

Desk Review of Factors and Activities Influencing Landscape Degradation: Case Study of Kayelekera Village, Malawi

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Abstract The desk study research was conducted in order to evaluate the factors and activities influencing landscape degradation of Kayelekera village in Malawi. Upon extensive review of published articles, project reports and books several factors and human activities were noted to be the main factors and activities influencing landscape degradation. These factors include: poor agricultural practices (erosion, desertification); water pollution by human and industrial waste; air pollution caused by the human need to use energy for personal use and for industrial applications; extinction of animal and plant species caused by people converting natural ecosystems to managed agricultural ecosystems; Poverty and the need for development, population growth, natural resource consumption patterns, road network development, agriculture, fire, irrigation, uranium mining, deforestation, modernization, destructive effects of exploitation of natural resources (eg the uranium mining) have all played a role in landscape degradation of kayelekera. However, the study also looked at the strategies that can be employed to best manage and minimize landscape degradation of kayelekera. The suggested strategies are the use of environmental impact assessment (EIA), sustainable natural resource consumption patterns and inclusion of the communities.

Keywords Landscape; ecosystem; Degradation; Biodiversity

Introduction

Landscape is a system of varied ecosystems, often interspersed with human construction. It is a combination where the mix of local ecosystems or land uses is repeated in similar form over a wide area (local ecosystems recur), it is defined as an area of interaction between human culture and the non-human environment [1]. A major focus of landscape ecology is to infer how a system responds to its disturbance regime (natural or anthropogenic). Landscape disturbance has been variously defined as any relatively discrete event in space and time that disrupts ecosystem, community, or population structure and changes resources, substrate, or the physical environment" [2]. Disturbances are environmental changes that alter ecosystem structure and function. Disturbances within a landscape maybe as a result of natural or anthropogenic activities, this paper will focus on the anthropogenic activities that have influenced the changes of kayelekera landscape from the previous state of the village to the current state.

Kayelekera is located in northern Malawi, 52 km west (by road) of the provincial town of Karonga and 12km south of the main road that connects Karonga with the township of Chitipa to the west. It is a terrestrial ecosystem with few rivers within the ecosystem such as the Sere River. The people living in the community depend on agriculture, fishing and small scale business such as carpentry, selling of charcoal, fuel wood for a living, and the introduction of the uranium mining in 2009 helped most households in the surrounding communities to secure employment.



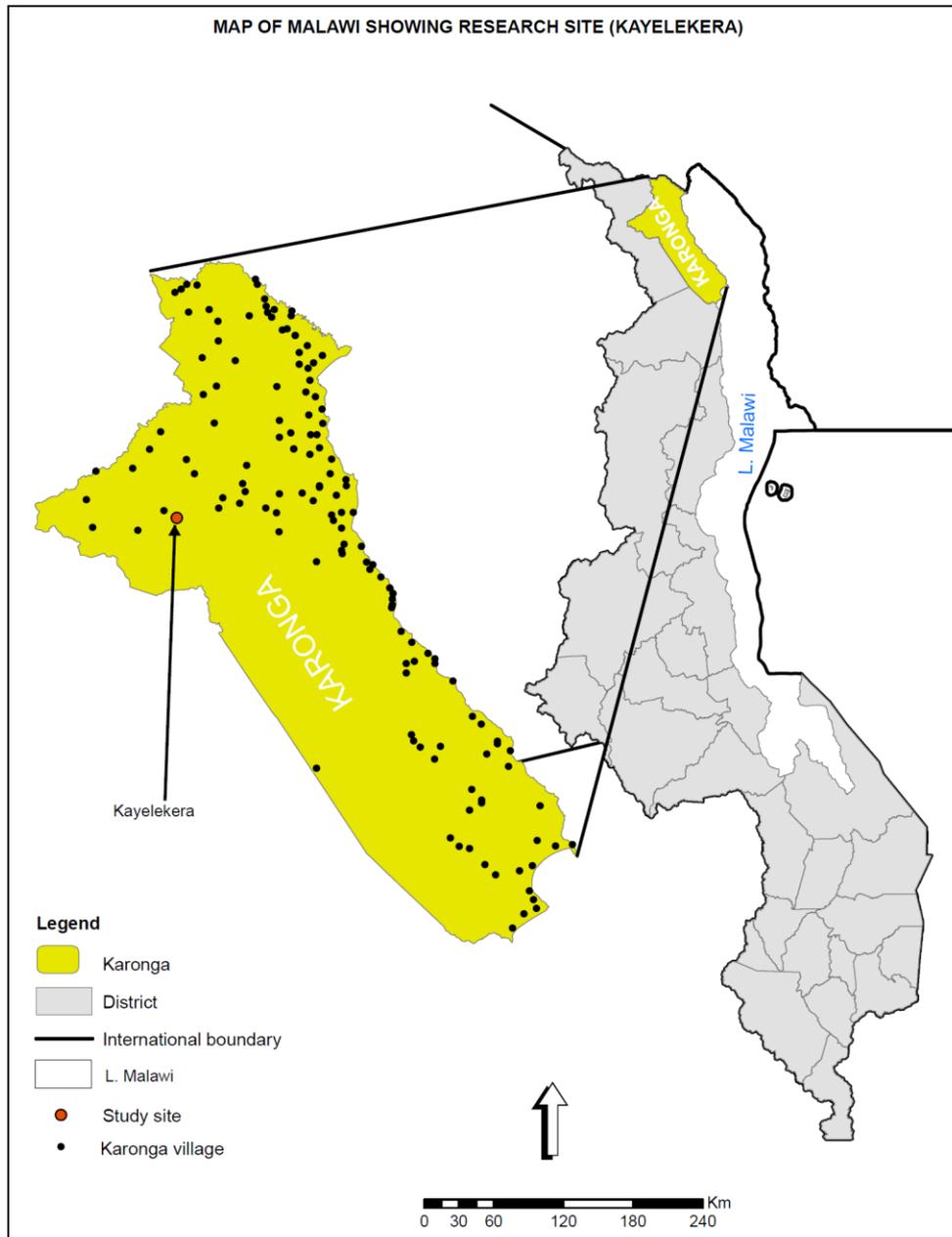


Figure 1: Map of Malawi showing the research study area, Kayelekera village

Source: Own survey data, March 2017

In the race for progress and prosperity the communities have disturbed the delicate balance of Nature and the two main dynamic processes within an ecosystem, recycling of chemical nutrients and the flow of energy. Human population have directly or indirectly modified the landscape of Karonga district furthermore altering the physical, chemical and biological processes of the ecosystem. These changes have disturbed a variety of ecosystem services that humans depend upon. These anthropogenic changes in the environment have caused significant loss of animal and plant diversity, leaving many niches empty and creating animal and plant communities dominated by invasive, exotic and weedier species. The aim of this paper is to better understand factors and human land-use activities influencing landscape degradation of Kayelekera village. Some of the notable human activities that are continuously contributing to the alteration of landscape are deforestation for charcoal burning, fuel wood, agriculture, irrigation, settlement, bush fires, mining (construction of a mining site), logging, damming rivers, intense grazing, floods, and bush fires.

In Malawi there has been minimal comprehensive studies to examining the factors contributing to landscape changes due to human activities and the ecological consequences of the landscape disturbance, hence forming the basis of this study. The main objective of this study research was to examine the factors and human land-use activities influencing landscape degradation in Kayelekera. The specific objective was to examine the ecological consequences of landscape disturbance of Kayelekera landscape degradation and further examine strategies that can be employed to best manage and minimize landscape degradation of Kayelekera.

Materials and Methods

A desk review was carried out to obtain existing information regarding the landscape changes in Kayelekera by conducting desk study review. Furthermore, ArcGIS and google earth was used to identify the geographical locations and landscape changes of the study area. Other sources of information for the research will include project reports, journals, and text books among others. Figure 1 below is a map showing the location of kayelekera village, the research study area.

Results and Discussion

a) Factors Contributing to Kayelekera Landscape Degradation Poverty

Kayelekera just like most places in Malawi is a growing economy, but a greater part of the population is still living below the poverty line. Poverty, forces the people in the area to depend on natural resources for energy (eg fuel wood), food, construction material, medicine, and fodder. Thus poverty forces the communities to trade-off long term sustainable resources for short term consumption of stocks since they depend entirely on the existing natural resources most communities around Kayelekera village are highly dependent on natural resources. This dependence on resources has and continues to deplete and degrade the ecosystem, affecting long-term food security and sustainable economic growth of the area has been seriously affected by land degradation and the changes in rainfall pattern due to these ecosystem changes.

Population Growth

The increased human population in Karonga and Chitipa is believed to have been swayed by the mining developments at kayelekera mining site, business, trade and agriculture activities. These populations induced activities have simplified and destroyed large portions of some parts of the Kayelekera natural ecosystems leaving behind fragments that have resulted into changes of the landscapes. High population densities are considered the greatest causes of biodiversity degradation since more land is cleared for settlement and in search of fertile areas to increase food production [3]. The mass clearing of the land for settlement has resulted in soil erosion and reduction in species composition and abundance. Due to the high population there is increased demand for indigenous plant resources for food, medicine, fodder, and fuel wood and construction material [4]. This coupled with unsustainable harvesting methods of plant resources, such as top rooting, tree felling and debarking have reduced their populations to non-sustainable levels. Wildlife has equally been threatened due to increased population in kayelekera since deforestation for cultivation and settlements destroys natural habitats for large animals. For as long as the population growth rate remains high, pressure on land for settlements, agriculture and resource use will be the biggest challenge in landscape conservation in this community.

Natural Resource Consumption Patterns

Continued increase in resource use and consumption of natural resources, including materials, energy and land in pursuit of economic development can have a multitude of environmental negative impacts and effects leading to ecological crisis and food security threats. Developmental activities contribute to habitat loss through conversion of arable land, wetlands and forests for road construction, urbanization and human settlements.

Road Network Development

Roads and other linear infrastructure are a major cause of habitat loss [5], fragmentation, and degradation and are abundant in most landscapes where there is human settlement and industrialization. Road infrastructure is important for society because it provides connectivity for people. However, linear infrastructure also exerts



significant negative effects on adjacent habitats, wildlife populations, communities, and ecosystem [6]. In Karonga and Chitipa coming up of the kayelekera mining came with a package of more road networks for easy accessibility to the mine and this caused more deforestation and degradation of the landscape through perforation, dissection. The image 2 and 3 below illustrates some of the landscape changes that have taken place in the Kayelekera landscapeeg the construction of various road networks. Hence development is somewhat responsible for the current unprecedented rate of biodiversity loss, pollution, fragmentation, and degradation of habitat across the landscape [7].



Figure 2: An image showing the road network in the research study area, Kayelekera village
Source: Wikipedia the free encyclopedia, Photo by Jessie Boylan taken near Kayelekera, Malawi.



Figure 3: A satellite image showing the road network for Kayelekera
Source: <https://www.googleearth.com/map>

b) Human Activities Influencing Landscape Changes of Kayelekera Poor Agricultural Practices

The earth is undergoing rapid landscape changes because of human actions. Humans have greatly impacted the rates of supply of the major nutrients that constrain the productivity, composition, and diversity of terrestrial ecosystems. The natural rates of nitrogen addition and phosphorus release to terrestrial ecosystems have been doubled, and atmospheric CO₂ concentrations have been increased to about 40% above preindustrial levels [8]. Soil calcium levels are declining in some ecosystems because of increased rates of leaching caused by acidic deposition [9]. The unregulated extensive use of fertilizers in agriculture by the smallholder farmers affect the phosphorus and nitrogen cycles hence the farmer impacts the phosphorus cycle mainly through the use of commercial synthetic fertilizers. Plants may not be able to utilize all of the phosphate fertilizer applied; as a consequence, much of it is lost from the land through the water run-off. The phosphate in the water is eventually precipitated as sediments at the bottom of the water body.

Fire

Through both active fire suppression and increased use of fire as a land clearing or management tool, the communities have regionally changed fire frequency [10], which is a major force structuring communities and ecosystems [11] the fire disturbances leads to drastic changes of the landscape by creating vacant space, which releases resources and alters species interaction.



Irrigation

Irrigation is being practiced in kayelekera primarily because it allows for increased productivity through more optimal timing of water application. Despite the increase in food security net increase in economic gains to farmers but it also have negative impacts such as the diversion of water for irrigation further reduces water supply downstream but it also causes water sharing conflicts among the community. A reduction in river base flow also reduces the dilution of municipal and industrial wastes added downstream posing pollution and health hazard [11]. Other negative impacts of these irrigation schemes are water logging and salinization of soils.

Uranium Mining

The constructed Kayelekera Uranium mine is an open cut mine near Karonga and Chitipa and is the country's largest mine. It is owned and operated by Australian mining company, Paladin Energy which received a license to develop the mine in 2007. The mine officially opened in 2009. The Kayelekera Uranium Mine is the first uranium mine in Malawi. It was operated by Australian company Paladin Energy Ltd. The government of Malawi offered the company a reduced regime of corporate and rent tax in exchange for a fifteen percent stake in the project. While the extraction of uranium is a dangerous activity that poses risks to the local community's health. The material is excavated from an open pit. This type of mining is particularly damaging to the environment because strategic minerals are often only available in small concentrations, which increases the amount of ore needed to be mined. When crushed, these rocks expose radioactive elements, asbestos-like minerals, and metallic dust [12]. During separation, residual rock slurries, which are mixtures of pulverized rock and liquid, are produced as tailings, toxic and radioactive elements from these liquids can leak into bedrock if not properly contained [9]. The environmental impact of these mining activities includes soil erosion, formation of sinkholes, loss of biodiversity, and contamination of soil, groundwater, surface water by chemicals from mining processes. In some cases, additional forest logging was done in the vicinity of mines to increase the available room for the storage of the created debris and soil. Besides creating environmental damage, the contamination resulting from leakage of chemicals also affected the health of the local population, recently cases of cancer have been reported from the workers at the mines some of which are dead as a result of cancer related cases.

The images below are showing the state of the environment before the mining activities and after the mining. This image is part of the kayelekera community where uranium mining activities were taking place.

Deforestation

Due to population increased there is demand of more food hence the communities seek more land in order to meet the required food, hence more land conversion from forest land to agriculture. Additional factors influencing deforestation is the demand for wood products, need for space, farmland, housing, roads. Deforestation continues to cause habitat fragmentation, where animals and plants are forced into confined areas. Cutting of trees for agriculture, industries and settlement has increased ecosystem instability, by disrupting the role and services that trees play in an ecosystem, such as protecting living organisms from the sun's harmful ultraviolet rays, mediate runoff and evapotranspiration and regulate nutrient cycling and also habitat for some other fauna and flora



Figure 4: An image showing the road network for Kayelekera in the early days of the mining in 2009

Source: Wikipedia the free encyclopedia





Figure 5: A satellite image showing the view of Kayelekera 6 years After the mining in 2015

Source: <https://www.googleearth.com/map>



Figure 6: An image of the Open cut mining of Kayelekera uranium, Photo by Rachel Ketter

Source: Wikipedia the free encyclopedia

Modernization

Technological advance and human progress has had a direct bearing on the exploitation of natural resources. Forest trees are cut to yield timber for building houses, for making furniture and for collecting wood as fuel. Industrialization have triggered a heavy demand on forest resources such as wood for paper making, exploitation of gums, resins and mining of forestland for mineral ores, building materials etc.

Furthermore, the fuel consumption through the use of machinery by humans seems to be increasing carbon dioxide levels in the air. This carbon dioxide prevents heat from escaping, causes slight worldwide temperature increases.

c) Ecological Consequences of Landscape Disturbances Habitat Destruction

Landscape changes due to deforestation has been one of the major causes for the depletion of wildlife. With the increase in human population and the growing need for resources, forests were cleared for agricultural operations, for human habitation and for grazing their livestock. In the process Habitat destruction thus has an adverse impact on wildlife as it leads to the loss of an environment, which provides them food and breeding grounds or nesting sites to facilitate rearing of their young ones. Wild animals are left with no alternative but to



adapt, migrate or perish [13]. Widespread landscape changes all over the country have diminished the population of many species, making them rare-and endangered.

Habitat Fragmentation

Habitat fragmentation occurs when continuous areas of habitat become disconnected by natural or human causes (for example, building roads through a forest). Fragmentation generally leads to small, isolated patches of hospitable habitat. Smaller habitats support fewer species and smaller populations, which are at greater risk of inbreeding and local extinction. The theory of island biogeography predicts that populations are more likely to persist in habitat patches that are large [14].

Habitat fragmentation can be viewed as either a positive or negative feature in the landscape. Fragmentation can be viewed as negative when: there is a loss of habitat, smaller habitat patches are created that lead to local extinctions or isolation, habitats are no longer connected, particularly if the fragmentation is caused by a non-forestry activity such as urbanization, and the amount of edge is increased.

Exotic Species Invasions

Introduction of exotic species by people accidentally or intentionally in order to enhance production. Can cause problems if no natural enemies are present hence they become invasive species and end up disrupting the food chain and the ecosystem. But also Animals and plants removed from their habitat causes an imbalance in the native ecosystem [15]. These alien species have transformed, and continue to transform the entire ecosystems. They have a direct impact on the presence, abundance and activities of biodiversity and have led to the extinction of communities and reduction of native plants and animals. Furthermore, there are genetic impacts due to the alteration of gene pools of native species through hybridization and introgression. Replacing a natural ecosystem with a few specifically chosen plant varieties reduces the genetic diversity found in wildlife and makes the organisms susceptible to widespread disease. Furthermore, Changes in population sizes, individual behavior and community structure may alter the flow of materials through the ecosystem e.g. availability of N, P and C to other species.

Disturbance of the Energy Flow of the Ecosystem

These are processes and resources that are provided by healthy natural ecosystems and benefit humans. Energy is an important natural resource whose use is governed by two laws in nature. First law of energy conservation is that one can't get something for nothing. Energy is neither created nor destroyed, second law of energy states that you can't break even (in any conversion, some of the initial input is always degraded to lower quality) [16]. Hence no energy is wasted in functioning natural ecosystems because everything gets recycled in one way or another through various food chains and food webs, these are the pathways for recycling of nutrients from producers, consumers and decomposers back to producers. This commercialized agriculture with modernized farming methods continues to put more stress on the environment thereby increasing entropy. Kayelekera has high levels of entropy because most farmers are now modernize depending more on the use of modern ways of cultivation, there are high cases of post-harvest losses, high waste of crop residues that gets burnt instead of utilizing it in the farm. This kind of agriculture disrupts the nitrogen cycle by increasing the amount of nitrates in the soil through application of inorganic fertilizers, this might lead to losses of soil nutrients such as calcium and potassium which are essential for long term soil fertility. Some of the consequences can be the loss of biodiversity especially among plants adapted to low nitrogen soils and subsequently animals and microbes that depend on these plants.

d) Strategies that can be Employed to Best Manage and Minimize Landscape Degradation of Kayelekera Environmental Impact Assessment (EIA)

Conducting an Environmental Impact Assessment before implementation of any project activity and industry can lead to sustainable management of land resources and protection of the Kayelekera community from further depletion of the landscape and in future avoid the aftermath like that of Kayelekera mining to the ecosystem. Environmental Impact Assessment is an assessment done prior to project implementation. It identifies and



evaluates the potential impacts of the project on the environment and how to mitigate the negative impacts and enhance the positive impacts identified and should be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.

Sustainable Natural Resource Consumption Patterns

This concept was put forward by the Government of India (1992) the aim is to ensure that the basic needs of the entire global community are met, excess is reduced and environmental damage is avoided by rethinking the product life cycle. In particular, sustainable consumption is related to production and distribution, use and disposal of products and services. Hence the community can mobilize themselves and determining how best they can use the resources through equal sharing of benefits, without depleting them for good.

Environmental Laws and Policies

The government should establish and implement laws and policies that should govern the environment by ensuring that all economic activities are happening within the limit of the environment. An example would include the polluter pays principle.

Adoption of ecosystem based-management for sustainable development. Anthropogenic interventions usually affect not only one aspect of the manipulated ecosystem, but a series of components and processes. An ecosystem based management of land resources addresses the preceding problem because it emphasizes the need to manage the whole ecosystem rather than a species or a process. It means conserving a full array of species, processes, and structures and about their interrelationships, which underlies the productive potential of a given site or ecosystem.

Inclusion of the Communities

Whatever management and control system is put in place is likely to face barriers in implementation, if it ignores the community role and benefit-sharing mechanisms. Oftentimes the exclusion of the communities creates conflict situations in the management of natural resources. The local people need to be involved in the development of policies and regulations for ensuring sustainable use of the resources; they must feel a sense of ownership and responsibility in the management of the resource, and in the benefits that accrue from its use [17]. Hence the government should not impose technologies, development activities and programs on the communities and also before implementing bigger projects such as the Kayelekera Uranium mining the government should have conducted public consultations and all stakeholders should have been consulted sadly most government projects like the Kayelekera Uranium mining do not fully consult and incorporate the communities.

Conclusion

Ecological services and natural resource management processes are dynamic and inter-related. A minor disturbance in any of the processes leads to short or long term impacts which can either be reversible or irreversible. Natural resources are neither indestructible nor infinite, they can be destroyed or depleted through agriculture and other land use practices [18]. Energy cycle and nutrient cycles are also threatened by the changes in the landscapes therefore the need for proper management of the landscape.

Recommendations

The government together with the citizens of Karonga district should facilitate the rehabilitation and management of essential ecosystems and ecological processes in order to restore the degraded landscape into its natural state. This can be done by promoting cooperation between Government, local communities, and women groups, non-governmental organizations and the private sector in the management and sustainable utilization of the natural resources and the environment. By using such as public awareness of the importance of sound environmental management.



Women and all other vulnerable groups should effectively participate in policy, program and project design and implementation to enhance their role in natural resource use and management activities. They should be sensitized in environmental issues to facilitate their participation in the conservation, protection and management of the environment as future custodians.

References

- [1]. Odum, E. (1996). *Fundamentals of Ecology*. Dehradun.: Natraj Publishers.
- [2]. Pickett, S.T.A., and P.S. White. (1985). *The ecology of natural disturbance and patch dynamics*. Academic Press, Orlando.
- [3]. Di Giulio, M., and R. Holderegger. (2009). Effects of habitat and landscape fragmentation on humans and biodiversity in densely populated landscapes. *Journal of Environmental Management* 90:2959-2968.
- [4]. Taylor, B. D., and R. Goldingay. (2009). Can road-crossing structures improve population viability of an urban gliding mammal? *Ecology and Society* 14(2): 13
- [5]. Jaeger, J. A. G., S. Grau, and W. Haber, (2005). Landscape fragmentation due to transportation infrastructure and urban development: from recognition of the problem to implementation of measures. Special issue of *GAIA* 14(2):98-185.
- [6]. Trocmé, M., S. Cahill, J. G. de Vries, H. Farrall, L. Folkesson, G. Fry, C. Hicks, and J. Peymen. (2003). COST 341 - Habitat fragmentation due to transportation infrastructure: The European review. Publications Office of the European Union, Luxembourg.
- [7]. Millennium Ecosystem Assessment. (2005) *Ecosystems and Human Well-being: Synthesis*. Washington, DC: Island Press.
- [8]. Miller, T. G. (1994). *Living in the Environment: principles, connections and solutions*. 8th Edition. Belmont: Wadsworth Publishing.
- [9]. Daniel Bodkin and Edward Keller (2004), *Environmental Science*, John Wiley and Sons; 5th edition, ISBN: 0471658723.
- [10]. Skinner, C.N., and C. Chang. (1996). Fire regimes, past and present. Pages 1041-1069 in *Sierra Nevada Ecosystem Project: Final report to Congress*. Vol. II. Univ. of California, Davis.
- [11]. Raven, H. R. (2010). *Environment* (7 ed.). Hoboken, 111 street: John Wiley and Sons Inc
- [12]. Vladimir F. Krapivin and Costas Varotsos, (2008) *Biogeochemical Cycles in Globalization and Sustainable Development*, Springer.
- [13]. Tilman, D., R. M. May, C. L. Lehman, and M. A. Nowak. (1994). Habitat destruction and the extinction debt. *Nature* 371:65-66.
- [14]. Van der Ree, R., S. Cesarini, P. Sunnucks, J. L. Moore, and A. C. Taylor. (2010). Large gaps in canopy reduce road crossing by a gliding mammal *Ecology and Society* 15(4): 35
- [15]. Opdam, P., R. van Apeldoorn, A. Schotman, and J. Kalkhoven. (1993). Population responses to landscape fragmentation. Pages 147- 171 in C.C. Vos and P. Opdam (eds.), *Landscape ecology of a stressed environment*. Chapman and Hall, London.
- [16]. Cardinale, B. J., Palmer, M. A., and Collins, S. L. (2002). Species diversity enhances ecosystem functioning through interspecific facilitation. *Nature* 415, 426–429
- [17]. G.Z. Banda and T.J. Ngwira 'Introduction to Environmental Law in Malawi. (2007), Image Printing Works
- [18]. Chiras, D. (1998). *Environmental Science: A System Approach to Sustainable Development* (2 ed.). Wardsworth.

