land-use intensity? Agriculture, Ecosystem and Environment 82: 321–331.

LRMP ,1986.Land Resource mapping Project, summary report. HMG/N and Govt. of Canada

MPFS., 1988. Master Plan for Forestry Sector Nepal. Ministry of Forest and Soil Conservation: Kathmandu.

Pahari KJ., 1993. Soil Erosion Susceptibility Using Remote Sensing and GIS: A Case Study of Andikhola Watershed Nepal. MSc dissertation NR 93–16. Asian Institute of Technology: Bangkok.

Ritter DF., 1986. Process Geomorphology. Brown: Dubuque, IA.

Roth G, La Barbara P., 1997. Morphological characterization of channel initiation. Physics and Chemistry of the Earth 22: 329–332.

Schneider LC, Pontius RG., 2001. Modeling land-use change in the Ipswich watershed, Massachusetts, USA. Agriculture, Ecosystems and Environment 85: 83–94.

Thapa GB., 1990. Integrated Watershed Management in the Upper Pokhara Valley Nepal. Doctoral thesis. Asian Institute of Technology: Bangkok.

Tiwari PC., 2000. Land-use changes in Himalaya and their impact on the plains ecosystem: need for sustainable land use. Land Use Policy 17:101–111.

Tucker GE, Catani F, Rinaldo A, Bras RL., 2001. Statistical analysis of drainage density from digital terrain data. Geomorphology 36: 187–202.