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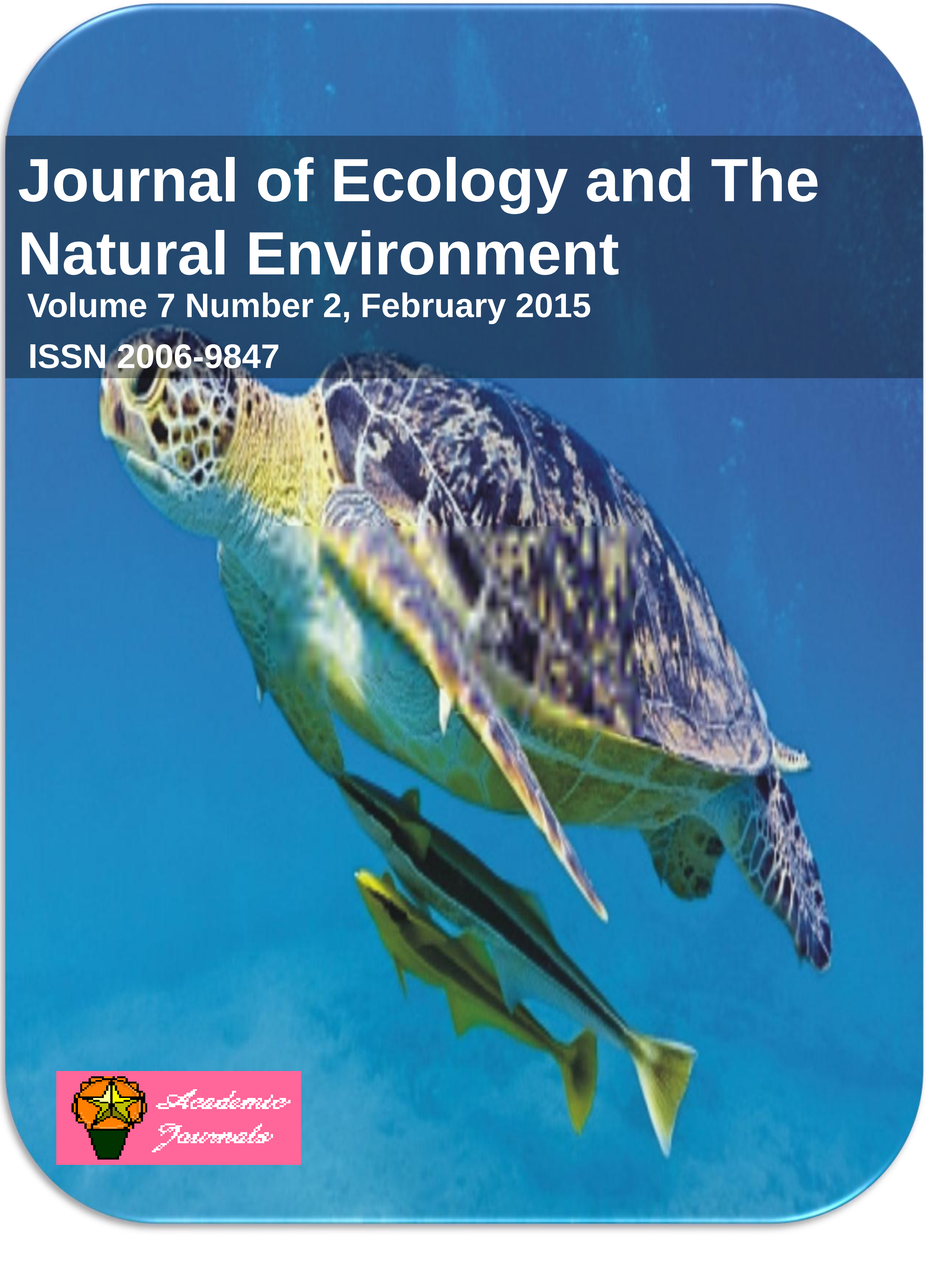

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Full Length Research Paper

Effects of municipal and industrial discharges on the quality of Beressa river water, Debre Berhan, Ethiopia

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The problem of environmental pollution is not simple and easy to ignore because it affects the survival and normal functioning of an ecosystem by changing the overall healthy interaction between its components and after once it occurs, will be difficult to control. Fortunately, in the town of Debre Berhan (Tebasie), it is a common phenomenon due to the discharge of untreated liquid and solid wastes from industrial and municipal activities. Thus, this study was conducted to determine the status of Beressa River and to reveal the effects of industrial and municipal discharges on the water quality of the river for irrigation and other domestic uses. After selecting six different sampling sites depending on the suspected and identified sources of pollution, the river water was analyzed for different parameters like temperature, pH, electrical conductivity (EC), oxygen demand [biological oxygen demands (BOD) and chemical oxygen demand (COD)], total suspended solids (TSS), total dissolved solids (TDS), PO_4^{3-}, SO_4^{2-}, HCO_3^-, NH_4^+, NO_3^-, Cl^- B, basic cations (Na, K, Ca and Mg), heavy metals (Cr, Pd, Cd, Ni, Hg and As) and micro nutrients (Fe, Mn, Cu and Zn). The water had no problem related to temperature, pH and EC. However, the COD, BOD, PO_4^{3-}, TSS, TDS, Pb and Hg contents at different site were above their respected maximum permissible limit but the rest detections were below the concerned allowable value while requiring an extra attention for restoring the quality with the control or avoidance of further deteriorations.

Key words: heavy metals, oxygen demand, pollution, river water quality.

INTRODUCTION

Environmental pollution is any change which affects the integrity of an ecosystem (Ekuri and Eze, 1999). Most of the time, the changes are caused by the action of human being like industrialization (Han et al., 2002), urbanization, construction and transportation (Jande, 2005) and poor agricultural and land use management practices (Novotny and Olem, 1994). According to Katyal and Satake (2006), the changes affect human being directly or indirectly through determining the supply of water, agricultural and other biological inputs, physical objects/ possession and

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opportunity to appreciate nature/ recreation.

Most of the time, water bodies are susceptible for pollution due to rapid population growth and improper waste disposal and management practices. For example, the Gombak River in Kuala Lumpur, Malaysia is under influence due to population status of the area (Zubaidah et al., 2011). Untreated domestic and industrial wastes have an effect on the water quality of the Nhue River in Hanoi, Vietnam (Kikuchi et al., 2009), the Cuvum and Adyar Rivers in Chennai, India (Gowri and Ramachandran, 2001), the Ibese and Ikopoba Rivers in Nigeria (Awomeso et al., 2009) and the Modjo, Kebena, Akaki, Chacha, Megecha, Wabe, Ghibe, Dabena and Sor Rivers in Ethiopia (Baye, 2006). And according to Negash et al. (2011), the quality of the Beressa river water for irrigation and other domestic uses is under problem because of improper waste disposal and management.

In the town of Debre Berhan (Tebasie), environmental pollution is a common phenomenon due to the absence of waste disposal access, lack of awareness and some control measures. However, the problem of environmental pollution is not simple and ignored for the reasons that it alters the survival and well-functioning of a given ecosystem and once it happens, it is difficult to control. Therefore, this study was conducted in order to determine the status of Beressa River and to reveal the effects of industrial and municipal discharges on the quality of the Beressa River water.

MATERIALS AND METHODS

Description of the study area

The study was conducted at Tebasie sub-town of Debre Berhan town which is located at 09° 35' 45'' to 09° 36' 45'' north latitude and from 39° 29' 40'' to 39° 31' 30'' east longitude and found at 125 km north east of Addis Ababa with an elevation ranging between 2800 and 2845 meters above sea level. The twenty seven (27) years (1985-2011) data obtained from the Ethiopian National Meteorological Agency indicates that, the area receives a mean annual rainfall of 927.10 mm and characterized by an unimodal rainfall pattern with a maximum (293.02 mm) and minimum (4.72 mm) peaks in August and December, respectively. The mean monthly maximum and minimum temperature ranged from 18.3 to 21.8 °C and from 2.4 to 8.9 °C, respectively.

Site selection, sample collection and preparation

In this study, six sites (Site 1- found around Eyerusalem Vegetable Farm, Site 2- found around the Debre Berhan Blanket Factory (DBBF) and the Ask Flower Farm Private Limited Company (AFFPLC), Site 3- at the Debre Berhan University's (DBU) waste disposal area, Site 4- found at different household waste disposal area, Site 5- found around the Terra Vegetable Farm and Site 6- found around the Debre Berhan Tanning and Leather Finishing Factory (DBTLFF)) were taken as water sampling area based on the suspected and observed sources of pollution.

Since the aim of this study was concerned with the detection of the water quality for irrigation and domestic uses, the water samples were collected once from each site in the morning (9 to 11 am) by the end of February 2013 (the maximum expected utilization and pollution time) using a plastic jar by considering its depth (about 50 cm), relative movement speed (being steady and moving), turbidity (dilution) status and distance from the land (about 2 m for the easy of irrigation accessibility and domestic uses). There were up to ten sub samples at each experimental site that were put and stirred in a 20 L plastic bucket to make a representative composite sample for each sites and were poured into a two litter plastic bottle. Generally, before laboratory analysis the samples were kept in refrigerator until the collection of all samples have been conducted within two successive days.

Laboratory analysis

The temperature and pH of the water samples were determined by using a hand-held thermometer and pH meter directly from the samples being prepared. With a conductivity meter, the electrical conductivity and total dissolved solids (TDS) were measured. The bicarbonate content was estimated by the acidimetric/ HCl titration method (USSLS, 1954). The boron content was determined using Azometiene H method (Kluczka et al., 2007) and the chloride was determined by Silver nitrate method (Mohr's argentometric method) using potassium chromate as the indicator. The water samples were analysed for soluble cations at which the Na and K contents were determined by flame photometer while the Ca and Mg were determined by atomic absorption spectrophotometer (AAS). The biochemical oxygen demand (BOD) was measured according to the standard methods (APHA, 2005) and chemical oxygen demand (COD), ammonia, nitrate, phosphate and total suspended solids (TSS) contents were measured by using spectrophotometer (Hach, 1997). Moreover, the water samples were analyzed for their heavy metals (Cd, Cr, Pd, Ni, As and Hg) and micronutrients (Fe, Cu, Zn and Mn) content by using AAS according to standard methods (APHA, 2005).

RESULTS AND DISCUSSION

The temperature of the Beressa River water at site 2 was highest among the other sites (Table 1). However, all were below the maximum permissible limit of 40°C (EEPA, 2003) which affect the growth and survival of normal aquatic biota and were found to meet the WHO permissible range (12 to 25°C) for healthy functioning of aquatic ecosystem. This means, all the recorded water temperature values are not likely to affect the quality of the water for sustaining life. The raised temperature at site 1 might be due to the machinery cooling activity of the DBBF. Temperature has an effect on important water properties like specific conductivity and solubility of dissolved solutes and gases (oxygen and carbon dioxide) and generally, warmer water holds less available/ free oxygen which results in respiration problem on aquatic organisms (Malina, 1996).

The pH values of the Beressa River water ranged between 7.24 and 7.42 (Table 1) which was in the permissible range of 6 to 9 (EEPA, 2003) for normal activity of the aquatic biota. Generally, high pH value could cause toxicity of some pollutants in the water body. For example, if the pH of water goes beyond 8.5, ammonia becomes more toxic and can adversely harm

Table 1. The mean temperature and chemical compositions of the River water at different sites.

Parameter	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Temperature (°C)	19.50	24.50	21.00	19.50	18.00	21.50
pH	7.38	7.31	7. 42	7.33	7.24	7.32
EC (µS cm^{-1})	181.19	197.59	198.71	198.33	196.84	193.28
COD (mg L^{-1})	20.18	75.23	164.00	153.67	52.26	86.00
BOD_5 at 20°C (mg L^{-1})	6.95	22.06	107.00	98.11	13.07	28.00
TSS (mg L^{-1})	46.50	40.50	46.50	45.50	57.50	39.50
TDS (mg L^{-1})	170.43	171.52	170.47	194.18	198.46	167.11
Phosphate (mg L^{-1})	9.20	10.01	15.71	8.06	10.31	20.04
Sulphate (mg L^{-1})	10.23	13.78	19.91	15.19	18.13	21.11
Bicarbonate (mg L^{-1})	116.23	127.55	132.27	128.68	127.89	125.46
Ammonia (mg L^{-1})	0.02	1.03	1.12	0.53	0.54	0.96
Nitrate (mg L^{-1})	0.04	0.19	0.43	0.34	0.43	0.48
Chloride (mg L^{-1})	9.78	12.66	16.22	15.26	18.15	13.51
Boron (mg L^{-1})	0.01	0.04	0.02	0.03	0.01	0.04
Sodium (mg L^{-1})	9.45	10.89	10.12	12.55	9.68	14.56
Potassium (mg L^{-1})	4.17	3.78	4.36	4.83	4.67	4.87
Calcium (mg L^{-1})	37.17	33.53	42.14	35.05	46.46	45.81
Magnesium (mg L^{-1})	5.70	5.90	6.32	4.90	4.41	7.50
Iron (mg L^{-1})	ND	0.026	0.010	0.004	ND	0.002
Manganese (mg L^{-1})	ND	ND	0.001	0.001	ND	ND
Copper (mg L^{-1})	0.001	0.013	ND	0.006	0.003	ND
Zinc (mg L^{-1})	0.001	0.006	ND	0.002	0.014	ND
Cadmium (mg L^{-1})	ND	0.026	0.022	0.013	ND	0.011
Chromium (mg L^{-1})	0.004	0.021	0.013	0.016	0.018	0.025
Lead (mg L^{-1})	0.002	0.005	0.007	0.009	0.003	0.006
Nickel (mg L^{-1})	ND	0.001	0.015	0.021	0.021	ND
Arsenic (mg L^{-1})	0.001	0.005	0.011	0.011	0.024	0.023
Mercury (mg L^{-1})	ND	0.001	0.001	0.001	0.001	ND

ND = Not detected.

the normal aquatic biota (Kallqvist and Svensson, 2002). Most of the living aquatic organisms are sensitive to pH which reduces or changes their abundance as it goes outside the tolerable limit (Novotny and Olem, 1994) and according to Kimmel (1983), it can have a direct effect on the physiology of organisms which results in detrimental biological community dominated by few tolerant taxa.

The electrical conductivity (EC) values of the Beressa River water ranged from 181.19 µS cm^{-1} at site 1 to 198.71 µS cm^{-1} at site 3 (Table 1) which was about five times below the maximum permissible limit of 1000 µS cm^{-1} (EEPA, 2003) beyond which the activity and growth of living organisms in the water body is limited due to osmotic effect. This implies that the River had no problem of salinity which affects its use basically for crop production.

The maximum and minimum biological oxygen demands (BOD) were found in the water of sites 3 and 4, respect-tively (Table 1) and were above the maximum permissible limit of 50 mg L^{-1} (EEPA, 2003) at which the decomposition of organic pollutants in the water bodies is affected due to the shortage of dissolved oxygen (DO). Apparently, the sources of BOD in the water were biodegradable organic substances contained in the discharged effluents of the DBU, DBTLFF, DBBF and households. The water at site 1 was the lowest in its chemical oxygen demand (COD) content while site 3 had the highest value and followed by site 4 (Table 1) which were above the maximum permissible limit of 150 mg L^{-1} (EEPA, 2003) which implies that more DO is required to decompose the organic pollutants in the water. According to Negash et al. (2011), the amount of COD in the Beressa River water was above the permissible limit of EEPA because of the effluents of DBU, DBTLFF, DBBF and municipal waste water discharged without treatment.

Generally, the highest and lowest contents of total suspended solids (TSS) were found in the water of sites 5 and 6, respectively (Table 1). However, all the sites had a TSS values above the maximum permissible limit of 30 mg L^{-1} (EEPA, 2003) beyond which the normal activity of aquatic organism is affected due to the reduced amount of light penetrating into the water and both the point and non-point sources might be a reason for the high TSS content in the Beressa River water. In the water of sites 5 and 6, the highest and lowest total dissolved solids (TDS) contents were found, respectively (Table) and all were about a fold higher than the maximum permissible limit value of 80 mg L^{-1} (EEPA, 2003) at which the concentration of heavy metals is increased to undesirable level. According to Negash et al. (2011), influx of untreated effluent/waste from different institutions, factories, municipal and poor land use practice in the watershed was blamed as causes for the raised TDS content.

The amounts phosphate in the water of sites 1 and 4 was relatively lower than the others which were above the maximum permissible limit of 10 mg L^{-1} (EEPA, 2003) at which the growth of aquatic plants is enhanced and cause shortage of DO. Negash et al. (2011) have also indicated that phosphate was among the pollutants in the Beressa River water due to untreated municipal effluents, domestic sewages, discharges of the DBU, tannery and poorly managed agricultural lands. Generally, waste water and domestic phosphate based detergents, human and animal wastes, decomposing plants and runoff from fertilized croplands are the main sources of phosphate which can allow the growth of aquatic plants and change the types and abundance of organisms in a stream (Morrison et al., 2001). The content of sulphate in the river water was minimum at site 1 and maximum at site 6 with an increasing manner (Table 1). However, all the detected amounts were below the maximum permissible limit of 200 mg L^{-1} (EEPA, 2003) beyond which the water becomes unsafe for drinking due to the interference in enzymatic activity. According to Negash et al. (2011), the river was free from the risk of sulphate pollution. The lowest and highest bicarbonate contents were 116.23 and 132.27 mg L^{-1} in the water of sites 1 and 3, respectively (Table 1) and were found to be below the maximum permissible limit of 200 mg L^{-1} (EEPA, 2003) beyond which precipitation of Ca and Mg in the soil solution occurs up on irrigation. Thus, the Beressa River water could not be an immediate source of bicarbonate pollution on the soils.

The maximum and minimum amounts of ammonia were recorded from the water at sites 3 and 1, respectively (Table 1) but all were below the maximum permissible limit of 30 mg L^{-1} (EEPA, 2003) beyond which the growth and survival of most aquatic organisms is affected. In this situation, the possible sources might be the discharge of human and animal wastes, industrial and domestic waste waters and decayed organic matter. Moreover, the other sources of ammonia in surface water are runoff from fertilized lands, leaching from septic tanks, sewage and erosion of natural deposits (Kafia et al., 2009). Sites 3 and 5 had similar content of nitrate (Table 1) with the lowest and highest amounts at sites 1 and 6, respectively. However, all were below the maximum permissible limit of 50 mg L^{-1} (EEPA, 2003) at which the growth of aquatic plants is stimulated and cause water quality reduction. In water bodies, nitrate could occur as a result of the deamination of ammonium nitrogen from nitrogenous materials and/or raw wastes that can be oxidized to nitrate by the action of microbiological agents (Morrison et al., 2001).

The maximum and minimum amounts of Na were recorded in the water of sites 1 and 5, respectively (Table 1). However, all the contents were below the maximum permissible limit of 200 mg L^{-1} (EEPA, 2003) at which the quality of water for irrigation and domestic uses is affected due to salinity, sodicity and specific ion toxicity problems. The lowest and highest concentrations of K were recorded in the water of sites 2 and 6, respectively (Table 1) and all the contents were below the maximum permissible limit of 5 mg L^{-1} (EEPA, 2003) beyond which the growth and metabolism of aquatic organisms is affected. The amounts of Ca and Mg ranged from 33.17 to 46.46 mg L^{-1} in the water of sites 2 and 3 and from 4.41 to 7.5 mg L^{-1} in the water of sites 5 and 6, respectively (Table 1). However, both Ca and Mg were below the maximum permissible limit of 100 mg L^{-1} (EEPA, 2003) which causes reduction of water quality for domestic uses due to hardness (reduced ion exchange). Generally, the amount basic cations in the water of site 6 was higher which could be due to the use of salts (NaCl and KCl) and other preservatives containing Na and K for soaking and curing purpose (Cassano et al., 2001) and the use of Ca and Mg containing limes for conditioning of raw hides and skins (Ramasami and Prasad, 1991).

The lowest and highest contents of Cl^- were recorded in the water of sites 1 and 6 (Table 1) but all were below the maximum permissible limit of 250 mg L^{-1} (EEPA, 2003) beyond which the growth and activity of organisms is affected. The observed amounts could come from the sewages containing chloride. The contents of boron ranged from 0.01 mg L^{-1} at sites 1 and 5 to 0.04 mg L^{-1} at sites 2 and 6 (Table 1). But, the contents in all sites were below the maximum permissible limit of 2 mg L^{-1} (EEPA, 2003) beyond which some deleterious effects are occur on certain agricultural crops and aquatic organisms. Since it is used in cleaning compounds and alloys, the observed concentration especially at sites 2 and 6 might come from the effluents from the DBBF and DBTLFF.

Copper was not detected in the water of sites 3 and 6 but it was highest in the water of site 2 (Table 1) and in all cases the concentration was below the maximum permissible limit of 2 mg L^{-1} (EEPA, 2003) beyond which the growth and activity of living biota is affected. According to Shanmugam et al. (2006), the abrupt increase in Cu concentration in water bodies is due to surface runoff and pipeline discharges which could be considered as sources for the case of the Beressa River.

Iron was not detected in the water of sites 1 and 5 while its maximum presence was found in the water of site 2 (Table 1) but in all cases it was below the maximum permissible limit of 1 mg L^{-1} (EEPA, 2003) beyond which the growth and activity of living biota is affected. Manganese was detected only in the water of sites 3 and 4 (Table 1) and it was below the maximum permissible limit of 5 mg L^{-1} (EEPA, 2003) beyond which the growth and activity of living biota is affected. The contents of zinc in the Beressa River were below the maximum permissible limit of 5 mg L^{-1} (EEPA, 2003) beyond which the growth and activity of living biota is affected. Generally, it was not detected in the water of sites 3 and 6 but was the highest in the water at site 5 (Table 1).

Cadmium was not detected in the water of sites 1 and 6 but was the highest in the water of site 2 (Table 1) and the Cr concentrations were minimum and maximum in the water of sites 1 and 6, respectively (Table 1). However, the concentrations of Cd and Cr in the water of all sites were below the maximum permissible limit of 0.05 mg L^{-1} (EEPA, 2003). All the contents of Pb in the water were above the maximum permissible limit of 0.001 mg L^{-1} (EEPA, 2003). But, the lowest and highest values were recorded in the water of sites 1 and 4, respectively (Table 1). Nickel was not detected in the water of sites 1 and 6 (Table 1) and it was below the maximum permissible limit of 0.02 mg L^{-1} (EEPA, 2003) in the remaining sites. The amount of As in the water of all sites was below the standard limit value of 0.01 mg L^{-1} (EEPA, 2003). The water at sites 6 and 1 had the maximum and minimum amounts of As, respectively. Mercury was not detected in the water of sites 1 and 6 and except the water of these sites, all had a similar value of 0.001 mg L^{-1} (Table 1) that was equal to the standard limit value of 0.001 mg L^{-1} (EEPA, 2003). Similar study by Negash et al. (2011) had shown the concentration of heavy metals like Cd, Cr, Pb, Ni, As and Hg in the water of the Beressa River were above the standard limit value due to untreated industrial and municipal wastes, fuels and gasoline from motor vehicles, fertilizer (Pb, Cd, As), pesticides (Pb, As, Hg), sewage sludge (Cd, Pb, Se), irrigation (Cd, Pb, Se) and manure (As, Se).

Conclusion

The highest and the lowest temperatures of the Beressa River water were recorded at sites 2 and 5, respectively, and the pH values ranged between 7.24 and 7.42. The EC was minimum at site 1 and was maximum at site 3 and the COD content at site 1 was the least and at site 6 was the highest while the BOD content at site 1 was the lowest and at site 3 was the highest. Generally, the maximum and minimum TSS and TDS were recorded at site 5 and 6, respectively. Sites 4 and 6 were the lowest and highest in their phosphate contents. In the river water, sulphate, bicarbonate, ammonia and nitrate ranged between 10.23 and 21.11, 116.23 and 132.27, 0.02 and 1.12 and 0.04 and 0.48 mg L^{-1}, respectively, and at sites 1 and 5 the minimum and maximum amount of chloride and minimum amount of boron were analyzed. Moreover, the concentrations of Na, K and Mg were higher at site 6 while Ca was highest at site 5. There was no detection of Fe at sites 1 and 5, Mn at sites 1, 2, 5 and 6, Cu and Zn at sites 3 and 6, Cd at sites 1 and 5 and Ni and Hg at sites 1 and 6. However, Cr was lowest and highest at site 1 and 6, respectively while Pb was minimum and maximum at sites 1 and 4, respectively.

Eventually, the Beressa River water had no problem related to temperature, pH and EC and generally the water of all sites were below the maximum permissible limit in their HCO_3^-, SO_4^{2-}, NH_4^+, NO_3^-, Na, K, Ca, Mg, Cl-, B, Cu, Fe, Mn, Zn and heavy metals (Cd, Cr, Ni and As) contents. However, extra attention is required because they were on the way to deteriorate the water quality in the near future. The amounts of COD and BOD in the water of sites 3 and 4, PO_4^{3-} in the water of sites except 1 and 4, TSS, TDS and Pb in the water of all sites were above their respective maximum permissible limits and Hg in the water of sites except 1 and 6 was equal to its maximum permissible limit. That means all of these excessive characters need an immediate remediation measure.

Conflict of interests

The authors did not declare any conflict of interest.

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Threat reduction assessment approach to evaluate impacts of landscape level conservation in Nepal

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Major challenges to the landscape level conservation intervention are to monitor and evaluate the conservation impacts in an accurate and cost-effective manner. Threat reduction assessment (TRA) has been proposed as a method to measure conservation success and as a proxy measurement of conservation impacts and monitoring threats. We conducted TRAs to evaluate the effectiveness of Nepal's Terai Arc Landscape (TAL) program in mitigating threats to forests of seven corridor and bottleneck sites. We modified Margoluis and Salafsky (2001) framework and scoring approach and calculated TRA index. Threats were standardized to allow comparisons across the sites and effectiveness of management modes in reducing threats between the community-based management (CBM) and conventional government managed system (GMS). TRA index of CBM was significantly higher from those of GMS as evident by various parametric and non-parametric tests including principal component analysis. However, the TRA approach is not immune to bias as it depends on subjective analysis, but it could be a simple and cost-effective conservation monitoring tool to be easily implemented by local communities and stakeholders.

Key words: Terai arc landscape (TAL), threat reduction assessment (TRA), community based management (CBM), government managed system (GMS).

INTRODUCTION

Nepal is exceptionally rich in biodiversity; however, it has experienced enormous challenges in biodiversity conservation particularly in the Terai region (Wagley and Ojha, 2002). Over time, a high proportion of the Terai forests have been modified by cutting, cultivation, burning, grazing and other anthropogenic actions (Chakraborty, 1999; FAO, 2009) and many of these forests have been significantly reduced in quality and quantity over time. The main threats to the Terai's biodiversity are forest encroachment and land use conversion, illegal logging, forest fire, wildlife poaching, uncontrolled grazing, comercial mining and invasive species (World Wildlife Fund, (WWF), 2004; National Planning Commission (NPC), 2010; Sapkota, 2009).

Nepal has experienced a series of policies and strategies for the management of forests and conservation of biodiversity (Multi-stakeholder Forestry Program (MSFP), 2013; NPC, 2013). Recently, the landscape-based conservation approach has been adopted as an opportunity to scale up conservation initiatives (WWF, 2004); and Terai arc

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landscape (TAL) programme, as the recent example, a very ambitious and long-term programme initiated to secure biodiversity conservation and sustainable development (NPC, 2010).

The TAL is part of an overall conservation strategy aimed at protecting the biodiversity both inside and outside protected areas. The various management interventions undertaken by the TAL program contribute to the emergence of a new agenda to improve the management and protection of species and ecosystems as well as people's livelihood (Baland and Platteau, 1996; Treves et al., 2005; Barbier and Burgess, 2001). Thus, search for common and efficient methodology or strategy for program improvement and change assessment is one of the priority concerns. Understanding of pressures and threats may form basis to design pragmatic regimes for the protection of biodiversity, assessment of performance and identify the changes (Haines-Young and Potschin, 2009).

Despite the challenge, complexity and time taking to determine the changes in conservation status of biodiversity, "biodiversity monitoring" and "biodiversity threat assessments" are the two main commonly used approaches currently in use to measure biodiversity impacts (GEF, 1998, 2008). To address the challenges faced in implementing biological indicator approaches to measuring conservation impacts and using results for decision making (Noss, 1999), scientists have responded to the need for practical and meaningful measures of conservation impacts by developing the TRA method (Margoluis and Salafsky, 1999; Lindner, 2012).

The TRA method is a low-cost and practical alternative to high cost and time-intensive approach (Lindner, 2012). This is a measurement tool that provides useful information at an acceptable cost and complements biological indicator approaches to measure conservation success. The TRA approach to measure conservation success is based on three key assumptions (Margoluis and Salafsky, 1998): a) All biodiversity destructions are human-induced; b) All threats to biodiversity at a given site can be identified and c) Changes in all threats can be measured or estimated.

The TRA method identifies threats, ranks them based on the criteria and assesses the progress in reducing them (Rome, 1999). The threats reduction can be evaluated using qualitative or quantitative measures and can serve a monitoring tool and alternative method of measuring conservation impacts (Margoluis and Salafsky, 1998; Rome, 1999). The TRA begins by following the procedural approach developed by IUCN (1998), Mugisha and Jacobsen (2003), Okot (2011), Margoluis and Salafsky (1999) which involves:

a) Defining the project area and listing all direct threats present at the site;
b) Ranking each threat based on 3 criteria: area, intensity and urgency (area refers to the percentage of the habitats in the site that the threat affects, intensity refers to the impacts of the threat within the site and urgency refers to the immediacy of the threat). Out of total threats, the highest ranked threat for each criterion receives the highest score, and the lowest ranked threat receives the lowest score;
c) Adding up the scores across all three criteria for total ranking;
d) Determining the degree to which each threat has been met;
e) Calculating the raw score for each threat and multiplying the total ranking by the percentage calculated to get the raw score for each threat; and
f) Calculating the final threat reduction index score by adding up the raw scores for all threats, dividing by the sum of the total rankings, and multiplying by 100 to get the TRA index.

Landscape level conservation with CBM has been lauded as a better approach to manage different resource regime than conventional, top-down GMS. However, the CBM has been appreciated for its success to achieve conservation and livelihood goals (Roche, 2007; Aryal et al., 2012) and empirical data are already generated in providing its effectiveness. However, in Nepal, both the GMS and the CBM approach have been operating concurrently for a decade. This study evaluates and compares the ability of landscape level conservation to mitigate threats, at the two different management regimes of CBM and GMS, as a proxy measure of conservation success.

Objectives and hypothesis

This study firstly identifies pressures and threats to biodiversity in TAL and develop TRA index; secondly determines and compares the effectiveness of conservation interventions between CBM and GMS; and thirdly identifies the suitability of TRA method in monitoring and performance assessment at landscape conservation. Moreover, the study was designed to test two main hypotheses, which include: a) areas where CBMs are being implemented have reduced threats as compared to area of GMSs; and b) TRA method is appropriate for monitoring and measuring the performance and impacts.

METHODOLOGY

Field sites

TAL is a transboundary landscape between Nepal and India consisting of a total area of 23,199 km^2 in Nepal with forest area of 14000 km^2. Four corridors (Mohana-Laljhadi, Basanta, Khata and Barandavar) and three bottleneck areas (Mahadevpuri, Lamahi and Dovan) of TAL were selected for study. The seven intervention sites had a total of 341 community forests, 114 government and 56 civil society institutions, totaling 511, which were considered as the population (N). Field study was conducted in 2012 and 2013 by

Table 1. Population and sample of respondent institutions.

Sites	CFUGs		Government staffs		Civil Society groups		Total	
	N	n	N	n	N	n	N	n
Basanta	105	30	32	28	13	9	150	66
Khata	49	15	9	8	4	4	62	27
Mahadevpuri	30	8	9	8	6	4	45	20
Lamahi	55	13	23	16	11	12	89	39
Dovan	35	9	7	7	5	4	47	21
Mohana Laljhadhi	52	11	22	15	`8	7	82	36
Barandabhar	15	4	12	7	9	6	36	16
Total	341	90	114	89	56	46	511	225

N = population size; n = sample size; one for Lamahi is added from district headquarters.

selecting 225 representatives, one per institution, (n), with sampling error of 5% using Cochran's sample size formula for categorical data collection. The sample size of each site was determined as proportionate to the population size of the site. Site sample sizes were determined by using Equation 1:

$$n_h = \left(\frac{Nh}{N}\right) \times n \qquad (1)$$

Where n_h is the sample size for site *h*, N_h is the population size for site *h*, N is total population size, and n is total sample size.

The participants were divided into three groups: Community forest user groups (CFUGs), n = 90); Government staff, n = 89); and Civil society groups, n = 46) (Table 1). Civil society respondents were identified as forestry sector stakeholders comprising federations of community based forest management groups, NGOs, INGOs, political parties, user groups of other natural resource management and development groups, private sector, professional organizations, donors and indigenous leaders. All three groups belonged to the forestry sector working with rural communities.

Methods

Series of interviews and discussions elicited an array of perspectives and a large amount of information. Four sets of questions were given to the participants to understand threats as per their experiences and perceptions. Firstly, participants were given a list of possible risks to the forest and biodiversity and asked to respond by indicating their level of agreement or disagreement on a 5-point Likert scale starting from '1 = strongly disagree' to '5 = strongly agree'.

Secondly, they had to answer how worrisome they estimated each threat using the same Likert scale to their respective site based on the five principal risks for which they thought improved preventive and remedial measures are required. Thirdly, open questionnaire survey was supplemented by discussions and field visits about the risks perceived by respondent such as potentially damaging to forests and biodiversity.

Participants were asked to consider threats to habitat integrity, quality and ecosystem functioning while natural phenomena such as earthquakes were not considered threats. Participants ranked the threats based on the relative importance and their experiences. Ranking scales of 1 (minimum) to 5 (maximum) were used throughout the exercise and all threats were ranked along one continuum. Total sum score was computed after all the threats were ranked with score. The respondents were individually asked to award mark, based on their evaluation of the extent to which management efforts had mitigated the threats. The scores for each threat were discussed to reach a consensus about a realistic score for the success of the management approach. After the scoring and ranking exercise, total ranking scores were multiplied by the percentage of the threat met to get a raw score for each threat. The TRA index was computed as (Equation 2) (Margoluis and Salafsky, 1999):

$$TRA\,index = \frac{Sum of\ raw score}{Sum of\ \ possible\ ranking} \times 100 \qquad (2)$$

Due to the proximity and topographical similarity between management modes CBM and GMS, it was possible to observe large differences in threat variables due to the social and management factors of the management categories of the forest area studied. Finally, the result obtained was presented and responses were received from field level government staff (N=37) regarding the assessment of TRA approach using the standard 5-point Likert scale: Strongly disagree = 1; disagree = 2; neutral = 3; agree = 4; and strongly agree = 5.

Variables

The independent variables, the presumed causes, in this study were the characteristics of respondents and types of forest management modes in relation to threat mitigation as listed in Table 2.

The dependent variables, the presumed effect of interest were the five priority threats which were assessed by using quantitative information as listed in Table 3 on both CBM and GMS.

RESULTS

Demographic characteristics

The sample largely mirrors the population and the respondents were well represented across the sites based on their size. Accordingly, site wise, highest number of 66 respondents, (29.33%) was from Basanta corridor, while lowest number of 20 respondents, (8.9%) was from Mahadevpuri bottleneck. Among the respondent categories, 90 respondents (40%) were community representatives, 89 respondents (39.6%) were government staffs and 46 respondents (20.4%) were from civil society.

Table 2. Independent variables.

Name	Type*	Explanation	Unit	Sources
Site name	N	Name of sites (1 to 7)	Number	Office record
Forest name	N	Name of forests	Number	Office record
Respondent groups	N	1= Community; 2= Government and 3= Civil society group	Number	Survey Design
Management modes	C	1= CBM (Community based management); 2= GMS (Government managed system)	Number	Office record

Table 3. Dependent variables.

Name	Variables	Type*	Unit	Sources
Different	Listing of threat variables	O	Likert scale	Survey design
CTRI	Threat reduction in CBM	C	Percent	
GTRI	Threat reduction in GMS	C	Percent	
CTR1	Encroachment and land use conversion in CBM	C	Percent	
CTR2	Poaching and trade in CBM	C	Percent	
CTR3	Forest fire in CBM	C	Percent	
CTR4	Commercial mining in CBM	C	Percent	Office records and field verification with map and questionnaire
CTR5	Invasive species and grazing in CBM	C	Percent	
GTR1	Encroachment and land use conversion in GMS	C	Percent	
GTR2	Poaching and trade in GMS	C	Percent	
GTR3	Forest fire in GMS	C	Percent	
GTR3	Commercial mining in GMS	C	Percent	
GTR5	Invasive species and grazing in GMS	C	Percent	

*N = Nominal; C = continuous, O = ordinal.

Age is an important factor that influences the working ability of the respondents. Results of analyses of data collected for this study reveal that the major age group of the respondents was of the 31 - 40 years age group (44.4%) followed by the 41 - 50 age group (28%), the 20 - 30 age group (18.1%) and the 51 - 60 years old group (9.3%).

Education, as a major component of empowering people and means of enhancing human capital varied among the respondents. In terms of the educational attainments, 36% of respondents had a capacity of simply to read and write; 38.2% of respondents attained school; 23.1% had a college degree and 2.7% had higher educations. Gender of respondents is considered as one of the variables influencing the perception on local forest resources, and in this study approximately 61% respondents were male followed by 39% of female respondents.

Patterning was also apparent in terms of respondents' socio-economic status. In terms of economic status, respondents indicated that they represented from high level (20%), medium level (56%) and lower level (20%). Social inclusion analyses showed that Brahmin and Chettri together added up 44% of the total participants followed by 28.4% indigenous group, 17.8% Madhesi and 9.8% Dalit community (Figure 1).

Threats in TAL

The threats were ranked based on value derived from Friedman test as a measure of non-parametric alternative to the one-way ANOVA with repeated measures to test for differences between groups when the dependent variable being measured is ordinal. The test statistics was found significant with $\chi^2_{23} = 1418.03$ and $p = 0.000$. Out of a total of 24 threats, five primary and common threats to the biodiversity across the TAL area were identified as (a) encroachment and land use conversion, b) poaching and trade (timber, NTFP and wildlife), (c) forest fire, d) commercial mining and e) invasive species and grazing (Table 4).

Table 5 shows the Chi-square test result based on proportion of respondents identifying and agreeing on existing or potential severity of threats on their locations. In general, higher number of threats were found statistically significant ($p<0.05$) with the some site-wise differences in: a) all five primary threats in Dovan bottlenecks were not statistically significant ($p>0.05$); b) threats of invasive species and grazing in Khata($p=0.097$) and poaching and trade in Mahadevpuri ($p=0.247$); encroachment ($p= 0.056$) and poaching and trade ($p=0.113$) in Barandavar were not significant. This reveals that the threats to biodiversity at a given site can be different depending on

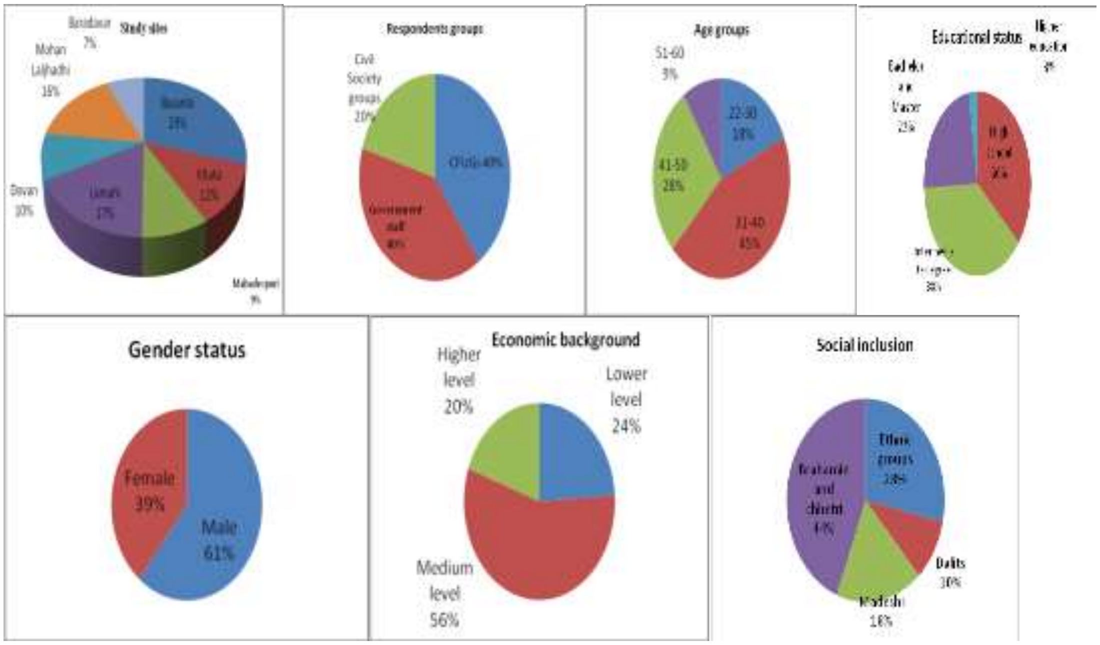

Figure 1. Demographic characteristics of the respondents (Source: field survey 2012 and 2013).

Table 4. Mean rank of threats based on Friedman test.

S/N	Threats	Mean Rank	S/N	Threats	Mean Rank
1	Encroachment and land use conversion	22.57	13	Land degradation and river cutting	10.78
2	Poaching and trade)	22.52	14	Charcoal burning	11.07
3	Forest fire	18.82	15	Poor management	12.41
4	Commercial mining	18.96	16	Lack of manpower and budget	11.34
5	Invasive species and grazing	18.95	17	Poor institutional capabilities	12.55
6	Unclear boundaries	11.58	18	Community rights denied	12.03
7	Highways and development projects	13.32	19	Bad community and staff relations	11.47
8	Human wildlife conflicts	11.52	20	Lack of awareness	12.49
9	Increased human population	13.16	21	Policy conflicts	11.18
10	Political interference	13.38	22	Illiteracy	12.44
11	Armed conflicts and insurgency	11.58	23	Poor law and order	10.51
12	Fuel-wood sell	13.24	24	Corruption and poor governance	12.11

Source: Field survey, 2012.

nature and magnitude of direct threats and indirect threats. Therefore, assessing how much the threat had changed at landscape level since project implementation also required support of experienced respondents on identification, quantification and interpretation of site level data which has been often challenging.

Reduction of primary threats

Twenty four threats were identified at the entire seven study sites. The most frequently reported common threats in all sites of both CBM and GMS were forest encroachment and land use conversion followed by poaching; trade of timber, NTFP and wildlife; forest fire; commercial mining and non-human factors such as invasive species and livestock grazing.

Encroachment was a main reason of land use change in recent years that occurred in all study areas. However, the trend has been slowed or halted due to the landscape conservation intervention such as security of land tenure and access to resources for local people through CBM, strengthening protected area system and expansion of buffer zone. As shown in Table 7, this was the largest threats in terms of area, intensity, urgency and greatly reduced in CBM against GMS. The paired t test revealed

Table 5. χ^2 test result on site specific risk of primary threats.

Sites	Threats														
	Encroachment and land conversion			Poaching and trade			Forest fire			Commercial mining			Invasive species and grazing		
	χ^2	n	P	χ^2	n	p	χ^2	n	p	χ^2	n	p	χ^2	n	p
Basanta	31.55	44	0.000	22.06	40	0.000	17.58	38	0.000	15.25	37	0.000	21.16	40	0.000
Khata	9.56	16	0.008	16.22	18	0.000	6.89	14	0.000	6.89	14	0.032	4.667	14	0.097
Mahadevpuri	12.40	14	0.02	2.80	10	0.247	6.70	12	0.035	9.80	15	0.007	16.30	15	0.000
Lamahi	25.95	29	0.000	15.42	25	0.000	34.39	31	0.000	15.42	25	0.000	22.88	28	0.000
Dovan	1.60	8	0.45	5.20	10	0.074	4.90	9	0.086	0.10	7	0.951	0.10	7	0.951
Laljhadi	35.09	27	0.000	21.27	23	0.000	27.46	25	0.000	12.18	18	0.002	24.18	24	0.000
Barandavar	5.765	10	0.056	4.353	9	0.113	1.53	8	0.000	7.882	11	0.019	18.47	14	0.000

that the threat of encroachment has been found lower at CBM ($\bar{x}$ =37.26 ± 1.29) than GMS ($\bar{x}$ =25.33 ± 1.54) with difference of $\bar{x}$ =11.92 ± 1.88 (t_{224}=6.324; p =0.000) but it was still common in both.

CBM has reduced poaching including illegal logging and deforestation by creating local village level institutions. Local people conduct regular patrolling against illegal activities inside forest. The over extraction of flora and poaching of fauna diversity have been reduced (CBM, $\bar{x}$ =37.97 ± 1.05 against the GMS, $\bar{x}$ =18.04 ± 0.68) resulting in difference of $\bar{x}$ =19.92 ± 1.37 and t_{224}=14.55; p =0.000). Interventions were created to combat the threats posed by poaching. This initiative was comprised of processes which address the complex and sensitive issues at local, national levels and was implemented in cooperation with the major stakeholders.

The traditional approach of focusing on legislation alone was not sufficient; and involving local communities were crucial to manage forest fires. Access to forest ownership have encouraged local participation and community based practices resulting in reduction in damaging and unwanted forest fires that led to more effective fire prevention and suppression. Legal obligations in fire management by government agencies have not been successful while local communities themselves were unable to manage intense and large fires. Nevertheless, awareness programs and community based forest fire management activities have been assisted by this program to manage forest fires. Result shows that the reduction of threats on fire was significant in CBM ($\bar{x}$ =37.00 ± 1.04) when compared with GMS ($\bar{x}$ =18.11 ± 0.68) with the difference of 18.89% and was statistically significant ($\bar{x}$ =18.89 ± 1.33 with t_{224} = 14.13; p = 0.000).

Although collection, processing, transportation and trade of boulder, stone and sand have become a serious issue in biodiversity conservation, it has been reduced in CBM ($\bar{x}$ =41.05 ± 1.05) and in GMS ($\bar{x}$ =16.51 ± 0.73) (t_{224}=17.77; p=0.000). Active community participation have gradually managed open grazing and invasive species particularly *Mikania micrantha* which have been widespread from east to west in Terai forests of Nepal which were significantly reduced in CBM ($\bar{x}$ =41.32 ± 1.04) as compared to GMS ($\bar{x}$ =17.75 ± 0.76) (t_{224}=17.16; p=0.000) (Table 6).

Threat reduction index

Threat reduction analysis conducted showed that at all levels of area, intensity and urgency, forest encroachment and land use conversion represents the largest threat with a total average rank value of 12.3, followed by poaching of timber and wildlife (rank value 9.49), forest fire (rank value 8.49), commercial mining (rank value 7.75), and invasive species and grazing (rank value 3.83). The extent of reducing threats differed between CBM and GMS. CBM illustrates reduction of threat with a range of 37.00 to 41.32%, whereas GMS shows the range between13.51 to 25.3% depending on specific threats.

Raw factor (percent threat reduction/100) and raw score (raw factor/total rank value) were used to estimate TRI. The result showed CBM with a total TRI of 38.47 with 10.32% in encroachment and land use conversion, 8.36% in poaching and trade, 6.94 in forest fire, 7.23 in commercial mining and 5.63 in invasive species and grazing. However, the GMS only showed a total TRI of only 19.31 with 6.96% in forest encroachment and land use conversion, 3.96% in poaching and trade, 3.36 in forest fire, 2.80 in commercial mining and 2.33 in invasive species and grazing (Table 7).

The TRI at CBM showed that there was significantly higher threat reduction than conventional GMS (mean difference of 19.16 ± 1.238, t_{224}=15.74; p = 0.000). With reference to the overall performance of CBM and GMS, the ANOVA test revealed the difference at p=000 (CTRI, $F_{6,218}$ = 41.596; and GTRI, $_{F6,218}$ = 59.195)

Principal component analysis (PCA) on major threats

The results of the KMO measure of sampling adequacy

Table 6. t-Test on comparing threats between CBM and GMS.

Comparisons	Mean difference	SE	t value	Df	Sig (2 tailed)
CTR1 - GTR1	11.92	1.88	6.34	224	.000
CTR2 - GTR2	19.92	1.37	14.55	224	.000
CTR3 - GTR3	18.89	1.34	14.14	224	.000
CTR4 - GTR4	24.54	1.38	17.77	224	.000
CTR5 - GTR5	27.79	1.62	17.16	224	.000

Source: field survey, 2012.

Table 7. Threat reduction index.

Threats	Average value of threats*			RV	CBM				GMS			
	Area	Intensity	Urgency		PTR	RF	RS	TRI	PTR	RF	RS	TRI
Encroachment and land use conversion	4.35	3.99	4.21	12.55	37.26	0.37	4.64	10.32	25.33	0.25	3.13	6.96
Poaching and trade (timber. NTFP and wildlife)	3.45	3.02	3.43	9.9	37.97	0.38	3.76	8.36	18.04	0.18	1.78	3.96
Forest fire	2.9	3.07	2.47	8.44	37.00	0.37	3.12	6.94	18.11	0.18	1.51	3.36
Commercial mining	2.46	2.57	2.9	7.93	41.05	0.41	3.25	7.23	16.51	0.16	1.26	2.80
Invasive species and grazing	1.84	2.35	1.99	6.18	41.32	0.41	2.53	5.63	17.75	0.17	1.05	2.33
Total	15	15	15	45			17.31	38.47				19.40

*Measured in scale (1 to 5): Vey low, low and medium; RV = rank value = area + intensity + urgency ; PTR= percent threat reduction; RF = raw factor = PTR/100; RS= raw score = RF/total rank value; TRI = threat reduction index= RS/corresponding individual RV.

Table 8. Rotated component matrix.

	Components	
	1	2
Eigen value	4.27	3.14
Variance explained	42.7	31.4
GTR3	0.969	
GTR5	0.924	
GTR2	0.910	
GTR4	0.861	
GTR1	0.604	
CTR2		0.880
CTR3		0.873
CTR5		0.841
CTR1		0.829
CTR4		0.778

Extraction Method: principal component analysis; rotation method: Varimax with Kaiser normalization; a. rotation converged in 3 iterations.

revealed 0.791 and Bartlett's Test of Sphericity revealed a significance at a level of 0.000 (χ^2 =2049.96, df=45). Thus, the variables must be related to each other for the factor analysis to be appropriate. In order to examine underlying dimensions of the threat reduction, a factor analysis with a varimax rotation was performed. The results are presented in Table 8 with the factor at the level of 0.50 (or higher). Two factors emerged with Eigen values of 1.0 or higher. These two dimensions, explained 74% of the variance. The two underlying dimensions were labeled as follows: 1. Threats on GMS; and 2. Threats on CBM. In addition, reliability was performed on each of the two factors, based on the assessment items retained in each dimension.

Factor one, which is identified as GMS threats explained 42.70% of the variance with an Eigen value of 4.27 and a reliability coefficient of 0.83. Factor two, which is labeled as threats on CBM, explained 31.3% of the variance with an Eigen value of 3.13 and a reliability coefficient of 0.78. In the rotated factors, GTR1 to GTR5 all have high positive loadings on the first factor (and low loadings on the second), whereas CTR1 to CTR5 all have high positive loadings on the second factor (and low loadings on the first).

Factor loading from GMS ranged between 0.969 and 0.604. Forest fire (0.969), invasive species and grazing (0.924), poaching and trade (0.910), commercial mining (0.861) and encroachment (0.604) were of great importance in the settlement of factor 1 of GMS. Similarly, factor loading from CBM ranged between 0.880 and 0.778. Poaching and trade (0.880), forest fire (0.873), invasive species and grazing (0.841), encroachment (0.829) and commercial mining (0.778) outstandingly contributed to the formation of factor 2 in CBM.

Analysis of additional threats

Nineteen additional threats were identified as the threats

Table 9. Comparing means of threats using McNemar test (df =1).

Additional threats	NF		CF		McNemar χ^2_1	p
	Yes	No	Yes	No		
Armed conflicts and insurgency	158	67	131	94	20.7	0.000
Bad community and staff relations	73	152	55	170	27.40	0.000
Charcoal burning	67	158	33	192	36	0.000
Poor law and order	128	97	130	95	4.0	0.046
Corruptions and poor governance	96	129	110	115	4.55	0.033
Fuelwood sale	137	88	101	124	11.01	0.000
Community rights restricted	74	151	96	129	25.671	0.000
Development projects	155	70	171	54	31.36	0.000
Human wildlife conflicts	159	66	161	64	37.16	0.000
Illiteracy	152	73	154	71	27.04	0.000
Increased population	145	80	122	123	8.73	0.003
Lack of awareness	144	81	126	99	9.78	0.002
Lack of manpower and budget	128	97	114	111	1.37	0.242
Land degradation and river cutting	152	73	133	92	17.47	0.000
Policy conflicts	152	73	119	106	11,02	0.001
Political interferences	159	66	134	91	23.12	0.000
Poor management	102	123	113	112	0.42	0.520
Unclear boundaries	163	62	141	84	30.74	0.000
Poor institutional capabilities	127	98	101	124	0.045	0.830

to sustainable management of resource. Comparison between CBM and GMS indicates significant differences in mitigation of additional threats. The specific threats identified and mitigated at different areas, however, offer a deeper understanding of conservation effectiveness. Closed questions with 3 options - yes, no, do not know were analyzed applying McNemar Chi Square test where "do not know "was taken closer to "no" and recoded as same variable and yes as the other. A p value of < 0.05 was taken as significant. The responses were compared between CBM and GMS and statistically significant threats as indicated by McNemar test (Table 9).

Statistically significant threats with p<0.05 included: armed conflicts and insurgency; b) bad community and staff relations; c) community rights restricted c) development projects; d) human wildlife conflicts; e) illiteracy; f) increased population; g) lack of awareness; h) land degradation and river cutting; i) policy conflicts; j) political interferences and k) unclear boundaries. Similarly, significant threats at marginal level were: a) poor law and order; b) corruptions and poor governance. However, statistically not significant threats at p>0.05 were: a) lack of manpower and budget (p=0.242); b) poor management (p=0.52) and c) poor institutional capabilities (0.83).

Assessment of TRA method

Reliability analysis was undertaken in order to understand whether the questions in this questionnaire all reliably measure the same latent variable (perception towards TRA), a Cronbach's alpha was run on a sample size of 37 respondents and the value 0.801 which indicated a high level of internal consistency within the given scale was found. One sample median test showed the mixed results of the 10 response questions on assessment of TRA. The test with reference to value 2.5 and 50% cut point revealed a significant difference toward positive conclusion on its simplicity to use, easy to understand, useful, cost effecttiveness and replicable with p = 0.000 and not positive conclusion on its accuracy (p = 0.324); training requirement (p=0.099); and comparatively better (p = 0.099) (Table 10).

Conclusion

In general, TRA acts as useful tool for monitoring and evaluating conservation interventions, with specific weakness as it indirectly measures threats in biodiversity conservation. Despite the merits, biases could have occurred in the process of selecting the sites and respondents to participate in the survey and discussion. The results could be subjective and the scores for management performance may not be directly linked to specific intervention on biodiversity conservation.

The assessment highlighted that the potential for involving communities in monitoring trends in biodiversity should be integrated with biodiversity conservation. The results provided a current snapshot of the variety and severity of threats throughout the TAL conservation system. It involved key stakeholders in identifying threats

Table 10. One sample median test on effectiveness of TRA method.

	OP of category			+/ -		OP of category			+/ -
	<2.5	> 2.5	p			<2.5	> 2.5	p	
Simple to use	0	1	.000	+	No training required	0.65	0.35	.099	-
Easy to understand	0	1	.000	+	Creates baseline	0.08	0. 92	.000	+
Useful	0	1	.000	+	Replicable	0	1	.000	+
Cost-effective	0	1	.000	+	Apt for all scales	0.11	0.89	.000	+
Accurate	0.59	0.41	.324	-	Comparatively better	0.35	0.65	.000	+

OP= Observed proportion; test proportion=50%; p = 0.000 for all; + = positive and - = negative weight.

and prioritizing problems from a multidisciplinary perspective and found that TRA approach could be used in TAL as a tool of monitoring and assessing impacts of conservation based on its scope and limitations.

In conclusion, the study findings indicated that the overall current management approaches under TAL fall short of addressing threats. Nevertheless, a trend in the data suggested that threats have been better and significantly mitigated at CBM as compared to GMS, indicating the CBM as a potentially more successful approach to conservation than the traditional top-down approach. It can therefore be concluded that CBM has performed better, as an approach to landscape conservation than the traditional top-down GMS. However, both approaches have not addressed all the threats which is expected.

Conflict of interests

The authors did not declare any conflict of interest.

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Promoting tertiary education through ecotourism development

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In general, this study was to encourage students to pursue, environmental science, biology and tourism programmes at tertiary level by embarking on educational tour with tertiary students to the study area, while at the same time, the paper performs its functions such as finding out how residents were empowered in funding, capacity building and conflict resolution skills in tourism development. Specifically, the study was to analyse areas in which residents were empowered to involve in ecotourism development. The sample of the study was 281 respondents including 14 key informants. Data were collected using household surveys, made up of questionnaires and interviews. The findings show that the residents were empowered through funding, capacity building and conflict resolution skills. In general, there was no significant difference in methods of empowerment among the socio-demographic characteristics of residents in the projects. Resident's commitment to ecotourism development in their communities is commendable. It was recommended that the government and the NGO's committed to the development of the projects in the local communities should integrate the local people fully and empower them as partners in the management of the projects by not only asking for their views when making decisions, but also, putting their ideas into action for the benefit of the projects. Again, since effective management of the projects is essential, residents should be empowered through training to enable them to participate fully in the projects.

Key words: Residents, empowerment, participation, ecotourism, development.

INTRODUCTION

Empowerment is a means and a goal to obtain basic human needs, education, skills and the power to attain a certain quality of life (Parpart et al., 2002). Obviously 'empowerment' is more than participation in decision-making; it must also include the processes that lead people to perceive themselves as able and entitled to make decisions (Rowlands, 1997). Empowerment may facilitate involvement in agreed-upon activities or alternatively, it can mean exclusion from activities that elements of the community may not wish to engage in (Ramos and Prideaux, 2014). This implies that the local people should be encouraged to enable them to have direct involvement in and control over what happens in their lives (Bahaire and Elliot-White, 1999).

The ability for community members to participate in ecotourism development projects is however limited by the extent to which ecotourism is accepted as replacement for traditional activities. Where there is an agreement for

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participation in ecotourism projects, the ultimate success of such projects depends to a large extent on the level of involvement of external stakeholders including tour operators, government agencies and wholesalers (Nault and Stapleton, 2011).

Empowerment may also be seen as the development of skills and abilities of residents to manage existing development projects better and have a say in whatever is done in their community. The Food and Agriculture Organization (FAO, 1990) used the term 'empowerment' to describe any development process or activity such as skill training, management techniques and capacity building which could have some impact on people's ability to deal with different political and administrative systems, and influence decision making.

According to Whitford and Ruhanen (2010), almost all policies for indigenous tourism lacked the vigour and depth required to achieve sustainable ecotourism development. Farrelly (2011) identified a lack of formal education and perceptions of weak leadership from residents which contributed to an inability for local communities to make fully informed decision in community-based ecotourism, leaving them politically disempowered. Rogerson (2004) also found that the main obstacle to meeting government objectives for promoting economic empowerment of the owners of small tourism firms was lack of training in marketing tourism products. In an examination of empowerment in tourism destination, it has been found out that power struggles in local communities continue to affect the most disadvantaged groups such as ethnic and racial minorities, women and the poor (Timothy, 2007) .

Participation in development projects however, reinforces empowerment through an individual's inclusion in an organization and its organizational decision-making (Rocha, 1997). To apply the concept of empowerment to ecotourism development, it would mean that tourist destination communities, rather than governments or the multinational business sector, hold the authority and resources to make decisions, take action and control ecotourism development (Timothy, 2007). Consequently, in order to achieve sustainable ecotourism, the empowerment of communities affected by ecotourism development is attached to the importance of political and socio-economic justice (Sofield, 2003). As a way to achieving public participation and empowerment, Reid (2003) stresses the necessity of communities' awareness raising and transformative learning processes in understanding their situation and the need to handle problems themselves. Ecotourism resources in Ghana and in particular Brong-Ahafo Region include national parks, nature reserves, waterfalls, cultural and historical attractions and tropical flora and fauna. Community involvement in the development of these natural resources into tourist attractions may offer the necessary antidote for sustainability in the development of the tourist attractions in the region (GTB, 2008). Yet there has been little work undertaken by researchers into issues such as funding, capacity building and conflict resolution skills related to empowerment of the local people in the study communities.

METHODOLOGY

The study area

Brong-Ahafo region is the second largest region of Ghana, after the Northern region, with a territorial size of about 39,557 km^2. Geographically, it is located at the centre of Ghana. It has a tropical climate with high temperatures of between 23 and 39°C, with a maximum rainfall of 450 mm in the northern parts, and up to 650 mm in the south of the region (Ghana Tourist Board (GTB), 2008). There are two main types of vegetation; the moist semi deciduous forest and the guinea savannah woodland.

The region has tourism facilities such as hotels, restaurants and fast food outlets found mainly in Sunyani and some of the district capitals. Some tourist's attractions in the region include Digya National Park, Bui National Park, Buoyem Caves and Bats Colony, Tanoboase Sacred Grove, Boabeng-Fiema Monkey Sanctuary, Hani Archaeological Site, Bono Manso Slave Market, Kintampo and Fuller Waterfalls (GTB, 2008). The study was however, conducted at Tanoboase, Boabeng and Fiema which form part of the communities selected for the implementation of the community-based ecotourism projects in the Brong-Ahafo region. Furthermore, the sites selected for this study were the earliest to be established in the region as CBEP sites (Zeppel, 2006) and as a result, were due for evaluation.

Tano sacred grove

Tanoboase is located 15 km north of Techiman, along Techiman-Kintampo road. The community began the development of Tano Sacred Grove as an ecotourism site in 1996 with the help of Ghana Association for the Conservation of Nature (GACON), which assisted the community in activities such as construction of green fire belt, tour guide training, wildlife conservation and bushfire prevention education at the initial stages of the project.

In 2001, Tanoboase was selected among the 14 communities to be developed under the Community-based Ecotourism Projects (CBEPs) in Ghana (GTB, 2008). Even though USAID assisted the project financially, its implementation was a collaborative effort among the major stakeholders such as the GTB, NCRC, United States Peace Corps Volunteer, SNV and the local community.

The aim of the project was to develop community-owned and operated ecotourism activities, which will conserve the ecosystems and also serve as income generating opportunities for the local people (GTB, 2008). A tourism management team made up of local community members was set up to manage the project at the local level. Development activities were based on community input, local workmanship and communal labour.

The community has a semi-deciduous forest which covers about 300 acres of land, a distance of about 1 km away from the village. The forest contains bats, baboons, antelopes, and a historic Bono Shrine. It also encloses a cluster of striking sandstone rock formations. The grove is believed to be the cradle of Bono civilization, and it served as a hideout for the Bono people during the slave trade and the Ashanti-Bono wars. Other tourist activities being promoted in the community are a visit to Tano Shrine and a 'village life' tour which includes a visit to local farms, homes and schools. This gives a visitor the opportunity to view local food preparation, village industries and listen to traditional songs and stories.

Boabeng-Fiema monkey sanctuary

Boabeng-Fiema is located 22 km north of Nkoranza. Two communities (Boabeng and Fiema) began the development of the monkey sanctuary as an ecotourism site in the early part of the

1970s with the help of officers from Ghana Wildlife Department (GWD), who protected the sanctuary from encroachers. The sanctuary, which is home to the black and white Colobus and the Mona monkeys that are used to interaction with human beings was opened to tourists in 1997 (Zeppel, 2006). The aim of the project was to develop community-owned and operated ecotourism project. It was also to serve as prospects for generating income by conserving local ecosystems and protecting the monkeys, which are generally regarded by the local people as sacred.

Stakeholders include the local communities, the Nkoranza Traditional Council, the Nkoranza North District Assembly, and NGOs such as NCRC, the United Nations Development Programme (UNDP), the European Union, the United States Peace Corps Volunteer and SNV (Netherlands Development Organization). Initially, USAID funded the project whilst Ghana Tourism Authority (GTA), NCRC and other NGOs supported it through training.

At the moment, the monkeys have spread to the surrounding communities, and based on the advice received from UNDP, the local people have set up a tourism management committee (TMC) made up of residents from all the nine communities which surround the sanctuary to direct the project at the local level. These communities are Boabeng, Fiema, Akrudwa Number 1, Akrudwa Number 2, Busunya, Bonte, Bomini, Senya and Kokorompe. Activities involving the development of the project are based on community input, local workmanship and communal labour.

Fieldwork

The study was conducted between 25th May, 2009 and 11th June, 2009. Four field assistants (two tour guides and two senior high school leavers) from Tanoboase, Boabeng and Fiema were given one day's training in English and Twi to assist the researcher in the distribution and administration of the questionnaires.

All the in-depth interviews were conducted at places of choice by the interviewees in the various communities. Though a total of 281 questionnaires were administered, 268 responses were obtained. This indicated a total response rate of 95.4%. The returned questionnaires were made up of 122 (43.4%), 50 (17.8%) and 96 (34.2%) respondents from Tanoboase, Boabeng and Fiema respectively.

Target population and sample size

The target population for the study was household heads or their representatives aged 18 years and above in the selected communities. This age group of people was targeted because people in this group were among the economically active population in the study area (Ghana statistical service - GSS, 2005). A list of household heads was compiled and used as a sampling frame for the selection of the respondents. The unit of data collection was individual household heads in the communities.

Those selected for the in-depth interview were the key informants or the opinion leaders in the study area. They were made up of fourteen representatives of the local people including TMC members, traditional authorities, service providers, assemblymen and unit committee members from Tanoboase and Boabeng-Fiema project sites.

Since it was not practically possible to observe all the elements in the target population, a sample was selected for the survey. The size of the sample required for the study depended on the purpose of the study and the availability of resources. In order to determine the sample size for the study, it was estimated that about 79% of the economically active population in the study area were aware of visitors' interest in the communities' tourism projects (GSS, 2005). This is because the region abounds in a wide range of tourist attractions. The sample size was therefore determined using Fisher's formula of determining samples (Chandam et al., 2004).

The calculated sample size indicated that at least 255 respondents had to be selected from Tanoboase, Boabeng and Fiema to get a representative population. 10% was however, added to make room for non-response. In total, 281 members of the communities took part in the study.

Sampling procedure

The study utilized a multi-stage sampling procedure to select respondents. The first phase centered on the listing of household heads in each of the communities. As part of this exercise, field assistants were tasked to list and identify the number of people in each house and also give identification marks to each of the household heads. Household refers to a person or group of persons related or unrelated who live together in the same house or compound, share the same housekeeping arrangement and are catered for as one unit (GSS, 2005).

The second phase dealt with the proportional allocation of the sample size of 281 among the three selected communities (Boabeng, Fiema and Tanoboase). To ensure fair representation, this exercise was based on the population of the communities instead of the household list. With this approach, the community with more people had more household heads participating in the study than its counterpart with less people. Therefore, using the list of household heads as a sampling frame, these sample sizes; 51, 103 and 127 were allocated to Boabeng, Fiema and Tanoboase respectively.

At the third phase, simple random sampling (without replacement) was used in selecting the individuals from the list of heads of households. Using simple random sampling, one household head was selected from the sampling frame to complete a questionnaire.

Additionally, 14 in-depth interviews were conducted with the opinion leaders or the key informants in the study area using an interview guide. Ten representatives of TMC members (including assemblymen and unit committee members), two elders representing traditional authorities and two service providers were purposively selected. It was the researcher's hope that the individuals selected would have knowledge, experience or information that would be useful to know about.

Research instruments

An interview schedule was the main instrument used for the study. The questionnaires were verbally administered in Twi. This approach was adopted because of the low literacy rate in the study area. The GSS (2005), reports that the effective literacy level for the study area is 48%, which is lower than the national average of 54.5%. Additionally, Twi was used because it is the lingua franca of the people involved in the study. Respondents were asked to respond to a series of close-ended and open-ended questions.

Data processing and analyses

The data were analysed by using the Statistical Product and Service Solution (SPSS) version 16. The quantitative responses were categorised, analysed, and examined based on various respondent groups such as sex, age and place of residence. Percentages and frequencies were also used in the analyses.

Qualitative data arising from open-ended questions that respondents answered using their own words, were coded into a set of categories developed from identified commonalities, that is, repeated themes were recorded together and categories of themes identified as they emerged. All the qualitative data were paraphrased while remaining faithful to the original meaning as it was given by the respondents during the in-depth interviews. It is also important to note that all the qualitative data had to be translated from Twi to English.

Table 1. Socio - Demographic Characteristics of Respondents.

Individual characteristics	Frequency	Percent
Sex		
Male	171	63.8
Female	97	36.2
Total	268	100.0
Residential status		
Resident	254	94.8
Non-resident	14	5.2
Total	268	100.0
Age		
30 – 39	109	40.7
40 – 49	118	44.0
50 and above	41	15.3
Total	268	100.0

RESULTS AND DISCUSSION

Socio-demographic characteristics of respondents

The socio-demographic characteristics of respondents were sex, residential status, and age. The highlights of the findings are as shown in Table 1.

Development of ecotourism tends to be sex-selective, thereby altering the composition of the population as well as its size in the destination area (Pearce, 1992). Mason and Cheyne (2000) observe that sex affects the needs, aspirations and attitude of people to issues and events.

Place of residence in relation to area of tourism concentration is known to affect people's perception and attitude towards tourism development. The impacts of tourism on urban areas or on people residing in tourism concentrated areas are found to be potentially so great that some method to reassure local residents has assumed prime importance (Bahaire and Elliot-White, 1999).

Age is known to determine individuals' needs, attitudes and perceptions towards tourism development in a community. Gilbert and Clarke (1997) notice that young and middle aged had a strong support for ecotourism development. The importance of the people found between 30 and 50 years age categories in the study area was that their ideas and grievances were generally heard and felt by the larger community. Consequently, these were the age groups which could influence certain decisions about the tourism projects. Most of the people in these age groups were breadwinners at home.

Residents' empowerment in ecotourism development projects

Among the key aspects of community participation in tourism development is the empowerment of the people to enable them to participate in decisions that affect their community and their lives. Community development involves empowerment of residents by providing them with the skills they need to make changes in their own lives and their communities (Korten, 1990). With specific reference to Ghana, CBEPs introduced support mechanisms to empower residents to participate effectively in the programme. Such support mechanisms were to improve the capacity of residents to plan and manage ecotourism development projects at the community level.

About 63.0 % of respondents agreed that funds were provided to residents to help them participate effectively in tourism development (Table 2). It was observed that, NCRC provided community leaders with money which enabled them to attend in-service training in bush fire prevention and sanitation. It was also revealed that funds were given to some of the Tourism Management Committee (TMC) members and individuals in the communities by UNDP to attend training workshops in tree planting and also, funds to buy mango seedlings for cultivation. One of the interviewees said: "*NCRC helps in capacity building, organise workshops to equip us with financial management and also offer technical advice. UNDP were giving us money to attend workshops but at the moment, it is not active. Landowners, at the end of every quarter of the year, are given part of the revenue from the project. Again* Hotel, Catering and Tourism Training Centre (*HOTCATT) in Ghana gave us training on how to receive visitors and how to present our local dishes to meet the taste of visitors.*"

At every quarter of the year, proceeds from the projects at Boabeng-Fiema for example, were shared among communities that surround the sanctuary. However, according to respondents, the money received from the project at a quarter of the year was woefully inadequate for any meaningful development in the communities. This made it necessary for management of the projects to halt 'quarterly sharing' of proceeds till the end of the year before they would decide whether to use the money accrued to develop at least one of the communities or use it to buy a bus that will carry tourists to and from the nearby towns. Meanwhile, at Tanoboase, proceeds from the tourism project were used to fund needy children's education, repair football field and the street lights in the community. Affected land owners in the study area were also given a share of the proceeds from the project.

Closely related to financial support to residents is the source of funding for the tourism projects. It was observed during the study that, funds were provided for the development of the ecotourism projects through levies. Moreover, the projects were funded through penalties or fines from those arrested for encroaching the forest reserves. Other sources of funding were through annual harvests and donations from individuals, groups and organizations.

Capacity building was identified as one of the modes through which residents were empowered to participate

Table 2. Ways in which residents were empowered to participate in ecotourism projects

Techniques	% in agreement	% not sure	% in disagreement
Provision of funds	63.0	2.0	35.0
Capacity building	62.0	8.0	30.0
Conflict resolution	87.0	2.0	11.0

in the CBEPs in the study area. This is a process and means through which a country, its people and organisation develop skills necessary to manage their resources in a sustainable manner (GubblesandKoss, 2000). The purpose of the capacity building as a component of the project was to strengthen the institutional structures in the communities to deal with the task of tourism development. At the institutional level, it was meant to promote decentralised management of tourism.

About 62.0% of respondents agreed that, the programme offered capacity building to local people especially residents who were desirous of venturing into ecotourism development (Table 2). The reason is that, series of workshops were organized for residents in the communities. For instance, NCRC organized workshops for the Tourism Management Committee members in financial accounting. That is, how to save money and what to do with the money accrued from the tourism projects. More so, courses were organised for residents on how to manage the resources in the forest reserves, and again, to train tour guides for the ecotourism projects in the communities. Workshops were also organized by UNDP to train residents in tree planting. Likewise, Netherlands Development Organization trained residents to plant trees like *mangifera indica,* popularly known as ‘mango tree’ and *terminalia glaucescens,* which is locally called *framo,* to serve as food for the animals in the forest reserves.

Skill training is one of the means of meeting the human resource capacity needs of any organization. This can be used to build the skills and knowledge as well as attitudes of local people in ecotourism development. As a result, it was initiated by the project to increase the quality of service provision and also raise ecotourism awareness. It was observed during the study that, in order to improve service quality, Hotel, Catering and Tourism Training Centre (HOTCATT) initiated skills development programme for community members on standards for service provision (how to receive visitors and also package the local dishes for tourists) and the protection of the communities’ natural assets. This was also confirmed by a resident at Tanoboase during the in-depth interview. He said: *“NCRC gives in-service training to us on how to manage the projects. I have been trained in data reporting, first aid, management and governance, private sector community partnership and tourism development plan. I sometimes give talks to the community on the benefits of tourism”*

This finding is consistent with that of Holland et al. (2003) study of heritage trails in the Czech Republic, where beneficiary communities were involved in capacity building through training in tourism skills. Paul (1987) observes that local people who participate in tourism projects need training and support to facilitate the development of the projects. This is also in line with Friedmann’s (1992) observation that empowerment of local people to participate in development projects could lead to both their economic and socio-political well-being. The empowerment of community members helps them to assume key roles and responsibilities in the management of ecotourism projects.

Eighty-seven percent of respondents were in agreement that residents, especially the community leaders, were taught how to resolve conflicts relating to tourism projects in the communities (Table 2). The in-depth interview conducted also revealed that most of the project’s management committee members attended workshops on conflict management. Efforts to provide community members with conflict resolution skills may have been informed by lessons from other projects in other countries. Abraham and Plateau (2001) have reported on the time consumed by community leaders in Kibera, a Nairobi slum, in protracted mediation to settle interpersonal conflicts. This was linked to the fact that community leaders lacked training in conflict resolution. Conflicts in the communities were often settled by the traditional authorities or the community leaders and in some few cases, judiciary. These were confirmed during the in-depth interview with some of the opinion leaders in the communities; *“Conflicts in this community may include herbs taken from the forest by local people, destruction of farms by monkeys in the forest and embezzlement of money by some leaders of the project. To resolve it, offenders are asked to refund the money embezzled. The Chief sometimes settles conflicts through re-allocation of land to the affected people whose lands have been taken by the projects*.”

The in-depth interview asserts that, the communities involved in the projects were empowered through funding, capacity building and conflict resolution skills. As confirmed by this study, empowerment involves getting rid of the barriers that work against the local communities and building their capacity, providing them with funds and conflict resolution skills to engage effectively in tourism development (Arnstein, 1969; Fariborz and Ma’of, 2008;

Table 3. Means of Empowerment by Socio-Demographic Characteristics of Respondents.

Individual Characteristics	Funding				Capacity Building			Conflict Resolution		
	N	Mean	Test Stats.	p-value	Mean	Test Stats.	p-value	Mean	Test Stats.	p-value
Sex										
Male	171	2.61	t-test	0.000*	2.63	t-test	0.000*	1.98	t-test	0.699
Female	97	2.18	2.017		2.27	2.080		1.97	0.057	
Age										
<34	109	2.37	Anova	0.567	2.52	Anova	0.355	2.05	Anova	
34-54	118	2.47	0.746		2.39	1.308		1.93	1.492	0.205
<54	41	2.40			2.45			1.71		
Community										
Tanoboase	122	2.55[a]	Anova	0.029*	2.54	Anova	0.084	1.93	Anova	
Boabeng	50	1.88[ab]	3.604		2.12	2.504		2.00	0.165	0.848
Fiema	96	2.63[b]			2.64			1.97		

N = 268. *The mean difference is significant at the 0.05 level; a and b indicate the difference in mean scores of the dependent variables across the individual characteristics.

Pretty, 1995; Tosun, 2000; ZhaoandRitchie, 2007).

Means of empowerment by respondents' socio-demographic characteristics

The mean responses of the ways in which residents were empowered by sex, age and community are presented in Table 3. Both t-test and one-way analysis of variance (ANOVA) were performed in order to assess the differences in the manner in which residents were empowered to participate in the projects. T-test statistical technique was employed on socio-demographic variable that was measured along a dichotomous scale such as sex (1 = male, 2 = female) of respondents. Other characteristics of respondents like age and community of residents which were measured along interval scale differences, were tested using one-way analysis of variance. It was hypothesized that; there is no significant difference in methods of empowerment among the socio-demographic characteristics (sex, age and community) of residents in the projects.

Pearce (1992) observes that development of tourism tends to be sex-selective, thereby altering the composition of the population as well as its size in the destination area. The t-test results (Table 3) show that there was a significant statistical difference between sex of respondents and funding (p-value 0.000) of tourism projects, and capacity building (p-value 0.000) of residents in the destination communities. There was however no significant difference between sex of respondents and conflict resolution (p-value 0.699) in the study area. Female respondents expressed high levels of agreement (funding: mean = 2.18, capacity building: mean = 2.27), whilst their male counterparts expressed their doubts (funding: mean = 2.61, capacity building: mean = 2.63) as to whether residents were empowered through funding and capacity building. The involvement of residents, especially women, in productive enterprises could lead to both their economic and socio-political well-being and empowerment (Friedmann, 1992). Responses from both males (mean = 1.98) and females (mean = 1.97) confirm that residents, were trained in how to resolve ecotourism-related conflicts in their various communities as shown in Table 3.

Gilbert and Clarke (1997) observe that young and the middle aged are in favour of ecotourism development in their communities. The one-way ANOVA revealed that there was no significant difference in the provision of funds (p-value 0.567), capacity building (p-value 0.355), and conflict resolution skills (p-value 0.205) with respect to respondents' age in the study area.

Responses from those aged ≤ 39 years indicated that residents benefited from community empowerment programmes such as funding (mean = 2.37) and conflict resolution skills (mean = 2.05) but expressed their doubts as to whether residents received training in capacity building (mean = 2.52). The reason being that many of the people aged ≤ 39 years might not have been around at the time the training was going on, or were in the communities but did not see that people were being trained. However, respondents found within 40 - 49 years age brackets agreed that residents were empowered through funding (mean = 2.47), capacity building (mean = 2.39) and conflict resolution skills (mean = 1.93). This was confirmed by respondents aged 50 years and above as shown in Table 3.

Place of residence in relation to area of ecotourism concentration is known to affect people's perception and attitude towards ecotourism development. The impacts of ecotourism on people residing in ecotourism concentrated areas are found to be so great that, some methods need to be taken to reassure the safety of local residents in destination communities (Bahaire and Elliot-White, 1999).

The one-way ANOVA revealed that there was a significant difference among the communities and funding (p-value 0.029) of ecotourism projects. There was however no significant difference among the communities and capacity building (p-value 0.084), and conflict resolution (p-value 0.848).

The results show that whilst respondents at Boabeng (community directly affected by the ecotourism project) were in agreement that residents were compensated by providing them with funds (mean = 1.88) and training in capacity building (mean = 2.12), their counterparts at Tanoboase and Fiema were divided as to whether people in their communities were provided with funds (Tanoboase: mean = 2.55, Fiema: mean = 2.63) and training in capacity building (Tanoboase: mean = 2.54, Fiema: mean = 2.64). The reason for the divided opinion among the communities may be due to the fact that the negative impact of the ecotourism project is felt by the people at Boabeng more than the rest of the communities. This finding confirms Bahaire and Elliot-White (1999) report that place of residence in relation to area of tourism concentration affects the local people.

It was observed that at Boabeng, residents were staying with the monkeys in their homes. Therefore, it was not surprising when the local people at Boabeng-Fiema Monkey Sanctuary project site received funds to build shrines, boreholes, visitor centres and internet café. But it is envisaged that, sooner or later, if measures are not put in place to compensate the local people adequately, they will run out of patience, looking at the inconveniences created by the monkeys to them and the inability of the management to provide the basic needs of the communities like senior high school, health centres, good roads and jobs to the youths.

Conclusions

The findings of the study led to the conclusion that residents at both project sites (Tano Sacred Grove at Tanoboase and Boabeng-Fiema Monkey Sanctuary at Boabeng and Fiema) were provided with funds, capacity building and conflict resolution skills all of which have influence on local people's participation in the projects. Effective management of the projects is very crucial if the communities and indeed all stakeholders are given the necessary training to enable them participate fully in the CBEPs. The statistical analysis done supports the null hypothesis set. That is, there is no significant difference in ways of empowerment among the socio-demographic characteristics of residents in the projects. The implication is that socio-demographic characteristics of residents did not significantly have impact on the way they were empowered.

The authorities need to integrate the communities fully and recognize them as partners in the management of the projects by not only asking for their views when making decisions but also putting their ideas into action for the benefit of the projects.

For communities to have more knowledge in ecotourism development, they should seek assistance of experts from organisations and institutions like Ghana Wildlife Department, GTA, and NGOs. Similarly, to rekindle students' interest in ecotourism and tertiary education, the authorities in tertiary institutions such as the universities and the polytechnics around the tourist sites, should encourage their students to embark on educa-tional tour to these sites at least once every academic year. The communities could join resources in the protection of attractions, training of human resources for ecotourism development, construction of roads, joint promotion, and research which relates to impact assess-ment and monitoring of communities' attitude towards ecotourism development. Collaboration would enable the communities to enjoy economies of scale as well as gaining recognition and support from government and international donors.

Since local people can be empowered through access to credit, efforts should be made to address it. Most of the community members would like to sell food and drinks to the visitors. Unfortunately, they do not have the initial capital for such establishments. In order to empower them to engage in this business, government through the rural banks in the area should initiate a special tourism-related micro-finance scheme for the communities. The interest rate on the loan facility should be affordable to make it attractive to ordinary people in the communities.

Development of every economy relies on its infrastructural base. As a result, government should come to the aid of the communities to help improve security, drinking water, sanitation, roads, education and health care facilities in the area.

Conflict of interest

The author did not declare any conflict of interest.

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Review

Assessment of land use/cover impacts on runoff and sediment yield using hydrologic models: A review

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Human activities have modified the environment over the years. Urbanization, agriculture lumbering, mining and other land uses have substantially altered the Earth's surface. Land use and the resultant change in land cover have significant effects on ecological, environmental and hydrologic systems and processes. An understanding of past and present land-cover change, together with an analysis of potential future change, is necessary for proper management; thus, the need for models. Hydrologic models are primarily used for hydrologic prediction and for understanding hydrologic processes. With recent technological advances, technological based tools such as GIS are incorporated into hydrologic models for assessing the impacts of various land use/cover. Hydrologic models incorporated with GIS can be used to project future land uses/cover to provide an increased clarity, probability or likelihood of potential consequences on ecosystem services such as biodiversity, water quality and climate. This paper critically examines land use/cover, effects of impacts of land use/cover and the use of hydrologic models to assess the impact of land us/cover on runoff and sediment yield. Hence it calls for their use by watershed managers and decision maker as management tool especially in developing countries.

Key words: Land use, land cover, runoff, sediment yield, hydrologic models.

INTRODUCTION

Human activities have modified the environment over the years. The world has changed dramatically especially after the industrial revolution. While Earth's landmass has remained essentially static over that time, the human demands on it have grown and changed, impacting the land and its flora and fauna in numerous ways. Land use change in Africa included the conversion of 75 million hectares of forest to Agriculture and pasture between the years 1990 and 2010, a rate second only to that in South America (FAO, 2010).

Rapidly changing human activity within the natural environment can put huge pressures on the natural environment's ability to adapt and change. These may be further complicated by the influences of climate change, such as extremes in weather. Maintaining a balance between urban development and natural systems is essential to a safe ecosystem.

Agriculture and urbanization are major forms or drivers of changes in land uses/land cover (Fisher and Unwin, 2005). Throughout history, agriculture has had a significant effect on the world's landscape. Agricultural production has caused greater environmental change to the biosphere

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than any other land use (Gliessman, 1998). Until the industrial revolution of the early to mid-1900, farming practices were relatively environmentally friendly. The modernization of farming practices around the 1950's resulted in extreme increases in productivity often to the detriment of environmental quality. These conventional agricultural practices, however, have numerous long-term ecological impacts such as soil degradation, habitat alteration, water quality impacts, species composition impacts and adverse effects of irrigation.

Urbanization is another major driver of land use/cover. Urban population has been increasing significantly in the last two centuries, since industrial revolution took place. The consequences of this process in curs great changes of the natural environment. Urbanization process tends to substitute natural vegetation for impervious surfaces, thus reducing infiltration. It also tends to eliminate natural detention ponds, to rectify river courses, among other actions, that greatly interfere with superficial flows (Miguez and Magalhaes, 2010). The conversion or transformation of land uses from one form to another has a resultant effect on the ecosystem, which may be immediate or remote. Conversion of agricultural, vegetation and wetlands to urban areas and the unattended population growth usually come with a vast increase in impervious surfaces, consumption and utilization of goods, and building on natural drainages (USEPA, 2001; Ifatimehin et al., 2009).

The hydrologic cycle involves complex interaction and processes among climate, landuse, vegetation cover density, erosion rates and sediment loads in watershed. The complexity and uncertainty in natural systems like hydrologic cycle make them difficult to understand, predict and manage. The need for more scientifically sound analyses has led to the development of hydrologic models. Hydrological models provide a framework to conceptualize and investigate the relationships between climate, human activities (e.g., land use change) and water resources (Legesse et al., 2003).

The resultant effects of these land changes and transformation can be classified into ecological and environmental, hydrologic and socio economic. This paper examines the different landuses, the consequences of land use/land cover changes and evaluates the use of hydrologic models in determining the impacts of landuse/cover on runoff and sediment yield. Such hydrologic models include SWAT, WEPP, AnnAGNPS, TOPMODEL, MIKE-SHE, DRAINMOD, etc.

DEFINITION OF LAND USE AND LAND COVER

The terms land cover and land uses are often confused and used inappropriately. Land use can be defined as a series of activities undertaken to produce one or more goods or services. Hence, land use is based on function, the purpose for which the land is being used (FAO, 1997). IPCC (2001) defined the term land use to cover the entire range of direct management activities that affect agricultural soils, result in land-use change, alter forest management, or affect the long-term storage of carbon-containing products. All such activities are implicitly human-induced. Examples of land uses are agriculture, forestry, recreation, etc.

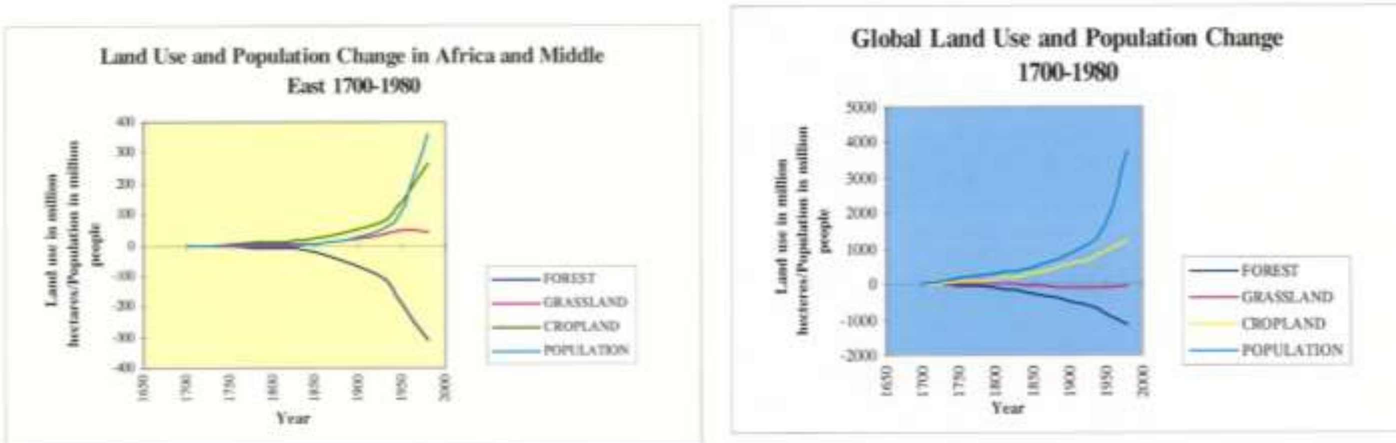
Land cover is the observed physical cover, as seen from the ground or through remote sensing, including the vegetation (natural or planted) and human constructions (buildings, roads, etc.) which cover the earth's surface (FAO, 1997). Water, ice or sand surfaces are examples of land cover.

This means that the cover on a land points to the kind of activities or uses on the land. For example, agricultural practices are usually carried out in a forested or vegetated land, while an urban area is usually filled with impervious area due to vegetation removal. Land cover information is captured using field survey or analysis of remotely sensed imagery. Land cover maps provide information to help managers best understand the current landscape, assess urban growth, model water quality issues, predict and assess impacts from floods and storm surges, track wetland losses and potential impacts from sea level rise, prioritize areas for conservation efforts, and compare land cover changes with effects in the environment or to connections in socioeconomic changes such as increasing population (www.http://oceanservice.noaa.gov/landuse, 2009). To see change over time, land cover maps for several different years are needed. With this information, managers can evaluate past management decisions as well as gain insight into the possible effects of their current decisions before they are implemented.

Figure 1 shows data on land use and population change for regional (Africa and Middle East) and global scale in the last 300 years for three main land use types. Figure 1a and b depict these changes. From Figure 1, it is seen that as population increases, there is an increase in cropland and grassland land uses while there is a decrease in forest land cover. These changes in land use/land cover have effects on the ecosystem.

LAND COVER/LAND USE CLASSIFICATION SYSTEM

Many classification systems are being used throughout the world. However, there is no single internationally accepted land cover classification system (FAO, 1997). Different organizations set up their classifications differently, because they are interested in different aspects of land use and land cover (CARA, 2006). General constraints for building land cover/land use classification are linked with general constraints of non-overlapping and completeness, textural rules and specific constraints linked with time of observation and data collection (Duhamel, 2012.). However, rules for land



(a) **(b)**

Figure 1. Land use and population change for regional (Africa and Middle East) and Global scale (Source: http://www.rri.wvu.edu/WebBook/Briassoulis/figure1.1.jpg).

use/land cover classification system can be obtained in Duhamel (2012) and (FAO, 1997).

Many land use/land cover classifications are based on a system developed by Anderson et al. (1976). Anderson's (1976) classification combines information on land use and land cover, placing all land into one of 9 level-I categories:

Anderson level-I categories
1. Urban or built up land; 2. Agricultural land; 3. Rangeland; 4. Forest land; 5. Water; 6. Wetland; 7. Barren land; 8. Tundra; 9. Perennial snow or ice.

Subcategories make finer distinctions. For example, level-I category 1 (urban land) could be divided into level-II subcategories such as:

One possible set of level-II subcategories
11. Low density residential; 12. Medium density residential; 13. High density residential; 14. Commercial; 15. Industrial; 16. Institutional; 17. Extractive; 18. Open urban land, including parks and golf courses.

Each of these subcategories also can be divided. For example, level-II subcategory 14 (Commercial) could be divided to distinguish between office buildings and shopping malls, or to distinguish among commercial buildings associated with different industries (retail, health care, etc.).

EFFECTS OF LAND USES/COVER CHANGES

Conversion of a land cover has its accompanying effects and impacts, of which in most cases negative and detrimental to the ecosystem. Analyzing land cover change is important because surface changes affect a wide variety of ecological processes. Hence the effects of land use/land cover are broadly classified into ecological and environmental, hydrological and socio economic effects.

Ecology and environmental impacts

The impacts of land use changes have received considerable attention from ecologists, particularly with respect to effects on aquatic ecosystems and biodiversity (Turner et al., 2001). According to Wu (2008), land use change is arguably the most pervasive socioeconomic force driving changes and degradation of ecosystems. Briassoulis (2013) classified the environmental impacts of land use/land cover at large (global) scale, regional scale and local level.

At global scale, environmental impacts include land degradation and desertification, biodiversity loss, habitat destruction and species transfer. Species such as the Upland Sandpiper have drastically declined in regions where native grasslands have been lost (Kirsch and Higgins, 1976).

At regional level, the environmental impacts of land use change are equally significant and felt. Its impacts include eutrophication of water bodies, acidification of aquatic and terrestrial ecosystems, floods, soil nitrate pollution, land degradation and desertification, groundwater pollution, marine and coastal pollution and many more are environmental alterations that follow either directly or indirectly from land use changes.

Finally, at the lower spatial level, which is mainly caused by urbanization, industrialization and development, land use/land change impacts include changes in the hydrological balance of the area, increase in the risk of floods and landslides, air pollution, water pollution, etc. Others are soil erosion, sedimentation, soil and groundwater contamination and salinization, extinction of indigenous species, marine and aquatic pollution of local water bodies, coastal erosion and pollution.

Hydrology

Land use change and cover have a strong impact on water resources both in terms of their quantity, quality and increased variability of hydrological components like rainfall, etc. Land-use change alters runoff patterns, change stream flows, and increase the likelihood of flood events. Land use changes in a watershed can impact water supply by altering hydrological processes such as infiltration, groundwater recharge, base flow and runoff. For instance, converting a forested watershed to a commercial or highly densely populated area may results in increased surface runoff and surface erosion rates.

Socio-economic impacts

In classical economics, land is one of the factors of production. Hence, land use is the backbone of agricultural economies and it provides substantial economic and social benefits (Wu, 2008). Land use change, however, does not come without costs. For instance, conversion of farmland and forests to urban development reduces the amount of lands available for food and timber production. Also, it may lead to reduction in land quality through soil erosion, salinization, desertification, and other soil degradations. Also, the conversion of one land cover to another diminishes the aesthetic value of nature.

APPLICATION OF HYDROLOGIC MODELS ON THE IMPACTS OF LAND USE CHANGE ON DISCHARGE AND SEDIMENT YIELD

Hydrologic models are simplified, conceptual representations of a part of the hydrologic cycle. They are primarily used for hydrologic prediction and for understanding hydrologic processes. Developments in computer technology have revolutionized the study of hydrologic systems.

An integrated landscape model can potentially extrapolate from management practices and land use pattern to determine potential environmental impacts (Turner et al., 2001). The usefulness of hydrologic models for environmental management is explained with a focus of prediction uncertainty. The prediction ability of these models makes them suitable as management tool for planning and decision making in our watershed. Thus, the development of an integrated approach that can simulate and assess land use changes, land use patterns and their effects on hydrological processes at the watershed level is crucial to land use and water resource planning and management (Lin et al., 2006). Numerous studies have developed modeling approaches to simulate the pattern and consequences of land use changes. Different types of models are used to explore land use changes. A review of some hydrologic model in this study includes SWAT, WEPP (GEOWEPP), AnnAGNPS, DRAINMOD, MIKE-SHE and TOPMODEL. Table 1 shows the application of some hydrologic model on different land scenarios and the results showing the impacts of land use change scenario as predicted by the hydrologic models.

Model performance

Hydrological models are usually evaluated using statistical analysis. They show relationship between simulated or predicted values and measured or observed value. They tell us how well the hydrologic model predicts or performs in simulating a process. The evaluation of hydrologic model behavior and performance is commonly made and reported through comparisons of simulated and observed variables (Krause et al., 2005). In this review, models were evaluated using Pearson's correlation coefficient (r) and coefficient of determination (R^2), Nash-Sutcliffe efficiency (NSE), Percent Bias (PBIAS) or Relative Errorand Root Mean Square Error (RMSE).

Pearson's correlation coefficient (r) and coefficient of determination (R^2) describe the degree of collinearity between simulated and measured data. Correlation coefficient ranges from -1 to 1 while coefficient of determination ranges from 0 to 1.

In general, model simulation can be judged as satisfactory if NSE > 0.50 and RMSE< 0.70, and if PBIAS ± 25% for stream flow, PBIAS ± 55% for sediment (Moriasi et al., 2007).

CONCLUSION AND RECOMMENDATION

As the global human population grows and its consumption patterns change, additional land will be needed for living space and agricultural production. This will result in land use/and cover change. It should also be noted that changes in land cover and land uses has it attendant problems and effects; hence the need for proper management. However, in trying to know how different changes in land uses and cover will work, models can be employed. Models are used to predict or forecast future configurations of land use patterns under various scenarios. Hydrologic models can play an instrumental role in impact assessment of past or future activities in the environmental and/or the socio-economic spheres. Developments in computer technology have

Table 1. Application of hydrologic models used to predict land use/cover change effects on discharge and sediment yield in different watershed across the world.

Authors	Study area and size	Model	Model performance	Land use change scenarios	Results
Zhaohua et al. (2008)	WS80 on the SEF, Berkeley county, south Carolina. 160 ha	DRAIN MOD MIKE SHE	Outflow (Calibration) R^2 = 0.95, E = 0.94 Average daily outflow Simulated =1.94mm/day, Observed = 2.01 mm/day Outflow (Calibration) R^2 = 0.98, E = 0.96 Average daily outflow Simulated =2.04mm/day, Observed = 2.01 mm/day	Four land use scenarios of converting forested watershed to varying proportions of croplands: 30, 40, 50 and 100%.	The results from the scenario analysis of land use change showed that the outflow was affected by converting forested land to cropland, and proportionally increased with an increase in the proportion (0.0-1.0) of cropland area at an average rate of 0.3 from MIKE HE and 0.35 from DRAINMOD during the three year period. Also, annual outflow can be increased by 64-69mm for a conversion of the forested land in the uplands on the watershed to cropland, and by 113-122 mm for a complete watershed conversion.
Gumingoga (2010)	Gilgel River Basin, Ethiopia	TOP MODEL	Discharge (Calibration) NSE = 0.805, RVE = 6.1% Discharge (validation) NSE = 0.75, RVE=-4%	Three land use in the watershed are agricultural, forest and shrubland for 1973, 1986 and 2001.	Results showed that the maximum peakflow from agricultural land increased by 51% from 1973-1986 and 44% between 1986 and 2001. Annual runoff volume increased by 12% between 1986 and 2001 which corresponds to increases in agricultural land from 1973-2001. From 1973 -1986 and from 1986-2001, forest and shrubland decreased in maximum peakflow by 29%. The annual runoff volume also decreased by 36% from 1973-1986 and 34% from 1986-2001.
Lopez et al. (1998)	Guadiana watershed in Puerto Rico.	RUSLE with GIS	R^2 = 0.78 Measured suspended sediment discharge = 17649Mg/yr	Six land use scenarios were evaluated: Bare soil, open canopy, agriculture, pasture, dense urban, closed canopy forest and dense urban	Results showed that Bare soil produced the highest erosion rate with 534Mg/ha/yr, followed by open canopy forest with 26 Mg/ha/yr, Agriculture with 22 Mg/ha/yr, pasture with 17Mg/ha/yr, less dense urban with 15 Mg/ha/yr, closed canopy forest with 7 Mg/ha/yr and dense urban 1 Mg/ha/yr. Also, simulations of different land use configurations indicate that reforestation of 5% of the watershed with the highest erosion rates would decrease basin wide erosion by 20%. If the entire watershed were reforested, soil erosion would decrease by 37%.

Table 1. Contd

Zyl and Lorentz (2003)	Weatherely catchment, South Africa, <10 km^2	ACRU	Sediment yield R^2=0.599 Total monthly sediment Simulated=453.47 Kg/ha, Observed=364.72 Kg/ha	Two land uses of the study area rangeland, and arable land	Results show that both models predicted a small increase in sediment yield when land in a pristine condition (natural erosion) was utilized for animal production, but a dramatic increase was predicted when rangeland was converted to arable land under conventional cultivation practices.
		WEPP	Sediment yield R^2 =0.5059 Total monthly sediment Simulated= 395.46 Kg/ha, Observed=364.72 Kg/ha		
Ozan and Thanos (2009)	South Amana Sub-Watershed (SASW), 26 km^2	WEPP	Water discharge R^2=0.84 Sediment discharge R^2 = 0.93 Average annual soil erosion Measured = 5288 tons/yr Predicted=5004 tons/yr Average annual discharge Measured=7647915m^3/yr Predicted=5918467 m^3/yr	Four major land uses of SASW are Brome grass fall till corn–no till bean (FTC-NTB), no till bean–spring till corn (NTB-STC) and no till corn–fall till bean (NTC-FTB)	Brome grass turned out the least erosion (0.6 t/ha/yr), followed by (5.2 t/ha/yr) , FTC-NTB (11.0 t/ha/yr), and NTC-FTB gave the highest erosion rate of 21.1 t/ha/yr.
Yuksel et al. (2001)	Kahramanmaras region, Turkey. 48.39 ha	WEPP	Average sediment discharge= 44.9 ton/yr Runoff=9.26mm	Three land use of the watershed were evaluated: Agricultural lands, Rangelands and Forestlands	The results indicated that the highest sediment yield per unit area produced from agricultural lands (23.95ton/ha/yr), and followed by rangelands (4.69 ton/ha/yr) and forest lands(1.32 ton/ha/yr).

Table 1. Contd

Lizhong Hua et al. (2012)	Yangtze River, China. 4184 km^2	AnnAGNPS	Runoff (Calibration) NSE = 0.01 , R^2 = 0.94, RE = 0.01 Observed = 81.97 mm Simulated = 82.05 mm Runoff (Validation) NSE = 0.93 , R^2 = 0.93, RE = -0.06 Observed = 61.72mm Simulated = 58.08mm Sediment yield (Validation) RE= 0.18 Average annual observed = 1.09×10^6 t/yr, Average annual simulated = 1.29×10^6 t/yr	Three land scenarios were evaluated: Forestland, shrub forestland and grassland.	The results showed that the forestland, shrub forestland and higher coverage grassland had low erosion amounts. The sloping land and lower coverage grassland covered 22% and 5% of the total watershed area, respectively, but their erosion amount accounted for 56% (363.328 $\times10^4$ t/yr) and 11% (71.368 $\times10^4$ t/yr) of the watershed total.
Ogwo et al. (2013)	Upper Ebonyi watershed, Enugu State. 250.89 ha	A*nn*AGNPS	Streamflow calibration R^2 = 0.9341 Mean daily Stream flow observed=0.565 m^3/s Predicted=0.394 m^3/s Sediment yield calibration R^2 = 0.7066 Mean daily sediment yield observed=9771.13kg/day, Predicted=23649.4kg/day Streamflow validation R^2 = 0.9901 Mean daily stream flow Observed=0.67m^3/s, Predicted=0.28 m^3/s Sediment yield validation R^2 = 0.9675 Mean daily sediment yield Observed=49150.2kg/day, Predicted=15393.2kg/day	Six land scenarios were evaluated: fallow (bare), cropland, forest, pasture, rangeland and tillage.	The results showed that forest predicted least sediment yield (1181.65 Mg/yr), while fallow (bare soil) predicted the most sediment (11690.32 Mg/yr).

Table 1. Contd

Alibuyog et al. (2009)	Manupali River watershed. 600 km^2	SWAT	Lower Kiluya sub watershed Weekly mean runoff volume R^2 =0.82, NSE = 0.82 Observed = 3809 m^3, Simulated = 4098 m^3 Weekly mean sediment yield R^2 =0.82, NSE = 0.80 Observed = 1.95 tons, Simulated = 2.09 tons	Four land use change scenarios, which are agricultural, pasture/grass land, forest and foot path	Simulation result of land use change scenarios indicated that runoff volume and sediment yield increased by 3 to 14% and 200 to 273%, respectively, when 50% of the pasture area and grasslands is converted to cultivated agricultural lands. Consequently, this results in a decrease of baseflow of 2.8 to 3.3%, with the higher value indicating a condition of the watershed without soil conservation intervention. Moreover, an increase of 15 to 32% in runoff volume occurs when the whole subwatershed is converted to agricultural land.
Shao et al. (2012)	Laurentian Great Lakes Basin with 4 sub watershed St. Joseph River (7097.36 km^2) St. Mary (1649.5 km^2) Peshtigo River watershed (450 km^2) and the Cattaraugus Creek (508.96 km^2)	SWAT	Average annual sediment yields Simulated St. Joseph River = 0.56 tons/ha/yr St. Mary River = 0.58 tons/ha/yr Peshtigo River 0.12 tons/ha/yr Cattaraugus Creek = 4.4 tons/ha/yr R^2 values were 0.76, 0.80, 0.72, and 0.81 respectively.	The baseline and two scenarios were studied. Two simulated scenarios are to convert all "other" agricultural row crop types (that is, sorghum) to corn fields and switch the current/baseline crop rotation into continuous corn. The second scenario was to further expand the corn planting to hay/pasture fields.	The average annual sediment yields increased 7−42% for different watersheds for the first scenario while the average annual sediment yields increased 33–127% compared to the baseline conditions for the other scenario
Phan et al. (2011)	Song Cau Catchment in Northern Vietnam, 2940 km^2	SWAT	Streamflow (Calibration) NSE = 0.822, RSR = 0.438, PBIAS = -1.587% Streamflow (Validation) NSE = 0.767, RSR = 0.425, PBIAS = 5.928% Sediment (Calibration) NSE = 0.66, PBIAS = -36.127% Sediment (Validation) NSE = 0.69, PBIAS = -26.443%	The land use were varied among agricultural land/pasture land, mixed forest/ pasture land, forest deciduous/ mixed forest and medium residential urban/ rice cultivation as scenario 1, 2, 3 and 4	All scenarios' simulations resulted in a decrease of soil losses and sediment yield comparing to the current land use status. Also, results showed that cultivation of pasture with forest-mixed resulted in the highest mean annual reduction in sediment yields (-6.08%), and 8.31% increase of stream flows in dry season.

Table 1. Contd

Pikounis et al. (2003)	Pinios river basin, 2976 km^2, Thessaly plain, central Greece.	SWAT	Mean runoff (Calibration) R = 0.90 Observed = 31.59mm RMSE = 16.30, NSE = 0.798 Mean runoff (Validation) R = 0.90, RMSE = 23.1%, NSE = 0.763 Observed = 43.19 mm	Three land use change scenarios were evaluated and they are expansion of agricultural land, complete deforestation and expansion of urban areas.	The result shows that all three scenarios resulted in an increase in discharge during wet months and a decrease during dry periods. The deforestation scenario was the one that resulted in the greatest modification of total monthly runoff.
Mbonimpa et al. (2012)	Wisconsin, US	SWAT	Average monthly flow (Calibration) R^2 = 0.99, NSE=0.99 , Relative Error=3.1% Predicted = 20.02 mm Measured = 15.44 mm Mean monthly flow (Validation) Relative Error=17.7% Predicted = 15.44 mm Measured = 18.77 mm Mean monthly sediment loss (Validation) RE=30% Predicted = 0.01ton/ha, Measured = 0.01 ton/ha	Conversion of corn-soybean to corn-corn-soybean and conversion of corn-soybean to continuous corn	Simulations using SWAT indicated that conversion of corn-soybean to corn-corn-soybean would cause 11 and 2% increase in sediment yield and TP loss, respectively. The conversion of corn-soybean to continuous corn caused 55 and 35% increase in sediment yield and TP loss, respectively.

revolutionized the study of hydrologic systems. Many computer models have been developed for hydrologic modelling and water resources management applications. However, hydrologic models can be used to prescribe optimum patterns of land use for sustainable use of land resources and development. This gives us the predicted effects and impacts of a given land use using different scenarios. Hence, it is a recommended tool for proper watershed management, especially for developing countries.

Conflict of Interests

The authors did not declare any conflict of interest.

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