International Journal of Earth Sciences Knowledge and Applications
journal homepage: http://www.ijeska.com/index.php/ijeska

Research Article

e-ISSN: 2687-5993

The Impact of Housing Development on Biodiversity – A Case of Rusike Phase Three, Marondera, Zimbabwe

Maridhadhi Patience[1], Kodzwa Jefline Jennifer[2], Lloyd Shorai Pisa[1]*

[1]*Department of Environmental Sciences and Technology, Marondera University of Agricultural Sciences and Technology, Marondera, Zimbabwe*
[2]*Institute of African Indigenous Vegetables, Marondera University of Agricultural Sciences and Technology, Marondera, Zimbabwe*

INFORMATION

Article history
Received 02 April 2023
Revised 09 May 2023
Accepted 09 May 2023

Keywords
Biodiversity
Urbanization
Conflict
Pollution
Environment

Contact
*Lloyd Shorai Pisa
lspisa86@gmail.com

ABSTRACT

Land-use is directly related to many environmental issues of global importance. Human alteration of the environment has triggered the major extinction events in the history of life and caused widespread changes in the global distribution of organisms. Therefore, land-use change can cause dynamics of biodiversity. The rate of global biodiversity loss has accelerated rapidly in the past century as the population has increased coupled with increased rate of human activities. Declines in biodiversity negatively affect local ecosystem functions and services and are thereby a major threat to humanity. Sixty questionnaires were used to gather information concerning the changes in biodiversity as a result of the Rusike Phase 3 housing development. Satellite images were also used to track the changes in vegetation cover in the area of study. There were more females than males amongst the respondents and the age of respondents ranged from 25 to 80 years with 83% of respondents having completed secondary level of education. It was noted that there was a change in flora and fauna of Rusike Phase 3 before and after the housing scheme from the responses on the questionnaires and from the normalized difference vegetation index satellite images. Lack of sustainable alternative energy sources has caused a surge in the cutting down of trees for firewood by the newly resettled residents. Clearing the land for housing and for small garden agricultural cultivation has also contributed to the loss in biodiversity in Rusike Phase 3 and the loss of habitats. It was concluded that land use activities like housing developments negatively affect biodiversity and require well planned and coordinated sources of energy for cooking to prevent deforestation of trees used for firewood.

1. Introduction

Land-use change is a complex, dynamic process that links together natural and human systems with direct impacts on soil, water and air (Meyer et al., 1994). Land-use is directly related to many environmental issues of global importance. Deforestation and consequent alteration of agricultural land are examples of land-use change with strong likely impacts on biodiversity, soil degradation and the earth's ability to support human needs (Lambin et al., 2003). Land-use change is also one of the important factors in the climate change cycle and the relationship between the two is dependent, changes in land use may affect the climate, with climate change influencing future land-use (Dale, 1997; Watson et al., 2000). Land use change is linked with economic development, population growth, technology and environmental changes. The rate of land-use change often parallel rates of population growth, whereas they generally diminish locally with increased economic development (Houghton, 1994). Human alteration of the environment has triggered the major extinction events in the history of life and caused widespread changes in the global distribution of organisms. These changes in biodiversity alter ecosystem processes and change the resilience of ecosystems to environmental change. This has profound consequences for services that humans derive from ecosystems (Fin and Stephen, 2017).

Land-use change generally simplifies the composition and structure of vegetation at the local scale (Foster et al., 2003; Angelstam et al., 2004), resulting in the loss and isolation of the original vegetative cover at the landscape scale (Mladenoff et al., 1993). These consequences of land-use change tend to decrease the populations of many species (Fischer et al, 2007). However, land-use change can also lead to increases in the population of some species, particularly those that can exploit simplified habitats and novel land cover such as agricultural land (Haila, 2002). Therefore, land-use change can cause dynamics of biodiversity (Kareiva et al., 2007).

The rate of global biodiversity loss has accelerated rapidly in the past century as the population has increased coupled with increased rate of human activities (Ceballos et al., 2015; Steffen et al., 2015). Habitat loss has been the main driver of this decline worldwide and is responsible for nearly two-thirds of the terrestrial surface having surpassed a proposed safe limit of local species extinctions (Newbold et al. 2016). More than three-quarters of the Earth's ice-free land area has been modified or is under use by humans to some extent (Ellis and Ramankutty 2008). A major contributor to human land-use change is agricultural production, with an estimated 37% of the terrestrial surface converted to agriculture by 2015 (World Bank, 2017).

Human land uses, including agricultural land, urban areas, and plantation forests, are predicted to further expand in the coming decades to meet the rising demand of a growing population (Kröger, 2014; Von Lampe et al., 2014). How landscapes evolve around the world in the near future will determine the rates of biodiversity loss, and understanding the impacts of land use is therefore central to the conservation of biodiversity.

Fig. 1. Satellite image of Rusike phase 3 housing development in Marondera, Zimbabwe

Declines in biodiversity negatively affect local ecosystem functions and services and are thereby a major threat to humanity (Cardinale et al., 2012). Plant and animal biodiversity are positively linked to plant productivity and soil health (Lal, 2004; Maestre et al., 2012), and thus may enhance the sequestration of atmospheric carbon (Lal, 2004). The loss of diversity may consequently slow down the reduction mitigation of CO_2 levels and undermine progress on limiting mitigating climate change. Additionally, increased crop yields and resilience to perturbations are associated with higher species diversity within agricultural lands (Di Falco, 2012).

Biodiversity conservation may therefore play an important role in securing food availability in the face of growing demand and changing environmental conditions. Land-use direct impacts predominantly consist of habitat loss and degradation, altered disturbance systems, modified soils, and other physical alterations caused by the formation of settlements (Reidsma et al, 2006). Land clearing in particular is the major activity in a land-use change where urban settlements are concerned. After Zimbabwe's independence in 1980, the country continues to experience an influx of people migration to towns and cities (Hove and Tirimboi, 2011). After 2000, Zimbabwe faced multiple socio-economic and natural misfortunes, such as droughts. This lead to increased migration and mushrooming of new settlements. (Cohen, 2006).

The town of Marondera has been no exception. Rusike Phase 3 is one such settlement. Rusike was established in 2008 on what was once of forest farm. This research aimed to assess the extent of the impacts of land-use change on biodiversity in the Rusike Phase 3 area of Marondera.

2. Methods and Materials

2.1. Site Description

Rusike Phase 3 is a newly developing urban settlement that was once a forested farm and snake park area situated approximately 10 km to the east of Marondera Town in Mashonaland East Province of Zimbabwe (Fig. 1). Marondera is in natural farming region IIa it receives rainfall of about 750 mm-1000 mm annually. The area has a miombo woodland type of forest which is dominated by *Brachystegia spiciformis*. Rusike Phase 3 is in ward 4 of Marondera Urban which comprises of 5920 females and 5215 males (Zimstats, 2022).

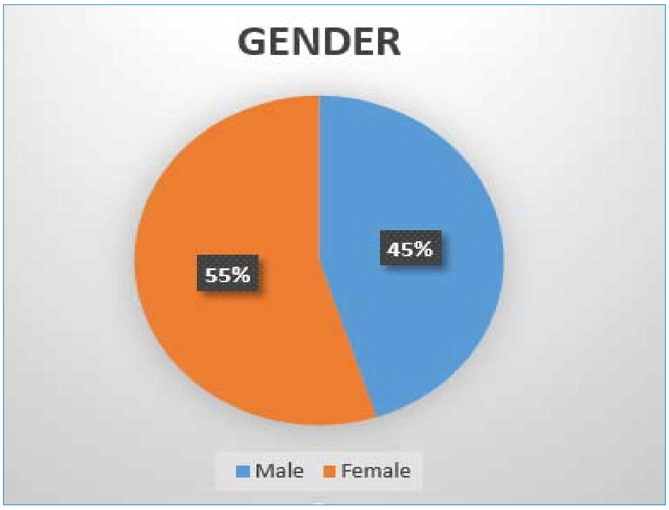

Fig. 2. Gender distribution of participants in Rusike phase 3

2.2. Data Collection

Satellite images and questionnaires were used. The sample size was determined using Slovin's formula (Nile, 2002) and 60 people were interviewed.

3. Results

3.1. Demographic Data of Respondents

The pie chart in Fig. 2 shows the distribution of gender of those who participated in the questionnaire survey in Rusike Phase 3 of Marondera. It shows a difference of 5% in favour of women.

The age of respondents ranged from 25 to 80 years there were 6 respondents in the age range of 25-30 years, 20 respondents in the age range of 30-40, 25 respondents were in the age range of 41-50, 5 respondents were in the age range of 51-60, 3 respondents were in the age range of 61 -70 and 1 respondents was in the age range of 71-80 years (Fig. 3).

The pie chart (Fig. 4) shows the level of education of the respondents 83% had attained secondary education, 12% tertiary and 5% primary education.

3.2. Effects of the Housing Scheme on Deforestation

As the people settled in Rusike Phase 3 there were effects on biodiversity as some people started cutting down trees for firewood and for clearing housing areas. The different energy sources used for cooking (Table 1) were electricity, gas and firewood.

Table 1 shows that of the 66.7 % people who uses firewood 61.7% respondents get their firewood from nearby forest farm and only 5 % respondents pointed out that they buy from the market.

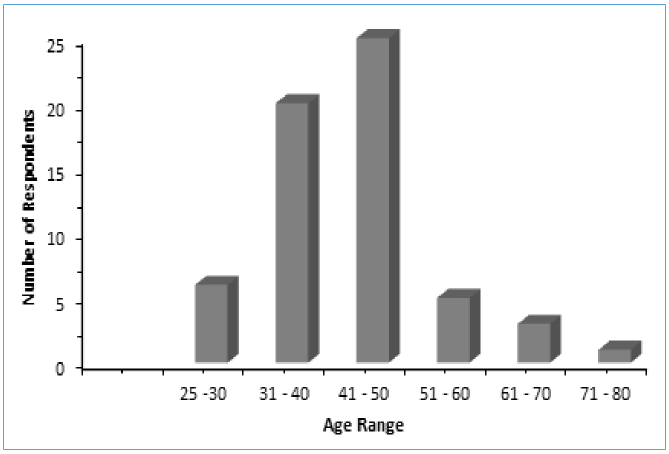

Fig. 3. Age of respondents in Rusike phase 3

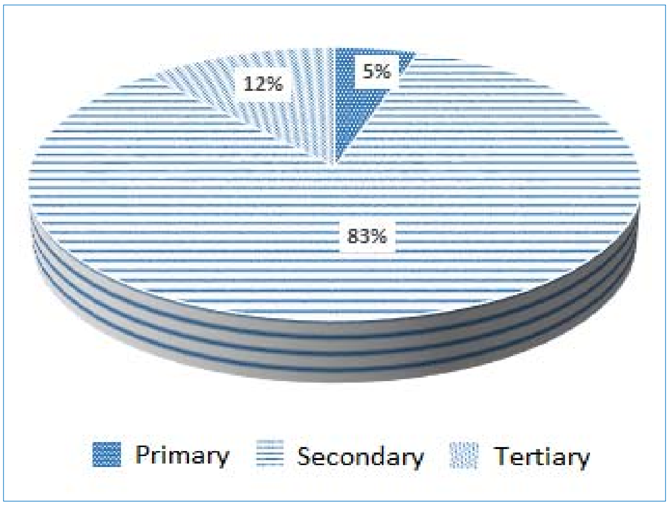

Fig. 4. Level of Education of respondents in Rusike phase 3

Table 1: Sources of energy for Rusike residents

Source of energy	Number of respondents
Electricity	16.7%
Gas	16.7%
Firewood	66.7%
Total	100%

3.3. Condition of Vegetation Before Settling and the Present Condition

Table 2 shows the responses of Rusike Phase 3 residents on the status of the past and present vegetation. 66.7% of the respondents pointed out that there used to be dense vegetation when they first settled in the area, 16.7% suggested that it was relatively dense and the other 16.7% said the vegetation was sparsely populated (Table 2). When answering the question of their present condition 83.3% respondents said the vegetation had declined, 15% said it has increased citing that they had planted trees on their stands while 1.7% said it was still the same.

3.4. Condition of Fauna in Rusike Phase 3 Before and after the Housing Scheme

Before the Rusike housing scheme the area was an expansion zone that had no land uses. Animals were seen in the area before the housing scheme (Table 3).

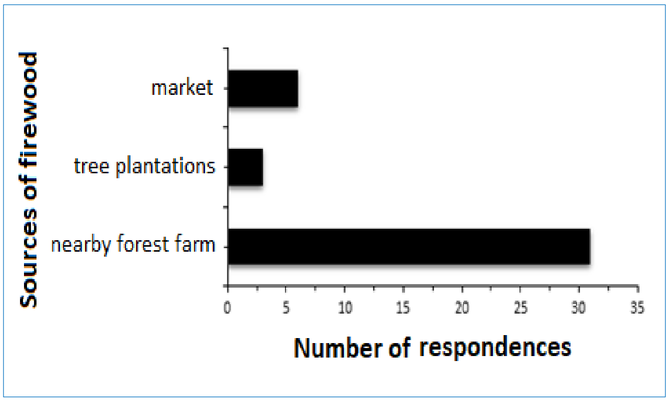

Fig. 5. Source of firewood used by Rusike phase 3 residents

Table 3 shows the number of respondents who have encountered animals in their homes, gardens and fields. Animals seen by an overwhelming number of respondent included snakes, birds, monkeys and baboons. The frequency of encountering animals by new settlers was also assessed to give an indication of the displaced animals.

Many indigenous species such as are found in the woodland area whereas there are a few remnants of the indigenous species such as regrowth of brachistegia spicirfomis. The residential area is dominated by exotic fruit trees that were grown as land use evolved. The wetland area has a few woody species and is dominated by grasses and perennial species (black jack).

The 2005 and 2015 normalized difference vegetation index (NDVI) images were compared to assess the effects of the housing scheme on vegetation. The 2005 satellite image is showing the vegetation before the Rusike Phase 3 housing scheme whereas the 2015 image is showing the same area after the established housing scheme.

The green patches on the images depicts the existence of vegetation. The 2005 satellite image shows the existence of vegetation which were dominated by woody indigenous trees such a *brachistegia spicifomis, uaparca kirkiana, combretana angolensis*. As land use evolved with increased clearing for residential settlements, the 2015 image shows absence of significant vegetation cover.

4. Discussion

This section analyses the results found in the research conducted in Rusike Phase 3 of Marondera on the assessment of the effects of land use change on biodiversity. The study revealed the existence of underlying factors contributing to the loss of vegetative diversity as well as loss of animal diversity.

Table 2. Vegetation density of Rusike Phase 3 before and after the housing scheme

Past condition	Number of respondents	Present condition	Number of respondents
Dense	66.7 %	Still the same	1.7 %
Relatively dense	16.7%	Declined	83.3%
Sparsely dense	16.7	Increased	15 %
Total	100 %	-	100 %

Table 3. Percentage of Fauna encountered in Rusike Phase 3

Fauna Encountered	Number of respondents	Percentage
Baboons	35/60	58.3%
Monkeys	43/60	71.7%
Snakes	55/60	91.7%
Birds	48/60	80%
Rabbits	35/60	58.3%
Squirrels	30/60	50%
Bush pigs	15/60	25%
Locusts	50/60	83.3%
Other insects	25/60	41.7%

4.1. Causes of Deforestation

The study reviewed that vegetation which consisted of both trees, grasses and other plants were lost due to land clearing for urban settlement. The survey shows the response of Rusike Phase 3 citizens on the status of their past and present vegetation. 66.7 % of the respondents pointed out that there was dense vegetation when they first settled in the area, present condition 83.3% of the respondent were of the observation that vegetation has declined, 15% said it has increased citing that they had planted fruit trees on their Stands while 1.7% did not observe any changes in the vegetation.

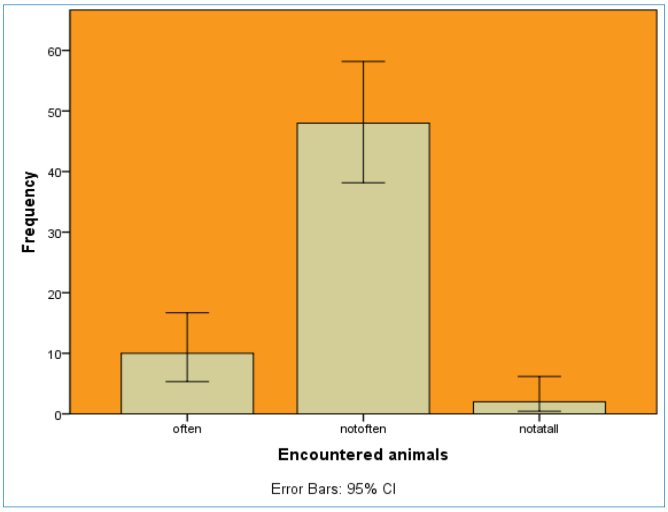

Fig. 6. Frequency of encountering animals

This may be due to the fact that they inhabited the place recently. Residential stands are cleared for various reasons such as reducing habitat for rodents and other harmful animal species such as snakes.it is of essence to clear land for anthropogenic purposes but by the end of the day a lot of diverse flora and fauna species that are of ecological importance are lost.

4.2. Need for Energy

As an emerging urban residential area the majority of the residents have not yet electrified their homes to use as energy. The majority uses firewood energy for their domestic purposes. The study shows that 92.5% of the respondents revealed they poach the firewood from the nearby forest farm for their personal use as well as for selling while 7.5% pointed that they cannot go to fetch for themselves so they buy from those who sell the firewood. A research conducted by Mutsai et al. (2006) in Epworth Harare alluded that electricity is a major problem in Zimbabwe and many people have resorted to the use of firewood as an affordable supplement for gas and electricity. Therefore, the need for energy is causing major deforestations as shown by this study.

Table 4. Species diversity within the three land uses of Rusike Phase 3

Woodland	**Residential Area**	**Wetland**
Acacia	Acacia	Acacia
Julbernardia globiflora	*Genus Pinus*	*Syzgium cordatum*
Berchemia discolor	*Litoria myola*	*Heteropogon contortus*
Guazuma ulmifoliaLam	*Persea americana*	*Bidens pilosa*
Lannea discolor	*Cynodon dactylon*	*Cynodon dactylon*
Ficus sycomorus	*Duranta erecta*	*Sporobolus pyramidalis*
Dichrostachys Cineria	*Zantedeschia virosa*	*Hyparrhenia*

4.3. Land Use Change and Habitat Loss

It has been shown that with the coming or establishment of housing schemes also comes other land use activities such as farming. The loss in biodiversity was probably caused by agricultural activities contributed by residents in Rusike Phase 3 when they cleared nearby land for their farming. This may be due to the fact that the wetland has evolved into a cropland where crops like maize and vegetables are being grown. Most of them were doing a bit agricultural activities on wetlands along the small stream producing mainly maize and vegetables to sustain their livelihoods.

According to Odine et al. (2016) in a study of wetland farming in Ogun State Nigeria, wetland farming or stream bank cultivation results in eutrophication due to fertiliser use that get washed into the water bodies or through seepage. Eutrophication also reduces the size of water bodies, changes the quality of water due to increase growth of water plants and it results in the mortality of the aquatic species. This has a negative impact on biodiversity and related ecological systems. Cultivation of wetlands also reduces groundwater recharge. During the land clearing process for either farming or building houses there is removal of plants and displacement of animals which certainly contributes to biodiversity loss and species extinctions (Newbold et al., 2016).

According to literature land use change is the main driver of habitat loss. A habitat is made up of shelter, food, water and hunting ground. When forests are cleared for agricultural, human settlements or any other uses, habitat is fragmented or lost and this causes animals to migrate or adapt to the present change. This is shown in Table 4. Table 4 shows a diversity in the type of animals encountered. Land use change has resulted in human wildlife conflict and reduces human security (Pisa and Katsande, 2021).

Fig. 6 shows that 80% of the respondents have encountered animals both in their fields and homes. The reason animals were encountered was that humans have encroached into wildlife space resulting in human wildlife conflict, birds, warthogs and other animals eating peoples, crops and snakes coming into peoples' houses. Animals encountered were birds, snakes, warthogs, baboons, monkeys among others, the majority of the respondents have encountered snakes in their homes this is because there was once a snake park that was abandoned when the farm area was converted to a residential area.

Fig. 2 shows that more women took part in the survey. Pisa et al. (2021), highlights the importance of women in environmental management and their role as custodians of the environment. Fig. 4 shows the level of education of the community interviewed. Though the there is a high level of literacy, the findings of this study shows a low level of awareness among the local residents regarding the use of forest resources. According to Sillah (2017), the use and management of forest resources should be well augmented to avoid overexploitation for the sake of the future generation. Given their level of education as the pie chart in Fig. 4 shows 83% having attained secondary education and that awareness of effects of deforestation such as land degradation and long term effects such as climate change starts from as far as primary school. So the lack of awareness cannot be entirely attributed to their level of education as the majority had attained secondary school and have learnt about this at some point. The community has a high number of middle aged people ranging for 30-50 as shown in figure 3. These are new home owner and have the responsibility of shaping their community.

Literature has it that not all land use changes have negative impacts on biodiversity, Lambin et al (2001) in his land use land cover study of Kenya revealed that vegetation diversity can increase in areas that were previously cleared for settlement as people tend to plant ornamental trees, flowers and shrubs around their properties. However, this is not the case with Rusike were vegetation diversity has not increased this may be due to the fact that the residents are not economically equipped to afford ornamental trees or it may not be a priority as most of them live from hand to mouth.

In fact, Fig. 7 maps show a loss in vegetation density over the last fifteen years. And also since most land is allocated for building houses there is less space or area that can be planted flowers shrubs and fruit trees.

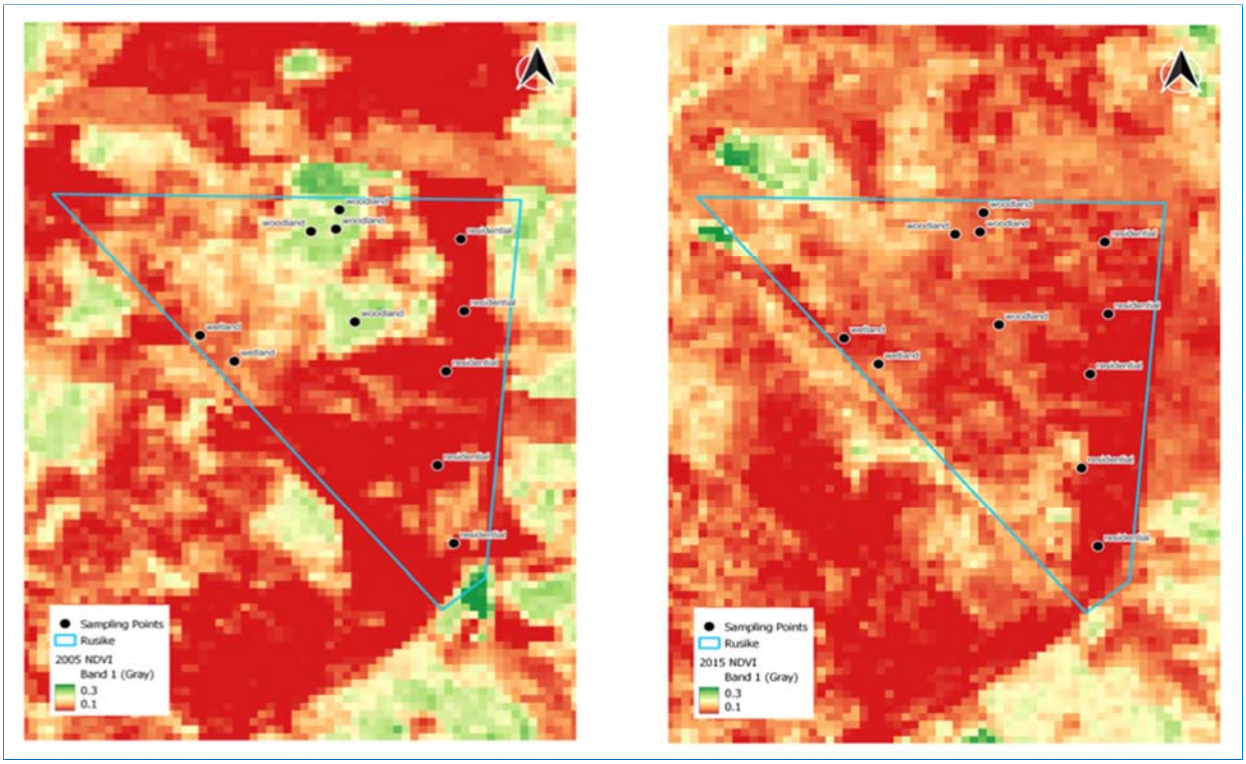

Fig. 7. NDVI Satellite images for the year 2005 and 2015

5. Conclusion

Due to rise in population there has been a high demand for residential space in Marondera which has resulted in housing developments expanding to farm areas. The developments have in turn contributed to habitat fragmentation, loss of both fauna and flora diversity. The study has shown there is a relationship between establishing housing schemes and loss of biodiversity.

6. Recommendations

The study has shown that land use planning approach has the potential of addressing deforestation and its resultant loss of species richness and diversity.

Reviewing current environmental policies such as the Forestry Act and the Environmental Management Act may assist in the preservation of woodlands and the consequential habitat loss for diverse fauna species.

Land developers should electrify residential areas before allocating people to settle to provide for energy needed in cooking to avoid deforestation.

References

Angelstam, P., Dönz-Breuss, M., 2004. Measuring forest biodiversity at the stand scale: An evaluation of indicators in European forest history gradients. Ecological Bulletins 51, 305-332.

Brazys, S., Elkink, J.A., Kelly, G., 2017. Bad neighbors? How co-located Chinese and World Bank development projects impact local corruption in Tanzania. The Review of International Organizations 12 (2), 227-253.

Cardinale, B.J., Duffy, J.E., Gonzalez, A., Hooper, D.U., Perrings, C., Venail, P., Narwani, A., Mace, G.M., Tilman, D., Wardle, D.A., Kinzig, A.P., Daily, G.C., Loreau, M., Grace, J.B., Larigauderie, A., Srivastava, D.S., Naeem, S., 2012. Biodiversity loss and its impact on humanity. Nature 486 (7401), 59-67. https://doi.org/10.1038/nature11148.

Ceballos, G., Ehrlich, P.R., Barnosky, A.D., García, A., Pringle, R.M., Palmer, T.M., 2015. Accelerated modern human–induced species losses: Entering the sixth mass extinction. Science Advances 1 (5), e1400253.

Dale, V.H., 1997. The relationship between land-use change and climate change. Ecological Applications 7 (3), 753-769.

Di Falco, S., 2012. On the value of agricultural biodiversity. Annual Review of Resource Economics 4 (1), 207-223. https://doi.org/10.1146/annurev-resource-110811-114543.

Ellis, E.C., Ramankutty, N., 2008. Putting people in the map: anthropogenic biomes of the world. Frontiers in Ecology and the Environment 6 (8), 439-447.

Fischer, J., Lindenmayer, D.B., 2007. Landscape modification and habitat fragmentation: a synthesis. Global Ecology and Biogeography 16 (3), 265-280.

Foster, D., Swanson, F., Aber, J., Burke, I., Brokaw, N., Tilman, D., Knapp, A., 2003. The importance of land-use legacies to ecology and conservation. BioScience 53 (1), 77-88.

Haila, Y., 2002. A conceptual genealogy of fragmentation research: from island biogeography to landscape ecology. Ecological Applications 12 (2), 321-334.

Houghton, R.A., 1994. The worldwide extent of land-use change. BioScience 44 (5), 305-313.

Hove, M., Tirimboi, A., 2011. Assessment of Harare water service delivery. Journal of Sustainable Development in Africa 13 (4), 61-84.

Kareiva, P., Watts, S., McDonald, R., Boucher, T., 2007. Domesticated nature: shaping landscapes and ecosystems for human welfare. Science 316 (5833), 1866-1869.

Kowe, P., Dube, T., Mushore, T. D., Ncube, A., Nyenda, T., Kizilirmak, G., 2022. Impacts of the spatial configuration of built-up areas and urban vegetation on land surface temperature using spectral and local spatial autocorrelation indices. Remote Sensing Letters 13 (12), 1222-1235. https://doi.org/10.1080/2150704X.2022.2142073.

Lal, R., 2004. Soil carbon sequestration to mitigate climate change. Geoderma 123 (1-2), 1-22.

Lambin, E. F., Geist, H. J., Lepers, E., 2003. Dynamics of land-use and land-cover change in tropical regions. Annual Review of environment and Resources 28 (1), 205-241.

Maestre, F. T., Quero, J. L., Gotelli, N. J., Escudero, A., Ochoa, V., Delgado-Baquerizo, M., ... & Zaady, E., 2012. Plant Species Richness and Ecosystem Multifunctionality in Global Drylands. Science 335, 214-218. https://doi.org/10.1126/science.1215.

Meyer, W.B., Meyer, W.B., B.L. Turner, I.I., (Eds.). 1994. Changes in land use and land cover: a global perspective (Vol. 4). Cambridge University Press.

Mladenoff, D.J., White, M.A., Pastor, J., Crow, T.R., 1993. Comparing spatial pattern in unaltered old-growth and disturbed forest landscapes. Ecological Applications 3 (2), 294-306.

Mutisi, L., Nhamo, G., 2015. Blue in the green economy: land use change and wetland shrinkage in Belvedere North and Epworth localities, Zimbabwe. Journal of Public Administration 50 (1), 108-124.

Newbold, T., Hudson, L. N., Hill, S. L., Contu, S., Gray, C. L., Scharlemann, J. P.W., Borger, L., Phillips, H.R.P., Sheil, D., Lysenko, I., Purvis, A., 2016. Global patterns of terrestrial assemblage turnover within and among land uses. Ecography 39 (12), 1151-1163. https://doi.org/10.1111/ecog.01932.

Niles, J.O., Brown, S., Pretty, J., Ball, A.S., Fay, J., 2002. Potential carbon mitigation and income in developing countries from changes in use and management of agricultural and forest lands. Philosophical Transactions of the Royal Society of London. Series A: Mathematical, Physical and Engineering Sciences 360 (1797), 1621-1639.

Pisa, L.S., Katsande, S., 2021. Human Wildlife Conflict in Relation to Human Security in the Gonarezhou National Park, Zimbabwe. International Journal of Earth Sciences Knowledge and Applications 3 (2), 98-106.

Reidsma, P., Tekelenburg, T., Van den Berg, M., Alkemade, R., 2006. Impacts of land-use change on biodiversity: An assessment of agricultural biodiversity in the European Union. Agriculture, Ecosystems & Environment 114 (1), 86-102.

Sillah, B., 2017. Economic Impacts of Climate Change: Evidence from OIC Member Countries. Journal of Economics 5 (4), 71-78.

Steffen, W., Richardson, K., Rockström, J., Cornell, S.E., Fetzer, I., Bennett, E M., Sörlin, S., 2015. Planetary boundaries: Guiding human development on a changing planet. Science 347 (6223), 1259855.

von Lampe, M., Kavallari, A., Bartelings, H., van Meijl, H., Banse, M., Ilicic-Komorowska, J., ... & Van Tongeren, F., 2014. Fertiliser and biofuel policies in the global agricultural supply chain: Implications for agricultural markets and farm incomes. OECD Food, Agriculture and Fisheries Papers, No. 69, OECD Publishing, Paris. http://dx.doi.org/10.1787/5jxsr7tt3qf4-en.

Watson, R.T., Noble, I.R., Bolin, B., Ravindranath, N.H., Verardo, D.J., Dokken, D.J., 2000. Land use, land-use change and forestry: a special report of the Intergovernmental Panel on Climate Change. Cambridge University Press.