Climate[1] and Land Use Changes in Murehwa District: Trends and Implications for Forest Ecosystems

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ABSTRACT

Climate change is disrupting human and ecological systems globally. Its impacts, evident in increased rainfall variability and more frequent droughts, are disrupting rural livelihoods. To mitigate the effects of climate change, smallholder farmers are resorting to livelihood strategies which, unfortunately, are exacerbating the degradation of ecosystems which serve as buffers against climate change. This study's aim was to establish climate change-induced land use changes between 1990 and 2021, and to also provide more options for sustainable land use management practices. Using the participatory mapping technique in a focus group setup, the study interviewed subsistence farmers in wards 26, 27 and 28 of Murehwa District, in April 2021. Whilst participatory mapping provides in-depth information on mapping issues, this article specifically focuses on the relationship between climate and land use alterations. The findings reveal significant changes in land use which include expansion of gardening, fields, settlements and wetland cultivation. The findings indicate a strong correlation between climate and land use changes. Farmers seeking to mitigate potential risks associated with rain-fed farming resort to extending their farmland, thus encroaching on forests. Also evident is the establishment of gardens and settlements in forested riparian areas and wetlands. Promoting sustainable agricultural practices is imperative for a harmonious coexistence between humans and ecological resources. Community awareness campaigns highlighting the importance of wetlands can help prevent further degradation. Furthermore, prioritising forest restoration in settlement planning can serve as a foundation for enhancing both human and ecological systems.

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NTRODUCTION

Climate change is an undeniable fact (Pacoma, 2019; Ontl *et al.,* 2020) that presents significant challenges to both human and natural systems across the world (Nunes *et al.,* 2020). The consequences of climate change are mainly manifesting in droughts, rainfall variability and increased temperature (Kupika & Nhamo, 2016). Mazvimavi (2010) argues that there has been a decrease of 100 mm in average annual rainfall over the past century, a period that was characterised by frequent droughts in Zimbabwe. The consequences of climate change are adversely affecting biodiversity, land uses, agricultural systems and the provision of ecosystem services, mostly in developing countries (Komba & Muchapondwa, 2018; Field & Barros, 2014), Zimbabwe being no exception. Although the effects of climate change vary in magnitude from place to place, rural communities which rely on rain-fed agriculture for sustenance and livelihoods, as well as climate-sensitive ecosystem resources and services, face severe challenges (Mpambela & Mabvurira, 2017; Muzari *et al.,* 2016; Brown *et al.,* 2012; Chagutah, 2010). Poverty-driven responses to climate change impacts are forcing rural communities to engage in forest-depleting coping strategies, which in turn result in undesirable land use changes (Béné *et al.,* 2014). The unsustainable climate-centred coping strategies increase the vulnerability of rural communities to further consequences of climate change (ZimVAC, 2019).

BACKGROUND TO THE STUDY

Forests are an integral component of ecological systems (Hui *et al.,* 2017; Liverman, 2009; Solomon *et al.,* 2007). They provide ecosystem services such as climate regulation through capturing and converting atmospheric carbon into biomass, which is an essential environmental service (Giri & Madla, 2017; Jenkins & Schaap, 2018). Globally, forest ecosystems store a greater amount of carbon than what is present in the atmosphere (Lal, 2005; Hui *et al.,* 2017; Seidl *et al.,* 2018; Federici *et al.,* 2017). However, the interactions between human and ecological systems have become disproportionate, causing environmental deterioration and forest cover losses (Mataruse *et al.,* 2021; Itzkin *et al.,* 2021). The human and

ecological systems are now defined by uncertain and unprecedented socio-economic and environmental changes (Cooper & Dearing, 2019). Hence, sustainable management requires an acknowledgement of the complexity of the interactions between human and ecological systems (Cumming *et al.,* 2013) in order to prevent further system degradation (Wyborn & Bixler, 2013).

Over the past 50 years, land use and land cover changes that are driven by communities' responses to the effects of climate changes in settlement patterns, as well as loss of livelihood opportunities, have intensified, thereby posing threats to forests (Gumbo *et al.*, 2018). Forest losses have been observed, primarily attributed to agricultural land clearing and wood extraction for income generation, usually occurring concurrently (Chirwa *et al.,* 2008; Campbell *et al.,* 2007). The degradation of forests has also been a result of development projects which involve substantial investments that expand fields for crops such as tobacco. In certain cases, these have led to displacement of local communities (German *et al.,* 2014). Lately, several national and regional land use policies have made minimal impact in changing these unsustainable land use changes (German *et al.,* 2014). Although regulations are in place, land and forest conservation is unlikely to occur in the future without adequate awareness, capacity building and sustainable land use management (Gumbo *et al.,* 2018).

The patterns of land use changes vary (Rudel *et al.,* 2005). They are usually characterised by intricate interactions between various factors, resulting in both large- and small-scale impacts that manifest as ecological degradation over long periods (Malhi *et al.,* 2020). Consequently, most woodlands are on a trajectory to becoming altered ecosystems (Bürgi *et al.,* 2017), with the extent of change depending on the severity and duration of the ongoing climate change trends and human-induced pressures (Malhi *et al.,* 2020). Millions of hectares of forests are being lost in Sub-Saharan Africa, the majority being *miombo* woodlands (Runganga & Mhaka, 2021; Chirwa *et al.,* 2008). Undesirable land use changes can significantly harm the conservation of essential ecological connections. This is an indicator that climate change and its effects can result in complex problems that require urgent intervention.

The active involvement of local communities significantly contributes to the success of maintaining land cover through embracing climate-friendly land use management strategies. It was for this reason that this study aimed at engaging local communities in appreciating the correlation between climate and land use alterations and their implication on forest ecosystems. The major goal was to draw lessons for maintaining sustainable land uses. The study made use of participatory mapping to collect data in wards 26, 27 and 28 of Murehwa District in Zimbabwe.

METHODOLOGY AND METHODS

This study used qualitative methodology within the framework of the Dynamics of Soil Carbon Sequestration in Temperate and Tropical Agricultural Systems project (DSCATT, www.dscatt.net). The DSCATT project considers the governance of forests utilisation, explores the drivers of forest cover loss, as well as institutional response to the drivers of deforestation. Ultimately, the project aims at creating a conducive environment for effective forest governance and improved carbon sequestration in Murehwa's agricultural systems.

STUDY AREA

This study was conducted in three wards (26, 27 and 28) of Murehwa District as shown in Figure 1. The selected wards constitute the DSCATT project's intervention sites. Murehwa District is situated in Mashonaland East Province, Zimbabwe, and is characterised by *miombo* woodlands. Murehwa is predominantly inhabited by smallholder subsistence farmers who live in communal areas, with only a small part of the district occupied by A2 farmers who produce on a large-scale for commercial purposes. The smallholder farmers depend on rain-fed farming, small-scale horticultural production and natural resources such as forests, for wood and income through selling forest products. In Murehwa's communal areas, traditional leaders such as village heads are the custodians of land and natural resources.

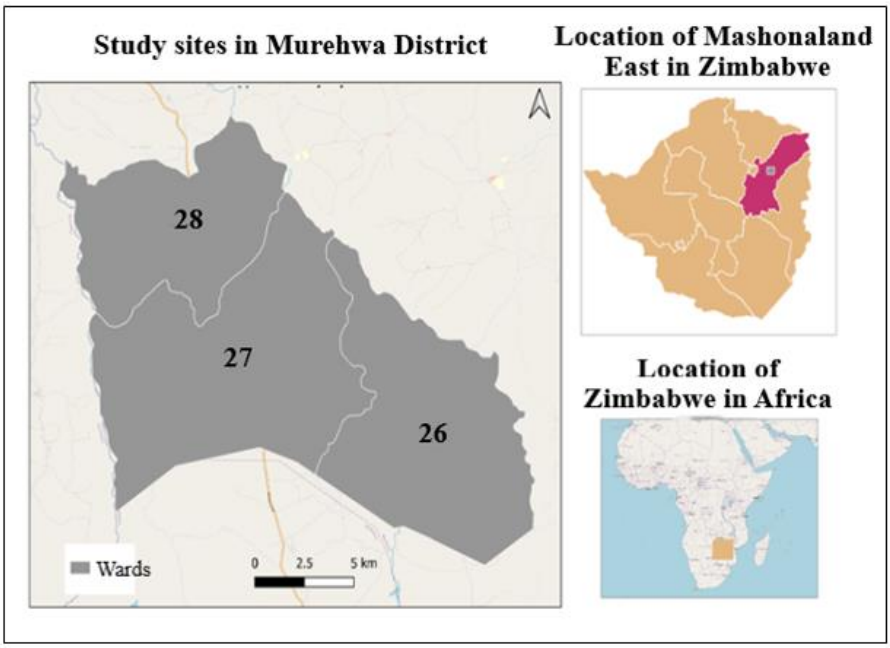


Figure 1: Location of study sites in Murehwa District

STUDY SITE SELECTION AND SAMPLING METHODS

Table 1: Sample size

Ward	Villages	Randomly-selected Villages	Number of Participants
26	16	4	24
27	17	5	30
28	18	6	36
Total	**51**	**15**	**90**

The selection of study sites and participants involved a multi-stage sampling process. The first stage for selecting the three wards used purposive sampling, followed by random sampling to select villages. The sample size for villages was determined proportionally as shown in Table 1. With the help of village heads, purposive sampling was then used to select participants aged between 40 years and 85 years. The choice to start at 40 years ensured the inclusion of mature individuals who were capable of recalling historical developments related to land use changes

between 1990 and 2021. For effective discussions, each participatory mapping group consisted of six participants.

DATA COLLECTION METHODS AND ANALYSIS PROCEDURES

Whilst acknowledging the existence of alternative approaches for detecting land use changes such as the use of satellite images, participatory mapping proved to be the most suitable approach owing to its ability to engage local actors in a deliberative process. Participatory mapping's strengths include capturing locally-generated visual descriptions of the changing land uses, as well as explanations for the observed changes. The method also allows local actors to collectively discuss features and landscapes in their community, facilitates discussion on the factors driving changes, and represents collective descriptions and explanations in the form of a map (Barton, 1997).

The participatory mapping process was explained in detail to the participants who were then requested to draw two maps characterising their village in 1990 and 2021. This was done to enable participants to compare the maps and determine if there had been any land use changes. For some groups, participatory maps were first drawn on the ground using grass, leaves, bricks, stones and other objects. The maps were finally re-drawn on paper by one member of the participatory mapping group. For other groups, participants drew their maps straight on paper. Participants subsequently engaged in discussions based on comparisons of land use and forest loss between 1990 and 2021. Through the discussions, drivers of land use and forest loss were obtained. The maps showing the various land uses were later scanned to create digital copies for inclusion in the results section. For each ward, two maps from a single village were chosen for presentation based on the quality of maps and representation of the dynamics of land use changes. Thematic analysis was used to obtain major themes and drivers of land use changes from participatory sessions.

RESULTS

Figure 2 presents the land use changes between 1990 and 2021 in Ward 26. The comparative maps show a significant reduction in forests between the two dates. Areas of forests that used to be in the village in 1990 have been lost to settlement developments which have encroached on most of

the forests. These settlements include houses, schools and shopping centres. The most affected areas are towards the south and south-west of the village where the conversion of forests into settlements is most visible. The 2021 map shows a growing trend of settlements which are expanding into wetlands, with notable agricultural activities along the same wetlands. More and bigger fields have encroached on the forests, thus more land on the 2021 map is under cultivation compared to the 1990 map. Figure 2 also shows a substantial rise and prevalence of gardens which are predominantly in the forests along Shavanhowe River.

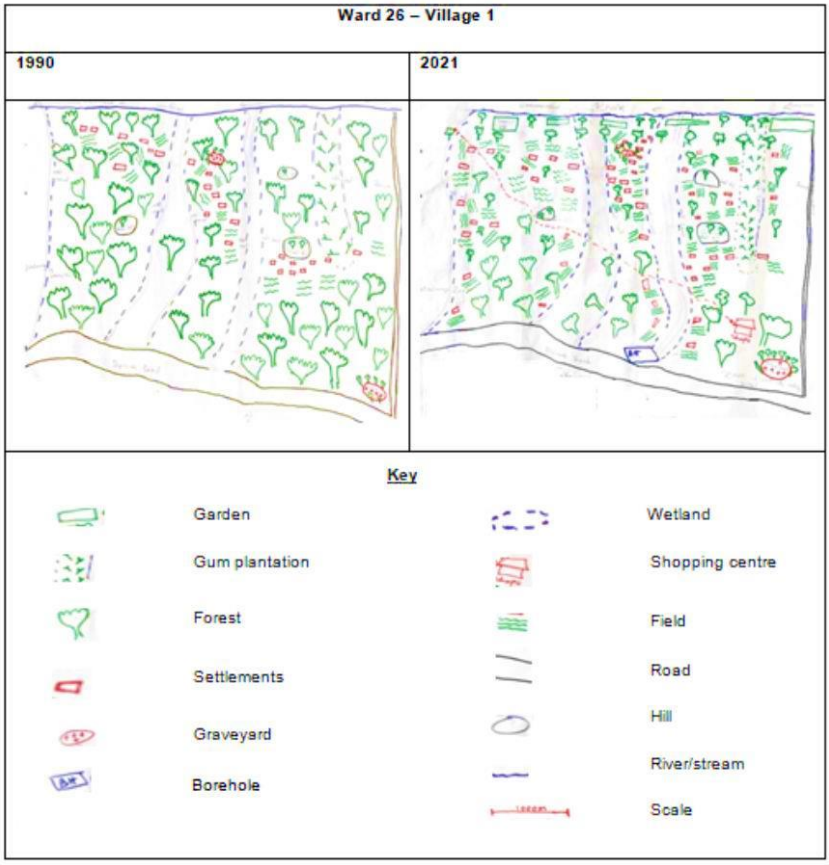


Figure 2: Participatory maps showing changes in land use between 1990 and 2021 in Ward 26

Figure 3 shows land use and forest cover dynamics between 1990 and 2021 in Ward 27. The maps reveal a notable shift in the distribution and

density of forests across the village, as there are more forests on the 1990 than on the 2021 map. The observed land use and forest cover changes can be attributed to an increase in the number of households in the village as shown on the maps. In 1990, households were concentrated along the main road, whereas the 2021 map shows households that are scattered throughout the village and which occupy areas which used to have dense forests. The increase in households also correlates with the increase in the number and sizes of fields which are encroaching on forests and wetlands. Additionally, the maps show a rise in gardens established in the forests along the river to the north of the village.

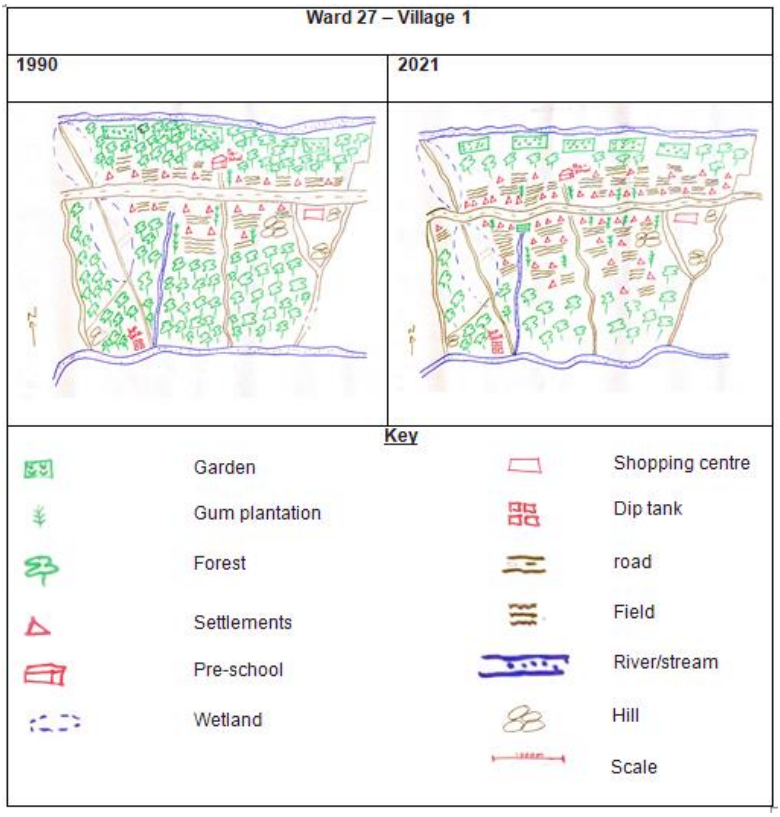


Figure 3: Participatory maps showing changes in land use between 1990 and 2021 in Ward 27

Figure 4 shows land use transformations between 1990 and 2021 in Ward 28. In 1990, the village had fewer households compared to what is depicted on the 2021 map. Notably, some households have encroached

on the dense forests towards the north of the map. This is coupled with the disappearance of trees and forests between homesteads, as shown on the 2021 map. The rise in household numbers also corresponds with the increase in the size and number of fields, as illustrated on the 2021 map. This increase is an indication of the village's demographic changes. Moreover, the 2021 map indicates a trend whereby more gardens are being established along the village wetlands. The gardens with a significant impact on forests are those along the major river on the village map.

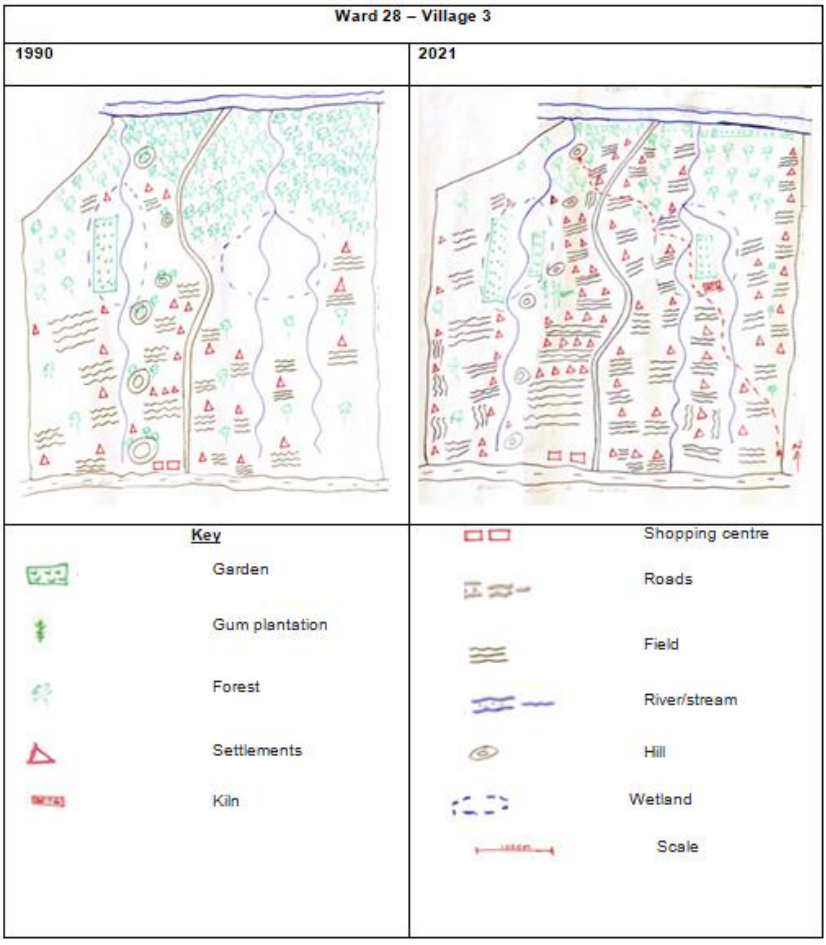


Figure 4: Participatory maps showing changes in land use between 1990 and 2021 in Ward 28

CLIMATE RELATED DRIVERS OF LAND USE CHANGES

RAIN-FED AGRICULTURE AND CLIMATE CHANGE

Climate change, characterised by rainfall and temperature variability, has disrupted rural livelihood strategies. Smallholder farmers in the rural areas of Murehwa largely depend on rain-fed agriculture. Participants indicated that the changing of climate is a key driver behind large-scale clearing of forested areas for agricultural expansion in all the three studied wards. This is supported by participatory maps (figures 2, 3 and 4). Smallholder farmers are practising extensive agriculture where they are clearing more land to enhance maize production as a measure to self-insure against food insecurity. Poor rainfall and droughts resulting from the changing of climate have negatively affected farmers' grain yields. The vulnerability of farmers is worsened by the death of livestock. By clearing more land encroaching on forests, farmers are hoping to produce yields that they used to get in previous years, but now on smaller pieces of land. This need to produce more under the changing climate has resulted in forest cover loss and change of land use. The climate change-driven conversion of forested areas into farms further increases the vulnerability of local communities, since climate-proofing services offered by forest ecosystems are sacrificed for agricultural expansion.

SETTLEMENTS ESTABLISHMENT AND CULTIVATION IN WETLANDS

The changing of climate has led to erratic rainfall, which has resulted in fields becoming very dry. In response, smallholder farmers are creating fields and gardens in the limited available wetlands as presented in Figure 3. Participants argued that cultivating in wetlands is a better alternative owing to the ability of the wetlands to retain soil moisture for longer periods. This is particularly so, given the increased frequency of droughts in recent years, as wetlands are the last to dry up during dry spells. In addition, more gardens where horticultural production takes place are being established in wetlands. Participants emphasised that gardens that are established in wetlands perform better under the changing climate, especially during droughts due to moisture and water availability in the wetlands. Hence, settlement developments, the need to have fields that retain moisture for long, and the existence of gardens close to wetland water sources, have compromised wetland ecosystems which provide climate-proofing and improved clean water supply.

INCREASED GARDENING

Furthermore, participants explained that severe and persistent droughts resulting from climate change are now forcing smallholder farmers to clear land in forests, especially along perennial rivers, in order to establish gardens. Participants highlighted that the increasing trend of gardening in forests is a mechanism adopted by smallholder farmers to supplement rain-fed agriculture, as shown on the participatory maps in figures 2, 3 and 4. According to participants, the drying up of water sources such as wells has led to the shifting of gardens from homesteads to forests along perennial rivers. Participants narrated that significant droughts in Zimbabwe during the 1990s and early 2000s saw an exponential rise in the number of gardens as livelihoods were disrupted and farmers relied more on gardens for food and income. The smallholder farmers believe that having a garden along perennial rivers ensures better yields and also generates household income through the sale of their produce to fellow farmers and markets in nearby towns. The expansion of gardens over the years has been corresponding with the frequency in droughts, making forests more vulnerable to land use changes. Therefore, climate change consequences are significantly contributing to substantial land use changes.

DISCUSSION

The results show that local communities perceive that land uses are changing, with forest cover decreasing mainly because of climate change and resultant coping strategies. In support of these findings, a study by Cui *et al.* (2021) on the relationship between climate change and land use changes observes that climate change-driven expansion of agricultural frontiers has contributed to forest cover loss, land degradation and soil erosion. Kleinshmit *et al.* (2015) also argue that favourable temperatures and adequate rainfall support the regeneration of forests and usually go along with sustainable land uses. In further support of the connection between climate and land use alterations, Barbier (2004) and Acheampong *et al.* (2019) argue that agriculture-driven land use changes are on the rise and severe in developing countries which are often characterised by poor intensification. Climate change exacerbates land use changes as farmers resort to extensive farming, and hence favourable climatic conditions offer livelihood options such as increased production through rain-fed agriculture. Subsequently, high crop yields and food security may mean less dependency on forests for income. The introduction and promotion of

nature-based solutions to address climate change and its consequences may translate into sustainable land use management. However, the negative trends of forest cover loss and undesirable land use changes may persist if communities do not embrace climate change mitigation and adaptation options in their agricultural systems.

The results show a trend whereby smallholder farmers are turning to wetland cultivation driven by the need to grow crops in areas with better water holding capacity to address problems posed by frequent and long dry spells on crops. This trend aligns with observations made in a study by Chikodzi and Mufori (2018) in Murehwa on the drivers of wetland fragmentation. Chikodzi and Mufori (2018) provide compelling evidence of wetland destruction attributed to an increase in agricultural activities that encroach on wetlands in the form of cultivation. As smallholder farmers seek to be food secure amidst climate change, their coping strategies raise concerns over the functioning of wetlands and provision of ecosystem services. The results of the current study, and the study by Chikodzi and Mufori (2018), foreground the urgent need to address the negative trends in Murehwa by finding a balance between agricultural production and conservation of wetlands under the changing climate.

The results also indicate that the drying up of water sources close to homesteads, coupled with the failure of rain-fed agriculture *vis-à-vis* the need to meet household food demands under the changing climate, are forcing smallholder farmers to establish gardens in forests along perennial rivers. Echoing this research's findings, a study by Afroz *et al.* (2023) in Bangladesh found out that the establishment of tea gardens contributed significantly to deforestation. In the Zimbabwean context, a study by Maridhadhi *et al.* (2023) in Marondera also highlights that gardens for horticultural production are a major driver of forest cover loss and land use changes. Maridhadhi *et al.* (2023) support the observation that these land use and land cover changes correlate with climate change. These findings stress the need to address challenges emanating from forest and land degrading coping mechanisms. If left unchecked, these climate change-driven coping mechanisms may further expose and make communities more vulnerable to the adverse impacts of climate change.

MITIGATING THE EFFECTS OF CLIMATE CHANGE

There is a strong relationship between climate change, human systems and land use changes in the studied wards in Murehwa District. Sustainable intensification of agricultural systems and emphasis on nature-based solutions can help to mitigate the effects of climate change. For example, the integration of crops and trees could be a viable nature-based solution to the problem of forest degradation. To prevent severe deforestation, government and development practitioners, through the agricultural extension officers, have a role to promote agro-forestry. Agricultural extension officers may also promote the use of humus as motivation for smallholder farmers to manage forests as a source of carbon to improve their soils. Through the Environmental Management Agency (EMA), communities could be made more aware of the importance of wetlands for climate proofing services. Close cooperation is needed between the department of environmental management under the local council, and village heads and local communities to ensure sustainable planning of settlements which does not destroy wetlands, rivers and forest ecosystems. Improved settlement planning which puts a priority on restoring existing forests may be the foundation for enhancing human and ecological systems. Through the provision of inputs and technical support to local communities, government and development practitioners can further promote reforestation and afforestation programmes. Strengthening the institutional arrangements without attending to problems resulting from climate change may not bring the desired results. Rather, the focus should be on helping communities respond to climate change without degrading land, wetlands and forests.

CONCLUSION

Evidence from the maps and discussions during participatory exercises show that climate-induced drivers of land use changes continue to bear on forests. Forest cover is massively decreasing, resulting in unbalanced human and ecological interactions. In spite of efforts to manage land uses and forests sustainably, climate change resulting in agricultural expansion, wetland cultivation and increased gardening in forests along perennial rivers, continues to threaten sustainable management of land uses. There is need, therefore, to acknowledge intricacies between climate and land uses, and address the climate-driven land use changes, together with existing imbalances between elements of human and ecological systems.

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