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Climate-proofing Rural Communities, Optimising Carbon Stores and Biodiversity Conservation of Indigenous Forests: False Starts, Wrong Turns and Dead Ends?

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Abstract
The primary purpose of the study is to interrogate how indigenous rural forests can be used to climate proof rural communities from the adverse effects of global warming. The secondary objectives are exploring strategies on how to optimise carbon sequestration and biodiversity conservation of Zimbabwe's indigenous rural forests to improve the resilience rural communities. There seems to be a practical knowledge gap in priori studies that focus on the significance of biodiversity conservation, optimising carbon sequestration in indigenous forests and improving resilience of rural communities. An investigation of these issues is important because climate change has a strong potential to stonewall and even retrogress human development in rural communities by precipitating negative externalities related to availability of water resources, agriculture and food production, disaster and risk management, and protection of natural environment. Two structured focus group discussions were utilised to collect qualitative data from purposively chosen participants residing in Muzarabani Rural District. Our main findings demonstrate that assigning property rights of indigenous forests to local communities and reforesting some depleted areas with fast-growing exotic trees may help to enlarge carbon stores and conserve biodiversity. Promoting partnerships that encompass multiple stakeholders such as the government, commercial forest enterprises, natural resources scientists and community leaders is likely to promote enduring long-term benefits for rural communities that live near indigenous forests. Facilitating access to carbon credits and green bonds may help to diversify income streams, promote climate change adaptability and climate proofing in rural areas. The study contributes to the knowledge on how to improve livelihood resilience of rural communities using indigenous forest resources.

Keywords: Indigenous Forests, Carbon Sequestration, Biodiversity Conservation, Rural Communities, Property Rights, Zimbabwe

1.0 INTRODUCTION AND BACKGROUND

Climate change is perchance one of the greatest existential headwind threatening sustainable economic growth and the national development of many developing economies. Particularly in Zimbabwe, the perceptible loss of biodiversity and carbon stores in indigenous forests is raising serious angst among numerous stakeholders on how to efficiently climate-proof rural communities. The consequences of climate change are well ventilated in prior studies, including the lengthening of mid to high latitude growing season (Brancalion and Hall, 2020), altitudinal and poleward shifts of animal and plant ranges (De Vitis et al., 2020), reductions of some plant and animal populations (Gardon et al., 2020), early tree flowering (Asbeck et al., 2021; Heilmayr et al., 2020), increase in the number of people exposed to vector-borne diseases such as malaria, typhoid and cholera (Schleussner et al., 2016; Huang et al., 2020; Hu et al., 2020), exposure to extreme overlapping flooding and droughts (Bhardwaj et al., 2021), intense cyclonic storms juxtaposed with persistent heat waves (Hohl et al., 2020; Hong et al., 2020), extinction of major flora and fauna species (Deere et al., 2020), unavailability of clean water and droughts (de Almeida et al., 2020; Hu et al., 2020), and reduced quality of crop and fruit yields (Kaushal and Baishya, 2021). Climate change and climate variability have a serious possibility of hamstringing economic growth of developing economies. These twin evils can even obverse human development due to the

adverse impacts on key national developmental multipliers such as agriculture and food production, disaster and risk management, and provision of water, health and education services.

The potential role of indigenous forests in climate-proofing marginalised rural communities residing in developing economies has received little interrogation in contemporary studies that focus on biodiversity conservation and carbon biogeochemical sequestration. In addition, numerous priori empirical literature has predominantly concentrated on exotic forests/plantations. Very little practical research has been done on the nexus among rural indigenous forests, biodiversity conservation, carbon sinking and marginalised communities that subsist on these forests. Compared to developed countries where many people live in urban areas, more people live in rural areas in most developing countries (de Almeida et al., 2020; Erbaugh et al., 2020). Due to the heavy dependency on subsistence farming and lower disposable incomes, rural communities are likely to be more exposed to the effects of climate change and climate variability. In this paper, we define climate proofing as processes, activities and measures that make marginalised rural communities become more tenacious and resilient to the effects of climate change, including climate variability. Past studies demonstrate that climate proofing assists rural communities to identify socio-economic culverts that enable them to mitigate risks and uncertainties precipitated by climate change and climate variability (Hu et al., 2020; Hoque et al., 2021).

Unlike exotic forests and commercial plantations, many indigenous forests are diverse and are multi-functional biological assets. As a consequence, indigenous forests have numerous important timber and non-timber benefits that provide a much broader range of ecological and economical services (Mutambara et al., 2024; Musundire et al., 2021). Apart for their timber extraction values, many indigenous forests provide a crucial link in the traditional food security value-chain systems. The non-timber benefits of indigenous forests include assisting in climate control by ensuring clean air, soil and water (Chazdon and Brancalion, 2019; Dolch et al., 2016; de Almeida et al., 2020;), providing habitat support for a biologically diverse system of animal and plant populations (Estrada-Villegas et al., 2019; Annos et al., 2019; Cuenca et al., 2018), removing air pollution, regulating atmospheric quality, maintaining watershed, and providing recreational facilities and ancillary aesthetic amenities (Joo and Suh, 2017; De Vitis et al., 2020; Crouzeilles et al., 2020).

More significantly, climate-proofing rural communities using indigenous forests can assist developing economies to create sustainable resilience by reducing endemic poverty and improving food security (Kwiri et al., 2020; Steur et al., 2020; Liu et al., 2020). Prior scholars also report that the availability and marketing of green financial instruments such as carbon credits and carbon bonds can provide alternative and tenable options for rural communities to generate and diversify their income streams. Furthermore, many indigenous forests have wilderness existence values that attract tourists seeking various interests such as spiritual healing, solace and piety (Mutambara and Muzurura, 2025; Muzurura et al., 2023). It has also been established in many studies that indigenous forests complements other touristic activities such as religious and cultural ceremonies, wood handcraft, wellness and community-based tourism (Muzurura et al., 2022; Chigora et al., 2020) wellness tourism and community-based tourism (Romeo et al., 2021). Many tourists also visit rural indigenous forests for various activities, including seeking herbal medicine, bird watching and trophy hunting, and forest-based cultural experiences (Muzurura et al., 2023). Other past studies also demonstrate a positive correlation among sustainable-community managed indigenous forests, economic growth and attainment of Social Development Goals (Asbeck et al., 2021; Bhardwaj et al., 2021; Tolangay and Moktan, 2020; Oldekop et al., 2019; Wyse and Dickie, 2018; Fagan et al., 2020; Deere et al., 2020; Dvderski and Jagodzinski, 2020). Of significance, several researchers have argued that because indigenous forests are polycultural in nature, they tend to efficiently store more long-lived stock and flow of carbon pollutants than monoculture exotic plantations (Wyse and Dickie, 2018; Hu et al., 2020; Muzurura et al., 2024). This is because when compared to exotic forests most indigenous trees are evergreen, support higher species diversity and therefore are likely to sequester more carbon (Das et al., 2021; Mattana et al., 2020; Friggens et al., 2020; Crouzeillej et al., 2016; Kaushal and Baishya, 2021; Dar et al., 2019; Hoque et al., 2020).

For the reasons stated above, this paper contends that climate proofing marginalised rural communities living in developing countries using abundant indigenous forests can be a critical colonnade for resisting the adversative impacts of climate change, climate variability and global warming (see Asbeck

et al., 2021; Bhardwaj et al., 2021). The rationale being that indigenous forests sequester more carbon due to their extensive biodiversity ecosystem and dense underground biomasses (Shaw et al., 2020; Steur et al., 2020). However, the main challenge is that most developing countries, especially Zimbabwe are at critical take off developmental phase where more land is required to support commercialisation, industrialisation, and agriculture and urbanisation expansion. Yet on the other hand, in most rural areas more indigenous forests are also needed for their timber and non-timber benefits especially, their role as safety nets for food security, eradicating poverty and community development.

Another important consideration is that unlike exotic forests, indigenous forests once depleted, many valuable non-timber benefits are often irretrievably lost as they have longer maturation period and also difficult to propagate using their seeds. The attendant challenges of depleting indigenous forests are numerous, including soil fertility losses, disruption of water systems and precipitating extensive hydrological conditions such as floods and droughts (Tolangay and Moktan, 2020). The continued loss of indigenous forests in rural areas of developing economies are even more malignant to marginalised communities particularly the impact of the opportunity costs of potential future income loss and erosion of their quasi-option and bequest values. As observed by many scholars, the quasi-option value of many indigenous forests relates to the abundant genetic material and potential medicinal benefits that are still to be discovered (Kaushal and Baishya, 2021; Hoque et al., 2021; Das et al., 2021).

There is also no ingrained mechanisms that permit rural communities to halt the stocks of indigenous trees from declining to zero. In fact, the inducement to convert indigenous forests into current incomes by switching indigenous forests use to agriculture, mining and other commercial activities that provide speed and effortlessly appropriated returns has always a driving force for the depletion of these forests (Muzurura et al., 2024). This is because most indigenous forests in countries like Zimbabwe, have longer maturation periods and have dormancy mechanisms that may require specific conditions for germination (Muzurura et al., 2024). Furthermore, many indigenous forests in rural areas are common-pool natural resources and hence, are more vulnerable to the tragedy of the commons due to uncontrolled anthropogenetic interference and lack of assigned property rights.

The tragedy of the commons usually refers to a circumstance or situation where some individuals acting rationally and independently in their own self-interest commonly deplete a shared indigenous forest ultimately harming everyone in that community, and also including themselves. This occurs because each individual in the community benefits from using the forests, but the costs of overuse, planting or maintenance among the group. Whilst in more recent years, the country has made phlegmatic efforts to confront the impact of climate change and climate variability, the deforestation of rural indigenous forests remains untamed in Zimbabwe. Most rural people that subsist from common-pool, non-excludable and rivalrous indigenous forests have therefore not been spared from the adversative impacts of climate change and climate variability.

Zimbabwe is a state party to various international multilateral agreements that protect the natural environment, including the Kyoto Protocol, the Paris Agreement, the Montreal Protocol, United Nations Conventions to Combat Desertification, United Nations Convention on Biological Diversity, and the Convention on the International Trade on Endangered Species of Wild flora and Fauna. More significantly, the country also ratified the United Nations Framework Convention on Climate Change (UNFCCC). The main objective of the UNFCCC is to stabilise greenhouse gas emission concentrations to a level that would prevent anthropogenetic with the climate systems. This objective should be achieved within a time period that permits ecosystems to adapt naturally to enable sustainable development in the atmosphere. To domesticate some of the provisions of the UNFCCC, the country adopted the National Climate Policy (NCP) in 2019 whose main objective is to influence the adoption of agroecology in order to adapt, mitigate and remedy the effects of climate change, climate variability and global warming. Despite being a state party to numerous international conventions and treaties on the protection of natural environment, the country has failed to arrest the rapid deforestation of indigenous forests in most rural areas. In some instances, the country has made many false starts by converting indigenous forests in rural areas to commercial use. It also took wrong turns by reforesting indigenous forests with exotic plantations. These strategies have proved pernicious to biodiversity conservation and the ability of these forest to sequester more carbon (Mutambara et al., 2024).

Zimbabwe is a land-locked country with a total surface area of 39 million hectares. The country is situated between 15° and 22° south latitude and 24° and 33° east latitude. Zimbabwe enjoys a pleasant subtropical climate with temperatures averaging 19°C in winter and 27° in summer. However, there are wide diurnal (daily) and location variations depending on the latitude. The subtropical climate supports a variety of indigenous and exotic forests. A total of 40% of Zimbabwe's total land is forested by indigenous trees, of which 15,624,000 hectares are native trees and the remainder of 153,000 hectares are exotic plantations (Food and Agricultural Organisation (FAO), 2020; Government of Zimbabwe (GoZ), 2023). At least 5.1% or about 801,000 hectares is categorised as primary forest that is, one that is most biodiverse and carbon-dense form of indigenous forests. The most common rural indigenous forests in Zimbabwe are the dry miombo woodlands, the Baikiaea plurijuga, the acacia and colophospermum mopane and combretum-terminalia (GoZ, 2022). These forests have a huge potential for sinking more carbon stores not only in their leaves but in soil. Whilst it is not known how much mega grams of carbon per hectare are stored in Zimbabwe's indigenous forests, rough estimates show that old-growth miombo woodlands can store an average of 33.9 ± 1.3 Mg C ha-1 in above-ground biomass only.

Nevertheless, most indigenous trees are also well-known for their poor regeneration and low growth rates with many maturing at between 50 to 100 years (GoZ, 2020). Between 1990 and 2020, the country lost over 33,000 hectares or 60,000,000 million indigenous trees annually to anthropogenic activities that include; overexploitation, unplanned deforestation, changes in land use from forestry to either residential, agricultural or artisanal mining activities (GoZ, 2022). In particular, an estimated 0.6% of Zimbabwe's indigenous forests are a lost to tobacco curing and production of charcoal whilst 10% of higher-biomass colophospermum mopane woodlands are damaged during harvesting of Gonimbrasia belina worms (GoZ, 2022). A lot of indigenous forests are lost to brickmaking, firewood and other domestic uses as rural access to electricity is only 14% (GoZ, 2023). Evidence also exists in the eastern highlands of Zimbabwe where some large swathes of indigenous forests were re-forested with non-indigenous trees that later became invasive and destructive to indigenous tree and animal species. In the past two years the country lost an estimated 9,050,000 hectares of indigenous forests, an equivalent of 3.82 metric tonnes of CO_2 emission (FAO, 2022). Anthropogenic activities are likely to result in a total loss of 15.62 million hectares of indigenous forests by 2030, using the current deforestation rate of 312,000 hectares per annum (Muzurura et al., 2024). The study is important for several reasons. First, the effects of climate change are likely to aggravate prevailing vulnerabilities of poor indigenous forest-dependent rural communities in Zimbabwe. As the availability and quality of indigenous forests diminish due to the impact of anthropogenetic activities, so do the increase in prolonged droughts and flooding, unavailability of freshwater and climate related diseases. Climate change and variability is likely to constrain the capacity of rural people to meet their basic survival needs, move out of chronic poverty and food insecurity, and especially to respond environment challenges including prolonged droughts, severe flooding and unavailability of fresh water among others.

Second, the loss of biodiversity and declining carbon sequestration in indigenous forests may affect carbon and nitrogen biogeochemical cycles that are central to the mitigation of climatic changes, climate variability and global warming (Annos et al., 2019; Estrada-Villegas et al., 2019; Fofana et al., 2020; Hohl et al., 2020). Starting from the late 2000s, the country has been predisposed to unpredictable severe weather patterns that often characterised by spasmodic cyclical droughts, flooding and shifting rainy seasons. As a result, extreme weather patterns, specifically cyclonic activities have intensified their frequency, duration and intensity leading to destruction of property and loss of lives. Going forward, without adequate climate-proofing rural communities, climate change and climate variability are likely to exacerbate pandemic waterborne diseases such as malaria, typhoid and cholera and other waterborne diseases.

Third, most indigenous trees produce large biomasses that have the potential to sink more carbon besides their numerous social value benefits such as enhancing ecosystem structure, improving biodiversity conservation, strengthening wildlife resilience, enhancing water catchment, preventing soil erosion and soil stability and moisture holding capacity (Muzurura et al., 2024). Hence, by ensuring adherence to modern agroecology and ecology in the management of indigenous forests, rural communities may able to diversify their income streams by selling carbon credits to developed economies,

in the process arresting hunger, diseases and poverty. Globally there is an upsurge in the availability and utilisation of green financing instruments such as carbon credits and green bonds in many developed economies (Erbough and Oldekop, 2018; Hell and Brancalion, 2020; Crane, 2020; Liu et al., 2020). However, despite the huge endowments of indigenous forest coverage in Zimbabwe's rural areas, the uptake of green financing instruments has been very low. Henceforward, promoting more biodiversity conservation and more carbon stores in indigenous forests may enable rural communities to attract international green investors. In this regard, the study may also assist in raising awareness on the part of policy makers on the need for developing strategies that enable developing economies to offset huge portions of their carbon emissions using carbon credits.

Fourth, there is a lacuna of empirical literature that link biodiversity conservation, carbon sequestration, and improving rural livelihoods in Zimbabwe's rural communities. The global compliance market for carbon credits has become a major source for green financing and for impelling national development. According to Refinitiv (2022), the total market size of carbon credits had risen from US$261 billion in 2020 to Euro 881 billion, representing and equivalent 10.3Gt CO_2. The GoZ (2020) estimated that the country requires at least US$55 billion to reduce greenhouse emissions to below 50% in line with the national climate policy. This expenditure is huge given that the country is also saddled with unsustainable external debt of US$18.8 billion. We argue that using indigenous forests in Zimbabwe to harness the full potential of carbon credits conservatively estimated at US$100 billion might help the country to reduce greenhouse emissions, pay off its external debt and achieve social progress in rural areas. Fifth, most indigenous forests in Zimbabwe are common-pool resources with ill-defined property rights. Legally all rural land in Zimbabwe is owned by the state, with rural people living on open lease without title. Therefore, enforceable property rights over most indigenous forests do not exist for many direct timber and non-timber benefits. In the absence of regulation or collective control over harvesting behaviour, the forest resource stocks are open to access and therefore, the strong possibility of the tragedy of the commons. The study may thus assist policy makers to formulate policies that may feasibly assign property rights of indigenous forests to rural councils, local chiefs and headmen. This study contributes to the literature on improving livelihoods in rural areas using indigenous forests and also opens the debate on how to harness the full potential of green financing to steer rural economic growth. The rest of the study is presented as follows. The second section covers the literature review. The third section covers the methodology whilst the fourth and fifth section present research findings, discussions and policy implications respectively.

2.0 LITERATURE REVIEW BIOLOGICAL CARBON SEQUESTRATION

Carbon sequestration is a complex process that covers various issues in the biophysical environment, and can be divided into three, biological carbon sequestration, geological carbon sequestration and technological carbon sequestration. Carbon sequestration refers to the process of acquiring and storing of carbon dioxide in order to reduce the impact of carbon emissions in the atmosphere (FAO, 2020; Das et al., 2021; Asbeck et al., 2021). If compared to pasture systems, single-species crop and geological carbon systems, forest ecosystems have a higher potential to sequester more carbon dioxide (FAO, 2020; Kaushal and Baishya, 2021) Hong et al., 2020, Hohl et al., 2020; Deere et al., 2020). This is because forests capture and utilise light, nutrients and water more efficiently than pastures or geological formations (Diaz et al., 2016; Bloomfield et al., 2019; Erinos et al., 2019). Mature indigenous trees are major long-term carbon stores due to their complex structure, hardwood nature of trees, stronger resilience to flooding, droughts, wild fires and other anthropogenetic activities (Seddon et al, 2019; NevenKamp et al., 2019; Maxwell, 2018).

Carbon sequestration in indigenous forests, can also be combined with biodiversity conservation and soil-based remedies that prevent carbon emissions and remove atmospheric carbon dioxide (Das et al., 2018; Chu et al., 2017; Joo and Suh, 2017; De Vitis et al., 2020; Crouzeilles et al., 2020) and the public sector (Chu et al., 2017; Joo & Suh, 2017). Trees help to conserve soil, water quality and provide recreation (Korner, 2017; Lewis et al., 2019; Molin et al., 2019; Noomau et al., 2018), provide people with invaluable products and services such as food, medicine, building materials (Brancalion and Holl, 2020; Diaz et al., 2016; Cuenca et al., 2018; Bannister et al., 2016; Korner, 2017), offer fibre, recreation

space, seed dispersion and pollution filtration (Chaisdon and Uriate, 2016; Chomba et al., 2016; Molin et al., 2019), reduce flood and fire risks (de Souza et al., 2016; Fagan et al., 2020; Hu et al., 2020) are important reservoirs of carbon dioxide (Bond et al., 2019; Boissiere et al., 2017; Bellard et al., 2016), and enhance water quality and nutrients (Douwes and Buthelezi, 2016; Feng et al., 2016; Das et al., 2018). Deforestation of indigenous forests comes with unintended consequences particularly, the reduction of pollination services (Hong et al., 2020; Heilmayr et al., 2020; Brancalion et al., 2018), disrupts water cycles (Das et al., 2018; Chu et al., 2017; Joo and Suh, 2017), decrease in carbon stored in above ground biomass (Reid et al., 2019; Perion et al., 2019), and lower albedo in boreal zones and inducing temperature rises (Kull et al., 2019 Besseau et al., 2018; Rozendaal et al., 2019; Fagun et al., 2020).

The extensive use of exotic monoculture plantations instead of promoting diverse and carbon rich-mix indigenous forests has serious implications on food security and sustainability (Kildisheva et al., 2020). This is because monoculture plantations discourage optimum carbon sequestration due to early harvesting and lower biomass (Hu et al., 2020; Crane, 2020; Hu et al., 2020). In addition, monoculture plantations decelerate biodiversity growth and recovery (Philpson et al., 2020; Parsa et al., 2019; Gardan et al., 2020), and have lower non-timber benefits and social value (Heilmayr et al., 2020; Brancalion et al., 2020; Pedrini et al., 2020; Kildisheva et al., 2020; Fofana et al., 2020). In spite of short growing season, many studies demonstrate that the loss of indigenous forests are not easily compensated by reforesting with exotic trees (Oldekop et al., 2019; Pedrini et al., 2020; Seddon et al., 2019; Ennos et al., 2019;Veldman et al., 2019; Wyse and Dickie, 2018).

3.0 METHODOLOGY

We used a revelatory case study of two communities in Muzarabani rural district that live near indigenous forests. The main advantage of using a focus group discussion within a single case was that the researchers were able to study and observe the ways in which various individuals within rural communities collectively made sense about the timber and non-timber benefits of indigenous forests. The focus group had three main objectives, the first was to explore strategies that can be used to by rural communities to optimise carbon sequestration and biodiversity conservation in indigenous forests. The second objective was obtaining the experts perceptions on improving rural livelihood resilience using carbon stores and the role of local communities as regards climate change and climate variability. The third objective was discussing the feasibility and accessibility of reforesting depleted forests with fast growing exotic trees. The focus group discussion was held under the assumption that rural community experiences would be different in particular, their local cultural, environmental and socio-economic contexts. Focus group discussions allow for flexibility (Mutambara et al., 2024) as we wanted to permit all participants to bring in their own insights to the conversations. . Although a discussion script was utilised to steer the conversation towards the predetermined themes and topics of interest, the researcher also used a relatively unstructured approach to asking questions that were in keeping with the broad nature of the study. Whilst it is accepted that focus group discussions cannot aim to be truly representative of the total population living in Muzurura rural areas, by including environmental economists and opinion leaders, the researchers ensured the results of the study could be deemed illustrative of the possible variation and therefore, be able to provide a limited generalisability. The validity and reliability of findings were enhanced by ensuring that all participants were purposively chosen using a pre-selected criteria that included being knowledgeable about environmental conservation of indigenous trees, direct beneficiaries of indigenous forest, and being botanists, ecologists or environmental economists The discussion used a combination of vernacular languages and English, and notes were taken by the researcher who later converted them into a codebook that summarised the main themes discussed and participant's views. The emerging themes are discussed in sections below

4.0 Findings and Discussions

4.1.1 Biodiversity Conservation of Indigenous and optimising carbon sequestration

The botanists argued that whilst monocultures of fast-growing plantations are used in other developing countries to improve carbon stores, however, in the long-term the main advantage of indigenous forests is that they maximise biomass, sink far more carbon in the soil and are more resilient

to wild fires, droughts and erratic rainfalls. It was also reported by the local headmen that from their traditional and cultural experiences, the disadvantages of indigenous trees were many including, longer maturation periods, inadequate seed supply that are also difficult to properly store due to their desiccation sensitivity, and are difficult to propagate on a larger scale. However, an important issue raised by some direct beneficiaries of indigenous trees were that indigenous trees in the area have huge biomasses and thus, an enormous potential for sinking more carbon in the soil and in underground geological formations. On optimising carbon stores, environmentalists argued for planting monoculture exotic plantations near indigenous forests and only in land not fit for agricultural use. This finding has support in literature where many studies demonstrate that mixing forest species has a higher capacity to conserve biodiversity, attract seed pollinators and dispersers, and thus more carbon sequestration (Dvderski and Jagodzinski, 2020; Crouzeilles et al., 2020; Holl and Brancalion, 2020; Horak et al. 2019).

Reforesting Depleted Indigenous forests

Given the extensive deforestation of indigenous forests in Zimbabwe the main theme that emerged was how to reforest depleted portions of some indigenous forests. Ecologists and environment economists were of the general opinion that reforesting sections or former indigenous forests with either indigenous trees or small monoculture plantations would assist rural communities that derive subsistence from trees to achieve multiple goals like mitigation of climate change, biodiversity conservation, economic growth and national development. Two direct beneficiaries of indigenous forests whilst noting the harmful effects of some exotic trees on food security, concurred that situating small monoculture plantations within indigenous forests could serve many objectives such as; climate-change mitigation and proofing, enhancing soil and hydrological stability, providing socio-economic benefits like food security, as well as creating employment for youth and women.

Combining exotic and indigenous forest systems as part of reforestation strategies has been reported to support high species and functional trait diversity that enhance ecosystem resilience and improve forest productivity (Kull et al., 2019 Besseau et al., 2018; Rozendaal et al., 2019; Fagun et al., 2020; Philpson et al., 2020; Dvderski and Jagodzinski, 2020. However, some ecologists disagreed by preferring displacement of indigenous trees with exotic trees since the later mature early and hence, high revenue turnover and employment generation capability. Nevertheless, this view is not supported by some studies that suggest that decisions to reforest parts of indigenous trees with exotic ones must take into cognisant ecological, historical, cultural and socio-economic factors at different spatial scales (Friggens et al., 2020; Dass et al., 2018; Crane, 2020; Lewis et al., 2019; Chazdon and Brancalion, 2019). In fact Horak et al (2019) aver that if patches of exotic forests are maintained within planation of native forest, such forests will not only regenerate autonomously but will becomes more resilient to fire, diseases and extreme droughts.

Assigning Property Rights of Indigenous forests to Local Communities

The findings by environmentalists show that assigning indigenous forest rights to local chiefs can play a significant role in fostering socio-economic development of rural communities that derive their subsistence from indigenous forests. However, some participants argued for assigning the indigenous forest property rights either to commercial forest enterprises or to local non-governmental organisations. It was noted that these entities were able to assist rural communities by providing essential ecological expertise, forest management skills and knowledge, reforestation strategies, computation of carbon credits, and how to mobilise revenues using green financing instruments. Environmental economics also argued for creating a missing market for carbon credit trading in Muzarabani rural area. This was against the background that most rural people in Muzarabani were not aware of how carbon credits were calculated and how green financing works since it involved cross-border transactions. In fact, the findings demonstrated that rural indigenous forests were largely used for their direct timber value and non-timber benefits such as a source of fuel, fibre, and traditional medicine, food, and cultural and spiritual purposes.

5.0 RECOMMENDATIONS AND CONCLUSIONS

Despite their significant contribution to carbon sink and biodiversity, most indigenous trees take time to mature and are difficult to reforest and therefore, the study recommends promoting some naturalist interactions that involve reforesting depleted portion of indigenous tree species with some

monoculture plantations, and introducing some seed-dispersing animals, fungi and pollinators to achieve a resilient and biodiverse ecosystem in community-managed forests. In this regard, as part of corporate social responsibilities, commercial forest enterprises and civil society organisations are encouraged to scale up non-timber value activities in community-managed indigenous forests such as bee-keeping, rearing of wild animals, growing of wild mushroom, handcrafting and other agroecological activities. These activities are likely to reduce the demand of timber value of indigenous trees whilst simultaneously arresting deforestation, generating and broadening sources of income.

Sustainable and diverse income streams for indigenous forest-dependent rural Communities

For community-managed-indigenous forests to be sustainable, the income streams generated by the forests must exceed those obtained from both timber and non-timber value. The findings show that rural communities in Seke District were not aware of green financing instruments like carbon credits. Therefore, the recommendation for policy makers is to assist rural communities to broaden revenue streams through promoting various tourism initiatives such as cultural, ecotourism and mountain tourism as these have a direct bearing with indigenous forests. Providing marketable watershed services and facilitating access to carbon credits and green financing in international markets is also important. District chairpersons must also help to create a missing market for non-timber forest products such as fruits, fungi, mushrooms, nuts, fibres, ornamental and medicinal plants, mosses, resins, gums, syrup, game meat and honey. These in turn can help to increase livelihood resilience of the forest based communities against food insecurity, poverty and unemployment Locals should be trained An example of mainstreaming would be the creation of communal safety nets and common resource pools (seeds, communal irrigation) in a region prone to droughts

Replanting depleted areas with seedlings with Appropriate Genetic Variability and Provenance

Large sections of indigenous forests in Seke Rural have been lost to anthropogenic activities. Providing rural communities with knowledge of vegetative propagation and by providing seeds with higher genetic diversity consistent with local genetic variation may assist to regenerate indigenous trees that are resilient to diseases, inbreeding depression and the effects of flooding and wildfires. Training local people in phenological monitoring regarding abiotic and biotic factors as well as seed physiology and morphology can help faster afforestation of depleted indigenous forests. The government should help local to build low-cost seed-storage facilities and seed banks for use in times of natural disasters such as wild fires and other cyclonic activities that completely destroy forests. Create synergies among rural communities, large forest enterprises, and technical experts in indigenous forest management may help in this endeavour. Most indigenous forest in Seke Rural have seeds that have dormancy mechanisms that require specific conditions for germination therefore, embracing both modern and traditional seed storage mechanism may help in preserving indigenous forest knowledge systems.

Helping rural communities to access green financing Instruments

The value of carbon dioxide in indigenous forests often outweighs the revenues from the main drivers of deforestation, especially the timber value. Therefore, monetising indigenous forests as carbon sinks may ensure that rural communities have access to direct carbon credit markets. Providing low-interest start-up loans to rural communities that subsist on indigenous forests can help enable community managed indigenous forests to be transformed to viable forest commercial-enterprises. In addition, the providing cheap loans to local rural communities may enhance livelihood adaptation during periods of financial hardship that are associated unplanned destruction of forests either by wild fires or cyclonic activities. Whilst harvesting rates of returns of monoculture plantations are reasonably high compared to indigenous forests, corporate social responsibility by commercial forest enterprises may help to smoothen volatilities in international markets particularly in the market prices of indigenous timber.

Assigning Indigenous Forests Rights to Local Communities

The study recommends partnership with local non-governmental organisations and assigning indigenous forest rights to local communities as represented by the headman of the area or chief. This might not only help to conserve these forests but also to improve access to green financing instruments. Guaranteeing indigenous forest property rights can incentivise rural communities to manage these forests over long time horizons. From the discussions it was clear that most local people were unfamiliar with the marketing

of indigenous forests ecotourism, and therefore the recommendation is for district leadership to help in monitoring revenues coming from the trading of carbon. Ensuring that payments actually benefit rural communities responsible for the upkeep of indigenous forests acts to dis-incentivise change of land use from forestry to other activities such as manufacturing, agriculture or artisanal mining. In addition, promoting partnerships that encompass multiple stakeholders such as the government, forest scientists, chiefs, community leaders and are likely to lead to enduring long-term benefits for rural communities that live near indigenous forests. Optimising carbon sequestration and biodiversity conservation may require overcoming political, cultural and socio-economic hindrances. It is important that the government of Zimbabwe must address land tenure concerns in rural areas through reducing regulatory and legal burdens on indigenous-forest based communities. Facilitating exports of indigenous timber, watershed protection and simplifying export regulations on game meat and products are some of the measures that can climate-proof rural communities. Forming strategic partnerships with big forest enterprises and Civil Society Organisations can increase payoffs and reduce transaction costs of community managed indigenous forests through benefit/risk sharing.

5.0 CONCLUSIONS

In many developing economies, rural indigenous forests if properly managed can be a major source of food security. The objective of the study was interrogating how rural communities that live near indigenous forest can benefit from strategies that optimise carbon sinks and biodiversity conservation. The main findings reveal that most rural communities are not aware of the benefits of green financing instruments that are linked to conservation of indigenous forests.

REFERENCES

Asbeck, T., Sabatini, F., Augustynczik, A. L., Basile, M., Helbach, J., Jonker, M., Knuff, A., & Bauhus, J. (2021). Biodiversity response to forest management intensity, carbon stocks and net primary production in temperate montane forests. *Scientific Reports*, *11*(1):1–11.

Bannister, J. R., Vargas-Gaete, R., Ovalle, J. F., Acevedo, M., Fuentes-Ramirez, A., Donoso, P. J., Promis, A., & Smith-Ramírez, C. (2018). Major bottlenecks for the restoration of natural forests in Chile. *Restoration Ecology*, *26*(6): 1039–1044.

Bhardwaj, D. R., Tahiry, H., Sharma, P., Pala, N. A., Kumar, D., Kumar, A., & Bharti, B. (2021). Influence of aspect and Elevational gradient on vegetation pattern, tree characteristics and ecosystem carbon density in north-western Himalayas. *Land*, *10*(11), 1109.

Bloomfield, G., Meli, P., Brancalion, P. H. S., Terris, E., Guariguata, M. R., & Garen, E. (2019). Strategic insights for capacity development on forest landscape restoration: Implications for addressing global commitments. *Tropical Conservation Science*, *12* (1):12-32

Bond, W. J., Stevens, N., Midgley, G. F., & Lehmann, C. E. R. (2019). The trouble with trees: Afforestation plans for Africa. *Trends in Ecology & Evolution*, 34(11): 963–965.

Brancalion, P. H. S., & Holl, K. D. (2020). Guidance for successful tree planting initiatives. Journal of Applied Ecology, 205(4969), 2349–2361.

Brancalion, P. H. S., Amazonas, N. T., Chazdon, R. L., van Melis, J., Rodrigues, R. R., Silva, C. C., Sorrini, T. B., & Holl, K. D. (2020). Exotic eucalypts: From demonized trees to allies of tropical forest restoration? *Journal of Applied Ecology*, *57*(1): 55–66.

Brancalion, P. H. S., Bello, C., Chazdon, R. L., Galetti, M., Jordano, P., Lima, R. A. F., Medina, A., Pizo, M. A., & Reid, J. L. (2018). Maximizing biodiversity conservation and carbon stocking in restored tropical forests. *Conservation Letters*, *11*(4): 1–9.

Burton, V., Moseley, D., Brown, C., Metzger, M. J., & Bellamy, P. (2018). Reviewing the evidence base for the effects of woodland expansion on biodiversity and ecosystem services in the United Kingdom. *Forest Ecology and Management*, 430, 366–379.

Chazdon, R., & Brancalion, P. (2019). Restoring forests as a means to many ends. An urgent need to replenish tree canopy cover calls for holistic approaches. *Science*, 365:6448.

Crouzeilles, R., Barros, F. S. M., Molin, P. G., Ferreira, M. S., Junqueira, A. B., Chazdon, R. L., Lindenmayer, D. B., Tymus, J. R. C., Strassburg, B. B. N., & Brancalion, P. H. S. (2019). A new approach to map landscape variation in forest restoration success in tropical and temperate forest biomes. *Journal of Applied Ecology*, *56*(12): 2675–2686

Crouzeilles, R., Beyer, H. L., Monteiro, L. M., Feltran-Barbieri, R., Pessôa, A. C. M., Barros, F. S. M., Lindenmayer, D. B., Lino, E. D. S. M., Grelle, C. E. V., Chazdon, R. L., Matsumoto, M., Rosa, M., Latawiec, A. E., & Strassburg, B. B. N. (2020). Achieving cost-effective landscape-scale forest restoration through targeted natural regeneration. *Conservation Letters*, *13*(3): 1-17.

Das, B., Bordoloi, R., Deka, S., Paul, A., Pandey, P. K., Singha, L. B., Tripathi, O. P., Mishra, B.P., & Mishra, M. (2021). Above ground biomass carbon assessment using field, satellite data and model based integrated approach to predict the carbon sequestration potential of major land use sector of Arunachal Himalaya, India. *Carbon Management, 12*(2): 201–214.

de Almeida, D. R. A., Stark, S. C., Valbuena, R., Broadbent, E. N., Silva, T. S. F., de Resende, A. F., Ferreira, M. P., Cardil, A., Silva, C. A., Amazonas, N., Zambrano, A. M. A., & Brancalion, P. H. S. (2020). A new era in forest restoration monitoring. *Restoration Ecology*, 28(1), 8–11.

De Vitis, M., Hay, F. R., Dickie, J. B., Trivedi, C., Choi, J., & Fiegener, R. (2020). Seed storage: Maintaining seed viability and Vigor for restoration use. *Restoration Ecology*, 28(S3): 1–7.

Deere, N. J., Guillera-arroita, G., Swinfield, T., Milodowski, D. T., Coomes, D. A., Bernard, H., Reynolds, G., Davies, Z. G., & Struebig, M. J. (2020). Maximizing the value of forest restoration for tropical mammals by detecting three-dimensional habitat associations. *Proceedings of the National Academy of Sciences of the United States of America*, 117(42): 26254–26262.

Domke, G. M., Oswalt, S. N., Walters, B. F., & Morin, R. S. (2020). Tree planting has the potential to increase carbon sequestration capacity of forests in the United States. *Proceedings of the National Academy of Sciences, 117*(40): 24649–24651

Dyderski, M. K., & Jagodziński, A. M. (2020). Impact of invasive tree species on natural regeneration species composition, diversity, and density. *Forests, 11*(4), 1–20.

Ennos, R., Cottrell, J., Hall, J., & O'Brien, D. (2019). Is the introduction of novel exotic forest tree species a rational response to rapid environmental change? A British perspective. *Forest Ecology and Management*, 432, 718–728

Erbaugh, J. T., Pradhan, N., Adams, J., Adams, J., Oldekop, J. A., Agrawal, A., Brockington, D., Pritchard, R., & Chhatre, A. (2020). Global forest restoration and the importance of prioritizing local communities. *Nature Ecology & Evolution., 4*, 1472–1476.

Estrada-Villegas, S., Bailón, M., Hall, J. S., Schnitzer, S. A., Turner, B. L., Caughlin, T., & van Breugel, M. (2019). Edaphic factors and initial conditions influence successional trajectories of early regenerating tropical dry forests. *Journal of Ecology*, 108, 160–174

Fagan, M. E., Reid, J. L., Holland, M. B., Drew, J. G., & Zahawi, R. A. (2020). How feasible are global forest restoration commitments? *Conservation Letters, 13*(3): 1–8.

FAO. (2020). *Global Forest Resources Assessment. Key Findings*. Available online: www.fao.org/forest-resources-assessment (accessed on 10 August 2023)

Fofana, B., Sacande, M., Blagna, F., Dibloni, T. O., Compaore, E., Sanon, K. B., Maiga, Y., & Ouattara, A. S. (2020). Boosting land restoration success in the Great Green Wall through the use of symbiotic microorganisms for propagated tree seedlings. International, *Journal of Biological and Chemical Sciences, 14*(1), 110–125.

Freitas, M. G., Rodrigues, S. B., Campos-Filho, E. M., do Carmo, G. H. P., da Veiga, J. M., Junqueira, R. G. P., & Vieira, D. L. M. (2019). Evaluating the success of direct seeding for tropical forest restoration over ten years. *Forest Ecology and Management, 438*, 224–232.

Friggens, N. L., Hester, A. J., Mitchell, R. J., Parker, T. C., Subke, J. A., & Wookey, P. A. (2020). Tree planting in organic soils does not result in net carbon sequestration on decadal timescales. *Global Change Biology, 26*(9): 5178–5188

Gann, G. D., McDonald, T., Walder, B., Aronson, J., Nelson, C. R., Jonson, J., Hallett, J. G., Eisenberg, C., Guariguata, M. R., Liu, J., Hua, F., Echeverría, C., Gonzales, E., Shaw, N., Decleer, K.,

& Dixon, K. W. (2019). International principles and standards for the practice of ecological restoration. *Restoration Ecology, 27*(S1), S1–S46.

Gardon, F. R., de Toledo, R. M., Brentan, B. M., & Ferreira dos Santos, R. (2020). Rainfall interception and plant community in young forest restorations. *Ecological Indicators,* 109, 105779

Heilmayr, R., Echeverría, C., & Lambin, E. F. (2020). Impacts of Chilean forest subsidies on forest cover, carbon and biodiversity. *Nature Sustainability, 3*(9), 701–709.

Höhl, M., Ahimbisibwe, V., Stanturf, J. A., Elsasser, P., Kleine, M., & Bolte, A. (2020). Forest landscape restoration – What generates failure and success? *Forests, 11*(9), 938.

Holl, K. D., & Brancalion, P. H. S. (2020). Tree planting: Not a simple solution. Science, 368(6491), 580–581.

Hong, S., Yin, G., Piao, S., Dybzinski, R., Cong, N., Li, X., Wang, K., Peñuelas, J., Zeng, H., & Chen, A. (2020). Divergent responses of soil organic carbon to afforestation. *Nature Sustainability, 3*(9), 694–700

Hoque, M. Z., Cui, S., Islam, I., Xu, L., & Ding, S. (2021). Dynamics of plantation forest development and ecosystem carbon storage change in coastal Bangladesh. *Ecological Indicators*, 130, 107954

Hu, J., Herbohn, J., Chazdon, R. L., Baynes, J., & Vanclay, J. (2020). Silvicultural treatment effects on commercial timber volume and functional composition of a selectively logged Australian tropical forest over 48 years. Forest *Ecology and Management, 457*, 117690.

IUCN. (2020). Guidance for using the IUCN global standard for nature-based solutions. A user-friendly framework for the verification, design and scaling up of nature-based solutions (1st ed.). IUCN

Kaushal, S., & Baishya, R. (2021). Stand structure and species diversity regulate biomass carbon stock under major central Himalayan Forest types of India. *Ecological Processes*, *10*(1): 1–18.

Kildisheva, O. A., Dixon, K. W., Silveira, F. A. O., Chapman, T., Di Sacco, A., Mondoni, A., Turner, S. R., & Cross, A. T. (2020). Dormancy and germination: Making every seed count in restoration. *Restoration Ecology, 28*(S3), S256–S265

Köhl, M., Neupane, P. R., & Mundhenk, P. (2020). REDD+ measurement, reporting and verification – A cost trap? Implications for financing REDD+MRV costs by result-based payments. *Ecological Economics,* 168, 106513.

Kull, C. A., Harimanana, S. L., Radaniela Andrianoro, A., & Rajoelison, L. G. (2019). Divergent perceptions of the 'neo-Australian' forests of lowland eastern Madagascar: Invasions, transitions, and livelihoods. *Journal of Environmental Management*, 229, 48–56

Kwiri R, Mujuru FM, Gwala W. (2020) Nutrient Composition and Bioactive Components of Mopane Worm (Gonimbrasia belina). African Edible Insects as Alternative Source of Food, Oil, Protein and Bioactive Components: *Springer* p. 241–56

Lewis, S. L., Wheeler, C. E., Mitchard, E. T. A., & Koch, A. (2019). Regenerate natural forests to store carbon. *Nature,* 568, 25–28.

Liu, Q., Zhang, Q., Yan, Y., Zhang, X., Niu, J., & Svenning, J.-C. (2020). Ecological restoration is the dominant driver of the recent reversal of desertification in the Mu Us Desert (China). *Journal of Cleaner Production,* 268, 12224

Mattana, E., Peguero, B., Di Sacco, A., Agramonte, W., Encarnación Castillo, W. R., Jiménez, F., Clase, T., Pritchard, H. W., Gómez-Barreiro, P., Castillo-Lorenzo, E., Terrero Encarnación, M., Way, M. J., García, R., & Ulian, T. (2020). Assessing seed desiccation responses of native trees in the Caribbean. *New Forests, 51*(4), 705–721.

Moomaw, W. R., Masino, S. A., & Faison, E. K. (2019). Intact forests in the United States: Proforestation mitigates climate change and serves the greatest good. *Frontiers in Forests and Global Change,* 2, 1–10.

Musundire R, Ngonyama D, Chemura A, Ngadze RT, Jackson J, Matanda MJ, (2021). Stewardship of wild and farmed edible insects as food and feed in Sub-Saharan Africa: A perspective. *Frontiers in Veterinary Science*. 8:102-114

Mutambara E; Muzurura, J* and Manzote, E., (2023), Prioritising Factors Influencing Mountain Tourism Using a Fuzzy Analytic Hierarchical Process: A Case Study of Mount Nyangani, Zimbabwe. *International Journal of Tourism and Hospitality 12*(2): 1-14

Mutambara, E and Muzurura, J* (2025) Ranking and Evaluating Tourists Heterogeneous Preferences and Destination Competitiveness Using Multi-Criteria Decision Models: *African Journal of Tourism, Hospitality and Leisure*, Vol. 14(1), 197-207.

NCC (Natural Capital Committee). (2020). Advice on using nature-based interventions to reach net zero greenhouse gas emissions by 2050. Department for Environment, Food and Rural Affairs, HM Government, 26 p

Oldekop, J. A., Sims, K. R. E., Karna, B. K., Whittingham, M. J., & Agrawal, A. (2019). Reductions in deforestation and poverty from decentralized forest management in Nepal. *Nature Sustainability, 2*(5): 421–428

Pedrini, S., & Dixon, K. W. (2020). International principles and standards for native seeds in ecological restoration. *Restoration Ecology,* 28(S3), S286–S303.

Pedrini, S., Dixon, K. W., & Kildisheva, O. A. (2020a). Seed enhancement: Getting seeds restoration-ready. *Restoration Ecology, 28*(S3).12-25

Pedrini, S., Gibson-Roy, P., Trivedi, C., Gálvez-Ramírez, C., Hardwick, K., Shaw, N., Frischie, S., Laverack, G., & Dixon, K. (2020). Collection and production of native seeds for ecological restoration. *Restoration Ecology, 28*(S3), S228–S238.

Rezende, G. M., & Vieira, D. L. M. (2019). Forest restoration in southern Amazonia: Soil preparation triggers natural regeneration. *Forest Ecology and Management*, 433, 93–104.

Seddon, N., Chausson, A., Berry, P., Girardin, C. A. J., Smith, A., & Turner, B. (2020). Understanding the value and limits of nature-based solutions to climate change and other global challenges. Philosophical Transactions B: *Biological Sciences,* 375. 15-35.

Shaw, N., Barak, R. S., Campbell, R. E., Kirmer, A., Pedrini, S., Dixon, K., & Frischie, S. (2020). Seed use in the field: Delivering seeds for restoration success. *Restoration Ecology, 28*(S3). 14-45.

Siegner, M., Panwar, R. and Kozak, R. (2021), Community forest enterprises and social enterprises: the confluence of two streams of literatures for sustainable natural resource management, *Social Enterprise Journal,* 17 (4):584-603.

Steur, G., Verburg, R. W., Wassen, M. J., & Verweij, P. A. (2020). Shedding light on relationships between plant diversity and tropical forest ecosystem services across spatial scales and plot sizes. *Ecosystem Services,* 4, 101107-101110.

Tolangay, D., & Moktan, S. (2020). Trend of studies on carbon sequestration dynamics in the Himalaya hotspot region: A review. *Journal of Applied and Natural Science, 12*(4): 647–660.