Evaluating Climate Change Effects on Natural Resources Using Remote Sensing Technologies: A Case of Kazimzumbwi Forest Reserve, Kisarawe in Tanzania

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Abstract: Poor countries are prone to climate change effects due to lack of mechanisms to mitigation. As such, they are most vulnerable to effects of climate changes which are floods, drought, deforestation, environmental degradation and so on. Many of affected communities particularly in rural areas and urban poor have resorted to migration to viable agricultural lands and urban areas increasing pressure on available social services. This situation has led to depletion of natural resources in the fringes of the cities in search for shelter, food, water, energy etc.. Dar es Salaam city is highly prone to environmental degradation by being highly populated and closer to the Kazimzumbwi Forest National Reserve, which has been a resource of logging at the guise of sustainable livelihood of Dar es Salaam city residents. This paper is reporting on a study undertaken in ENVI & ARCGIS software environment to evaluate the extent of environmental degradation in the forest reserve for the period of 16 years i.e. 1995-2011, firstly, for purpose of informing policy makers and administrators to determine the extent of the problem and secondly to provide evidence for development of effective mitigation measures. Results revealed a considerable environmental degradation within the forest reserve over the study period. This was attested by a decrease of forests by 42%, grass land, as well as increase of bare land and grass land by 26% and 42% respectively. This is a testimony that there was a significant environmental degradation and loss of natural resources during the study period which should be addressed by relevant authorities.

Key words: Climate change, environmental degradation, image classification, change detection.

1. Introduction

Climate change is a global phenomenon threatening livelihood of mankind; ironically it is caused by activities supporting mankind's existence and prosperity. The root cause of climate change is lack of natural balance of GHG (Green House Gases) effectively and CO₂ between the atmosphere and the earth. Whereas human activities such as deforestation, burning of fossil fuels from vehicles, plane travel, heavy industries are some of the activities which are acknowledged to catalyze climate change by emission of carbon dioxide; forests and vegetation in general

use carbon dioxide in photo synthesis and plant respiration.

As such, forests play a double role in the carbon dioxide equilibrium, firstly, as reservoirs of carbon dioxide from the atmosphere and secondly as generators of carbon dioxide when they are cut [1]. The major reservoirs of carbon include the oceans, the soils and the atmosphere. Carbon dioxide naturally, flows from one reservoir to another, over time, ranging from days to decades as noted by Pearson, T., et al. [2].

The carbon cycle helps to regulate the amount of CO₂ present in the atmosphere, and therefore a major component of climate system stability. Specifically, when fossil fuels are burnt, they upset the natural balance of GHG in the atmosphere, leading to

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depletion of ozone layer which protects the earth's surface from low wave length radiations e.g. ultraviolet radiation from the sun.

Burning of fossil fuels is also responsible for accumulation of other GHG e.g. methane which tends to tap longer wavelength radiations emitted from the earth's surface. Consequently, the earth receives radiations from the sun coupled with increased GHG from the atmosphere, causing global, temperature changes which results in variations in weather systems, melting of perma frost, sea rising and so on as observed by Lillesand, T. T. and Kiefer, R. W. [3] and Nelson, R. and Holben, B. [4].

The primary adverse effect of climate change is altering the complex web like system that allows life to thrive on the earth, thus affecting normalcy of cloud cover, rainfall availability, wind patterns, distribution of plants and animal species, leading to effects of floods, drought, famine, etc..

Kazimzumbwi Forest Reserve in Kisarawe district in Tanzania is endowed with a myriad of natural resources, including but not limited to forests, fauna and flora. These resources are susceptible to climate changes which put them to risk of extinction in the cause of sustaining livelihoods of people in the proximity of the forest reserve.

2. Problem Statement

As populations increase and national economies continue to move away from agriculture based systems, cities grow and spread i.e. urban sprawl. Urban sprawl often infringes upon viable agricultural land or production forest land neither of which can resist nor deflect the overwhelming urbanization momentum; as such, it results in degradation of the environment and deforestation [5], which particularly in developing countries is not well controlled due to limited knowledge and skills. This has an effect of disturbing the carbon dioxide equilibrium, resulting in polluting the environment. It is estimated that deforestation in Tanzania alone stood at 112,000

hectares per annum in 2009. This is an alarming rate which cannot be tolerated, as such, it has to be reversed to save the environment and the earth in general. However, reversing this trend requires quantitative data from which to design evidenced strategies that are designed to effectively curb or control it.

This paper is reporting on results of a study undertaken to quantify the extent of degradation that had taken place in Kazimzumbwi Forest Reserve in the period of 16 years effectively 1995 to 2011, for purpose of influencing policy intervention to control the situation.

3. Location of the Study Area

Kazimzumbwi Forest Reserve is situated in the Pugu Hills, approximately 20 km south-west of Dar es Salaam city in Tanzania; it is within 1 km of Pugu Forest Reserve (24 km²) as seen in Fig. 1. Together the two reserves form part of what was once a large forest block extending to within 10 km of Dar es Salaam. The TAZARA (Tanzania Zambia Railway) line goes through the reserve, through a nearby station Vigama on the western edge of the reserve.

4. Methodology

The study was based on multi-temporal satellite image analysis; Satellite images used were Landsat TM, all with cloud cover less than 10%. The images were pre-processed to remove radiometric and geometric errors prior to further processing [6]. The images were classified using ENVI software and post processing was done using ARCGIS.

5. Results and Analysis

Four land cover maps of the covering the forest reserve for the years 1995, 2000 2009 & 2011 were generated. Typical classes prevalent in the forest were found to be forest, shrubs, grass land and bare land. The results are as shown in Figs. 2-5.

Fig. 1 Location sketch of Kazimzumbwi Forest Reserve.

Fig. 2 Land cover map of Kazimzumbwi Forest Reserve in 1995.

Fig. 4 Land cover of Kazimzumbwi Forest Reserve in 2009.

Fig. 3 Land cover map of Kazimzumbwi Forest Reserve in 2000.

Fig. 5 Classified image results of 2011.

Table 1 Summary of accuracy assessment of classified images.

Classes	Forests (ha)	Shrubs (ha)	Bare land (ha)	Grass land (ha)	Overall accuracy %
1995	94.90	54.80	77.19	38.33	82.9
2000	398.43	50.63	67.15	87.91	82
2009	96.61	4.10	3.49	73.44	88.3

Table 2 Summary of land cover change from 1995 to 2011.

	Forests areas (ha)	Bare land areas (ha)	Shrubs areas (ha)	Grass land areas (ha)
2000	5,047.67	195.68	149.87	167.513
2009	2,927.65	246.56	50.96	234.478
2011	1,727.31	308.20	16.82	332.958
Average change (%)	- 42	+ 26	- 66	+ 42

Fig. 6 Overall land cover change from 1995 to 2011.

5.1 Image Classification Accuracy Assessment

Satellite image classification accuracy was performed using the confusion matrix tool. The results are as summarized in Table 1.

5.2 Land Cover Change Detection

Change detection was performed by image differencing so as to assess the extent to which land cover of Kazimzumbwi Forest Reserve has changed from 1995 to 2011 (16 years) as done by Lu, D. [7] and Jensen, J. R. and Toll, D. L. [8]. The results are summarized on the Table 2 and Fig. 6.

6. Conclusions and Recommendations

In overall, the forests reserve have decreased by 42%; bare land has increased by 26% whereas shrubs decreased by 66% and grass land increased by 42% during the study period.

These results indicate a negative change in the forest resources, which is attributed to climate change effects, as forests are used to support livelihoods of most Dar es Salaam residents.

The Kazimzumbwi Forest Reserve was declared in 1936 and the government tolerated logging until the 1970s. After that time, human activities were not allowed in the forest reserve. During that time, the population around the area was small compared to the recent years. The rapid population increase around the area has lead to increasing demand in land for settlement and agriculture. Agricultural activities involves the cutting down of forests for clearance and trees for construction purposes as well as for firewood settlements, specifically in construction which involves the use of trees for wood for roofing also in social economic activities such as making of charcoal and firewood for cooking.

Allowing passage of a railway line across the forest reserve also contributed to degrading the environment, as the railway line attracted more population to the area with actions whose activities have always been detrimental to the environment.

Therefore, this decrease in dominant species in the reserve specifically forest and the shrubs is a testimony of environmental degradation and the decline of natural resources which collectively affect the entire ecosystem.

Controlling these activities is necessary so as to effectively mitigate the adverse effects of degradation and climate change for sustainable development.

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