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Original Research Article

Landuse and landcover changes and Soil erosion in Yezat Watershed, North Western Ethiopia

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ABSTRACT

Soil erosion affects land qualities and water resources. This problem is severe in Ethiopia due to its topographic features. The present research was aimed to estimate spatiotemporal changes in land-use/land-cover pattern and soil erosion in the Yezat watershed in Ethiopia. This study was carried out by using landsat imageries of 2001, 2010 and 2015. Images were classified into categories using supervised classification by maximum likelihood algorithm. They were also classified into different biomass levels by using Normalized Difference Vegetation Index (NDVI) analysis. Revised Universal Soil Loss Equation modeling was applied in a GIS environment to quantify the potential soil erosion risk. The area under grassland, woodland and homesteads have increased by 610.69 (4%), 101.69 (0.67%) and 126.6 ha (0.83%) during 2001–2015. The extent of cultivated land and shrub/bushland was reduced by 323.43(0.02%) and 515.44 ha (3.41%), respectively, during the same period. The vegetation cover in the watershed decreased by 91% during 2001–2010, and increased by 88% during 2010–2015. Increase of NDVI values indicates better ground cover due to implementation of integrated watershed development program in the region. The estimated annual soil losses were 7.2 t ha^{-1} yr^{-1} in 2001, 7.7 t ha^{-1} yr^{-1}in 2010 and 4.8 t ha^{-1} yr^{-1}in 2015. Management interventions are necessary to improve the status and utilization of watershed resources in response to sustainable land management practices for sustainable livelihood of the local people.

1. Introduction

Environmental problems are alarming humanity all over the world. Its effects on ecosystem services challenge conservation, management and rehabilitation activities (Ayele, Suryabhagavan, & Sathishkumar, 2014; Haregeweyn et al., 2015; Zewdu, Suryabhagavan, & Balakrishnan, 2016). Land degradation and associated decline in the productive potential of agricultural lands are threatening economic and social well-being of the present and future generations (Berhanu & Suryabhagavan, 2014; Haregeweyn, Berhe, & Tsunekawa, 2012; Kouli, Soupios, & Vallianatos, 2009). Land degradation is one of the major and widespread environmental threats that the planet earth has been facing since long (Ganasri & Ramesh, 2016; Krishna Bahadur, 2009; Rawat, Mishra, & Bhattacharyya, 2016; Xu, Xu, & Meng, 2012). Soil erosion negatively affects the soil quality, decreasing agricultural efficiency, water intention properly, flooding, debris flow and habitat destruction as a whole (Kidane & Alemu, 2015; Park, Oh, Jeon, Jung, & Choi, 2011). In order to meet livelihoods, to address economic stress and to accelerate development, people in the developing countries utilize land and soil resources in an unsustainable way as evidenced by overgrazing, destruction of forest for urban expansion and high intensive and unscientific agricultural activities, and the resulted improper land-use/land-cover changes (de Meyer, Poesen, Isabirye, Deckers, & Raes, 2011). According to Hurni (1985b), degradation and loss of soil resulting from soil erosion was estimated to be about 20 t per hectare in Ethiopia, i.e., about 1 mm of soil depth per year. Ethiopia loses about 1.9 billion metric tons of fertile soil from the highlands every year and the degradation of land through soil erosion is increasing at a high rate (Fitsum, Pender, & Nega, 1999; Hurni, 1989). Similarly, as reported by Ethiopian highlands reclamation study, soil erosion was forecasted to cost the country 1.9 billion USD between 1985 and 2010 (FAO, 1986). According to Phillips (1989, as cited in Maria, Pantelis, & Filippos, 2009), the off-site effects of erosion such as reservoir

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sedimentation and pollution of water resources are more costly and severe than the on-site effects on land resources. There are two main approaches to study soil erosion depending on spatial and temporal scales (Xu et al., 2012). The other is the off-site measurement through modeling, which can be applied to reveal potential patterns of the soil erosion, to evaluate soil erosion process from time to time on a larger scale.

In order to build a dynamic model, as many as possible criteria, which influence soil erosion, should be taken into consideration. The Universal Soil Loss Equation (USLE) was developed by Wischmeier and Smith (1978). The Revised Universal Soil Loss Equation (RUSLE) is a widely used soil erosion intensity evaluation model, modified and improved from the USLE, developed by Wischmeier (1976). Revised Universal Soil Loss Equation was developed to estimate the annual soil loss per unit area based on erosion factors. It provides an estimate of the severity of erosion and also numerical results that can validate the benefits of planned erosion control measures in areas of soil erosion risk. For the last over twenty years, multi-temporal, high-resolution, remotely sensed data and GIS have been used extensively to monitor environmental changes specifically, to assess soil erosion rate, to map land-cover changes on the local, regional and global scales (Ai, Fang, Zhang, & Shi, 2013; Checkol, 2014; Eweg, Van Lammeren, & Woldu, 1998; Gebreselassie, 1996; Girma, 2005; Ringo, 1999). Geographical information system technology is thus appropriate due to its powerful multi-criteria processing and calculation capability (Chretien, King, Jamagne, & Hardy, 1994). Moreover, highly significant spatio-temporal phenomena or changing patterns are revealed by applying GIS and remote sensing based soil erosion and land degradation modeling (Fistikoglu & Harmancioglu, 2002; Gelagay & Minale, 2016; Hoyos, 2005). Thus, evaluation and prediction are easy and faster to address hazards caused by soil erosion. The present study was aimed to detect the spatiotemporal changes in the status and utilization of watershed resources in response to sustainable land management interventions and to assess the extent and rate of soil erosion, which is a major driving force of land degradation.

2. Materials and methods

2.1. Study area

This study was conducted in Yezat watershed, West Gojam Zone of the Amhara Regional State of Ethiopia. It falls in two districts, *viz.*, Gonji Kolla and Yilmana Densa. This area is situated at 37°31'32"–37°31'32"E longitudes and from 11°08'22"–11°09'45"N latitudes covering a total area of about 15,085 ha (Fig. 1), around 430 km from Addis Ababa and 70 km south of Lake Tana, Bahir Dar Town, the capital of Amhara Regional State. The altitude of the study area ranges between 1485–3207 m. The slope gradient of the watershed ranges from 4 to 66.5°. Higher elevation ranges are located at the southwest and eastern parts of the watershed (MoARD, 2006). According to the 2007 National Population and Housing Census, the two districts have a total population of 321,508 of which 160,709 are men and 160,829 are women. About 91.9% of the area is predominantly used for crop production. The livelihood of the people depends on mixed farming (Checkol, 2014). Based on the agro-climatic classification of Ethiopia (Hurni, 1986), the majority of the study watershed falls in Woina Dega agro-climatic zone (traditional climate classification), which is similar to dry sub-humid. Heavy rainfall causes in the area during June–October. Based on long term climatic data and the average annual rainfall of Adet meteorological station near the study area was 1508 mm and mean maximum and minimum temperatures were 29.6 °C and 12.9 °C, respectively. The highest mean monthly temperature was recorded in March and the lowest during December–January.

2.2. Soil and vegetation

According to the FAO-WRB (2006) soil map unit classification system, vertisols are the predominant soil type with the area coverage of 7166.2 ha in moderately gentle slopes and in very deep soils of the study area. This soil class can be characterized by heavy black clay, mostly water logged during the rainy season. It has high cation exchange capacity and base saturation content both in surface and subsurface horizons. The rest of the physiographic units are dominated by cambisols, regosols, luvisols, and leptosols. Moderately deep to very deep major soil types dominate the study area.

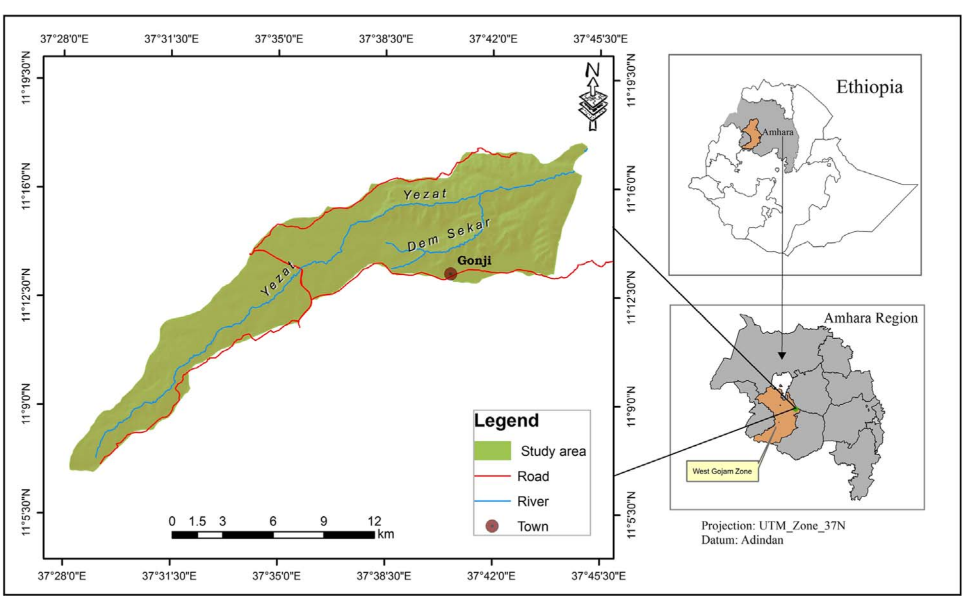

Fig. 1. Location map of the study area.

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