



Save the Sand: a restoration of the Sabie-Sand River Catchment

Feasibility Study

Client: Sand Catchment (Pty) Ltd.

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List of acronyms and abbreviations

Acronym	Full term
AGB	aboveground biomass
ARR	afforestation, reforestation, and revegetation
AFOLU	agriculture, forestry, and other land use
BGB	belowground biomass
CCB	Climate, Community, and Biodiversity Standard
CCBA	Climate, Community and Biodiversity Alliance
CF	carbon factor
CH ₄	methane
COD	chemical oxygen demand
CO ₂	Carbon dioxide
CPA	Communal Property Association
C4	C4 EcoSolutions (Pty) Ltd.
DBH	diameter at breast height
DOC	dissolved organic carbon
EDM	Ehlanzeni District Municipality
ER	emission removal
GDP	Gross Domestic Product
GL	Gold Level
GIS	Geographic Information System
GHG	greenhouse gas
GPS	Global Position Satellite
FS	Feasibility Study
FPIC	free, prior and informed consent
GHG	greenhouse gas
IALM	improved agricultural land management
ICRAF	World Agroforestry
IDP	Integrated Development Plan
IPCC	Intergovernmental Panel on Climate Change



Acronym	Full term
IRD	Institute for Research and Development
IRR	internal rate of return
IUWMA	Inkomati-Usuthu Water Management Area
IWRM	Integrated Water Resources Management
KBA	Key Biodiversity Area
KNP	Kruger National Park
K2C	Kruger to Canyon Biosphere Reserve
LULC	land use land cover
NDVI	Normalised Difference Vegetation Index
NGO	Non-governmental organisation
NPV	net positive value
NTFP	Non-timber Forest Product
N ₂ O	Nitrous oxide
PDD	project design document
PTO	Permission to Occupy
QAQC	Quality Assurance Quality Control
SANLC	South African National Land Cover
SALM	Sustainable agriculture land management
SC	Sand Catchment (Pty) Ltd.
SExi-FS	Spatially Explicit Individual-based Forest Simulator
SOC	soil organic carbon
SPLUMA	Spatial Planning Land Use Management Act
SGM	sustainable grassland management
SRS	stratified random sampling
tCO ₂ -e	Tonnes of carbon dioxide equivalent
TOC	Theory of Change
UCU	Unverified Carbon Unit
UNFCCC	United Nations Framework on Climate Change Convention
VCS	Verified Carbon Standard
VCU	Verified Carbon Unit



Executive summary

Sand Catchment (Pty) Ltd. (SC) has commissioned C4 EcoSolutions (Pty) Ltd. (C4) to conduct a Feasibility Study (FS) for an Afforestation, Reforestation and Revegetation (ARR) project in the Sabie-Sand River Catchment. The potential project area spans ~630,000 hectares (ha) in the Ehlanzeni District Municipality (EDM) of South Africa's Mpumalanga province and is home to more than 2.3 million people. This region is economically, ecologically and culturally valuable with agriculture, tourism, biodiversity and community livelihoods closely interconnected. The Sabie-Sand River Catchment exhibits land degradation due to unsustainable agricultural practices and overgrazing, deforestation, unregulated water extraction, forestry and river sand mining. This leads to soil erosion, river siltation, water scarcity and vegetation loss which threaten not only the region's environment and biodiversity but also the livelihoods of its inhabitants.

The proposed project will restore targeted landscapes, sequester carbon and enhance ecosystem services and biodiversity while providing improved and sustainable livelihood options, as well as training and mentorship for local communities. This three-pronged, climate-, biodiversity- and community-oriented approach will integrate indigenous and fruit- and nut-bearing trees into several land-use systems, including croplands, rural residences and rangelands. Potential to scale the project into degraded forests and woodlands is noted. The FS follows the guidelines of Verra's Verified Carbon Standard (VCS), the VM0047 Methodology for ARR and the Climate, Community, and Biodiversity (CCB) Standard. VM0047 provides a framework for quantifying carbon sequestration and generating verifiable carbon units (VCUs), while the CCB Standard assesses non-carbon climate benefits and the projects impact on communities and biodiversity. The project will adopt a VCS-grouped approach with a 40-year project duration and a 5–7-year implementation phase.

The project design incorporates agroforestry practices by planting trees using a census-based approach for: i) ~10,000 ha or cropland at 200 trees/ha; ii) ~20,000 ha of residences at 50 trees/ha; and iii) ~5,000 ha of rangeland at 100 trees/ha. Species include, *inter alia*, the indigenous apple-leaf (*Philenoptera violacea*), marula (*Sclerocarya birrea*) and African fig (*Ficus sycomorus*), and avocado (*Persea americana*), macadamia (*Macadamia integrifolia* or *tetraphylla*), mango (*Magifera indica*) and citrus species — sweet orange (*Citrus sinensis*), lemon (*Citrus limon*) and lime (*Citrus aurantifolia*). Aboveground biomass (AGB) and belowground biomass (BGB) carbon pools are selected with focus on carbon dioxide (CO₂) as greenhouse gas (GHG) for emissions and removals. Preliminary calculations indicate a total net emission removal of 6.9 million tonnes of CO₂-equivalent (tCO₂-e), with ARR activities in croplands, residences and rangelands contributing 2.9 million, 2.4 million and 1.3 million tCO₂-e, respectively. Leakage and project emissions are considered negligible, while uncertainty is conservatively estimated as 10%. After accounting for potential carbon reversals, the project is estimated to sequester ~6.0 million tCO₂-e — termed Unverified Carbon Units (UCUs) in this study.

The project addresses interconnected environmental and socio-economic challenges by using an integrated approach. It focuses on climate change mitigation via agroforestry and reforestation, community development through livelihood improvement and skills training, and biodiversity conservation by restoring habitats and creating wildlife corridors. The project aligns with local requirements, national climate commitments and global sustainability goals. Its strategy demonstrates potential for CCB certification — possibly at the Gold Level — highlighting the commitment to impactful benefits across all three areas.

Several challenges are noted, including, *inter alia*, complex land tenure systems, potential conflicts over resource use and the requirement for long-term community engagement and benefit-sharing mechanisms. The preliminary risk assessment indicates a 15% risk rating,



necessitating risk mitigation strategies. To ensure project success, the steps below are recommended:

- undertake detailed stakeholder mapping and engagement;
- perform cost-benefit analysis and secure funding sources;
- develop a robust monitoring and evaluation system;
- establish pilot projects to refine methodologies and build community support; and
- pursue CCB certification alongside VCS to increase project benefits and marketability.

Overall, the FS concludes that the proposed ARR project in the Sabie-Sand River Catchment is feasible and has the potential to deliver several environmental, social and economic benefits. Further detailed planning and stakeholder engagement are recommended to address identified challenges and optimise project outcomes.

1. Introduction

The Sabie-Sand River Catchment forms part of the Maputuland-Pondoland-Albany Global Biodiversity Hotspot¹ and is categorised as a Key Biodiversity Area (KBA)². Across its river network and several nature and game reserves, the catchment supports diverse, endemic and endangered flora and fauna^{3,4}. Spanning most of the Ehlanzeni District Municipality (EDM) which is home to more than 2.3 million people⁵, it sustains livelihoods through agriculture, mining, manufacturing, forestry, trade, tourism, conservation and wildlife management⁶. Consequently, the catchment's environmental, social and economic interests are linked to its ecosystem services. Unsustainable and unregulated practices relating to agriculture and grazing, forestry, water extraction and river sand mining have led to land degradation resulting in soil erosion, siltation of river systems, water scarcity and vegetation loss^{7,8}. These effects — compounded by climate change — threaten the catchment's ecosystem services and the communities relying on them.

The Feasibility Study (FS) explores the implementation of an Afforestation, Reforestation and Revegetation (ARR) project to address land degradation and its effects in the Sabie-Sand River Catchment. This study provides an evaluation of the potential to integrate indigenous and fruit- and nut-bearing trees into several land-use systems, including croplands, rural residences, rangelands and forests. These trees are selected for their multiple environmental and socio-economic benefits. The FS assesses the project's capacity to address

¹ Critical Ecosystem Partnership Fund (CEPF). 2024. Explore the biodiversity hotspots. CEPF. Available at: <https://www.cepf.net/our-work/biodiversity-hotspots>. Accessed on: 22 August 2024.

² South African National Biodiversity Institute (SANBI). 2024. Key biodiversity areas in South Africa. SANBI. Available at: <https://www.sanbi.org/biodiversity/building-knowledge/biodiversity-monitoring-assessment/key-biodiversity-areas-in-south-africa/>. Accessed on: 22 August 2024.

³ South African River Health Programme (SARHP). 2001. State of the rivers report: Crocodile, Sabie-Sand and Oliphant's River systems. South African Department of Water and Sanitation. Available at: https://www.dws.gov.za/iwqs/rhp/state_of_rivers/crocsabieolif_01_toc.html. Accessed on: 22 August 2024.

⁴ South African National Biodiversity Institute (SANBI). 2020. National Biodiversity Assessment 2018: Mpumalanga. SANBI. Available at: <https://opus.sanbi.org/sanbiserver/api/core/bitstreams/e381b1c8-f5ac-47b2-8e03-8b6c507236bc/content>.

⁵ Ehlanzeni District Municipality (EDM). 2024. Ehlanzeni District Municipality's Integrated Development Plan and Budget 2024/2025 review. EDM. Available at: <https://www.ehlanzeni.gov.za/wp-content/uploads/2024/05/Final-IDP-Budget-2024-25-22-May-2024.pdf>

⁶ Ibid.

⁷ South African River Health Programme (SARHP). 2001. State of the rivers report: Crocodile, Sabie-Sand and Oliphant's River systems. South African Department of Water and Sanitation. Available at: https://www.dws.gov.za/iwqs/rhp/state_of_rivers/state_of_crocsabieolif_01/sabie_eco_5.05.html. Accessed on: 22 August 2024.

⁸ Mpumalanga Tourism and Parks Agency. 2012. Eco Status of the Sabie and Sand River Catchments. Incomati Catchment Management Agency. Available at: https://www.dws.gov.za/iwqs/rhp/state_of_rivers/Ecstatus_Sabie_Sand_2011.pdf.



environmental degradation, enhance biodiversity and improve community livelihoods while sequestering carbon and generating verifiable carbon credits.

The project uses guidance from two frameworks: i) Verra's VM0047 Methodology for ARR v1.0 2023⁹; and ii) the Climate, Community and Biodiversity (CCB) Standard¹⁰. VM0047 provides a framework for quantifying carbon sequestration and generating verifiable carbon units (VCUs). The CCB Standard complements VM0047 by assessing the impact on local communities and biodiversity, ensuring the project delivers benefits beyond carbon sequestration. An outline of the FS is: i) an eligibility assessment; ii) project design, scale and timeline; iii) project boundary determination; iv) baseline determination; v) additionality analysis; vi) quantification of greenhouse gas (GHG) emission removals; vii) deductions for leakage, project emissions and uncertainty; viii) risk analysis; ix) estimation of potentially verifiable carbon units; and x) monitoring.

2. Background

The Sabie-Sand River Catchment covers ~630,000 hectares (ha) and is located in the Ehlanzeni District Municipality (EDM) of the Mpumalanga province in South Africa¹¹. It forms part of the larger Inkomati-Usuthu Water Management Area (IUWMA), which is one of nine water management areas in South Africa established under the National Water Act of 1998¹².

A west to east variation is noted in the catchment's topography. In the western region, the high-altitude Drakensberg Escarpment reaches elevations exceeding 2,000 meters, while the eastern plains drop below 400 m. This topographical variation creates distinct zones, including steep mountain slopes, hills and flat lowland areas, each with diverse ecosystems¹³.

The catchment is made up of two sub-catchments — the Sabie and the Sand. Forming the primary watercourse in the Sabie sub-catchment, the Sabie River originates in the Drakensberg Escarpment near Graskop and flows eastward for 175 km through the Kruger National Park (KNP) west of Lilleydale. It continues into the Inkomati River and Corumana Dam in Mozambique — ultimately ending in the Indian Ocean. The Sand River — main watercourse of the Sand sub-catchment — and Marite River — a large river in the Sabie sub-catchment — are major tributaries to the entire Sabie River system^{14,15}. A map of the Sabie-Sand River Catchment with main towns, settlements of importance and river network is provided in Figure 2.1.

⁹ Verra. 2023. VM0047 Afforestation, Reforestation, and Revegetation, v1.0. Available at:

<https://verra.org/methodologies/vm0047-afforestation-reforestation-and-revegetation-v1-0/vm0047>.

¹⁰ Climate, Community and Biodiversity Standards (CCB). 2017. VCS, Third Edition, Version 3.1. Available at:

https://verra.org/wp-content/uploads/CCB-Standards-v3.1_ENG.pdf.

¹¹ South African River Health Programme (SARHP). 2001. State of the rivers report: Crocodile, Sabie-Sand and Oliphant's River systems. South African Department of Water and Sanitation. Available at:

https://www.dws.gov.za/iwqs/rhp/state_of_rivers/state_of_crocsabieolif_01/sabie_eco.html. Accessed on: 22 August 2024.

¹² Department of Water and Sanitation (South Africa). 2016. National Water Act, 1998 (Act No. 36 of 1998): the new nine water management areas of South Africa. (Notice 1056). Government Gazette, 40269: 169, 16 September.

¹³ Ibid.

¹⁴ South African River Health Programme (SARHP). 2001. State of the rivers report: Crocodile, Sabie-Sand and Oliphant's River systems. South African Department of Water and Sanitation. Available at:

https://www.dws.gov.za/iwqs/rhp/state_of_rivers/state_of_crocsabieolif_01/sabie_eco.html. Accessed on: 22 August 2024.

¹⁵ Knight J and Evans M. 2022. Characterising the geomorphic dynamics of river systems: An example of the Sabie River, South Africa. *Koedoe*. 64(1):1–6

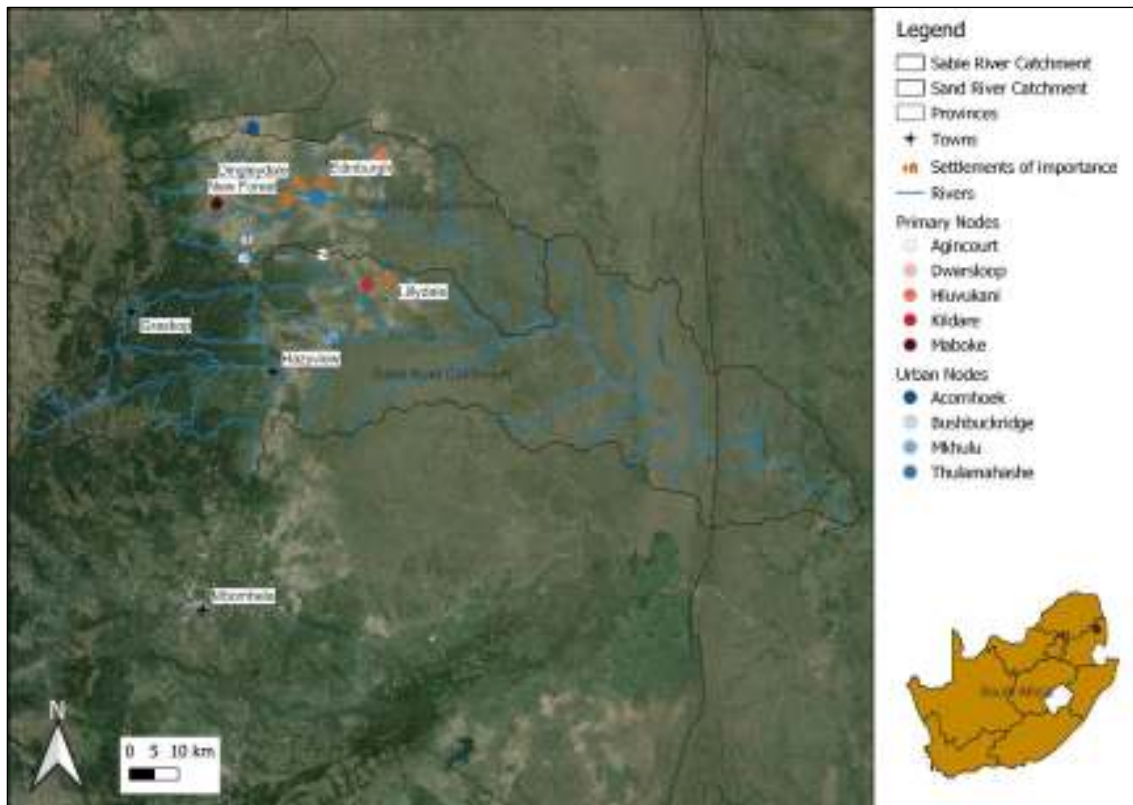


Figure 2.1. The Sabie-Sand River Catchment with important towns, settlements and river network.

2.1. Geology

Geological formations shape the terrain, affect soil composition, and guide both surface water patterns and groundwater movement. This impacts the catchment's ecosystem and water resources. The Sabie-Sand River Catchment's bedrock geology comprises three litho-stratigraphic units: i) the Archaean basement granite-gneiss complex in the lower-lying eastern parts; ii) the early Proterozoic Transvaal sequence of sedimentary rocks in the western mountainous regions; and iii) the younger Permian to Jurassic Karoo sequence of sedimentary and volcanic rocks found in patches across the catchment^{16,17,18}. This geological diversity leads to a range of soil types across the catchment^{19,20}:

- shallow, rocky lithosols with high organic content in the cool, moist mountain grasslands of the upper catchment;
- deep highly weathered ferrallitic clays rich in iron and aluminium oxides alongside coarse-textured arenosols with low water retention in the warmer and drier lower parts of the catchment; and
- fertile alluvial soils in the eastern region exhibiting floodplain characteristics with layered deposits of sand, silt and clay formed by periodic flooding.

¹⁶ Knight J and Evans M. 2022. Characterising the geomorphic dynamics of river systems: An example of the Sabie River, South Africa. *Koedoe*. 64(1):1–6

¹⁷ O'Keefe J. 1985. The conservation status of the Sabie and Groot Letaba rivers within the Kruger National Park. Rhodes University, Grahamstown.

¹⁸ Heritage GL and Moon BP. 2000. The contemporary geomorphology of the Sabie River in the Kruger National Park. *Koedoe*. 43(1):5–35.

¹⁹ O'Keefe J. 1985. The conservation status of the Sabie and Groot Letaba rivers within the Kruger National Park. Rhodes University, Grahamstown.

²⁰ Brady NC and Weil RR. 2016. *The Nature and Properties of Soils*, 15th Edition. Pearson Education, Inc., Upper Saddle River, NJ.



Water resources are similarly influenced by geology, with the dolomitic areas of the Transvaal Sequence frequently host aquifers that provide necessary groundwater resources. In contrast, the Basement Complex yields less groundwater. Varied geology also affects river channel morphology, as resistant rock types create rapids and gorges, while softer rocks enable wider floodplains^{21,22,23}.

Within the Sabie-Sand River Catchment, the interplay of geological and pedological factors contributes to the area's biodiversity and diverse ecosystem types. Rock formations and soil characteristics combine to create habitats from rocky outcrops supporting specialised plant communities to areas with deep, nutrient-rich soils with dense forests. Environmental heterogeneity resulting from these varied conditions creates a wide array of ecological niches, enhancing the region's species richness and habitat diversity²⁴.

2.2. Climate

Varied topography within the Sabie-Sand River Catchment creates distinct temperature and rainfall gradients. The mountainous regions — reaching above 2,000 m above sea level — have cooler conditions with mean annual temperatures of 16°C. In contrast, the eastern lowlands experience warmer climates, with mean annual temperatures of 22°C. Seasonal extremes are notable with summer temperatures in the lowveld peaking at 40°C, while winter temperatures in the highlands occasionally drop below freezing²⁵.

Annual evaporation rates average at 1,700 mm, particularly in the lower reaches of the catchment and regularly surpassing annual rainfall. The rainfall patterns in the catchment are similarly varied by topography, higher altitudes in the western regions receive annual rainfall of ~2,000 mm and the eastern lowlands are drier, receiving ~600 mm per year. This rainfall is predominantly seasonal, occurring during summer months and causing variation in river throughout the year²⁶.

2.3. Hydrology

Hydrology of the Sabie-Sand River Catchment is characterised by a mean annual run-off of 760 million cubic meters (m³) and the different flow regimes of its three main rivers and is influenced by several water infrastructure components²⁷. The Sabie River — while perennial — has highly variable flow with average discharge of 2–3 m³/s per second (m³/s) in the winter and 20–50 m³/s in the summer. Peak seasonal flood events reach discharges of 300–400 m³/s

²¹ Knight J and Evans M. 2022. Characterising the geomorphic dynamics of river systems: An example of the Sabie River, South Africa. *Koedoe*, 64(1):1–6.

²² Parsons M, *et al.* 2006. The biotic and abiotic legacy of a large infrequent flood disturbance in the Sabie River, South Africa. *River Research and Applications*. 22(2):187–201.

²³ Heritage GL and Moon BP. 2000. The contemporary geomorphology of the Sabie River in the Kruger National Park. *Koedoe*. 43(1):5–35.

²⁴ Knight J and Evans M. 2022. Characterising the geomorphic dynamics of river systems: An example of the Sabie River, South Africa. *Koedoe*, 64(1):1–6.

²⁵ South African River Health Programme (SARHP). 2001. State of the rivers report: Crocodile, Sabie-Sand and Oliphant's River systems. South African Department of Water and Sanitation. Available at: https://www.dws.gov.za/iwqs/rhp/state_of_rivers/state_of_crocsabieolif_01/sabie_eco.html. Accessed on: 22 August 2024.

²⁶ South African River Health Programme (SARHP). 2001. State of the rivers report: Crocodile, Sabie-Sand and Oliphant's River systems. South African Department of Water and Sanitation. Available at: https://www.dws.gov.za/iwqs/rhp/state_of_rivers/state_of_crocsabieolif_01/sabie_eco.html. Accessed on: 22 August 2024.

²⁷ *Ibid.*



in the middle and lower reaches of the catchment^{28,29}. The Marite River — like the Sabie — is also perennial, with flow that fluctuates with seasonal rainfall. In contrast, the Sand River is ephemeral and flows intermittently in response to rainfall events.

To manage these varying water resources, the catchment features several important water infrastructure components. The Inyaka Dam is the largest, with a capacity of 124 million m³ providing water to the Bushbuckridge Municipality³⁰. Da Gama Dam, with a capacity of ~14 million m³, primarily serves forestry and commercial farming. Two additional dams, Orinoco with capacity of ~2 million m³ and Casteel holding ~1 million m³, are used for agricultural irrigation³¹. Other important water sources include the Dingledale, Allendale, New Forest and Hoxani dams and irrigation schemes.

The region typically has limited groundwater-bearing capacity³². This, combined with highly variable rainfall patterns, increases water scarcity in the catchment area. Most water users are concentrated along the river, leading to possible illegal or unregulated water abstraction³³. This practice prevents water from reaching the lower catchment, which already receives minimal rainfall³⁴. These varying runoff patterns, flow characteristics across the three rivers and the presence of multiple dams underscore the complex hydrology of the Sabie-Sand River Catchment. They highlight both the challenges and opportunities in managing water resources in this diverse system. Effective management should consider not only these seasonal variations and infrastructure but also balance the requirements of human populations with those of the ecosystems dependent on these rivers.

2.4. Vegetation

Three main biomes — savanna, grassland and forest — comprise the Sabie-Sand River Catchment, each with distinct vegetation characteristics and contributing to the region's biodiversity and ecological importance^{35,36,37}. Figure 2.2 provides a map of the biomes within the catchment.

Characterised by a continuous grassy understory punctuated by an open canopy of trees and shrubs, the savanna biome is the most extensive in the region. It encompasses the three bioregions below.

- **Granite Lowveld (SVI 3):** Features tall shrubland to moderately dense low woodland, with species like silver clusterleaf (*Terminalia sericea*) and red bushwillow (*Combretum*

²⁸ Heritage GL and Moon BP. 2000. The contemporary geomorphology of the Sabie River in the Kruger National Park. *Koedoe*. 43(1):5–35.

²⁹ Knight J and Evans M. 2022. Characterising the geomorphic dynamics of river systems: An example of the Sabie River, South Africa. *Koedoe*, 64(1):1–6.

³⁰ Tlou T. 2011. Bushbuckridge Local Municipality: First order Reconciliation Strategy for the Inyaka Regional Water Supply Scheme Area. Department of Water Affairs, South Africa. Contract: WP 9712.

³¹ Pollard S and Walker P. 2000. Catchment management and water supply and sanitation in the Sand River Catchment, South Africa: description and issues. WHIRL Project Working Paper 1 (draft). Natural Resources Institute, Chatham, United Kingdom.

³² Pollard S, *et al.* 2008. Towards a socio-ecological systems view of the Sand River Catchment, South Africa: An exploratory analysis. Report Number TT364/08. Water Research Commission, Pretoria, South Africa.

³³ Pollard S and du Toit D. 2008. Integrated water resource management in complex systems: How the catchment management strategies seek to achieve sustainability and equity in water resources in South Africa. *Water SA*. 34(6):671–680.

³⁴ DWA (Department of Water Affairs). 2010. Comprehensive Reserve determination study for selected water resources (rivers, groundwater and wetlands) in the Inkomati Water Management Area, Mpumalanga. Sabie and Crocodile systems: EcoSpecs report. In: Louw MD & Koekemoer S (eds). Department of Water Affairs, Pretoria, South Africa.

³⁵ Mucina L and Rutherford MC (eds). 2006. The vegetation of South Africa, Lesotho and Swaziland. *Strelitzia* 19. South African National Biodiversity Institute, Pretoria.

³⁶ Van Wyk B. 2013. Field guide to trees of southern Africa. Penguin Random House, South Africa.

³⁷ Van Oudtshoorn F. 2012. Guide to grasses of southern Africa. Briza Publications, Pretoria.



apiculatum). The ground layer includes herringbone grass (*Pogonarthria squarrosa*) and blue-seed grass (*Tricholaena monachne*).

- **Gabbro Grassy Bushveld (SVI 6):** An open savanna with dense grass cover and scattered trees such as knob thorn (*Senegalia nigrescens*) and marula (*Sclerocarya birrea* subsp. *caffra*). Common grasses include red grass (*Themeda triandra*) and common finger grass (*Digitaria eriantha*).
- **Legogote Sour Bushveld (SVI 9):** Dense woodland dominated by mobola-plum (*Parinari curatellifolia*) and red bauhinia (*Bauhinia galpinii*), with tall trees like kiaat (*Pterocarpus angolensis*).

The grassland biome is dominated by grasses and herbaceous plants with few trees and is prone to fires. This biome includes the three bioregions below.

- **Northern Escarpment Dolomite Grassland (Gm22):** Features a diverse shrub layer including Protea species like common sugarbush (*Protea caffra*). Dominant grasses include red grass (*Themeda triandra*) and Natal red-top (*Melinis repens*).
- **Northern Escarpment Quartzite Sourveld (Gm23):** A rocky landscape with short, closed grassland rich in forb species. Notable plants include krantz aloe (*Aloe arborescens*) and common russet grass (*Loudetia simplex*).
- **Northern Escarpment Afromontane Fynbos (Gm24):** Dominated by sclerophyllous shrubs and herbs, including krantz aloe (*Aloe arborescens*) and forest beechwood (*Faurea galpini*).

Tall evergreen afro-temperate forests characterise the Forest Biome, represented by the Northern Mistbelt Forest (FOz4). Canopy trees in this biome include real yellowwood (*Podocarpus latifolius*), forest bushwillow (*Combretum kraussi*), and forest waterberry (*Syzigium gerrardii*).

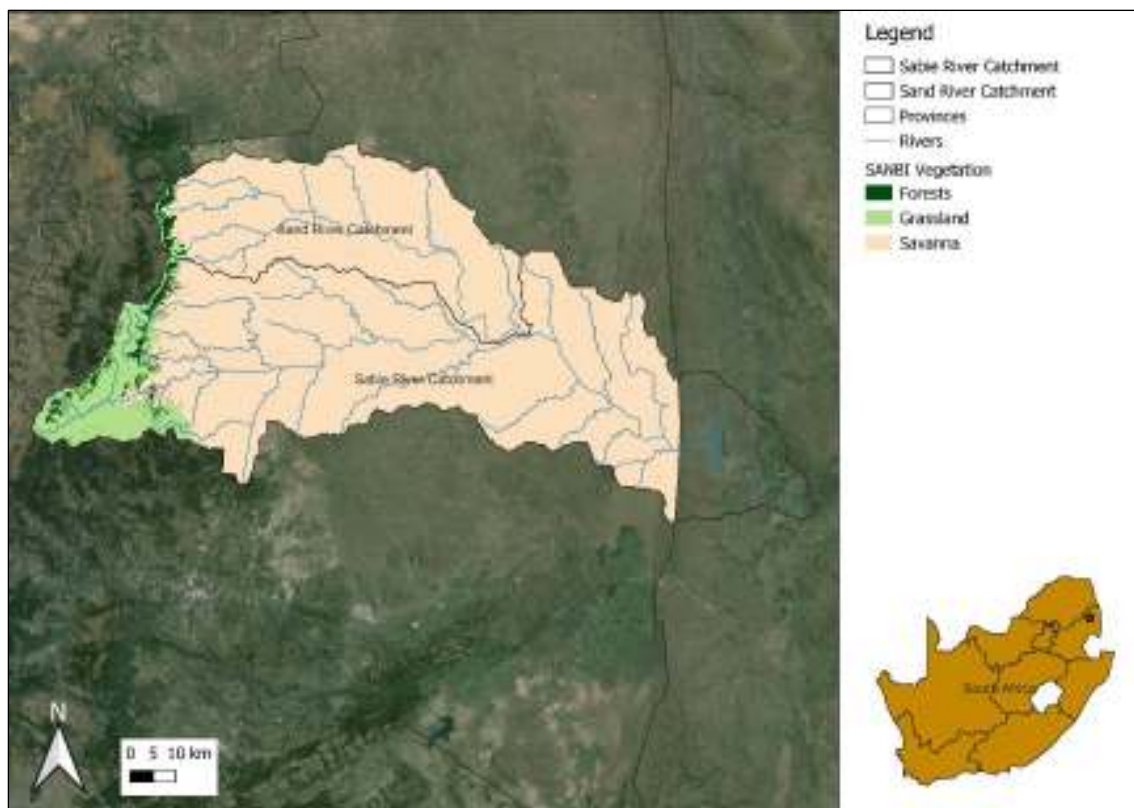


Figure 2.2. The vegetation types within the Sabie-Sand River Catchment.



2.5. Catchment value and land use

The Sabie-Sand River Catchment is valuable for the economy, ecology and culture of the region, supporting several land uses that contribute to both local and national interests while supporting biodiversity and cultural heritage. Situated within the Ehlanzeni District Municipality (EDM), the catchment is characterised by an array of land uses including urban, peri-urban and rural settlements, forestry, agriculture, mining, manufacturing, trade, tourism, conservation and wildlife management³⁸. Historically, the region has struggled with underdevelopment and poverty. While electricity is available, it remains unaffordable for many residents — particularly in rural settings. Infrastructure challenges persist, with numerous unpaved roads and limited access to piped water in some areas³⁹. Despite these ongoing developmental challenges, the district is home to a population of more than 2.3 million people, distributed at an average density of 265 people per square kilometre (km²)^{40,41}. Land tenure in the region is varied, comprising private ownership, tribal ownership and Communal Property Association (CPA) ownership — where groups collectively manage land on behalf of communities. Land tenure is discussed in Section 4.2.

The EDM is composed of the four local municipalities below⁴².

- **City of Mbombela Local Municipality (MLM):** As the provincial capital, it occupies the central and southern parts of the district, covering ~714,000 ha with a population of ~820,000. It contributes 66% to the district economy encompassing finance, business and government services, manufacturing, trade, transport, communications, agriculture, construction, mining and tourism sectors.
- **Bushbuckridge Local Municipality (BLM):** Spanning ~1,000,000 ha in the northern part of EDM, it accounts for one third of the total land area and is home to ~750,000 people. The local economy is primarily driven by agriculture and tourism — contributing ~15% to the district GDP.
- **Thaba Chweu Local Municipality:** Located in the western part of the district, it covers ~572,000 ha and has ~109,000 residents. An escarpment bisects the municipality, with the western half — called the Lydenburg area — dominated by agriculture and farming, while the eastern, Sabie, Graskop half focuses on forestry. This local municipality contributes 9% to the GDP for EDM.
- **Nkomazi Local Municipality:** The smallest of the four, it covers ~479,000 ha and houses ~592,000 people. Its economy is primarily based on agriculture, mining and tourism contributing 11% to the district GDP.

These local municipalities have multifaceted roles that include land use management, development planning and essential service delivery. They implement the Spatial Planning and Land Use Management Act (SPLUMA)⁴³ and formulate Integrated Development Plans (IDPs)⁴⁴ to align spatial development frameworks with broader regional and national goals. Additionally, these municipalities are responsible for providing basic services like water supply, sanitation, waste management and local road maintenance. Their mandate extends to local

³⁸ Ehlanzeni District Municipality (EDM). 2024. Ehlanzeni District Municipality's Integrated Development Plan and Budget 2024/2025 review. EDM. Available at: <https://www.ehlanzeni.gov.za/wp-content/uploads/2024/05/Final-IDP-Budget-2024-25-22-May-2024.pdf>.

³⁹ Ibid.

⁴⁰ Ibid.

⁴¹ Ehlanzeni District Municipality (EDM). 2021. Ehlanzeni District Municipality Annual Report 2020/2021. EDM. Available at: <https://www.ehlanzeni.gov.za/wp-content/uploads/2022/06/Final-Annual-Report-2020-2021.pdf>.

⁴² Ehlanzeni District Municipality (EDM). 2020. Ehlanzeni district municipality's final IDP and budget review 2020-2021. EDM. Available at: <https://ehlanzeni.gov.za/wp-content/uploads/2021/04/EDM-Final-IDP-2019-2020.pdf>.

⁴³ The Republic of South Africa. 2013. Spatial planning and Land Use Management Act (No. 16 of 2013). Government Gazette: 36730, 5 August.

⁴⁴ Ehlanzeni District Municipality (EDM). 2024. Ehlanzeni District Municipality's Integrated Development Plan and Budget 2024/2025 review. EDM. Available at: <https://www.ehlanzeni.gov.za/wp-content/uploads/2024/05/Final-IDP-Budget-2024-25-22-May-2024.pdf>.



economic development initiatives, community engagement, disaster management and the enforcement of municipal by-laws. They also play a role in environmental management, including the protection of local ecosystems and natural resources within their jurisdictions. Figure 2.3 provides a map of EDM with four local municipalities.



Figure 2.3. The Ehlalzeni District Municipality (EDM).

2.5.1. Land cover and land use

The Land Use Land Cover (LULC) map of the Sabie-Sand River Catchment as provided by the South African National Landcover (SANLC) ⁴⁵ Dataset is provided in Figure 2.4.

The dominant land cover is several forms of woodland and forest. Large areas of green indicate contiguous indigenous forest, contiguous low forest, dense forest and woodland and open woodland, particularly in the eastern and central parts of the catchment. The western portion of the catchment is characterised by considerable areas of plantation forestry, shown in orange and red representing open and sparse plantation forest as well as dense plantation forest. This reflects the important role of commercial forestry in the region's economy. Yellow patches scattered throughout the catchment — prevalent in the north — represent residential areas, both formal and informal settlements. This indicates a notable human presence and urbanization within the natural landscape. Agricultural activities are evident with areas of commercial orchards, annual crops — both irrigated and rain-fed — and smallholdings visible in varying shades of brown and pink. These are interspersed with patches of fallow land and old fields, suggesting a dynamic agricultural landscape. Natural grasslands, shown in beige, are present but appear less extensive than the forested areas. The catchment also includes some wetland areas and water bodies, though these cover a relatively small portion of the total area.

⁴⁵ South African Department of Forestry, Fisheries and the Environment. 2024. SA National Land-Cover Datasets. Available at: https://egis.environment.gov.za/sa_national_land_cover_datasets. Accessed on 22 August 2024.

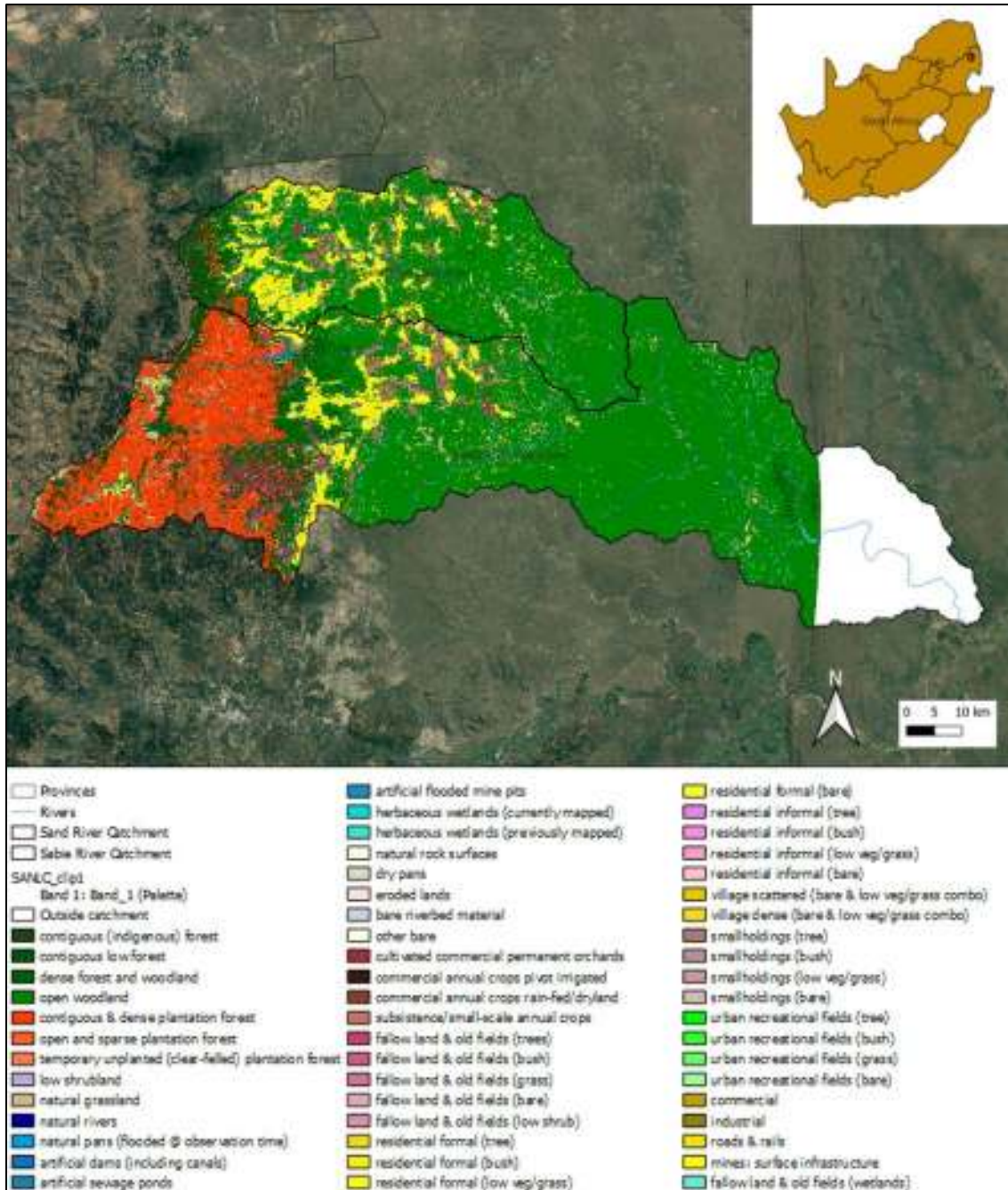


Figure 2.4. Land Use Land Cover (LULC) map of the Sabie-Sand River Catchment.

2.5.2. Economic Value

Economic growth and diversification have been demonstrated by the Ehlanzeni District Municipality (EDM) in recent years. According to the 2024–2025 Integrated Development Plan (IDP), the EDM's economy was estimated at ~R180 billion as of 2022, contributing 35% to Mpumalanga's Gross Domestic Product (GDP). The EDM's economy is characterised by several sectors, with community services, finance, trade — including tourism — and manufacturing collectively contributing 80% to the district's economy as of 2022⁴⁶. Despite this growth, the district faces challenges such as considerable unemployment rates. As of 2022,

⁴⁶ Ehlanzeni District Municipality (EDM). 2024. Ehlanzeni District Municipality's Integrated Development Plan and Budget 2024/2025 review. EDM. Available at: <https://www.ehlanzeni.gov.za/wp-content/uploads/2024/05/Final-IDP-Budget-2024-25-22-May-2024.pdf>.



the official unemployment rate in EDM was ~38%, with youth unemployment at 53%. The EDM's IDP outlines strategies to address these challenges, focusing on leveraging the district's comparative advantages in agriculture and tourism to stimulate inclusive economic growth and job creation⁴⁷.

Agriculture

The agriculture in the catchment encompasses subsistence and commercial farming. Most households engage in farming primarily for household consumption due to limited access to markets, which means that many producers only sell within the community⁴⁸. The main crops cultivated in the area are maize, peanuts, pumpkin and cowpeas. In addition, several fruit trees such as mangoes, avocados, peaches and bananas, as well as vegetables like spinach, lettuce, tomatoes and cabbage are grown in the area. Livestock farming is prevalent, with grazing land used for cattle and goats. Most of the households within the catchment own chickens, while other livestock found in the area are sheep and pigs⁴⁹.

Agricultural development in the region faces challenges — particularly due to water scarcity and competition with domestic and conservation needs. This situation necessitates careful resource management and highlights the need for sustainable agricultural practices⁵⁰. Moreover, inefficiencies and untargeted activities have left income potential untapped, with many former development corporation projects left abandoned and unused⁵¹. Targeted interventions are expected to enhance subsistence farming to smallholding activities, generating disposable income and potentially allowing small farmers to transition into more commercial operations, thereby increasing capital inflow into the area.

Tourism

Renowned for its biodiversity and landscapes, the Sabie-Sand River Catchment is a prime destination for ecotourism. The region comprises several protected areas, including private nature reserves, government-owned reserves, community-owned reserves and part of KNP. These areas not only contribute to conservation efforts but also play a role in the local and national economy. Tourism remains an economic driver across EDM, with 2022 spend totalled at ~R13 billion and equal to 8% of the district's GDP. The Greater Kruger area — which includes private reserves like Sabi Sands — generates an estimated R2 billion annually and supports over 22 thousand jobs⁵².

While tourism in the Sabie-Sand River Catchment's protected areas benefits the local economy, it also presents challenges such as water resource strain, infrastructure pressure and human-wildlife conflicts; furthermore, the threats of climate change — including altered wildlife distributions and increased extreme weather events — necessitate the development of adaptive management strategies to ensure the long-term sustainability of both conservation efforts and tourism in this region⁵³.

⁴⁷ Ehlanzeni District Municipality (EDM). 2020. Ehlanzeni District Municipality's Profile and Analysis District Development Model. EDM. Available at: https://www.cogta.gov.za/ddm/wp-content/uploads/2020/07/Take3_Final-Edited-Ehlanzeni-DM_07July2020-FINAL.pdf.

⁴⁸ Shackleton CM and Shackleton SE. 2004. The importance of non-timber forest products in rural livelihood security and as safety nets: a review of evidence from South Africa. *South African Journal of Science*. 100:658–664.

⁴⁹ Ragie FH. 2016. Relationships between household resource dependence, socio-economic factors, and livelihood strategies: A case study from Bushbuckridge, South Africa. Master's dissertation. University of the Witwatersrand, Johannesburg.

⁵⁰ South African Department of Provincial and Local Government. 2003. Bushbuckridge Nodal Economic Development Profile. The DPLG. Available at: https://www.btrust.org.za/library/assets/uploads/documents/1_CIPP_N_Bushbuckridge%20narrative.PDF.

⁵¹ Ibid.

⁵² Taylor A, *et al.* 2020. The economic impact of nature tourism in the Greater Kruger National Park. *Journal of Sustainable Tourism*, 28(5):681–699.

⁵³ Dube K and Nhamo G. 2020. Evidence and impact of climate change on South African national parks. Potential implications for tourism in the Kruger National Park. *Environmental Development*, 33, 100485.



2.5.3. Ecological Value

Serving part of the UNESCO-recognised Kruger to Canyons (K2C) Biosphere Reserve⁵⁴, and classified as a Key Biodiversity Area (KBA)⁵⁵ within the Maputoland-Pondoland-Albany Global Biodiversity Hotspot⁵⁶, the Sabie-Sand River Catchment is ecologically valuable. This area is a biodiversity hotspot, encompassing diverse ecosystems including grassland, savanna, woodland and forest habitats. These support wildlife such as elephants, lions, several antelope species, bird life, smaller mammals and several plant species. Central to the catchment's ecological significance are the Sabie, Marite and Sand Rivers. These support diverse aquatic ecosystems — including numerous fish species and riparian vegetation — and serve as water sources for agriculture, industry and domestic use in surrounding communities⁵⁷.

The Sabie-Sand River Catchment provides a suite of necessary ecosystem services. These include, *inter alia*: i) nutrient cycling which maintains soil fertility necessary for the region's land and agricultural productivity; ii) flood control with natural vegetation and wetlands which helps protect both wildlife habitats and human settlements; iii) carbon sequestration by forests and grasslands, contributing to climate change mitigation; and iv) pollination services provided by diverse insect populations, which are essential for both natural ecosystems and agricultural crops⁵⁸.

The catchment comprises the several private nature reserves, including: i) Sabi Sands Private Nature Reserve⁵⁹; ii) Manyeleti Game Reserve⁶⁰; and iii) Timbavati Private Nature Reserve⁶¹. Government-owned Nature Reserves include: i) Blyde River Canyon Nature Reserve⁶²; ii) Mac Mac Nature Reserve⁶³; and iii) Andover Nature Reserve⁶⁴. The Bushbuckridge Nature Reserve is owned by a CPA⁶⁵. A portion of the KNP also falls within the catchment area⁶⁶. Figure 2.5 provides a map portraying the different protected areas within the catchment.

⁵⁴ Kruger to Canyons (K2C) Biosphere Reserve. 2024. Partnering to achieve a Sustainable Future. K2C. Available at: <https://kruger2canyons.org/>. Accessed on 22 August 2024.

⁵⁵ South African National Biodiversity Institute (SANBI). 2024. Key biodiversity areas in South Africa. SANBI. Available at: <https://www.sanbi.org/biodiversity/building-knowledge/biodiversity-monitoring-assessment/key-biodiversity-areas-in-south-africa/>. Accessed on: 22 August 2024.

⁵⁶ Critical Ecosystem Partnership Fund (CEPF). 2024. Explore the biodiversity hotspots. CEPF. Available at: <https://www.cepf.net/our-work/biodiversity-hotspots>. Accessed on: 22 August 2024.

⁵⁷ Riddell ES, *et al.* 2019. The importance of the Sabie-Sand River system for biodiversity conservation in the Kruger National Park. *African Journal of Aquatic Science*, 44(3):207–219.

⁵⁸ Egoh B, *et al.* 2012. An African account of ecosystem service provision: Use, threats and policy options for sustainable livelihoods. *Ecosystem Services*, 2:71–81.

⁵⁹ Sabi Sand Nature Reserve (SSNR). 2024. Sabi Sand Nature Reserve Official website. Available at: <https://www.sabisand.co.za/>. Accessed on 22 August 2024.

⁶⁰ South African National Parks. 2020. Manyeleti Game Reserve. SANParks Available at: https://www.sanparks.org/parks/kruger/conservation/scientific/ff/tourism_impacts.php. Accessed on: 22 August 2024.

⁶¹ Timbavati Private Nature Reserve. 2021. Timbavati Private Nature Reserve Official website. Available at: <https://www.timbavati.co.za/>. Accessed on: 22 August 2024.

⁶² Mpumalanga Tourism and Parks Agency (MTPA). 2021. Blyde River Canyon Nature Reserve. MTPA. Available at: <https://www.mtpa.co.za/>. Accessed on: 22 August 2024.

⁶³ Mpumalanga Tourism and Parks Agency (MTPA). 2021. Mac Mac Falls. MTPA. Available at: <https://www.mtpa.co.za/>. Accessed on: 22 August 2024.

⁶⁴ Mpumalanga Tourism and Parks Agency (MTPA). 2020. Andover Nature Reserve. MTPA. Available at: <https://www.mtpa.co.za/>. Accessed on: 22 August 2024.

⁶⁵ Mpumalanga Tourism and Parks Agency (MTPA). 2019. Bushbuckridge Nature Reserve. MTPA. Available at: <https://www.mtpa.co.za/>. Accessed on: 22 August 2024.

⁶⁶ South African National Parks. 2021. Kruger National Park. SANParks. Available at: <https://www.sanparks.org/parks/kruger>. Accessed on 22 August 2024.

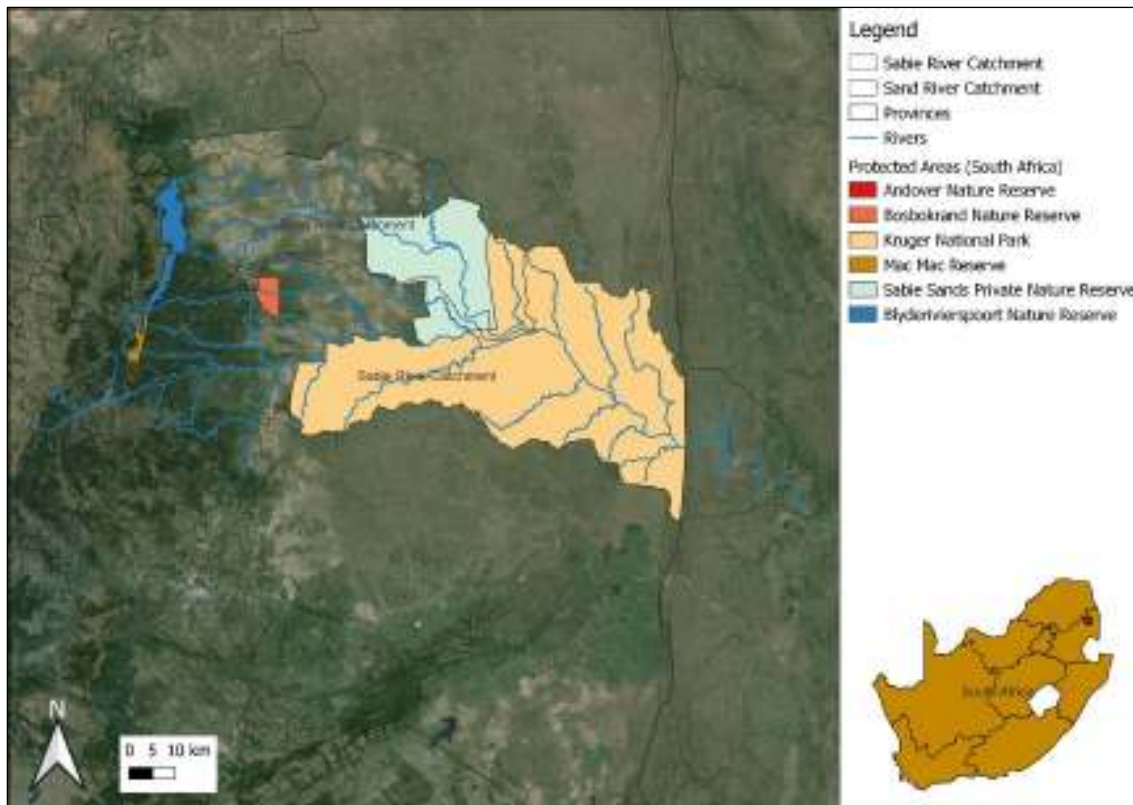


Figure 2.5. Protected areas in the Sabie-Sand River Catchment⁶⁷.

These protected areas aid in conserving the region's biodiversity, including several endemic, endangered, and threatened species. Private nature reserves such as Sabi Sands, Manyeleti, and Timbavati form part of the Greater Kruger ecosystem, providing habitat for endangered species like the African Wild Dog (*Lycaon pictus*) and the White-backed Vulture (*Gyps africanus*). Government-owned reserves like Blyde River Canyon, Mac Mac, and Andover contribute to the protection of unique landscapes and species such as the Southern Ground-hornbill (*Bucorvus leadbeateri*). The community-owned Bushbuckridge Nature Reserve serves as an ecological corridor — particularly for endangered species movement. KNP, partially within the catchment, is a cornerstone of conservation efforts, housing the critically endangered Black Rhino (*Diceros bicornis*). These protected areas collectively safeguard not only charismatic megafauna but also lesser-known yet equally important species such as the endangered Pepper-bark tree (*Warburgia salutaris*) and the critically endangered Wild Ginger (*Siphonochilus aethiopicus*), both of which are endemic to the region and have ecological and cultural value. The interconnected nature of these reserves enhances their conservation impact, allowing for wildlife movement, genetic exchange and the maintenance of ecosystem processes across the broader landscape. Consequently, the catchment forms an important part of a larger wildlife corridor, facilitating the movement of species between protected areas. This connectivity is necessary for maintaining genetic diversity and enhancing species resilience, particularly when considering the effects climate change and habitat fragmentation⁶⁸.

⁶⁷ South Africa Protected Areas Database (SAPAD). 2024. Available at: https://egis.environment.gov.za/protected_and_conservation_areas_database

⁶⁸ Lindsey PA, *et al.* 2017. Relative efforts of countries to conserve world's megafauna. *Global Ecology and Conservation*, 10:243–252.



2.5.4. Cultural Value

Several communities attribute cultural significance to the Sabie-Sand River Catchment. Local groups — including the Shangaan people — have inhabited the region, developing practices related to the natural environment⁶⁹. These practices include the use of local plants for medicinal purposes and the recognition of certain natural areas as sacred sites. Several archaeological sites — including rock art and stone tools — are observed in the catchment, which provide information about early human habitation in the area⁷⁰. Indigenous knowledge systems in the region include information about local biodiversity, seasonal patterns and resource management. This knowledge has been passed down for generations and is applied in some conservation and land management strategies⁷¹. For example, traditional fire management techniques have been incorporated into certain modern conservation approaches. Some natural features in the catchment — such as Mariepskop mountain and specific sections of the Sabie River, hold spiritual importance for local communities⁷². These locations are used for traditional ceremonies and are components of local belief systems.

2.6. Current challenges

Land degradation and water deficit are main challenges observed in the Sabie-Sand River Catchment. These are induced by anthropogenic activities and unsustainable resource use, exacerbated by climate change. Land degradation encompasses soil erosion, vegetation loss, declining soil fertility and siltation — with effects that extend to ecosystem health, agricultural productivity and local livelihood⁷³.

The region's topography — characterized by steep slopes in some areas — combined with intense seasonal rainfall, creates a natural susceptibility to erosion. However, human activities have accelerated this process. Agricultural practices, particularly on marginal lands and steep slopes, have removed protective vegetation cover, exposing soil to erosive forces. Overgrazing has compacted soils and reduced vegetation cover, limited water infiltration and increased surface runoff. This has also altered vegetation compositions, often in favour of less desirable invasive plants. Deforestation for agriculture and fuelwood has removed necessary root systems that bind soil particles together. Moreover, the construction of roads and urban expansion have altered natural drainage patterns and concentrated water flows — exacerbating erosion in certain areas⁷⁴.

Unregulated and illegal river sand extraction contributes to land degradation and erosion. This activity disrupts river morphology, leading to increased siltation downstream. Sand mining impacts groundwater recharge, resulting in turbid water and the creation of deep pools that hinder downstream flow. It also leads to hydrocarbon pollution from heavy equipment used in the extraction process. Furthermore, sand mining damages riparian habitats, affecting both ecological balance and recreational activities⁷⁵.

⁶⁹ Makhubele JC, *et al.* 2019. Indigenous knowledge systems and conservation of natural resources in Bushbuckridge, South Africa. *International Journal of African Renaissance Studies*, 14(1):147–164.

⁷⁰ Delius P, *et al.* 2014. *Forgotten world: The stone-walled settlements of the Mpumalanga Escarpment*. Wits University Press.

⁷¹ Cock J and Fig D. 2000. From colonial to community-based conservation: Environmental justice and the national parks of South Africa. *Society in Transition*, 31(1):22–35.

⁷² Cocks M, *et al.* 2012. Cultural importance of non-timber forest products: Opportunities they pose for bio-cultural diversity in dynamic societies. In *Non-timber forest products in the global context* (pp. 107–128). Springer.

⁷³ Hoffman MT and Todd S. 2000. National review of land degradation in South Africa: the influence of biophysical and socio-economic factors. *Journal of Southern African Studies*. 26:743-758.

⁷⁴ Le Roux JJ, *et al.* 2007. Sediment yield modelling in the Mfolozi River catchment. *Water SA*. 33(5):629–638.

⁷⁵ Illegal mining destroys Sabie River valley ecology. Available at <https://www.citizen.co.za/lowvelder/news-headlines/2022/09/16/illegal-mining-destroys-sabie-river-valley-ecology/>. Accessed on: 22 August 2024.



The impacts of land degradation are far-reaching. Soil erosion leads to the loss of fertile topsoil, reducing agricultural productivity and potentially causing land abandonment or unsustainable agricultural intensification. Gully erosion creates deep channels that fragment landscapes, making land unsuitable for agriculture and posing physical hazards. Severely degraded areas face desertification risk, potentially resulting in permanent loss of productive capacity. The process impacts biodiversity, destroying habitats for various plant and animal species and disrupting soil ecosystems important for overall soil health⁷⁶.

Water deficit, the second major challenge, is closely interlinked with land degradation. The catchment is experiencing a significant water deficit as the supply fails to meet the increasing demand for fresh water⁷⁷. This issue is aggravated by illegal water extraction points and sand mining activities, which significantly deplete available water resources. These unauthorized extractions disrupt the allocation of potable water and the ecological reserve, leading to a decline in both water quality and quantity⁷⁸.

Urban development and forestry have altered the catchment, leading to several water use and management challenges. This expansion increases point source pollution from wastewater treatment plants and transportation, as well as non-point source pollution from agricultural runoff. Additionally, forestry and commercial plantations contribute to reduced water quality by the leaching of metals and organic matter^{79,80}.

Invasive alien plants in riparian zones and wetlands exacerbate both land degradation and water deficit. They cause habitat degradation, reduce water availability, and increase wildfire risks. These plants outcompete native species, disrupt ecosystem processes, alter habitat structure, and change soil chemistry, further contributing to land degradation and water scarcity^{81,82}. Commercial plantations, predominantly pine (*Pinus patula*) and eucalyptus (*Eucalyptus saligna*), occupy 16% of the catchment area, primarily in its upper reaches. These exotic species impact local hydrology, reducing river flows by 17 to 45% in the Sabie River and 31% in the Sand River. Their water consumption, which exceeds that of Indigenous species, is particularly pronounced during dry seasons and droughts when they use a larger share of the available water resources^{83,84,85}. Unlike their exotic counterparts, indigenous forests contribute positively to water regulation and soil conservation. They also benefit the local economy through ecotourism, provide non-timber forest products such as medicinal plants and wild fruits, and offer valuable cultural services⁸⁶.

⁷⁶ Lal R. 2015. Restoring soil quality to mitigate soil degradation. *Sustainability*. 7(5):5875–5895.

⁷⁷ Department of Water Affairs and Forestry. 2004. National Water Resource Strategy. Pretoria: DWAF.

⁷⁸ Pollard S and du Toit D. 2008. Integrated water resource management in complex systems: How the catchment management strategies seek to achieve sustainability and equity in water resources in South Africa. *Water SA*. 34(6):671–680.

⁷⁹ Jewitt G. 2002. Can Integrated Water Resources Management sustain the provision of ecosystem goods and services? *Physics and Chemistry of the Earth, Parts A/B/C*. 27(11-22): 887–895.

⁸⁰ Stolz, M. 2018. Water quality assessment of the Sabie River catchment with respect to adjacent land use. PhD dissertation, North-West University.

⁸¹ Garner, RD. 2006. Vegetation response to clearing of exotic invasive plants along the Sabi River, South Africa. Master's dissertation, University of the Witwatersrand.

⁸² Le Maitre DC, *et al.* 2002. Invasive alien trees and water resources in South Africa: case studies of the costs and benefits of management. *Forest Ecology and Management*. 160(1-3):143-159.

⁸³ Moon BP, *et al.* 1997. A geomorphological approach to the ecological management of rivers in the Kruger National Park: the case of the Sabie River. *Transactions of the Institute of British Geographers*. 22(1):31-48.

⁸⁴ Le Maitre DC, *et al.* 2002. Invasive alien trees and water resources in South Africa: case studies of the costs and benefits of management. *Forest Ecology and Management*. 160(1-3):143-159.

⁸⁵ Vieira ML. 2015. An assessment of instream flow requirements in the Sabie-Sand River catchment. Masters dissertation. University of the Witwatersrand, Johannesburg.

⁸⁶ Shackleton CM and Shackleton SE. 2004. The importance of non-timber forest products in rural livelihood security and as safety nets: a review of evidence from South Africa. *South African Journal of Science*. 100:658-664.



Climate change intensifies these problems with increased drought frequency and severity. The consequences are severe, including potential conflicts over water usage due to population growth, deterioration of the river's ecological health and increased challenges in meeting water management obligations⁸⁷.

The economic repercussions of these challenges are substantial, with decreased agricultural yields causing hardship for farmers and increased costs for soil remediation and flood control interventions. Paradoxically, the sand mining industry, driven by demand from construction and manufacturing sectors due to urbanization and development, provides income and employment in rural communities^{88,89}. This creates a complex socio-economic challenge, balancing environmental protection with economic requirements. Ultimately, these combined effects impact local food security and livelihoods, while also highlighting the intricate relationship between land use, resource extraction and environmental sustainability in the Sabie-Sand River Catchment.

2.7. Potential solutions

Several potential solutions are expected to address the challenges of land degradation and water deficit in the Sabie-Sand River Catchment. Implementing sustainable land use practices — particularly in agriculture — is necessary for reducing soil erosion⁹⁰. Reforestation initiatives with indigenous trees, is expected to restore degraded landscapes, preserve biodiversity and contribute to carbon sequestration⁹¹. Agroforestry systems — including integrated tree-crop systems, boundary planting, riparian buffers, conservation hedgerows and silvopasture — offer similar benefits as reforestation and also soil improvement, erosion control, water management, microclimate regulation, pest and disease management and productivity increase⁹². Community homestead planting provides additional benefits such as sustainable resource production, education and awareness and cultural preservation⁹³.

Addressing the illegal and unregulated water extraction is required; this involves implementing stricter monitoring systems, enforcing penalties for non-compliance and improving water allocation management⁹⁴. Similarly, enhancing the regulation and upgrading of non-conforming wastewater treatment plants is necessary to reduce water pollution and improve overall water quality in the catchment⁹⁵. The removal of alien invasive plant species is another necessary strategy, as these plants consume excessive water and outcompete native vegetation; their systematic eradication is able to help restore natural ecosystems and improve water availability⁹⁶.

⁸⁷ Schulze RE. 2011. A 2011 Perspective on Climate Change and the South African Water Sector. Water Research Commission Report TT 518/12.

⁸⁸ Maphanga T and Madonsela BS. 2023. Land degradation associated with illegal sand mining in rural areas and lack of formalization of the industry in South Africa: A review. *International Journal of Environmental Impacts*. 6(4):251–256.

⁸⁹ Chevallier R. 2014. Illegal Sand Mining in South Africa. South African Institute of International Affairs Policy Briefing 116.

⁹⁰ Lal R. 2015. Restoring soil quality to mitigate soil degradation. *Sustainability*. 7(5):5875–5895.

⁹¹ Aronson J and Alexander S. 2013. Ecosystem restoration is now a global priority: time to roll up our sleeves. *Restoration Ecology*. 21(3):293–296.

⁹² Jose S. 2009. Agroforestry for ecosystem services and environmental benefits: an overview. *Agroforestry systems*. 76(1):1–10.

⁹³ Mbow C, *et al.* 2014. Agroforestry solutions to address food security and climate change challenges in Africa. *Current Opinion in Environmental Sustainability*. 6:61–67.

⁹⁴ Molle F and Berkoff J. 2007. Irrigation water pricing: The gap between theory and practice. CABI.

⁹⁵ Edokpayi JN, *et al.* 2017. Challenges to Sustainable Safe Drinking Water: A Case Study of Water Quality and Use across Seasons in Rural Communities in Limpopo Province, South Africa. *Water*. 9(4):225.

⁹⁶ Le Maitre DC, *et al.* 2002. Invasive alien trees and water resources in South Africa: case studies of the costs and benefits of management. *Forest Ecology and Management*. 160(1-3):143–159.



Implementing and enforcing regulations for sustainable resource harvesting, particularly for activities like sand mining, is necessary for protecting the river and surrounding ecosystems⁹⁷. For sand mining specifically, authorities should conduct environmental impact evaluations, align extraction limits with natural sediment yield and enhance monitoring capacities⁹⁸. However, effectively regulating sand and water extraction presents a challenge that will require input and commitment from government at all levels. This includes developing policies, allocating adequate resources for enforcement, coordinating between different departments and stakeholders and potentially addressing challenges related to corruption or lack of capacity in regulatory bodies⁹⁹. Similar input and commitment from government and forestry organisations is required to regulate plantations and associated alien invasives. The complexity of the challenges related to regulation — of sand and water extraction and plantations — necessitates a long-term, multi-faceted approach with strong political will and sustained government engagement to ensure successful implementation.

Education and training are necessary, with programmes focusing on sustainable land management, tree planting techniques and potential economic opportunities¹⁰⁰. These educational initiatives should be coupled with efforts to develop alternative livelihoods and income generation strategies. This includes establishing and strengthening markets for agroforestry products and non-timber forest products (NTFPs) such as fruits, nuts, medicinal plants and handicrafts¹⁰¹. By creating value chains for these sustainable products, local communities can be incentivized to participate in conservation efforts while improving their economic resilience. Support for small-scale enterprises, cooperative development and skills training in sustainable resource management and product processing can further enhance these alternative livelihood opportunities¹⁰². Additionally, exploring eco-tourism potential and benefits sharing mechanisms is able to provide additional income streams that align with conservation goals¹⁰³. These approaches to education and economic development are necessary for ensuring the long-term success and community buy-in of land restoration and water management initiatives.

2.8. Proposed intervention

A multi-faceted approach with long-term input and commitment from local communities, private sector and government is required to solve the problems in the Sabie-Sand River Catchment as a whole. However, efforts to restore the land are expected to reduce degradation and improve the water deficit and alleviate the negative effects of these on the environment and local communities. An Afforestation, Reforestation and Revegetation (ARR) initiative — including agroforestry in croplands, rural residences and rangelands, and possibly targeted reforestation in woodlands and forests — is expected to reduce land degradation and improve the water deficit by restoring vegetation cover, enhancing soil stability, improving water infiltration, increasing biodiversity and creating sustainable resource management practices that benefit both the environment and local communities.

⁹⁷ Pereira K and Ratnayake R. 2013. Water Integrity in Action: Curbing Illegal Sand Mining in Sri Lanka. Water Integrity Network.

⁹⁸ Peduzzi P. 2014. Sand, rarer than one thinks. *Environmental Development*. 11:208–218.

⁹⁹ Sowman M and Wynberg R. 2014. Governance for Justice and Environmental Sustainability: Lessons across Natural Resource Sectors in Sub-Saharan Africa. Routledge.

¹⁰⁰ Reed MS, *et al.* 2011. Cross-scale monitoring and assessment of land degradation and sustainable land management: A methodological framework for knowledge management. *Land Degradation & Development*. 22(2):261–271.

¹⁰¹ Shackleton S, *et al.* 2011. Opportunities for enhancing poor women's socioeconomic empowerment in the value chains of three African non-timber forest products (NTFPs). *International Forestry Review*. 13(2):136–151.

¹⁰² Leakey RRB, *et al.* 2005. Agroforestry tree products (AFTPs): targeting poverty reduction and enhanced livelihoods. *International Journal of Agricultural Sustainability*. 3(1):1–23.

¹⁰³ Milder JC, *et al.* 2010. Trends and future potential of payment for ecosystem services to alleviate rural poverty in developing countries. *Ecology and Society*. 15(2):4.



To ensure the long-term success and community buy-in of the ARR project, it should incorporate education and training workshops for local communities and actively develop alternative livelihood and income generation opportunities tied to the ARR activities. By creating value chains for these sustainable products, local communities are likely to be incentivised to participate in and maintain the ARR initiatives while improving their economic resilience. Support for small-scale enterprises, cooperative development and skills training in sustainable resource management and product processing are also necessary to enhance these alternative livelihood opportunities. This integrated approach combining ecological restoration with education and economic development is necessary for addressing both the environmental challenges and the socio-economic requirements of the Sabie-Sand River Catchment.

This study analyses the feasibility of the three-pronged approach that combines ARR initiatives with education and alternative livelihood development. The study assesses the potential for carbon sequestration in the Sabie-Sand River Catchment and funding options through carbon credits and other environmental service credits.

3. Standards and methodologies

Environmental and social impact standards and methodologies provide frameworks that are used to quantify and manage a project's effects on climate, communities, the environment and biodiversity. These frameworks provide guidelines and criteria for developing, implementing, measuring, reporting and verifying a project's impacts, including greenhouse gas (GHG) emissions reductions or removals, environmental and community benefits and biodiversity conservation. Standards outline overarching principles and requirements, while methodologies detail specific procedures and calculations to assess several impacts, such as carbon footprints, community development indicators and biodiversity metrics. These result in different types of credits or certifications, *inter alia*, Verified Carbon Units (VCUs) or Climate, Community and Biodiversity (CCB) accreditation.

Sand Catchment (Pty) Ltd. (SC) intends to generate verifiable carbon credits through the voluntary carbon market. Applicable standards include, *inter alia*: i) the Verified Carbon Standard (VCS)¹⁰⁴, a comprehensive standard for several project types; ii) Gold Standard¹⁰⁵, which emphasises sustainable development alongside emissions reduction; iii) International Carbon Registry¹⁰⁶, providing a global platform for credit registration and trading; iv) Plan Vivo¹⁰⁷, focusing on community benefits in smallholder and community projects; v) Social Carbon¹⁰⁸, emphasising social impacts alongside emissions reduction; vi) Credible Carbon¹⁰⁹, targeting poverty alleviation in South Africa; vii) ACORN¹¹⁰, specialising in smallholder agroforestry using blockchain technology; and viii) ReSeed¹¹¹, focusing on regenerative agriculture and soil carbon sequestration.

Project activities in carbon markets fall under two main categories: emission reductions, which are activities that decrease or avoid carbon emissions, and emission removals, which are activities that actively remove carbon dioxide (CO₂) from the atmosphere. These activities are further categorised into sectors such as energy, transport and agriculture, forestry and other

¹⁰⁴ Verra. 2024. Verified Carbon Standard (VCS). Available at: <https://verra.org/programs/verified-carbon-standard/>. Accessed on: 22 August 2024.

¹⁰⁵ Gold Standard. 2024. Available at: <https://www.goldstandard.org/>. Accessed on: 22 August 2024.

¹⁰⁶ International Carbon Registry (ICR). 2024. Available at: <https://www.carbonregistry.com/>. Accessed on: 22 August 2024.

¹⁰⁷ Plan Vivo Foundation. 2024. Available at: <https://www.planvivo.org/>. Accessed on: 22 August 2024.

¹⁰⁸ Social Carbon. 2024. Available at: <https://www.socialcarbon.org/>. Accessed on: 22 August 2024.

¹⁰⁹ Credible Carbon. 2024. Available at: <https://www.crediblecarbon.com/>. Accessed on: 22 August 2024.

¹¹⁰ Plan Vivo Foundation. 2024. ACORN Standard. Available at: <https://www.planvivo.org/acorn>. Accessed on: 22 August 2024.

¹¹¹ ReSeed. 2024. Available at: <https://reseed.farm/>. Accessed on: 22 August 2024.



land use (AFOLU). The proposed project activities fall within the AFOLU sector, specifically under forestry as Afforestation, Reforestation and Revegetation (ARR), and are eligible for carbon credit generation under all the aforementioned standards. Additionally, the specific challenges within the project area are likely to benefit from activities relating to Improved Agriculture and Land Management (IALM), similarly falling under the AFOLU sector as part of agriculture and also eligible under these standards.

3.1. Carbon methodologies

Several carbon standards approve different methodologies for IALM and ARR projects. These methodologies provide guidelines for quantifying GHG emissions reductions or removals, outlining procedures for baseline setting, additionality, leakage, risk, uncertainty monitoring, reporting and verification. The choice of methodology depends on specific project activities, with each having its own applicability conditions, calculation methods and monitoring requirements. Table 3.1 provides a list of appropriate standards and applicable methodologies.

Table 3.1. List of appropriate standards and applicable methodologies for the proposed project.

Standard	Applicable methodologies
VCS	Several methodologies including, <i>inter alia</i> : i) VM0017: Adoption of Sustainable Agricultural Land Management (SALM); ii) VM0021: Soil Carbon Quantification Methodology; iii) VM0026: Sustainable Grassland Management (SGM); iv) VM0032: Methodology for the Adoption of Sustainable Grasslands through Adjustment of Fire and Grazing; v) VM0042: Methodology for IALM; and vi) VM0047: Methodology ARR.
Gold Standard	Several methodologies including, <i>inter alia</i> : i) Agriculture Methodology: Increasing Soil Carbon through Improved Tillage Practices; ii) Soil Organic Carbon Framework Methodology; iii) Agroforestry Methodology; and iv) Improved Forest Management Methodology.
Plan Vivo	Technical specifications for, <i>inter alia</i> : i) agroforestry systems; ii) reforestation and afforestation; iii) improved forest management; iv) avoided deforestation; and v) restoration of degraded grasslands.
ACORN	Small holder methodologies with protocols for, <i>inter alia</i> : i) agroforestry; and ii) regenerative agriculture.
ReSeed	Small holder methodologies with protocols for: i) existing management of carbon stock; and ii) soil organic carbon (SOC).
Social Carbon	Applicable methodologies for Sustainable Agriculture Land Management (SALM).
Credible Carbon	Adapts existing methodologies — likely from VCS or Gold Standard — to the South African context for alleviation of poverty.
International Carbon Registry	Accepts methodologies from other standards, including all of the above.

3.1.1. Verified Carbon Standard (VCS)

The VCS offers several advantages for carbon projects. Its range of methodologies — which are regularly updated to reflect current best practices — provides flexibility for different project types and scales. VCS’s global recognition and rigorous verification process enhance the credibility and marketability of generated carbon credits in the international carbon market. The standard’s emphasis on additionality, coupled with mechanisms for addressing permanence and leakage, ensures the environmental integrity of projects. VCS also allows for integration with other standards like CCB, enabling projects to demonstrate co-benefits beyond carbon sequestration. The standard’s support for grouped projects and scalability is particularly beneficial for large or diverse project areas. Furthermore, VCS maintains a transparent registry and requires expert third-party auditing. These features, combined with



the VCS's alignment with some compliance markets and its allowance for methodology development, position it as a leading standard in the voluntary carbon market.

For the proposed project, the VCS is recommended for several reasons listed below.

- **Project scale and complexity:** The project spans a large area with diverse land use types including croplands, rural residences and rangelands. VCS's ability to handle large-scale, complex projects makes it well-suited for this landscape-level intervention.
- **Methodology applicability:** VCS offers methodologies specifically designed for ARR activities, which align perfectly with the project's focus on agroforestry and targeted reforestation. The VM0047 Methodology for ARR, in particular, caters to the project's planned interventions.
- **Flexible quantification approaches:** VCS allows for both area-based and census-based quantification approaches, which is ideal for the project's diverse activities across different land use types.
- **Grouped project approach:** The project's phased implementation strategy — starting with pilot projects and gradually scaling up — aligns with VCS's support for grouped projects. This approach allows for the addition of new project activities over time within the defined project area.
- **Integration with CCB Standards:** The project is expected to deliver climate, community and biodiversity benefits. VCS's integration with the CCB Standards allows for certification of these multiple benefits.
- **Credibility and market recognition:** Given the project's potential to sequester a large amount of carbon dioxide (CO₂), VCS's global recognition and credibility ensure market acceptance and potentially higher carbon credit values.
- **Long-term perspective:** VCS's provisions for long crediting periods (up to 100 years for ARR projects) match the project's long-term vision for landscape restoration and sustainable land management.
- **Adaptability to local context:** While VCS provides a globally recognized framework, it also allows flexibility in adapting to local conditions, which is necessary for addressing the specific socio-economic and environmental challenges in the project area.
- **Monitoring and reporting framework:** VCS's robust monitoring, reporting and verification requirements align with the project's comprehensive monitoring plan, ensuring accurate tracking of carbon, community and biodiversity impacts over time.

3.1.2. VM0047 Methodology

Projects using ARR generate removal credits, which are generally recommended in carbon markets, and typically provide large carbon sequestration amounts due to the introduction of biomass particularly trees that grow large over long periods of time. These projects often require less frequent interventions after the initial establishment phase — potentially simplifying long-term management — and are expected to deliver additional benefits, including improved biodiversity habitat and enhanced water regulation. ARR projects generally use well-established methodologies for measuring carbon stocks, which are expected to streamline monitoring and verification processes. For these reasons and those provided in Section 3.1.1, this Feasibility Study (FS) assesses the potential of an ARR project in the Sabie-Sand River Catchment using the VCS VM0047 Methodology¹¹².

The VM0047 Methodology is designed to quantify benefits from activities that promote biomass regrowth. It is applicable to projects implementing planting activities in forests, woodlands and tailored agroforestry systems across several land types, including croplands, rural residences and rangelands. The methodology incorporates elements of flexibility in project implementation — allowing for adaptability and scalability — and outlines procedures

¹¹² Verra. 2024. VM0047 Afforestation, Reforestation, and Revegetation, v1.0 (28 September 2023). Available at: <https://verra.org/methodologies/vm0047-afforestation-reforestation-and-revegetation-v1-0/>.



for monitoring and verification of project outcomes. It includes provisions for community engagement, enabling local participation in project activities.

The certification process for projects using VM0047 involves several steps. Initially, project developers assess the applicability of the methodology to their specific context and design their project accordingly. This is followed by the development of a detailed project description document (PDD) that outlines how the project meets the methodology's requirements. The project then undergoes validation by an independent third-party auditor to ensure compliance with VM0047 and VCS rules. Once validated, the project is registered with Verra or other registries accepting VCS methodologies. Ongoing monitoring and periodic verification are required to quantify and verify the GHG emission reductions or removals achieved by the project.

Implementing projects under VM0047 presents certain challenges. The methodology requires detailed baseline assessments and projections of carbon stock changes, which are complex and data-intensive. Accurate measurement and monitoring of tree growth and biomass accumulation across diverse landscapes are technically challenging and resource-intensive. Additionally, ensuring meaningful community engagement and equitable benefit-sharing — as encouraged by the methodology — present social and logistical challenges, particularly in areas with complex land tenure systems or diverse stakeholder interests.

In comparison to other ARR methodologies, VM0047 offers specific features that may be advantageous. Unlike the methodologies that focus solely on forest systems, VM0047 allows for implementation across a broader range of land use types, including agricultural lands. This provides greater flexibility for projects in mixed-use landscapes. VM0047's approach to community engagement and benefit-sharing aligns with broader sustainability goals, similar to standards like the CCB Standard, although VM0047 itself focuses primarily on carbon benefits.

3.2. The Climate, Community and Biodiversity (CCB) Standard

The CCB Standard, managed by Verra, is a certification option for VCS carbon projects, addressing non-carbon benefits^{113,114}. This standard is used to evaluate projects based on their impacts on climate action, local communities and biodiversity. Implementing CCB enhances a project's credibility, attracts investors and potentially increases carbon credit values by demonstrating additional social and environmental benefits beyond carbon sequestration. The Climate, Community & Biodiversity Alliance (CCBA), comprising CARE, Conservation International, The Nature Conservancy, The Rainforest Alliance and the Wildlife Conservation Society, developed these standards through a multi-stakeholder process.

The CCB Standard assesses projects on their ability to generate social impacts for local communities and smallholders, support biodiversity conservation and integrate climate benefits. It uses monitoring, reporting and verification processes to evaluate project outcomes. Projects certified under CCB Standards are required to demonstrate benefits across multiple areas, which influences their funding potential. In the context of sustainability frameworks, the CCB Standard focuses on integrating climate, community and biodiversity benefits. It aligns with the Sustainable Development Goals (SDGs) and is used to demonstrate contributions to multiple SDGs. However, unlike carbon-focused standards, the CCB Standard does not generate carbon credits itself.

¹¹³ Verra. 2024. Climate, Community and Biodiversity Standards. Available at: <https://verra.org/programs/ccbs/>. Accessed on: 22 August 2024.

¹¹⁴ Climate, Community and Biodiversity Alliance (CCBA). 2017. Climate, Community and Biodiversity Standard, v3.1 (21 June 2017). Available at: https://verra.org/wp-content/uploads/CCB-Standards-v3.1_ENG.pdf.



For CCB a Theory of Change (TOC) is required to illustrate the projected delivery of climate, social and biodiversity benefits. This TOC consists of three result chains that map relationships between activities, outputs, outcomes and long-term impacts. Project design involves a participatory process to identify the main social and biodiversity challenges. The standard differentiates between the project area — where climate benefits are achieved — and the project zone, which encompasses community and biodiversity activities and benefits.

The CCB certification process involves several stages. Project developers should design their project to meet CCB criteria and prepare a PDD. This is followed by a public comment period and an independent third-party audit. Certified projects undergo verification at least every five years to assess the delivery of claimed benefits.

Implementing the CCB Standard presents certain challenges. The comprehensive nature of the standard necessitates considerable resources and expertise. Projects are required to demonstrate measurable impacts across multiple aspects, which is complex. Engaging diverse stakeholders throughout the project lifecycle present difficulties, particularly in areas with complex social dynamics or limited local capacity.

4. Eligibility

The project's activities comply with the VCS Programme requirements as outlined in the VCS Standard (Version 4.7, 16 April 2024)¹¹⁵. It considers all seven Kyoto Protocol greenhouse gases and is supported by the VCS-approved methodology — VM0047 for Afforestation, Reforestation and Revegetation (ARR)¹¹⁶. The project is not within a jurisdiction covered by a Jurisdictional REDD+ Programme, does not engage in activities excluded under Table 2.1 of the VCS Standard and has not generated emissions primarily for their subsequent reduction or removal.

Direct and indirect ARR interventions that increase vegetative cover are eligible under VM0047. The project activities include planting marula or other indigenous and fruit- and nut-bearing trees forests, woodland, rangelands, croplands and built areas. VM0047 provides two quantification approaches, which the project uses in distinct, non-overlapping areas, listed below.

- **Area-based approach:** Considered for planting activity in the forests and woodlands, this method uses plot sampling to estimate biomass per unit area, which is then scaled to the entire project area. It employs a dynamic performance benchmark based on vegetative cover changes in matched control areas to establish additionality and determine the crediting baseline at each verification. The approach applies to both direct planting and indirect activities promoting natural regeneration. It compares business-as-usual scenarios with project outcomes.
- **Census-based approach:** Considered for croplands, rangelands and residences, this method counts and measures all individual woody planting units in the project area. Each unit is uniquely identified, marked and geo-referenced with GPS. It is used when project activities do not change land use and complete plant counting is feasible, such as in urban or agroforestry. This approach applies to direct planting only and uses project-specific data to demonstrate additionality and set the baseline, unlike the comparative method used in the area-based approach.

The intended project expects to provide additional non-carbon, community and biodiversity benefits. This provides potential for joint CCB certification under the VCS allowing these

¹¹⁵ Verra. 2024. Verified Carbon Standard (VCS) Program Guide, v4.4 (29 August 2023). Available at: <https://verra.org/wp-content/uploads/2023/08/VCS-Program-Guide-v4.4.pdf>.

¹¹⁶ Verra. 2024. VM0047 Afforestation, Reforestation, and Revegetation, v1.0 (28 September 2023). Available at: <https://verra.org/methodologies/vm0047-afforestation-reforestation-and-revegetation-v1-0/>.



additional benefits to be accounted. Land management projects, including those that reduce or remove GHGs are eligible under CCB Standards. The project must demonstrate clear objectives to generate net positive impacts on climate change mitigation, local communities and biodiversity. It must also ensure additionality of benefits and involve communities and other stakeholders through full and effective participation, including obtaining free, prior, and informed consent (FPIC). The project must respect land rights, comply with applicable laws, and implement a monitoring plan with public transparency¹¹⁷.

The proposed ARR project — classified as an agriculture, forestry and other land use (AFOLU) activity under the VM0047 Methodology — is eligible for CCB certification as it facilitates CO₂ removal from the atmosphere. The project is designed to achieve net positive impacts across climate, community and biodiversity, offering environmental benefits such as reducing soil erosion, improving soil health and enhancing water quality. The project actively involves local communities in its design and implementation, providing sustainable livelihood options, jobs and ensuring benefit-sharing. It secures additionality by implementing activities that would not occur without the project and respects land rights by engaging stakeholders through full and effective participation — including obtaining FPIC. The project adheres to all applicable laws, with a monitoring plan in place to ensure transparency and accountability. Biodiversity benefits include strengthening ecosystems, supporting the return of native species and promoting ecological resilience.

4.1. Applicability conditions

The VM0047 Methodology has specific applicability conditions for ARR activities¹¹⁸. These conditions are that:

- the project area does not contain organic soils;
- the project area is not a wetland or peatland;
- the land has not been cleared of natural vegetation within 10 years before the project start date; and
- project activities do not involve mechanical removal offsite or burning of pre-existing dead wood stocks for site preparation.

A geographic information system (GIS) assessment using remotely sensed data verified these conditions. The South African National Land Cover (SANLC)¹¹⁹ dataset and soil classification by SoilGrids¹²⁰ confirm the absence of wetlands in the project region, with soils classified as sandy or clay. To determine the extent of land cleared of natural vegetation within 10 years before the project start, the most recent SANLC dataset was compared to the historical version from 10 years ago. Any forest, woodland or rangeland converted to another land-use was excluded. Additionally, project activities will avoid removal offsite or burning of pre-existing deadwood during site preparation.

As mentioned, the project uses the area-based and census-based quantification approaches in non-overlapping areas. Additional applicability conditions apply to each, listed below.

¹¹⁷ Climate, Community and Biodiversity Alliance (CCBA). 2017. Climate, Community and Biodiversity Standard, v3.1 (21 June 2017). Available at: https://verra.org/wp-content/uploads/CCB-Standards-v3.1_ENG.pdf.

¹¹⁸ Verra. 2024. VM0047 Afforestation, Reforestation, and Revegetation, v1.0 (28 September 2023). Available at: <https://verra.org/methodologies/vm0047-afforestation-reforestation-and-revegetation-v1-0/>.

¹¹⁹ South African Department of Forestry, Fisheries and the Environment. 2024. SA National Land-Cover Datasets. Available at: <https://egis.environment.gov.za/sa-national-land-cover-datasets>. Accessed on 22 August 2024.

¹²⁰ ISRIC. 2024. Soil Classification: World Reference Base 2006 Soil Groups. Soil Grids v2.0. Available at: <https://soilgrids.org/>. Accessed on 22 August 2024.



Area-based approach

- Project activities produce continuous tree and/or shrub cover on any contiguous area exceeding one hectare.

Census-based approach

- Project activities do not produce continuous tree and/or shrub cover on any contiguous area exceeding one hectare.
- Individual planting units are defined and identifiable in the field, with each unit given a physical marker onsite, a unique ID and GPS-recorded location (minimum 5-metre accuracy).
- Activities occur in areas classified as non-forest for the past 10 years with less than 10% pre-existing woody biomass cover, or in areas of continuous cropping in settlements or other lands.
- An initial complete census of all planting units is conducted at the project start.
- The project does not incorporate planting units serving a similar purpose as woody biomass removed in the past 10 years.
- Soil disturbance occurs only once during the project crediting period and does not involve soil inversion exceeding 25cm depth.

To meet the area-based approach requirements, the project will implement planting plans to establish contiguous blocks of planting units exceeding one hectare. These plans will use density planting techniques to promote canopy closure over time, ensuring continuous cover. For the census-based approach, the project will design agroforestry layouts that space tree clusters to avoid continuous cover exceeding one hectare. Individual planting units will be marked with durable tags and assigned unique IDs using a standardised naming convention. GPS devices will record each unit's location to within 5-metre accuracy. Historical land use analysis using SANLC and Hansen tree cover loss data has verified the non-forest classification and quantified pre-existing woody biomass cover. An initial census will be conducted at project start, using mobile data collection tools and quality control measures. Planting plans will avoid areas where similar woody biomass was removed in the past decade, based on land-use history and SANLC data. Soil disturbance will be minimised through low-impact planting techniques, with soil preparation activities conducted only at the project's initiation and without exceeding 25 cm depth of soil inversion.

4.2. Land tenure

As mentioned in Section 2, the project area is in the Sabie-Sand River Catchment, forming part of the Ehlanzeni Municipality District (EDM) in Mpumalanga, South Africa. The EDM displays a range of land tenure systems which influence carbon ownership and management approaches, affecting the implementation of carbon sequestration projects and benefit-sharing mechanisms. In EDM, land tenure is divided into the following four distinct categories, each with implications for carbon rights and environmental stewardship.

- **Government owned:** This refers to land directly owned and managed by several levels of government — national, provincial or local. It includes, *inter alia*, protected areas, state forests, public infrastructure sites and land reserved for future development or conservation. The government has full authority over the use, management and transfer of these lands navigating said authority with several legal frameworks that regulate the management of assets^{121,122,123,124}.

¹²¹The Republic of South Africa. 2007. Government Immovable Asset Management Act (No. 19 of 2007). Government Gazette: 30520, 27 November.

¹²²The Republic of South Africa. 1961. State Land Disposal Act (No. 48 of 1961). Government Gazette Extraordinary, 28 June.

¹²³The Republic of South Africa. 1999. Public Finance Management Act (No. 1 of 1999). Government Gazette: 19814, 2 March.

¹²⁴The Republic of South Africa. 2003. Municipal Finance Management Act (No. 56 of 2003). Government Gazette: 26019, 13 February



- **Privately owned:** This category includes land held by individuals, families or private entities with full legal title. Private landowners have the right to use, develop, sell, or lease their land within the constraints of applicable laws and regulations. This type of ownership provides the highest degree of tenure security and is typically governed by formal property laws including, *inter alia*, the Deeds Registries Act 47 of 1937¹²⁵.
- **Communal Property Association (CPA) ownership:** CPAs are legal entities established under the Communal Property Associations Act of 1996¹²⁶ to enable communities to acquire, hold and manage property communally. This system is often used in land restitution cases or when communities want to collectively own and manage land. CPAs have a constitution that governs how the land is used and managed, with decisions made collectively by the community members. Oversight and regulation of CPAs are the responsibility of the Department of Agriculture, Land Reform and Rural Development (DALRRD). The DALRRD ensures the implementation of policies related to land reform, supporting the establishment and operation of CPAs while ensuring they adhere to legal requirements. Their oversight aims to effectively manage communal land for the benefit of community members, promoting sustainable land use and development practices.
- **Customary ownership:** This traditional form of land tenure is based on the customs and practices of local communities, particularly in rural areas. Under customary ownership, land is typically held communally and a permission to occupy (PTO) is allocated by traditional leaders or tribal authorities. While individuals or families may have land-use rights to specific plots, the overall ownership is vested in the community. This system is widely recognised and respected within the community and local government under the Traditional Leadership and Governance Framework Amendment Act of 2003¹²⁷, Traditional and Khoi-San Leadership Act 3 of 2019¹²⁸ and Interim Protection of Informal Land Right Act 31 of 1996¹²⁹. As mandated, traditional leaders administer community affairs, allocate land, guide local governance and facilitate municipal development planning. A total of 14 Traditional leaders participates in the EDM council, with 26 traditional leaders participating in the local municipal councils for Bushbuckridge, City of Mbombela, Nkomazi and Thaba Chweu, respectively¹³⁰.

Implementing ARR projects on government-owned and privately-owned land presents distinct challenges and considerations. For government land, project developers navigate bureaucratic processes, obtaining permits and aligning with national or local land management strategies while considering how the project fits into broader public land use plans. Government stability offers project security, but potential policy changes should be anticipated. Partnerships with government agencies provide resources and expertise. On privately-owned land, developers focus on negotiating clear, long-term agreements with landowners, establishing transparent benefit-sharing mechanisms and addressing potential conflicts between carbon sequestration and other land use priorities. Compliance with zoning laws and regulations is required for both land ownership types. Private land projects may involve aggregating multiple small holdings, necessitating coordination strategies and consistent management practices. Both scenarios require consideration of future land transfers or sales that could affect the project. For private land, additional thought should be

¹²⁵ The Republic of South Africa. 1937. Deeds Registries Act (No. 47 of 1937). Government Gazette Extraordinary, 26 May.

¹²⁶ The Republic of South Africa. 1996. Communal Property Association Act (No. 28 of 1996). Government Gazette: 17205, 22 May.

¹²⁷ The Republic of South Africa. 2009. Traditional Leadership and Governance Framework Amendment Act (No. 23 of 2009). Government Gazette: 32904, 25 January.

¹²⁸ The Republic of South Africa. 2019. Traditional and Khoi-San Leadership Act (No. 3 of 2019). Government Gazette: 42865, 28 November.

¹²⁹ The Republic of South Africa. 1996. Interim Protection of Informal Land Rights Act (No. 31 of 1996). Government Gazette: 17277, 26 June.

¹³⁰ Ehlanzeni District Municipality (EDM). 2020. Ehlanzeni District Municipality's Profile and Analysis District Development Model. EDM. Available at: https://www.cogta.gov.za/ddm/wp-content/uploads/2020/07/Take3_Final-Edited-Ehlanzeni-DM_07July2020-FINAL.pdf.



given to incentivising continued landowner participation and managing potential withdrawals from the project.

Approximately 70% of the EDM is unsurveyed and classified as rural¹³¹, with numerous land ownership disputes arising under the Restitution of Land Rights Act 22 of 1994¹³² and Land Reform (Labour Tenants) Act 3 of 1996¹³³. These disputes impact land tenure security in the project area and despite ongoing efforts to survey land and issue title deeds, a backlog persists, requiring additional resources for resolution. Therefore, land tenure in the EDM mostly consists of the customary and CPA-type ownership with portions of the rural land owned by government. This situation complicates project implementation, necessitating navigation of land tenure to ensure the long-term viability of ARR initiatives in the region.

ARR projects on land under CPA ownership or customary tenure require extensive community engagement and sensitivity to local governance structures. For CPAs, project developers must engage with leadership and members to obtain community consent, aligning project goals with the CPA's constitution and land use plans. In customary tenure areas, engagement extends to traditional leaders and community members for project approval, respecting and incorporating traditional land use practices into project design. Both scenarios necessitate developing inclusive decision-making processes and equitable benefit-sharing mechanisms that reach all community members. Projects must navigate the complexities of internal community dynamics and, in customary areas, the intersection of customary law and formal legal systems. The impact of unwritten land use rights in customary settings parallels the need to consider CPA constitutions in project implementation. Capacity building is necessary in both contexts, with CPA members requiring support in project management and monitoring, while customary communities may benefit from education and awareness programmes to build project support. These approaches ensure project stability, equitable benefit distribution and long-term community engagement in ARR initiatives.

Governed by diverse regulations, municipalities regulate land use, provide essential services, develop infrastructure, govern locally and collect revenue. This framework guides equitable service delivery and infrastructure development across tribal lands, ensuring sustainable community growth. Project developers must consider the integrated development plans of the local and district municipalities on rural land to ensure that the project aligns with these plans, thereby promoting longevity and compatibility with the broader municipal vision. Consequently, project developers must work closely with land-users, traditional leaders and local government to ensure successful implementation, fostering a collaborative approach that respects local knowledge and governance structures.

4.3. Legislature, policies and frameworks

Beyond land tenure considerations, several legislative and policy frameworks govern land use, environmental management and development in South Africa. The frameworks provide the regulatory context for land management decisions across all land tenure types.

- The National Environmental Management Act 107 of 1998¹³⁴ establishes principles for decision-making on environmental matters.

¹³¹ Ehlanzeni District Municipality (EDM). 2020. Ehlanzeni District Municipality's Profile and Analysis District Development Model. EDM. Available at: https://www.cogta.gov.za/ddm/wp-content/uploads/2020/07/Take3_Final-Edited-Ehlanzeni-DM_07July2020-FINAL.pdf.

¹³² The Republic of South Africa. 1994. Restitution of Land Rights Act (No. 22 of 1994). Government Gazette: 16106, 25 November.

¹³³ The Republic of South Africa. 1996. Land Reform (Labour Tenants) Act (No. 3 of 1996). Government Gazette: 17051, 22 March.

¹³⁴ The Republic of South Africa. 1998. National Environmental Management Act (No. 107 of 1998). Government Gazette: 19519, 27 November.



- The National Environmental Management: Biodiversity Act 10 of 2004¹³⁵ provides for the management and conservation of South Africa's biodiversity.
- The National Water Act 36 of 1998¹³⁶ regulates the use and management of water resources.
- The National Forest Act 84 of 1998¹³⁷ provides for the sustainable management and development of forests.
- The National Environmental Management: Protected Areas Act 57 of 2003¹³⁸ applies to ARR projects that may be implemented in or near protected areas.
- The National Environmental Management: Air Quality Act 39 of 2004¹³⁹ may be relevant for ARR projects in terms of their impact on air quality and climate change mitigation.
- Conservation of Agricultural Resources Act 43 of 1983 regulates the conservation of soil, water sources and vegetation¹⁴⁰.
- The National Heritage Resources Act 25 of 1999¹⁴¹ provides for the protection of South Africa's heritage resources.
- The Spatial Planning and Land Use Management Act 16 of 2013¹⁴² outlines a framework for spatial planning and land use management.
- The Constitution of the Republic of South Africa, 1996¹⁴³ enshrines the right to an environment that is not harmful to health or well-being and requires the environment to be protected for present and future generations.

These policies apply across different land tenure systems (government-owned, privately-owned, Communal Property Association ownership and customary ownership). They form a comprehensive regulatory environment that guides land use decisions, environmental protection and sustainable development practices. For ARR project developers, understanding these frameworks is important. Projects must align with the specific requirements of each land tenure system and comply with these national and international regulations. This may — as part of project design and implementation — involve:

- conducting environmental impact assessments;
- obtaining necessary permits;
- implementing biodiversity conservation measures;
- managing water resources sustainably;
- protecting heritage resources;
- aligning with spatial development plans;
- contributing to climate change mitigation and adaptation; and
- adhering to sustainable development principles.

¹³⁵ The Republic of South Africa. 2004. National Environmental Management: Biodiversity Act (No. 10 of 2004). Government Gazette: 26436, 7 June.

¹³⁶ The Republic of South Africa. 1998. National Water Act (No. 36 of 1998). Government Gazette: 19182, 26 August.

¹³⁷ The Republic of South Africa. 1998. National Forests Act (No. 84 of 1998). Government Gazette: 19408, 30 October.

¹³⁸ The Republic of South Africa. 2003. National Environmental Management: Protected Areas Act (No. 57 of 2003). Government Gazette: 26025, 18 February.

¹³⁹ The Republic of South Africa. 2004. National Environmental Management: Air Quality Act (No. 39 of 2004). Government Gazette: 27318, 24 February.

¹⁴⁰ The Republic of South Africa. 1983. Conservation of Agricultural Resources Act (No. 43 of 1983). Government Gazette: 9238, 22 November.

¹⁴¹ The Republic of South Africa. 1999. National Heritage Resources Act (No. 25 of 1999). Government Gazette: 19974, 28 April.

¹⁴² The Republic of South Africa. 2013. Spatial Planning and Land Use Management Act (No. 16 of 2013). Government Gazette: 36730, 5 August.

¹⁴³ The Republic of South Africa. 1996. The Constitution (Act No. 108 of 1996). Available at: <https://www.gov.za/documents/constitution/constitution-republic-south-africa-1996-04-feb-1997>. Accessed on 22 August 2024.



By considering these frameworks in project planning and implementation, ARR initiatives will contribute to sustainable land management practices while meeting broader national and international objectives for environmental conservation and sustainable development. Project developers must navigate this complex legal landscape, considering the numerous types of land ownership (communal, government, and private) and the roles of different stakeholders including traditional leaders, communal property associations, government departments and private landowners. This ensures that projects align with local development plans, respect several ownership structures and adhere to environmental and planning regulations.

4.4. Carbon ownership

Sand Catchment (Pty) Ltd. (SC) complies with the VCS Standard v4.7¹⁴⁴ definition of ownership through enforceable and irrevocable agreements with rights holders, by means of legal contracting with voluntarily registered beneficiaries participating in the project.

Carbon rights are not explicitly defined in South African legislation but are derived from forest resource property rights under the National Forests Act 84 of 1998¹⁴⁵. This act stipulates that individuals planting trees on land they have the right to use retain ownership of those trees and their products. These individuals manage and use the trees and tree products and retain all revenue from any tree product sales. This interpretation allows for potential transactions of carbon rights as property rights. Due to the absence of specific carbon rights legislation, contractual arrangements will be used to assign these rights. The voluntarily registered beneficiaries participating in the project agree to project terms and carbon rights transfer to SC, as documented in legally binding contracts compliant with South African law. As per the land tenure acts discussed in Section 4.2, all individuals, organisations or associations with land-use rights under each of the tenure classifications discussed are eligible for voluntarily registering as a participating beneficiary in a legally binding contract. SC agrees to provide training and long-term mentorship to these beneficiaries to establish tree nurseries, plant seedlings, maintain trees, manage harvesting and replanting cycles and market support.

As most of the land within the project area falls under traditional or communal jurisdiction, support and input is required from the traditional leaders and communities under the Traditional and Khoi-San Leadership Act 3 of 2019¹⁴⁶, which acknowledges the role of traditional leaders in land management. Traditional leaders, chiefs and local councils play an important role in land allocation and dispute resolution, which may affect carbon rights. From interactions with these authorities, landholders, community members and local council have obtained approval and support for the initial project activities. Evidence of these interactions and signed support letters must be kept. Additional letters of support from the applicable stakeholders will be obtained as the project expands.

5. Project design

Section 5 outlines the project design concerning structure, goals and implementation strategies. It begins by detailing the organisational schemes, including the roles and responsibilities of the primary stakeholders and lists several external and secondary stakeholders. The section then elaborates on the project objectives — environmental restoration, carbon sequestration and community development. Finally, it describes the specific project activities, focusing on agroforestry and targeted reforestation practices.

¹⁴⁴ Verra. 2024. Verified Carbon Standard (VCS) v4.7 16 April 2024. Available at: <https://verra.org/wp-content/uploads/2024/04/VCS-Standard-v4.7-FINAL-4.15.24.pdf>

¹⁴⁵ The Republic of South Africa. 1998. National Water Act (No. 36 of 1998). Government Gazette: 19182, 26 August.

¹⁴⁶ The Republic of South Africa. 2019. Traditional and Khoi-San Leadership Act (No. 3 of 2019). Government Gazette: 42865, 28 November.



5.1. Organisational schemes and stakeholders

The primary stakeholders of the project are summarised in Table 5.1, providing roles and responsibilities for each. These entities are directly involved in the project's planning, execution and outcomes.

Table 5.1. Roles and responsibilities of primary stakeholders.

Organisation	Role	Responsibilities
Sand Catchment (Pty) Ltd. (SC)	Project proponent Implementation Monitoring Evaluation	<ul style="list-style-type: none"> • General project management • Secure project funding • Coordinate with primary, external and secondary stakeholders • Implement project activities • Oversee monitoring and reporting of project outcomes • Manage benefit-sharing mechanisms • Support establishing tree product and agriculture markets
Roots and Ground	Technical, training and implementation partner	<ul style="list-style-type: none"> • Provide technical expertise on tree planting and growth • Establish tree nurseries and growing of trees • Assist in developing optimal planting strategies • Provide training and long-term mentorship to project participants • Support monitoring of tree growth and health • Support establishing tree product and agriculture markets
C4 EcoSolutions (Pty) Ltd. (C4)	Technical partner	<ul style="list-style-type: none"> • Investigate project feasibility • Advise on project activities, biodiversity conservation strategies and community involvement • Provide technical guidance on carbon accounting • Develop project design document • Assist in developing monitoring and evaluation systems • Support in validation and verification processes • Guide project implementation

Additional stakeholders are identified and classed into external and secondary categories. External stakeholders are not directly involved with the project planning, execution and outcomes but are directly affected by the project or directly affect the project. Secondary stakeholders are indirectly affected by or involved in the project.

External stakeholders include:

- communities in the Sabie-Sand River Catchment;
- traditional authorities of the region;
- farmers participating in the agroforestry initiatives; and
- residents participating in the home gardens initiatives.

Secondary stakeholders include:

- district and local government;



- environmental Non-Government Organisations (NGOs) operating in the region;
- suppliers of materials and equipment for the project design, training, implementation and monitoring phases;
- tourists visiting the Kruger National Park and several nature and game reserves; and
- businesses in the local supply chain that might be indirectly affected by the project.

Several stakeholders have engaged with the project, generally expressing support for its initiatives and activities. These stakeholders include: i) three community members—Lotus, Cry and Velly — who have local knowledge and maintain extensive networks within the area; ii) December Ndlovo, a water activist involved in farming, river cleaning and alien invasive clearing near Injaka Dam in Bushbuckridge, with connections to local, district and provincial government as well as regional organisations such as the Ten Trees Initiative in Acornhoek; iii) the central traditional authority of the region, Chief Hosi Abednigo Nxumalo, who is accepted by the community as king of the 10 chiefdoms in the Bushbuckridge Local Municipality (BLM); iv) farmers like Cindy and Kensani, who cultivate approximately 5 ha using permaculture and conventional techniques and have agreed to participate in the agroforestry initiative; v) the head of the Department of Economic Development of BLM; vi) the Centre for Farmers Development, which actively supports training and market establishment; and vii) the Kruger to Canyons Biosphere Reserve, which encompasses part of the project area and offers collaborative opportunities through its regional network.

5.2. Project objectives

The project objectives are classified into primary, secondary and tertiary objectives. Primary objectives represent the core aims of the project, addressing the main environmental and social goals. The primary objectives for the project are:

- to implement tree planting initiatives that increase carbon sequestration and mitigate climate change;
- to restore the environment, enhance ecosystem resilience and conserve the biodiversity; and
- to facilitate community development, improve local livelihoods and enhance community resilience.

Secondary objectives form methods or strategies needed to achieve the primary objectives. The secondary objectives of the project are:

- to promote sustainable land-use and water resource management; and
- to generate verifiable carbon credits with the Verified Carbon Standard (VCS) under VM0047; and
- to obtain accreditation from the Climate, Community and Biodiversity (CCB) Standard, potentially increasing the value of carbon credits.

Tertiary objectives are important supporting goals that enhance the overall success and sustainability of the project. The tertiary objectives for the project are:

- to develop sustainable economic opportunities such as markets and value chains; and
- to demonstrate project feasibility through pilot projects.

5.3. Project activities

The project design includes a range of activities that address environmental degradation in the Sabie-Sand River Catchment while improving community livelihoods. These activities are aligned with the VM0047 Methodology for ARR and focus on agroforestry practices, training and long term-mentorship, establishing nurseries and markets for NTFPs and other crops, and pilot projects for proof of concept. The specific activities have been selected based on their



potential to enhance carbon sequestration, restore degraded landscapes and provide sustainable livelihood options for local communities.

5.3.1. Agroforestry

The project will introduce specific agroforestry practices into croplands, rural residential areas and rangelands. All agroforestry systems contribute to improved soil health, increased biodiversity, enhanced climate resilience, carbon sequestration and diversified farm income while providing ecosystem services¹⁴⁷. The agroforestry practices will include, *inter alia*, integrated tree-crop systems, boundary planting, homestead planting, silvopasture, riparian buffers and conservation hedgerows, defined below with potential benefits.

- **Integrated tree-crop systems:** Combining trees or shrubs with agricultural crops in the same field, often in alternating rows or alleys at 50–250 trees/ha¹⁴⁸. This system improves soil health, prevents erosion, enhances nutrient cycling, improves water management, increases biodiversity, aids pest control, builds climate resilience, increases carbon sequestration, provides additional income streams, provides shade and creates favourable microclimates for crop growth.
- **Homestead planting:** Growing trees and shrubs around homes and farm buildings at 10–100 trees/ha¹⁴⁹. This provides shade, enhances aesthetics and supplies NTFPs for household use or sale. It also improves air quality, reduces energy costs for heating and cooling and is able to provide a source of emergency food during times of scarcity.
- **Silvopasture:** Integrating trees with livestock and grazing land management at 100–400 trees/ha¹⁵⁰. This system provides shade and shelter for animals, improves pasture quality, offers fodder and provides additional income from tree products. It also enhances animal welfare, reduces heat stress in livestock and improves meat and milk production.
- **Boundary planting:** Planting trees or shrubs along field boundaries or property lines at 100–250 trees/km¹⁵¹. This method serves as windbreaks, controls animal movement and marks property borders. It also improves landscape connectivity, reduces pesticide drift and is expected to improve crop pollination by providing habitat for pollinators.
- **Riparian buffers:** Planting trees and shrubs along waterways at 500–1,000 trees/ha¹⁵² to protect water quality and prevent erosion. These buffers create wildlife habitats. They filter agricultural runoff, stabilise streambanks, regulate water temperature and provide harvestable biomass or timber under careful management.
- **Conservation hedgerows:** Linear plantings of trees and shrubs at 1,000–2,500 trees/ha¹⁵³ to provide habitat for wildlife, reduce soil erosion and act as windbreaks. These hedgerows serve as corridors for beneficial insects and animals. They contribute to landscape aesthetics, are able to be used for biomass production and help in maintaining local biodiversity.

The census-based approaches will be used, In contrast, stipulating that a project activity must not produce continuous tree and/or shrub cover on any contiguous area exceeding 1 ha. This approach will be used for croplands, rural residential areas, grasslands and for possible riparian buffers and conservation hedgerows. Table 5.2 provides a summary of the applicable agroforestry systems and typical indigenous tree species used.

¹⁴⁷ Jose S. 2009. Agroforestry for ecosystem services and environmental benefits: an overview. *Agroforestry Systems*, 76(1):1–10.

¹⁴⁸ Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer Academic Publishers.

¹⁴⁹ Jose S. 2009. Agroforestry for ecosystem services and environmental benefits: an overview. *Agroforestry Systems*, 76(1):110.

¹⁵⁰ Sharrow SH. 1999. *Silvopasture design and management*. *Agroforestry Notes (USDA-NAC)*.

¹⁵¹ Garrity DP. 2004. Agroforestry and the achievement of the Millennium Development Goals. *Agroforestry Systems*, 61(1):5–17.

¹⁵² Schultz RC, *et al.* 2004. Riparian forest buffers in agroecosystems – lessons learned from the Bear Creek Watershed, central Iowa, USA. *Agroforestry Systems*, 61(1):35–50.

¹⁵³ Baudry J, *et al.* 2000. Hedgerows: An international perspective on their origin, function and management. *Journal of Environmental Management*, 60(1):7–22.



Table 5.2. Typical indigenous and fruit- and nut-tree species used for different agroforestry systems.

Agroforestry system	Typical tree species
Croplands	Marula (<i>Sclerocarya birrea</i>) Kiaat (<i>Pterocarpus angolensis</i>) Knob thorn (<i>Acacia nigrescens</i>) Sulphur bark (<i>Acacia xanthophloea</i>) African fig (<i>Ficus sycomorus</i>) Apple-leaf (<i>Philenoptera violacea</i>) Avocado (<i>Persea americana</i>) Macadamia (<i>Macadamia integrifolia</i> or <i>tetraphylla</i>) Mango (<i>Magifera indica</i>) Litchi (<i>Litchi chinensis</i>) Sweet orange (<i>Citrus sinensis</i>) Lemon (<i>Citrus limon</i>) Lime (<i>Citrus aurantifolia</i>) Grapefruit (<i>Citrus paradisi</i>) Mandarin (<i>Citrus reticulata</i>)
Rural residences	Marula (<i>Sclerocarya birrea</i>) African fig (<i>Ficus sycomorus</i>) Cape mahogany (<i>Trichilia emetica</i>) Monkey orange (<i>Strychnos spinosa</i>) White stinkwood (<i>Celtis africana</i>) Avocado (<i>Persea americana</i>) Macadamia (<i>Macadamia integrifolia</i> or <i>tetraphylla</i>) Mango (<i>Magifera indica</i>) Litchi (<i>Litchi chinensis</i>) Sweet orange (<i>Citrus sinensis</i>) Lemon (<i>Citrus limon</i>) Lime (<i>Citrus aurantifolia</i>) Grapefruit (<i>Citrus paradisi</i>)
Boundary planting	Tamboti (<i>Spirostachys africana</i>) Zebrawood (<i>Dalbergia melanoxylon</i>) Leadwood (<i>Combretum imberbe</i>)
Silvopasture	Marula (<i>Sclerocarya birrea</i>) Knob thorn (<i>Acacia nigrescens</i>) Apple-leaf (<i>Philenoptera violacea</i>)
Riparian buffers	African fig (<i>Ficus sycomorus</i>) Sulphur bark (<i>Acacia xanthophloea</i>) Cape mahogany (<i>Trichilia emetica</i>)
Conservation hedgerows	Sicklebush (<i>Dichrostachys cineria</i>) Red bushwillow (<i>Combretum apiculatum</i>) Monkey orange (<i>Strychnos spinosa</i>)

5.3.2. Education, workshops and training

The project will implement training workshops as part of its education activities to equip stakeholders in local communities with relevant knowledge and skills. This education and training component is important for the success and sustainability of the project, particularly in the context of the Ehlanzeni District Municipality (EDM), which faces challenges common to many developing countries.

In EDM — as in many parts of South Africa — communities often experience limited access to quality education, high unemployment rates and a large proportion of vulnerable



demographics, including women, youth and rural populations¹⁵⁴. These factors hinder the adoption and long-term success of the intended agroforestry and reforestation initiatives. By providing education and training, the project aims to address several main challenges listed below.

- **Bridging the knowledge gap:** Many community members have limited formal education in sustainable agriculture and land management practices. The workshops will provide essential knowledge, enabling participants to implement and maintain project activities effectively.
- **Skill development:** Training sessions will equip participants with practical skills necessary for project implementation, maintenance and monitoring, increasing their capacity to contribute to the initiative and potentially improve their livelihoods.
- **Empowerment of vulnerable groups:** By focusing on inclusive participation — particularly of women and youth — the project helps address social inequalities and provides economic opportunities to those most in need.
- **Unemployment mitigation:** The skills and knowledge gained through these workshops enhances participants' employability or enables them to create their own income-generating activities within the project framework.
- **Ensuring project sustainability:** By building local capacity, the project increases the likelihood of long-term success and continuity, even after the initial implementation phase.
- **Promoting community ownership:** Education and training foster a sense of ownership and investment in the project among local stakeholders, important for its long-term sustainability.
- **Adapting to local context:** Workshops will incorporate local Indigenous knowledge, ensuring that project activities are culturally appropriate and aligned with community needs.

Through education and training initiatives, the project aims to create a foundation for sustainable development in EDM, addressing both environmental and socio-economic challenges faced by local communities. The workshop and training structure will focus on four main areas: i) sustainable land management; ii) carbon credit system; iii) community development and livelihoods; and iv) technology and innovation in land management. Sustainable land management forms the core of the programme, encompassing several interconnected disciplines listed below.

- **Agroforestry:** Covers tree species selection for different practices, integrated tree-crop systems, silvopasture management, windbreak establishment, agroforestry in residential areas, sustainable harvesting of timber and non-timber forest products (NTFPs), nursery management, propagation techniques, tree growth and health.
- **Permaculture and sustainable agriculture:** Addresses permaculture design principles, companion planting, polyculture systems and food forest implementation.
- **Water Management:** Focuses on illegal and unregulated water extraction, rainwater harvesting, efficient irrigation systems, water conservation practices, riparian zone management and river sand extraction.
- **Organic Farming:** Covers principles of organic agriculture, organic pest and disease management, soil fertility management, certification processes and market opportunities.
- **Soil Conservation:** Addresses erosion control methods, composting techniques, soil fertility management and soil testing and interpretation.
- **Ecological Knowledge and Biodiversity Conservation:** Includes understanding local ecosystems, biodiversity conservation in agricultural landscapes, pollinator-friendly practices, wildlife corridor creation and invasive species management. Incorporates Indigenous knowledge systems.

¹⁵⁴ Ehlanzeni District Municipality (EDM). 2024. Ehlanzeni District Municipality's Integrated Development Plan and Budget 2024/2025 review. EDM. Available at: <https://www.ehlanzeni.gov.za/wp-content/uploads/2024/05/Final-IDP-Budget-2024-25-22-May-2024.pdf>.



- **Climate Change Adaptation in Agriculture:** Covers climate-smart practices, drought-resistant crop varieties and understanding climate change impacts on local ecosystems.

The carbon credit system module covers carbon sequestration principles and practices in agroforestry systems, carbon markets and carbon accounting methodologies and standards. It includes training on measuring and monitoring carbon stocks, project development cycles, verification and certification processes and community benefit-sharing mechanisms. Participants will learn about legal and regulatory frameworks for carbon projects and risk management strategies.

The community development and livelihoods modules incorporate financial literacy, project management, cooperative formation and management and value chain analysis for agroforestry products. It includes marketing strategies, entrepreneurship, small business management and gender mainstreaming in agroforestry projects. The module also addresses conflict resolution, community engagement techniques and the health and nutrition benefits from agroforestry systems.

The technology and innovation in land management component includes training on GPS and GIS use for land mapping and planning, remote sensing techniques for land use change monitoring and mobile apps for agricultural extension and data collection. It covers precision agriculture techniques, innovative agroforestry technologies, data management and analysis for agroforestry systems and climate modelling for land use planning. The module also introduces blockchain technology for supply chain transparency and Internet of Things applications in agriculture and forestry.

These modules provide a thorough understanding of the technical, economic and social aspects of implementing and managing agroforestry and reforestation projects, with a focus on practical skills and knowledge applicable to the local context.

As part of the initiative's first phase, SC, Roots and Ground and, select government agencies and private entities have launched an education, workshop and training programme with 25 female farmer participants. The programme covers the topics discussed above and provides willing participants who register as project beneficiaries with a tablet and training on its use for management, financial tracking and monitoring of farming activities as a citizen science initiative. The programme focuses on vulnerable demographics, particularly women, and aims to onboard and train an additional 1,000 farmers by the end of 2025.

5.3.3. Alternative livelihoods income generation and market establishment

To ensure the project's long-term success, activities centred around job creation, providing incentive, NTFPs, market creation and eco-tourism will be promoted. These activities are designed to provide alternative income sources for local communities while supporting forest conservation efforts and are listed below.

Employment opportunities and incentives

- Creation of jobs that are related to the project design, implementation, maintenance and monitoring.
- Establishing community nurseries for marula and other indigenous and fruit- and nut-bearing tree species.
- Employing a benefits sharing mechanism with project participants where they receive money for their active and continued involvement in the project activities.



Agricultural market development

- Assisting the community in accessing larger agricultural markets for marula, fruits, nuts and vegetables. This is achieved creating pack houses and processing facilities where subsistence and smallholder farmers bring produce for sale to larger markets.
- Promoting certified organic and free-range farming to open additional specialised market opportunities.

Value-added product development

- Setting up small-scale processing facilities for producing marula- and other fruit and nut-based products such as jams, juices, beers, wines, oils and biochar.
- Developing guidelines and providing training for the sustainable harvesting and value addition of medicinal plants and other NTFPs.
- Supporting the production of woodcraft and artisanal products from agroforestry systems, providing training in artisanal skills and linking artisans to fair trade markets.

Eco-tourism and cultural tourism initiatives

- Organising guided tours highlighting the ecological and cultural significance of the marula and other indigenous fruit- and nut-bearing tree species.
- Developing educational experiences showcasing traditional uses of forest products and sustainable natural resource management practices.

Support for complementary catchment initiatives

- Supporting alien invasive species control programmes to improve ecosystem health and water availability.
- Supporting regular river cleaning activities to maintain water quality and aquatic habitats.
- Promoting Improved Agricultural Land Management (IALM) practices to enhance soil conservation, water use efficiency and agricultural productivity.
- Developing sustainable water and river sand extraction guidelines and finding suitable alternatives to conserve and use water efficiently and protect riverbanks and aquatic ecosystems.

These activities create a systematic approach to sustainable land use while improving livelihoods and preserving cultural heritage. By offering multiple pathways for economic development, the project seeks to reduce pressure on natural resources and foster a sustainable relationship between local communities and their environment.

5.3.4. Pilot Projects

To demonstrate project feasibility and gain community support, several pilot projects will form the first project activities. These pilots will serve as learning opportunities to refine project approaches and methodologies while showcasing the potential benefits to the broader community. Pilot projects are necessary in the initial stages of the larger conservation and community development initiatives. These smaller-scale, targeted efforts will include the following.

- **Serve as proof of concept:** By implementing main project components on a smaller scale, pilot projects will demonstrate the viability and potential impact of the proposed interventions. This tangible evidence could help secure further funding and support from stakeholders.
- **Foster community engagement:** Involving local community members in these pilot projects will encourage active participation and ownership. This firsthand experience will help build trust and enthusiasm for the broader project goals.
- **Provide valuable insights:** Each pilot will act as a real-world laboratory, allowing project managers to identify challenges, opportunities and unforeseen factors that may influence the success of larger-scale implementation.
- **Refine methodologies:** Lessons learned from these initial efforts will inform adjustments to project approaches, ensuring that scaling up is done efficiently and effectively.



- **Create early success stories:** Positive outcomes from pilot projects will be used to inspire and motivate other community members to participate in future phases of the project.
- **Test different approaches:** Multiple pilot projects are used to compare various strategies or focus on different aspects of the overall project, helping to determine the most effective methods for full-scale implementation.
- **Build capacity:** Pilot projects offer an opportunity to train local community members and project staff, developing the skills and expertise needed for long-term project success.
- **Establish partnerships:** These initial efforts help forge relationships with local organisations, government agencies and other stakeholders, creating a supportive network for the broader project.

By carefully selecting and implementing these pilot projects, the initiative gains valuable momentum, refines its approach and builds a strong foundation for larger-scale, sustainable impact in the region. Currently, three pilot projects are in the initial stages of stakeholder negotiations, each representing different land ownership models and agricultural practices prevalent in the area and are listed below.

- **Large-scale Community Farm (1,000 ha):** This pilot is owned by a Community Property Association (CPA). The property encompasses several smaller farming plots for various fruits and vegetables. This offers an opportunity to demonstrate how the project will work within a communal ownership structure. This pilot will explore: i) collaborative management strategies for shared resources; ii) scaling of sustainable practices across multiple sub-plots; and iii) balancing individual farmer needs with community-wide benefits.
- **Customary Rangeland Ownership (5 ha):** This pilot, situated in the Amashangane tribal authority, involves two plots of rangeland under customary ownership, managed through Permission to Occupy (PTO) agreements from the Tribal Authority. This model will allow the project to: i) work within traditional governance structures; and ii) develop strategies for sustainable rangeland management within the context of the project.
- **Mixed Farming Practices Cropland (10 ha):** This pilot is situated in the Hoxani tribal authority and focuses on a cropland area where multiple farming methods are employed, also under customary ownership with a PTO. This diverse site will enable the project to: i) compare and contrast the environmental and economic impacts of different farming practices — permaculture versus conventional farming; and ii) develop transition strategies from conventional to more sustainable agriculture.

By engaging with these different pilot projects, the initiative aims to address the complexities of land ownership, agricultural practices and community dynamics present in the region. These pilots will serve as living laboratories, providing insights into the challenges and opportunities associated with implementing sustainable land use practices across different contexts. The lessons learned from these initial efforts will inform the broader project strategy, ensuring that future expansions are well-adapted to local needs and conditions.

5.3.5. Other potential activities

Reforestation activities will potentially form a smaller part of the project compared to the agroforestry activities. The project will implement targeted reforestation using an area-based approach in degraded forests, woodlands. Either an area- or census-based approach will be used in degraded savanna depending on the nature of the area to be restored — dense or open savanna. Forests and woodlands are characteristic of continuous tree cover over larger contiguous areas with canopy cover exceeding 60% for forests and ranging between 20 and



60% for woodlands^{155,156,157,158}. Typical planting densities are ~500–1,000 trees/ha for forests^{159,160} and ~50–100 trees/ha for woodlands.

Several ecosystems are found in the project area, with specific vegetation types and naturally-occurring tree species. These are summarised in Table 5.3 and will be considered for the potential reforestation activities to promote diverse and resilient ecosystems^{161,162,163}.

Table 5.3. Vegetation and ecosystem type with associated tree species.

Vegetation and ecosystem type	Typical tree species
Afromontane forest Forest	Real yellowwood (<i>Podocarpus latifolius</i>) Stinkwood (<i>Ocotea bullata</i>) White stinkwood (<i>Celtis Africana</i>) Cape beech (<i>Halleria lucida</i>)
Lowveld Riverine forest Woodland/savanna	African teak (<i>Breonadia salicina</i>) Apple-leaf (<i>Philenoptera violacea</i>) Cape mahogany (<i>Trichilia emetica</i>)
Granite Lowveld Woodland/savanna	Marula (<i>Sclerocarya birrea</i>) Red bushwillow (<i>Combretum apiculatum</i>) Sicklebush (<i>Dichrostachys cineria</i>) Leadwood (<i>Combretum imberbe</i>) Silver terminalia (<i>Terminalia sericea</i>) Zebrawood (<i>Dalbergia melanoxylon</i>) Monkey orange (<i>Strychnos spinosa</i>) Tamboti (<i>Spirostachys africana</i>)
Mixed Lowveld Bushveld Woodland/savanna	Marula (<i>Sclerocarya birrea</i>) Knob thorn (<i>Acacia nigrescens</i>) Silver terminalia (<i>Terminalia sericea</i>) Sicklebush (<i>Dichrostachys cineria</i>) Leadwood (<i>Combretum imberbe</i>) Zebrawood (<i>Dalbergia melanoxylon</i>) Monkey orange (<i>Strychnos spinosa</i>) Tamboti (<i>Spirostachys africana</i>)
Subtropical Alluvial Vegetation Woodland	African fig (<i>Ficus sycomorus</i>) Sulphur bark (<i>Acacia xanthophloea</i>)
Legogote Sour Bushveld Woodland	Kiaat (<i>Pterocarpus angolensis</i>) Wild syringa (<i>Burkea africana</i>)

The privately owned nature and game reserves in the region and the Bushbuckridge Nature Reserve — which is currently excluded from the project due to ongoing land disputes — form a potential project activity. Protected areas offer high potential for carbon sequestration and biodiversity conservation but present challenges regarding additionality and intervention

¹⁵⁵ Scholes RJ and Archer SR. 1997. Tree-grass interactions in savannas. *Annual Review of Ecology and Systematics*, 28:517–544.

¹⁵⁶ House JI, *et al.* 2003. Conundrums in mixed woody–herbaceous plant systems. *Journal of Biogeography*, 30(11):1763–1777.

¹⁵⁷ Torello-Raventos M, *et al.* 2013. On the delineation of tropical vegetation types with an emphasis on forest/savanna transitions. *Global Ecology and Biogeography*, 22(11):1097–1110.

¹⁵⁸ O'Connor TG and Bredenkamp GJ. 1997. Grassland. In RM Cowling, DM Richardson and SM Pierce (Eds.), *Vegetation of Southern Africa* (pp. 215–257). Cambridge University Press.

¹⁵⁹ Geldenhuys CJ and Venter SM. 2002. Plant communities and landscapes of the Parys area, Free State Province, South Africa. *Koedoe*, 45(1):19–43.

¹⁶⁰ Crowther TW, *et al.* 2015. Mapping tree density at a global scale. *Nature*, 525(7568): 201–205.

¹⁶¹ Mucina L and Geldenhuys CJ. 2006. Afro-temperate, Subtropical and Azonal Forests. In: Mucina L and Rutherford MC. (eds) *The Vegetation of South Africa, Lesotho and Swaziland*. Strelitzia 19. South African National Biodiversity Institute, Pretoria. pp. 584–615.

¹⁶² Scholes RJ and Walker BH 1993. *An African Savanna: Synthesis of the Nylsvley Study*. Cambridge University Press.

¹⁶³ Low AB and Rebelo AG (eds) 1996. *Vegetation of South Africa, Lesotho and Swaziland*. Department of Environmental Affairs and Tourism, Pretoria.



design. The project will reassess the inclusion of protected areas pending further discussions and resolution of disputes. If included interventions in protected areas will focus on enhancing existing ecosystems and supporting conservation efforts, using area-based or census-based approaches as appropriate. The project will work closely with conservation authorities to ensure alignment with management plans and to demonstrate additionality beyond existing conservation measures. This approach aims to support both carbon sequestration goals and the broader conservation objectives of protected areas.

6. Project scale

A standalone project limits its scope to the area defined at registration. Adding land subsequently requires separate registrations with full validations. To address this limitation, the Verified Carbon Standard (VCS) grouped project approach is recommended. This method allows registering a large land portion at the project's start, providing flexibility to add areas post-commencement within the registered project boundary. The grouped approach consolidates project activities under a single Project Design Document (PDD) registration, supporting progressive expansion by adding activities over multiple instances into one project.

The project will adopt a VCS-grouped approach, allowing flexibility and scalability within the defined Sabie-Sand River Catchment project area. The three pilot projects described in Section 5.3.4 form the initial project activity instances (PAIs), including training initiatives and tree-growing nurseries. Future agroforestry and reforestation PAIs will be introduced as successful stakeholder and voluntarily registered beneficiary agreements are established. Each PAI will adhere to VM0047 eligibility criteria and applicability conditions for Afforestation, Reforestation and Revegetation (ARR), maintaining consistency with the original baseline scenario, permanence risk and additionality justification. The initial focus will be on private, customary and Community Property Association (CPA) land where relationships have been forged. These include, *inter alia*, the Amashangane tribe king, community farmers, land rights holders, established CPAs, non-governmental organisations such as the Kruger to Canyons Biosphere Reserve and local government. Areas with ongoing land disputes will be included in future PAIs once these disputes are resolved. Primary focus will be placed on agroforestry activities in croplands and rural residences. Project activities planned for rangelands — which include the silvopasture, riparian buffer and conservation hedgerow agroforestry — and reforestation will be implemented where agreements are forged to ensure additionality and reduce permanence risk due to unstable land tenure.

7. Project timeline

The Verified Carbon Standard (VCS) Standard v4.4¹⁶⁴ outlines that project crediting periods should range from 20 to 100 years, with up to four renewals permitted, not exceeding a total of 100 years. Main considerations for project duration include the timing of carbon credit sequestration, implementation phase and leakage assessment provisions. A minimum 40-year project duration is advised as it reduces the permanence risk with 5–7-year implementation phase and crediting periods every five or ten years. However, longer timeframes may be necessary to accommodate the gradual introduction of project activities under the grouped approach, ensuring later instances achieve full carbon sequestration potential. In this event, use of the renewal options is recommended. Whilst extending the project timeline offers a solution, it requires consideration of investment horizons and return expectations, carbon price projections and market, increased maintenance and monitoring costs, potential changes in land use or socio-economic situation and baseline determination considerations.

¹⁶⁴ Verra. 2024. Verified Carbon Standard Program Guide v4.4 (29 August 2024). Available at: <https://verra.org/wp-content/uploads/2023/08/VCS-Program-Guide-v4.4.pdf>.



8. Project boundary

This section delineates the project boundary and identifies the appropriate carbon pools for the proposed agroforestry activities in the Sabie-Sand River Catchment. Accurately defining these elements establishes the geographical scope of the project, determines eligible areas for different interventions and identifies the carbon stocks to be measured and monitored.

8.1. Delineating project boundaries

Given that the agroforestry activities depend on land use, a stratification of the project area according to land cover classification is made. The main strata include: i) croplands; ii) rural residences or homesteads; and iii) rangelands. These are discussed below.

- **Croplands:** This stratum is the primary focus of the project, employing a census-based approach with agroforestry activities — such as, *inter alia*, integrated tree-crop systems, multi-story systems, boundary planting and windbreaks. Croplands are prioritised because of the contribution of unsustainable farming practices to degradation.
- **Rural residential areas:** These are the secondary focus, employing a census-based approach to plant trees in residential yards, community areas and near farm buildings. Rural residences are prioritised due to their contribution to localised degradation by increased human activity, which leads to soil compaction, vegetation loss and altered water runoff patterns. The concentration of settlement frequently results in bare, compacted soils that increase surface runoff and erosion, contributing to downstream siltation. Most roads in the region are unpaved, exacerbating dust problems and erosion during rainfall events. Tree planting in these areas help stabilise soils, reduce dust and mitigate the impacts of unpaved roads. Moreover, these trees provide direct benefits to residents, including shade, improved air quality, potential food sources from fruit trees and enhanced aesthetic value.
- **Rangelands:** This stratum encompasses woodlands, savanna and grassland areas used primarily for cattle grazing. Rangelands are prioritised due to their vulnerability to multiple forms of degradation, including overgrazing, soil erosion, bush encroachment and climate change impacts. These factors lead to reduced vegetation cover, altered species composition, decreased water retention capacity and loss of biodiversity. Project activities will be focussed on planting trees in savanna and grassland areas as, *inter alia*, silvopasture systems, riparian buffers and conservation hedgerows depending on area-specific challenges. This flexibility allows for tailored interventions that effectively combat degradation while enhancing carbon sequestration potential. Rangelands present unique challenges related to land tenure and potential future development plans. To address this and reduce permanence risks, the project will stratify rangelands based on development plans and implement targeted interventions.

After applying the required applicability criteria for the census-based approach — detailed in Section 4.1 — to the remote sensing analysis, ~10,000 ha of cropland, ~20,000 ha of residential area and ~5,000 ha of rangelands are eligible for the intended project activities. It is important to note that these boundaries will need to be confirmed and verified in further steps of the project design, particularly for the residential extents. Local municipal departments will need to provide an indication of the extent of rural versus urban settlements in the region. Different applicability conditions concern urban settlements. The extents were determined using the most recent and a 10-year vintage of the South African National Land Cover (SANLC)¹⁶⁵ Dataset and the Hansen Global Tree Cover Loss¹⁶⁶ Dataset to ensure that only

¹⁶⁵ South African Department of Forestry, Fisheries and the Environment. 2024. SA National Land-Cover Datasets. Available at: https://egis.environment.gov.za/sa_national_land_cover_datasets. Accessed on 22 August 2024.

¹⁶⁶ Hansen/UMD/Google/USGS/NASA. 2023. Hansen Global Forest Change v1.11 (2000–2023). Available at: <https://glad.earthengine.app/view/global-forest-change>. Accessed on: 7 July 2024.



areas classified as non-forest for the past 10 years with less than ten percent pre-existing woody biomass cover are included.

8.2. Selected carbon pools and greenhouse gases

Carbon pools are components of an ecosystem that store or release carbon. Table 8.1 presents the carbon pools included in or excluded from the project for the census-based approach, along with the rationale for each decision.

Table 8.1. Carbon pools included in or excluded for the census-based approach.

Source	Included	Reason
Aboveground woody biomass	Yes	Major carbon pool as per VM0047
Aboveground non-woody biomass	No	Conservative to exclude
Belowground woody biomass	Yes	Major carbon pool as per VM0047
Belowground non-woody biomass	No	Conservative to exclude
Deadwood	No	Conservative to exclude
Litter	No	Conservative to exclude
Soil organic carbon (SOC)	No	Conservative to exclude
Wood products	No	Conservative to exclude

Greenhouse gas (GHG) sources are activities or processes that emit gases contributing to the greenhouse effect. Table 8.2 outlines the GHG sources considered for the project, indicating whether each is included or excluded and providing the reasoning behind these choices.

Table 8.2. Greenhouse gas (GHG) sources excluded from the project boundary.

Scenario	Source	Gas	Reason
Baseline	Biomass burning	Carbon dioxide (CO ₂)	Conservative to exclude
		Methane (CH ₄)	Conservative to exclude
		Nitrous Oxide (N ₂ O)	Conservative to exclude
	Emissions for nitrogen fertiliser	CO ₂	Conservative to exclude
		CH ₄	Conservative to exclude
		N ₂ O	Conservative to exclude
	Burning of fossil fuels	CO ₂	Conservative to exclude.
		CH ₄	Conservative to exclude
		N ₂ O	Conservative to exclude
Project	Biomass burning	CO ₂	De minimis
		CH ₄	De minimis
		N ₂ O	De minimis
	Emission for nitrogen fertiliser	CO ₂	Conservative to exclude
		CH ₄	Conservative to exclude
		N ₂ O	Conservative to exclude
	Burning of fossil fuels	CO ₂	De minimis
		CH ₄	De minimis
		N ₂ O	De minimis

9. Carbon potential

This section provides an assessment of the carbon sequestration potential of the project, covering aspects of carbon accounting in agroforestry initiatives. It provides an outline of the baseline scenario, a demonstration of additionality, an estimation of gross emission removals, calculations of applicable buffers and deductions, and the estimation of net emission removals.



The analysis incorporates Verra's VM0047 Methodology for Afforestation, Reforestation and Revegetation (ARR), focusing on the census-based approach.

9.1. Baseline scenario

The baseline scenario for the census-based approach assumes that woody biomass or carbon stocks would not increase substantially without the project intervention. As outlined in Section 4.1, this approach is applicable to areas with less than 10% pre-existing woody biomass cover, or in areas subject to continuous cropping, settlements or lands categorised as 'other land' based on definitions from the Intergovernmental Panel on Climate Change (IPCC)¹⁶⁷. Under these conditions, the methodology assumes that afforestation, reforestation or revegetation would not occur naturally or by other means. Consequently, the crediting baseline is set to zero, effectively excluding all other potential baseline scenarios. This is applicable to the planned agroforestry activities in croplands, rural residences, savanna and grassland. The project should, however, demonstrate at each verification that activities continue to meet the applicability conditions justifying this zero-baseline assumption.

9.2. Additionality

Three steps are applied to demonstrate additionality for the project under the census-based approach, listed as below.

- **Regulatory surplus:** Demonstrate that the project activities are not mandated by any law, statute or regulatory framework.
- **Investment barrier:** Demonstrate that the project activity is not financially attractive without carbon credit revenues; and
- **Common practice:** Demonstrate that the project activity is not common practice, and that the adoption rate is below 15%.

9.2.1. Regulatory surplus

Applicable legislature is detailed in Section 4.3 and, as South Africa is a non-Annex I country under the United Nations Framework Convention on Climate Change (UNFCCC) — only systematically enforced laws, statutes or regulatory frameworks need to be considered for regulatory surplus. Incidentally, none of the listed acts and regulations explicitly mandate afforestation, reforestation or revegetation activities. While these is likely to influence several aspects of the project design and implementation, there are no systematically enforced regulations mandating ARR activities. Therefore, the proposed ARR project in the Sabie-Sand River Catchment demonstrates a regulatory surplus, as it goes beyond any existing, systematically enforced regulatory requirements.

9.2.2. Investment Barrier

Based on an initial analysis of the proposed agroforestry project, there is evidence to suggest the presence of investment barriers. However, it should be emphasised that a comprehensive and accurate assessment will only be undertaken in the next phase of the project when detailed cost analyses are performed.

The preliminary findings based on assumed project implementation and maintenance cost data indicate potential investment barriers for an ARR project under VM0047. Financial indicators show negative Net Present Value (NPV), resulting in an annual deficit. The project's

¹⁶⁷ Intergovernmental Panel on Climate Change (IPCC). 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry and Other Land Use, Chapter 3: Consistent Representation of Lands. Prepared by the National Greenhouse Gas Inventories Programme, Eggleston HS, Buendia L, Miwa K, Ngara T and Tanabe K. (eds). Published: IGES, Japan.



Internal Rate of Return (IRR) falls below the assumed benchmark for similar risk investments. Break-even analysis reveals that changes would be required for project viability. Additional factors that could impact investment include high upfront costs, delayed returns from tree components, limited credit access for smallholders and several technical and institutional challenges.

These findings suggest that the project is likely to face investment barriers. The financial indicators imply that the project might not attract investors without additional support or incentives. To provide a more comprehensive assessment of investment barriers, further analysis is recommended. This would involve detailed, site-specific cost analyses, refined revenue projections based on local market conditions, a thorough risk assessment, analysis of local alternative land use options and their financial returns, evaluation of capital access for project participants and assessment of regional agroforestry adoption rates to support common practice analysis. Such a detailed examination would offer an accurate evaluation of the investment barriers and overall additionality of the project.

9.2.3. Common practice

The project proponent is required to confirm that the activities are not considered common practice — with an adoption rate of less than 15% — within the project area. Based on preliminary calculations using remote sensing, literature^{168,169} and information derived from stakeholder consultations with local farmers and community leaders, initial estimates of adoption rates for agroforestry activities are below the threshold for additionality. As a result, they are not considered common practice.

This low adoption rate is attributed to factors such as limited awareness of agroforestry benefits, lack of access to appropriate tree species and insufficient technical support. It should be noted that these are preliminary results and additional data at the stratum level is required to obtain a precise adoption rate value for the project area. This will be accomplished in the next phases of the study by:

- comprehensive stakeholder engagement sessions;
- detailed surveys of current land use practices; and
- collection of project-specific data, including, *inter alia*, soil conditions, existing tree cover and local climate patterns.

These activities in the next phases of the study will focus on gathering categorised data to consider variations in geographical and socio-economic conditions across the project area. Additionally, the project will implement a monitoring and verification system to track adoption rates over time, ensuring ongoing additionality.

9.3. Gross emission removals

Project gross emission removals (ERs) are estimated for the agroforestry activities in three land use scenarios: i) croplands using planting densities of 200 trees/ha; ii) residences using planting densities of 50 trees/ha; and iii) rangelands also using planting densities of 100 trees/ha. Activities will use a mix of indigenous and common species in the region as detailed in Table 5.2, Section 5.3.1. As part of the next phases in project design, an expert will be required to determine the appropriate species mix and planting densities.

¹⁶⁸ Meijer SS, *et al.* 2014. The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. *International Journal of Agricultural Sustainability*, 13(1):40–54.

¹⁶⁹ Dagninet A and Dietrich D. 2020. Agroforestry adoption as a systems concept: A review. *Forest Policy and Economics*. 120:102299.



For the purposes of this study, a preliminary selection of three species includes apple-leaf (*Philenoptera violacea*), marula (*Sclerocarya birrea*) and African fig (*Ficus sycomorus*). These are selected to represent small, medium and large trees, respectively. Tree height and DBH are similar for the smaller apple-leaf and other fruit bearing species such as avocado (*Persea americana*) and mango (*Magifera indica*), and also for the medium marula, knob thorn (*Acacia nigrescens*) and Cape mahogany (*Trichilia emetica*) species. Consequently, growth and sequestration are expected to be closely related within each of these groups. The larger African fig's growth parameters differ and will be modelled separately. Table 9.1 provides annual carbon sequestration in tonnes of carbon dioxide equivalent (tCO₂-e) for each of the groupings listed.

Table 9.1. Annual carbon sequestration amounts (tCO₂-e) for individual agroforestry tree species. The average per tree per year (tCO₂-e/pu/yr) and total per planting unit (tCO₂-e/pu) are also listed.

Year	Apple-leaf (small)	Marula (medium)	African fig (large)
1	0.00	0.03	0.00
2	0.00	0.08	0.02
3	0.01	0.13	0.07
4	0.02	0.19	0.17
5	0.04	0.27	0.32
6	0.06	0.34	0.51
7	0.09	0.42	0.72
8	0.12	0.51	0.97
9	0.16	0.60	1.23
10	0.20	0.69	1.51
11	0.23	0.79	1.79
12	0.28	0.88	2.09
13	0.32	0.97	2.40
14	0.36	1.07	2.72
15	0.40	1.16	3.04
16	0.45	1.25	3.38
17	0.49	1.34	3.72
18	0.53	1.42	4.06
19	0.58	1.50	4.50
20	0.62	1.58	4.85
21	0.66	1.66	5.21
22	0.72	1.74	5.57
23	0.76	1.81	5.92
24	0.80	1.88	6.41
25	0.84	1.95	6.76
26	0.88	2.03	7.12
27	0.92	2.10	7.47
28	0.96	2.17	7.81
29	1.02	2.23	8.15
30	1.06	2.30	8.48
31	1.09	2.37	8.81
32	1.13	2.43	9.14
33	1.17	2.50	9.46
34	1.21	2.56	9.78
35	1.25	2.62	10.09
36	1.28	2.69	10.66
37	1.33	2.75	10.96
38	1.37	2.80	11.26
39	1.41	2.86	11.84
40	1.45	2.92	12.44
Average (tCO₂-e/pu/yr)	0.70	1.50	5.30
Total (tCO₂-e/pu)	26	62	211



The approximate eligible area for the agroforestry activities in croplands, residences and rangelands — provided in Section 8.1 — are ~10,000 ha, ~20,000 ha and ~5,000 ha, respectively. Consequently, the number of trees for each respective scenario is 2,000,000 for croplands, 1,000,000 for residences and 500,000 in rangelands — all estimated from the planting density and eligible planting area.

The aboveground biomass (AGB) stock is estimated using appropriate allometric equations based on tree height and diameter at breast height (DBH)¹⁷⁰. Allometric equations are used because they provide a reliable and non-destructive method to estimate tree biomass, accounting for species-specific growth patterns and local environmental conditions. These equations have been developed and validated by using extensive field measurements and are widely accepted in forestry and carbon accounting practices. Where allometric equations are not available, the biomass is determined from an estimation of the biovolume — using height and DBH — and application of wood density¹⁷¹, biomass expansion factor¹⁷². The belowground biomass (BGB) stock is estimated using the AGB and an average root-to-shoot ratio of 0.27¹⁷³. This ratio is appropriate because it represents a conservative estimate for tropical and subtropical dry forest ecosystems. The value is consistent with Intergovernmental Panel on Climate Change (IPCC) guidelines for these forest types and provides a reasonable approximation of BGB without the need for destructive root sampling.

During the project lifespan, tree parameters — including height, diameter and mortality — are regularly monitored and estimates are formed therefrom. For this feasibility study, tree growth was modelled using the Spatially Explicit Individual-based Forest Simulator (SEXI-FS) model developed by the World Agroforestry Centre (ICRAF) and the Institute of Research and Development (IRD)¹⁷⁴. This model incorporates a Richard-Chapman tree growth function and allometric equations to model the height and DBH of a tree while considering competition factors relating to light, space, mortality, regeneration and other environmental conditions. An annual mortality rate of 1.25% is derived from the SEXI-FS model for this analysis, however, accurate rates should be determined yearly during monitoring.

To estimate the project carbon stock change, two factors are applied to the total woody biomass, calculated as described above. These are the carbon fraction (CF) of the woody biomass — assumed at 0.47 — and the ratio of molecular weight of CO₂ to carbon, assumed as 3.67. This calculation aligns with Equations 1, 2, 5, 6 and 7 in the VM0047 Methodology¹⁷⁵. An implementation phase of 10 years is incorporated using a linear function for trees planted over time.

Error! Reference source not found. provides the project yearly change in carbon stock for the agroforestry activities in the three scenarios, but for a system using only the marula species. Several scenarios can be tailored using the per tree carbon sequestration rates for other species provided in Table 9.1.

¹⁷⁰ Chave J, *et al.* (2014). Improved allometric models to estimate the aboveground biomass of tropical trees. *Global change biology*, 20(10):3177–3190.

¹⁷¹ Carsan S, *et al.* 2012. African wood density database. World Agroforestry (ICRAF). Available at: <https://apps.worldagroforestry.org/treesmarkets/wood/index.php>. Accessed on 22 August 2024.

¹⁷² FAO. 2020a. Global Forest Resources Assessment 2020: Country Reports. Food and Agriculture Organisation of the United Nations, Rome. Available at: <https://www.fao.org/forest-resources-assessment/fra-2020/country-reports/en/>.

¹⁷³ IPCC. 2006. The 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry and Other Land Use. Prepared by the National Greenhouse Gas Inventories Programme, Eggleston HS, Buendia L, Miwa K, Ngara T and Tanabe K (eds). Published: IGES, Japan.

¹⁷⁴ Harja D and Vincent G. 2009. SEXI-FS User Guide and Software v2.1.0. World Agroforestry Centre (ICRAF). Available at: <https://www.worldagroforestry.org/output/sexi-fs/download>.

¹⁷⁵ Verra. 2023. VM0047 Afforestation, Reforestation, and Revegetation, v1.0. Available at: <https://verra.org/methodologies/vm0047-afforestation-reforestation-and-revegetation-v1-0/VM0047>.



Table 9.2. Carbon sequestration (tCO₂-e) for agroforestry in croplands, residences and rangelands.

Year	Croplands	Residences	Rangelands
1	6,557	3,092	1,639
2	30,634	14,405	7,659
3	77,418	36,315	19,452
4	150,414	70,923	38,348
5	251,583	119,982	65,590
6	383,080	184,919	101,726
7	540,436	266,497	146,576
8	725,788	365,629	201,717
9	935,486	482,403	266,734
10	1,167,734	616,561	342,782
11	1,290,760	698,843	388,599
12	1,410,931	781,675	434,567
13	1,526,036	864,810	480,374
14	1,633,654	947,728	527,024
15	1,738,089	1,030,062	571,862
16	1,834,759	1,111,263	617,059
17	1,928,131	1,191,299	660,412
18	2,017,678	1,270,503	701,568
19	2,104,356	1,348,606	741,506
20	2,183,526	1,425,415	781,436
21	2,258,797	1,500,542	820,200
22	2,327,815	1,574,177	857,263
23	2,391,721	1,646,460	892,972
24	2,453,343	1,717,220	929,375
25	2,513,058	1,786,366	964,855
26	2,571,815	1,854,495	1,000,093
27	2,629,119	1,921,268	1,035,386
28	2,684,885	1,986,784	1,069,479
29	2,740,510	2,051,217	1,102,958
30	2,795,550	2,114,489	1,136,527
31	2,847,745	2,176,496	1,169,579
32	2,898,555	2,237,160	1,201,792
33	2,946,545	2,296,851	1,233,265
34	2,992,373	2,355,243	1,264,834
35	3,035,356	2,412,630	1,295,815
36	3,079,227	2,468,458	1,326,014
37	3,122,518	2,522,941	1,355,639
38	3,165,138	2,576,458	1,384,898
39	3,206,819	2,629,368	1,414,009
40	3,249,208	2,635,542	1,442,491

9.4. Applicable deductions

This section provides an overview of the applicable buffers and deductions relevant to the project. It covers three main areas: i) leakage; and ii) uncertainty and outlines how these factors are addressed within the context of the project’s census-based approach and in accordance with the Verra’s VM0047 Methodology for ARR projects. Details on the assumptions made for leakage effects and the calculations used for uncertainty estimation are included.

9.4.1. Leakage

The census-based approach applies to ARR project activities that will not produce continuous vegetative cover — associated with the planting units — on any contiguous area exceeding 1 ha. Therefore, any significant displacement of a pre-existing land use is avoided, and leakage effects are assumed to be negligible.



9.4.2. Uncertainty

Uncertainty for the population size — parameter N — is assumed to be zero and is addressed by the requirement for a complete census of planting units with associated GPS co-ordinates. The baseline uncertainty, similarly, equals zero associated with an absence of planting units. Therefore, only propagating errors associated with the estimates of woody biomass are used to calculate uncertainty. These pertain to sampling and measurement of the required parameters and modelling of the woody biomass and carbon sequestration.

Measurement of tree parameters — such as height and diameter — and survival rates will be undertaken by project participants as a citizen science initiative for which they will receive payment from the revenue potential credits generated. Therefore, all project trees will be measured and sampling errors not applicable. Project participants will be provided with the required tools and training to accurately measure the tree parameters and survival rates, leading to reduced measurement errors. As a result, sampling and measurement uncertainty is expected to be low.

Allometric equations used for woody biomass estimation in this project are expected to have low uncertainty for several reasons listed below.

- **Species-specific equations:** The project uses allometric equations that have been developed specifically for the tree species present in the project area, ensuring high accuracy.
- **Local calibration:** Where possible, the equations have been calibrated using data from trees grown under similar conditions to those in the project area, further reducing uncertainty.
- **Robust statistical validation:** The selected equations have undergone statistical validation, with high coefficient of correlation values and low residual standard errors.
- **Conservative approach:** In cases where multiple equations are available, the project employs the most conservative option to avoid overestimation of biomass.

The equations used to determine carbon sequestration also demonstrate low uncertainty for the reasons listed below.

- **Direct relationship to biomass:** Carbon sequestration is calculated based on the woody biomass estimates, which — as noted above — have limited uncertainty.
- **Well-established conversion factors:** The project uses internationally recognised and peer-reviewed conversion factors for transforming biomass to carbon content.
- **Conservative estimates:** The calculations incorporate conservative assumptions concerning carbon allocation in different tree components — such as roots, stems and branches.
- **Regular updates:** The carbon sequestration models are periodically updated with the latest scientific findings to maintain their accuracy.
- **Validation against field measurements:** The project plans to validate carbon sequestration estimates against direct field measurements on a subset of trees, further reducing uncertainty.

By combining population counts, field measurements, allometric equations and conservative carbon sequestration calculations, the overall uncertainty in the project's carbon benefit estimations is likely reduced.

9.4.3. Project emissions

Emissions of methane (CH₄) and nitrous oxide (N₂O) from burnt biomass are considered negligible for this ARR activity. Carbon dioxide (CO₂) emissions from burnt biomass are already incorporated into the carbon stock change calculations. As nitrogen fertiliser



application is assumed to be zero, there are no associated N₂O emissions to account for. Given these factors — along with the small-scale and dispersed nature of the planting units — the overall project emissions are deemed negligible.

9.5. Net emissions removals

The project net emissions removals (ERs) are estimated by applying the appropriate buffers and deductions where applicable. Leakage and emissions of methane (CH₄) and nitrous oxide (N₂O) emissions from burnt biomass and nitrogen fertiliser application is assumed zero — as detailed in Sections 9.4.1 and 9.4.3 — and do not affect emissions removal estimate. Uncertainty is assumed at 10% for these calculations but is subject to change as described in Section 9.4.2. Table 9.3 provides the project net ERs with leakage, uncertainty and project emissions applied.

Table 9.3. Net emissions removals (ERs) for agroforestry in croplands, residences and rangelands. The totals, annual averages (tCO₂-e/yr), annual averages per planting unit (tCO₂-e/pi/yr and per hectare (tCO₂-e/ha/yr) are also listed.

Year	Croplands	Residences	Rangelands
1	5,901	10,182	1,475
2	21,670	19,719	5,417
3	42,106	31,147	10,614
4	65,697	44,153	17,006
5	91,051	58,443	24,518
6	118,347	73,421	32,522
7	141,621	89,218	40,366
8	166,817	105,097	49,627
9	188,728	120,742	58,515
10	209,023	74,054	68,443
11	110,724	74,548	41,235
12	108,154	74,822	41,371
13	103,595	74,626	41,226
14	96,856	74,101	41,985
15	93,992	73,081	40,354
16	87,003	72,032	40,678
17	84,035	71,284	39,017
18	80,592	70,293	37,040
19	78,010	69,128	35,945
20	71,253	67,614	35,937
21	67,744	66,272	34,888
22	62,116	65,055	33,356
23	57,516	63,685	32,138
24	55,460	62,231	32,763
25	53,743	61,316	31,933
26	52,881	60,096	31,714
27	51,573	58,964	31,764
28	50,189	57,990	30,684
29	50,063	56,945	30,131
30	49,536	55,806	30,212
31	46,975	54,597	29,747
32	45,729	53,722	28,991
33	43,191	52,554	28,326
34	41,245	51,648	28,413
35	38,685	50,245	27,883
36	39,484	49,035	27,179
37	38,961	48,166	26,663
38	38,358	47,619	26,333
39	37,514	10,182	26,200
40	38,150	19,719	25,633



Total (tCO₂-e)	2,924,287	2,363,648	1,298,242
Average (tCO₂-e/yr)	73,107	62,201	31,664
Average per pu (tCO₂-e/pu/yr)	0.98	1.48	1.50
Average per ha (tCO₂-e/ha/yr)	7.31	3.11	6.49

9.6. Non-permanence risk

A preliminary risk assessment was undertaken for this study using the agriculture, forestry and other land use (AFOLU) Non-Permanence risk tool¹⁷⁶ to calculate a risk rating that determines the number of buffer carbon credits required. The result of this assessment was a risk score of 15%. However, the study is currently in the feasibility stage, making this score preliminary and subject to change. It assumes that certain activities will be included in the project and the assessment should be revisited if any of these prove unfeasible, which will affect the risk rating. The risk determines the number of credits allocated to the buffer account.

Table 9.4. Risk assessment of the proposed ARR project.

Risk Category	Risk Type	Rating
Internal	Project Management (PM)	-6
	Financial Viability (FV)	1
	Opportunity Cost (OC)	-5
	Project Longevity (PL)	0
	Total Internal Risk (PM + FV + OC + PL)	0
External	Land Tenure (LT)	10
	Stakeholder engagement (SE)	0
	Political Control (PC)	-2
	Total External Risk (LT + SE + PC)	8
Natural	Natural risk associated with climate change impact (NR-c)	7
	Natural risk not associated with climate change impact (NR-nc)	0
	Total Natural Risk (NR-c + NR-nc)	7
Total Risk		15

For the ARR project to succeed and mitigate risks effectively, several safeguards and considerations should be implemented. The project should develop a comprehensive adaptive management plan that includes a grievance redress mechanism for participant satisfaction and dispute resolution. This mechanism will help address challenges that might deter stakeholders from participating. Strong community engagement is necessary, involving a wide range of stakeholders in project decisions while considering diversity and acknowledging changes in stakeholder dynamics over time. Land tenure agreements and dispute resolution mechanisms should be established to address potential conflicts. Given the project area's susceptibility to fires and extreme weather events, robust strategies to mitigate natural risks — particularly fire management — are necessary. A strong benefit-sharing mechanism should be implemented to maintain low opportunity cost risk and ensure continued participant commitment. Throughout the project's lifecycle, it is necessary to regularly inform all stakeholders about potential modifications and maintain transparent communication. By implementing these interventions, the project is likely to address challenges that might deter stakeholder participation, maintain project commitment and effectively mitigate several risks associated with implementation.

This preliminary assessment indicates that the proposed ARR project has a low risk profile being only slightly above the minimum threshold of 10%. However, there are areas that require careful management, particularly around natural risks and land tenure. As the project develops, a detailed risk assessment should be undertaken with specific project data.

¹⁷⁶ Verra. 2023. AFOLU Non-Permanence Risk Tool, v4.2. Available at: <https://verra.org/wp-content/uploads/2023/10/AFOLU-Non-Permanence-Risk-Tool-v4.2-FINAL.pdf>



10. Verified carbon units (VCUs)

Verified Carbon Units (VCUs) are Verra certified credits that represent independently verified greenhouse gas (GHG) reductions or removals. To calculate the number of VCUs likely to be issued — termed Unverified Carbon Units (UCUs) in this Feasibility Study as they have not yet been verified — the project proponent should factor in the buffer credits deposited in the agriculture, forestry and other land use (AFOLU) pooled buffer account. These buffer credits are derived by multiplying the non-permanence risk rating of 15% with the net change in carbon stocks. The buffer pool serves as an insurance mechanism against carbon stock reversals — which occur when previously sequestered carbon is released back into the atmosphere due to unforeseen events like natural disasters or human activities — ensuring the long-term integrity of the carbon credits.

Table 10.1. Potential Unverified Carbon Units (UCUs).

Stratum	Cropland	Residences	Rangeland
Total net emission removals (ERs) (tCO ₂ -e)	2,924,287	2,363,648	1,298,242
Buffer credits (tCO ₂ -e)	438,643	354,547	194,736
UCUs (tCO ₂ -e)	2,485,644	2,009,101	1,103,506

11. Climate, community, and biodiversity (CCB) potential

The Climate, Community and Biodiversity (CCB) Standards require projects to develop a Theory of Change (TOC) that connects project activities to expected climate, community and biodiversity benefits. This framework outlines how project activities lead to short-term outputs, medium-term outcomes and long-term impacts, demonstrating how interventions achieve benefits across climate, community and biodiversity dimensions. Projects that show exceptional benefits in climate change adaptation, community involvement or biodiversity conservation are likely to qualify for Gold Level status, indicating performance beyond core CCB requirements.

The TOC provides the framework for the three main project activities: i) agroforestry and reforestation; ii) education and training workshops; and iii) alternative livelihood, income generation and market establishment initiatives. Potential climate, community and biodiversity related outputs, outcomes and impacts from the project activities are provided in Table 11.1, Table 11.2 and Table 11.3, respectively.

11.1. Climate

Table 11.1. Climate-related outputs, outcomes and impacts for the project activities.

Activity	CCB benefit
Agroforestry and reforestation	<p>Outputs^{177,178,179}</p> <ul style="list-style-type: none"> • Enhanced awareness of climate change impact • Increased knowledge of climate-smart practices • Improved capacity for sustainable land management

¹⁷⁷ Sauer TJ, *et al.* 2021. Agroforestry Practices for Soil Conservation and Resilient Agriculture. In: Udawatta RP, Jose S. (eds) Agroforestry and Ecosystem Services. Springer, Cham.

¹⁷⁸ Everson CS, *et al.* 2009. The effect of tree canopies on rainfall interception, soil physical properties and soil moisture in a semi-arid environment. *Water SA*, 35(5):639–646.

¹⁷⁹ Zignol F, *et al.* 2023. The understory microclimate in agroforestry now and in the future – a case study of Arabica coffee in its native range. *Agricultural and Forestry Meteorology*, 340(10958).



	Outcomes ^{180,181,182}	<ul style="list-style-type: none"> • Increased carbon sequestration • Improved water cycle regulation • Increased soil fertility • Improved agricultural outputs • Increased resilience to extreme weather events
	Impacts ^{183,184,185,186}	<ul style="list-style-type: none"> • Contributions to national climate change mitigation and adaptation goals • Reduced deforestation pressures • Improved food security • Reduced sedimentation in water bodies • Maintained ecosystem functions • Increased resilience to climate change
	Outputs ¹⁸⁷	<ul style="list-style-type: none"> • Enhanced awareness of climate change impacts • Increased knowledge of climate-smart practices • Improved capacity for sustainable land management
Education and training workshops	Outcomes ^{188,189,190}	<ul style="list-style-type: none"> • Implementation of climate-resilient agricultural practices • Enhanced capacity to use climate information for decision-making.
	Impacts ^{191,192,193,194}	<ul style="list-style-type: none"> • Increased resilience to climate change • Reduced greenhouse gas (GHG) emissions • Contributions to national climate change mitigation and adaptation goals.
	Outputs ^{195,196,197}	<ul style="list-style-type: none"> • Diversification of income sources

¹⁸⁰ Chirwa PW, *et al.* 2015. Soil carbon sequestration and carbon markets for smallholder agroforestry systems in Africa: A review. *Current Opinion in Environmental Sustainability*, 15:89–97.

¹⁸¹ Everson CS, *et al.* 2009. The effect of tree canopies on rainfall interception, soil physical properties and soil moisture in a semi-arid environment. *Water SA*, 35(5):639–646.

¹⁸² Sauer TJ. *et al.* 2021. Agroforestry Practices for Soil Conservation and Resilient Agriculture. In: Udawatta RP, Jose S. (eds) *Agroforestry and Ecosystem Services*. Springer, Cham.

¹⁸³ Duguma LA, *et al.* 2014. Climate change mitigation and adaptation in the land use sector: from complementarity to synergy. *Environmental management*, 54(3):420–432.

¹⁸⁴ Wall DH, *et al.* 2015. Soil biodiversity and human health. *Nature*, 528(7580): 69–76.

¹⁸⁵ Altieri MA, *et al.* 2015. Agroecology and the design of climate change-resilient farming systems. *Agronomy for sustainable development*, 35(3):869–890.

¹⁸⁶ Jose S. 2009. Agroforestry for ecosystem services and environmental benefits: an overview. *Agroforestry systems*, 76(1):1–10.

¹⁸⁷ Zierovogel G, *et al.* 2014. Climate change impacts and adaptation in South Africa. *Wiley Interdisciplinary Reviews: Climate Change*, 5(5):605–620.

¹⁸⁸ Quandt A, *et al.* Climate change adaptation through agroforestry: opportunities and gaps. *Current Opinion in Environmental Sustainability*, 60(101244).

¹⁸⁹ Meijer SS, *et al.* 2015. The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. *International Journal of Agricultural Sustainability*, 13(1):40–54.

¹⁹⁰ Tall A, *et al.* 2018. Do climate services make a difference? A review of evaluation methodologies and practices to assess the value of climate information services for farmers: Implications for Africa. *Climate Services*, 11:1–12.

¹⁹¹ Nyasimi M, *et al.* 2017. Adoption and dissemination pathways for climate-smart agriculture technologies and practices for climate-resilient livelihoods in Lushoto, Northeast Tanzania. *Climate*, 5(3):63.

¹⁹² Khatri-Chhetri A, *et al.* 2017. Farmers' prioritization of climate-smart agriculture (CSA) technologies. *Agricultural systems*, 151:184–191.

¹⁹³ Thornton PK, *et al.* 2018. A framework for priority-setting in climate smart agriculture research. *Agricultural Systems*, 167:161–175.

¹⁹⁴ Lipper L, *et al.* 2014. Climate-smart agriculture for food security. *Nature climate change*, 4(12):1068–1072.

¹⁹⁵ Shackleton CM, *et al.* 2007. The importance of dry woodlands and forests in rural livelihoods and poverty alleviation in South Africa. *Forest Policy and Economics*, 9(5):558–577.

¹⁹⁶ Blignaut J, *et al.* 2010. Restoring and managing natural capital towards fostering economic development: Evidence from South Africa. *Ecological Economics*, 69(6):1313–1323.

¹⁹⁷ Keprate A, *et al.* 2024. Climate Resilient Agroforestry Systems for Sustainable Land Use and Livelihood. In: Kanga S, Singh SK, Shevkani K, Pathak V, Sajjan B. (eds) *Transforming Agricultural Management for a Sustainable Future*. World Sustainability Series. Springer, Cham.



Alternative livelihood, income generation and market establishment	Outcomes ^{198,199}	<ul style="list-style-type: none"> • Adoption of efficient farming techniques • Establishment of new market linkages • Reduced pressure on natural resources • Reduced reliance on climate-vulnerable activities
	Impacts ^{200,201}	<ul style="list-style-type: none"> • Increased resilience to climate change • Reduced greenhouse gas (GHG) emissions • Contributions to national climate change mitigation and adaptation goals

11.2. Community

Table 11.2. Community-related outputs, outcomes and impacts for the project activities.

Activity	CCB benefit	
Agroforestry and reforestation	Outputs ²⁰²	<ul style="list-style-type: none"> • Increased diversity of agricultural products such as fruits, nuts, timber and non-timber forest products (NTFPs)
	Outcomes ^{203,204,205}	<ul style="list-style-type: none"> • Diversified income sources for local communities • Improved food security through varied crop production • Improved health and nutrition by using diverse agricultural products
	Impacts ^{206,207,208}	<ul style="list-style-type: none"> • Reduced poverty and enhanced economic stability in rural communities; ii) • Improved overall quality of life and well-being • Increased environmental stewardship and conservation ethic; • Contribution to sustainable rural development
Education and training workshops	Outputs ²⁰⁹	<ul style="list-style-type: none"> • Enhanced skills in sustainable land management and agroforestry techniques • Increased community engagement in conservation efforts • Enhanced knowledge of climate change and adaptation strategies

¹⁹⁸ Wilk J, *et al.* 2013. The perspectives of the urban poor in five Southern African cities on climate change. *Urban Climate*, 1:95–108.

¹⁹⁹ Thornton PK and Herrero M. 2014. Climate change adaptation in mixed crop–livestock systems in developing countries. *Global Food Security*, 3(2):99–107.

²⁰⁰ Ellis F. 2000. The determinants of rural livelihood diversification in developing countries. *Journal of Agricultural Economics*, 51(2):289–302.

²⁰¹ Asfaw S, *et al.* 2016. What determines farmers' adaptive capacity? Empirical evidence from Malawi. *Food Security*, 8(3):643–664.

²⁰² Shackleton CM, *et al.* 2007. The importance of dry woodlands and forests in rural livelihoods and poverty alleviation in South Africa. *Forest Policy and Economics*, 9(5):558–577.

²⁰³ Tibesigwa B, *et al.* 2015. Gender differences in climate change risk, food security and adaptation: a study of rural households' reliance on agriculture and natural resources to sustain livelihoods. *Environment, Development and Sustainability*, 17(5):1195–1222.

²⁰⁴ Leakey RRB, *et al.* 2005. Agroforestry tree products (AFTPs): targeting poverty reduction and enhanced livelihoods. *International Journal of Agricultural Sustainability*, 3(1):1–23.

²⁰⁵ Jamnadass R, *et al.* 2013. Agroforestry for food and nutritional security. ICRAF Working Paper No. 170. Nairobi: World Agroforestry Centre.

²⁰⁶ Garrity DP. 2004. Agroforestry and the achievement of the Millennium Development Goals. *Agroforestry Systems*, 61:5–17.

²⁰⁷ Mbow C, *et al.* 2014. Agroforestry solutions to address food security and climate change challenges in Africa. *Current Opinion in Environmental Sustainability*, 6:61–67.

²⁰⁸ Jose S. 2009. Agroforestry for ecosystem services and environmental benefits: an overview. *Agroforestry Systems*, 76:1–10.

²⁰⁹ Everson TM, *et al.* 2012. Adaptation to Climate Change and Variability: Farmer Responses to Intra-seasonal Precipitation Trends in South Africa. *Climatic Change*, 110(3-4):477–495.



	Outcomes ^{210,211}	<ul style="list-style-type: none"> • Preservation of traditional knowledge and practices • Enhanced social cohesion through community projects and cooperatives
	Impacts	<ul style="list-style-type: none"> • Enhanced community capacity for self-governance and resource management • Increased environmental stewardship and conservation ethic
Alternative livelihood, income generation and market establishment	Outputs ²¹²	<ul style="list-style-type: none"> • Established community nurseries and processing facilities • Improved access to markets for agricultural products • Creation of new job opportunities in agroforestry and related sectors such as NTFPs
	Outcomes ²¹³	<ul style="list-style-type: none"> • Empowerment of women and youth by using targeted training and opportunities • Reduced rural-urban migration due to improved local prospects • Increased revenue from sales of tree products and NTFPs • Improved food security and economic stability • Enhanced resilience to climate-related shocks • Strengthened value chains benefiting local communities
	Impacts	<ul style="list-style-type: none"> • Reduced poverty and enhanced economic stability in rural communities • Improved overall quality of life and well-being • Development of local craft industries and ecotourism initiatives • Enhanced community capacity for self-governance and resource management

11.3. Biodiversity

Table 11.3. Biodiversity-related outputs, outcomes and impacts for the project activities.

Activity	CCB benefit	
Agroforestry and reforestation	Outputs ²¹⁴	<ul style="list-style-type: none"> • Increased diversity of native plant species in agricultural landscapes • Creation of wildlife corridors and habitat connectivity • Enhanced structural complexity of vegetation; and • Creation of buffer zones around protected areas
	Outcomes ²¹⁵	<ul style="list-style-type: none"> • Improved habitat for native flora and fauna • Increased populations of pollinators and beneficial insects • Enhanced soil biodiversity • Reduced pressure on natural forests for resources • Improved water quality in local streams and rivers

²¹⁰ Ibid.

²¹¹ Vetter S. 2013. Development and sustainable management of rangeland commons – aligning policy with the realities of South Africa's rural landscape. *African Journal of Range & Forage Science*, 30(1-2):1–9.

²¹² Shackleton CM, *et al.* 2007. The importance of dry woodlands and forests in rural livelihoods and poverty alleviation in South Africa. *Forest Policy and Economics*, 9(5):558–577.

²¹³ Ibid.

²¹⁴ O'Connor TG and Kuyler P. 2009. Impact of land use on the biodiversity integrity of the moist sub-biome of the grassland biome, South Africa. *Journal of Environmental Management*, 90(1):384–395.

²¹⁵ Samways MJ, *et al.* 2010. Conservation of threatened orthoptera in the Cape Floristic Region of South Africa: patterns, problems and prospects. *Journal of Insect Conservation*, 14(3):279–289.



		<ul style="list-style-type: none"> • Improved riverine and phytoplankton biodiversity • Increased overall biodiversity in the landscape • Enhanced ecosystem services such as pollination and pest control • Conservation of threatened or endemic species • Contribution to national and global biodiversity targets • Reduced human-wildlife conflict • Enhanced ecological balance supporting tourism activities
	Outputs ²¹⁶	<ul style="list-style-type: none"> • Reduced use of chemical pesticides and fertilisers • Increased community knowledge about local biodiversity
Education and training workshops	Outcomes ²¹⁷	<ul style="list-style-type: none"> • Increased community engagement in biodiversity conservation • Better integration of traditional ecological knowledge in conservation
	Impacts	<ul style="list-style-type: none"> • Long-term sustainability of ecosystem functions • Improved resilience of ecosystems to climate change
	Outputs ²¹⁸	<ul style="list-style-type: none"> • Establishment of community-based biodiversity monitoring programmes • Development of sustainable harvesting practices for NTFPs • Creation of local enterprises based on biodiversity-friendly products — honey production, medicinal plants • Implementation of biodiversity-focused ecotourism initiatives • Establishment of community nurseries for indigenous plant species • Development of agroforestry systems integrating native biodiversity
Alternative livelihood, income generation and market establishment	Outcomes ^{219,220}	<ul style="list-style-type: none"> • Increased community awareness and valuation of local biodiversity • Reduced pressure on endangered species and habitats due to alternative income sources • Enhanced local capacity for sustainable resource management • Improved integration of biodiversity conservation with economic activities • Increased income from biodiversity-friendly products and services • Improved understanding of local ecosystem dynamics by using monitoring programmes
	Impacts ^{221,222,223}	<ul style="list-style-type: none"> • Conservation of threatened or endemic species • Reduced human-wildlife conflicts

²¹⁶ Cockburn, J, *et al.* 2019. How to build science-action partnerships for local land-use planning and management: lessons from Durban, South Africa. *Ecology and Society*, 24(1).

²¹⁷ *Ibid.*

²¹⁸ Shackleton CM, *et al.* 2007. The importance of dry woodlands and forests in rural livelihoods and poverty alleviation in South Africa. *Forest Policy and Economics*, 9(5):558–577.

²¹⁹ *Ibid.*

²²⁰ Berkes F. 2004. Rethinking Community-Based Conservation. *Conservation Biology*, 18(3):621-630.

²²¹ Shackleton CM, *et al.* 2007. The importance of dry woodlands and forests in rural livelihoods and poverty alleviation in South Africa. *Forest Policy and Economics*, 9(5):558–577.

²²² Berkes F. 2004. Rethinking Community-Based Conservation. *Conservation Biology*, 18(3):621-630.

²²³ Secretariat of the Convention on Biological Diversity. 2020. *Global Biodiversity Outlook 5*. Montreal.



- Contribution to national and global biodiversity targets
 - Long-term sustainability of ecosystem functions
 - Enhanced ecological balance supporting tourism activities
 - Improved resilience of ecosystems to climate change
 - Increased biodiversity in managed landscapes
 - Sustainable economic development based on biodiversity resources
-

Potential negative effects of the project activities on the climate, community and biodiversity include, *inter alia*: i) initial reduction in short-term agricultural yields during transition; ii) potential conflicts over land use changes or benefit distribution; iii) possible increase in workload — particularly for women — in managing diverse agricultural systems; iv) initial increases in resource use for training; v) short-term emission increases during transition to new practices; vi) unintended consequences if new practices are not fully adapted to local conditions; vii) introduction of non-native species if not carefully managed; viii) disruption of existing ecological relationships; and ix) unintended consequences of habitat change on several species including, *inter alia*, ground-nesting birds, animals adapted to open habitat, micro-organisms in the soil and native grass species^{224,225}.

11.4. Qualification for CCB and Gold Level Status

The project demonstrates eligibility to qualify for CCB certification, with a TOC that links activities to outputs, outcomes and long-term impacts across climate, community and biodiversity dimensions, which is a core requirement of CCB. Its climate-related activities — including agroforestry and reforestation — promise considerable carbon sequestration and increased climate resilience. The focus on community development with education, alternative livelihoods and market establishment addresses necessary socio-economic aspects. In addition, the project's emphasis on biodiversity conservation aligns well with CCB's biodiversity criteria. The consideration of potential negative effects demonstrates a realistic approach.

Notably, the project shows eligibility for Gold Level status under the CCB Standards. For Climate Change Adaptation (GL1), it enhances ecosystem and community resilience by improved water management, drought-resistant crops and diversified livelihoods. Exceptional Community Benefits (GL2) are evident in its focus on vulnerable groups, equitable benefit-sharing and cultural preservation. Located within the Sabie-Sand River Catchment, which includes protected areas such as Kruger National Park, the project supports its case for Exceptional Biodiversity Benefits (GL3) by improving habitat connectivity and quality. This contributes to the conservation of endangered species such as African Wild Dogs (*Lycaon pictus*), White-backed Vultures (*Gyps africanus*), Black Rhinos (*Diceros bicornis*) and Southern Ground-hornbills (*Bucorvus leadbeateri*). To fully secure GL3 status, the project should demonstrate alignment with Key Biodiversity Area (KBA) criteria and provide measurable benefits to these select species.

12. Preliminary monitoring plan

The preliminary monitoring plan outlined in this section provides a framework for assessing and quantifying the impacts of the project activities. This plan is designed to align with the

²²⁴ Cilliers SS, *et al.* 2013. Patterns of exotic plant invasions in fragmented urban and rural grasslands across continents. *Landscape Ecology*, 28(9):1675–1687.

²²⁵ O'Connor TG and Kuyler P. 2009. Impact of land use on the biodiversity integrity of the moist sub-biome of the grassland biome, South Africa. *Journal of Environmental Management*, 90(1):384–395.



VM0047 Methodology for Afforestation, Reforestation and Revegetation (ARR) to monitoring carbon sequestration, enable adaptive management of project activities and support the project's potential certification under the Climate, Community and Biodiversity (CCB) standards. While a detailed monitoring plan is not required at feasibility stage, this section provides an overview of the requirements and necessary considerations.

A monitoring plan should detail procedures for collecting and reporting all data and parameters including: i) specifications of the quantification approach; ii) description of monitoring tasks and technical requirements; iii) definition of accounting boundaries; iv) parameters to be measured; v) data collection techniques; vi) monitoring frequency; and vii) quality assurance and quality control (QAQC) procedures. The CCB Standard requires monitoring of climate, community and biodiversity impacts, with a focus on high conservation values. A monitoring plan should include indicators linked to the project's objectives and predicted outcomes, assess differentiated impacts on community groups and evaluate the effectiveness of interventions to maintain or enhance high conservation values. Both VM0047 and CCB emphasise the importance of stakeholder engagement, requiring that monitoring results be made publicly available and communicated to communities and other stakeholders by using appropriate means.

12.1. Monitoring purpose and objectives

The purpose of monitoring is to systematically evaluate the project's environmental and socio-economic impacts, ensuring that the activities achieve their intended outcomes while identifying and mitigating any potential adverse effects. Monitoring objectives for this project include:

- monitoring carbon stock changes in the applicable carbon pools such as aboveground biomass (AGB), belowground biomass (BGB), soil organic carbon (SOC), litter and dead wood;
- monitoring potential emissions from biomass burning and fertiliser use if relevant;
- assessing the impacts of the project activities on biodiversity;
- assessing the socio-economic impacts of the project activities on local communities; and
- assessing the effectiveness of the project activities including, *inter alia*, stakeholder engagements, benefits-sharing mechanism and potential negative impacts.

12.2. Overview of monitoring approach, scope and boundaries

VM0047 provides two distinct quantification approaches for monitoring carbon removals in ARR projects: i) area-based; and ii) and census-based. These approaches are designed to accommodate different project scales and types. The choice between these approaches depends on the project's scale, design and specific circumstances. Projects may use a combination of both approaches in different, non-overlapping areas within the same project. A dual monitoring strategy will be used, with both approaches to effectively capture carbon removals across different intervention types.

- **Area-based:** This approach is applied to targeted reforestation activities in forests and rangelands — particularly woodlands. Main features include: i) plot-based sampling in representative areas; ii) monitoring of multiple carbon pools; iii) use of a dynamic performance benchmark for additionality and baseline determination; and iv) inclusion of both direct planting and natural regeneration.
- **Census-based:** This approach is applied to agroforestry interventions in croplands, rural residences, and savanna and grassland areas within rangelands. Main features include: i) complete enumeration of all planting units — trees planted such as marula; ii) a focus on direct planting activities; iii) individual tree monitoring with unique identifiers and GPS locations; iv) primary focus on AGB and BGB carbon pools; and v) simplified calculations with baseline and leakage potentially set to zero.



This combined approach allows the project to tailor its monitoring strategy to the specific characteristics of each intervention. The area-based method will capture the broader ecological changes in forested and woodland areas, while the census-based approach will provide precise data on the growth and survival of individual planting units in agricultural, residential, savanna and grassland settings. Beyond carbon sequestration, the project's scope includes biodiversity conservation and community development, aligning with the CCB Standards. This involves monitoring impacts on local flora and fauna and assessing socio-economic effects on communities within and around the project area.

12.3. Monitoring tasks, parameters and data collection

Monitoring tasks are tailored to the area- or census-based approach and intended project activity. The area-based approach includes AGB, BGB, SOC, litter and dead wood as carbon pools and requires using high-resolution satellite imagery and ground-based measurements using sampling plots to monitor stock changes. Monitoring sites will be selected using a stratified random sampling (SRS) approach by dividing the project area into strata based on select factors — for example vegetation type or land use — and randomly select sample plots within each stratum²²⁶. The monitoring tasks will include:

- evaluating total tree height using a clinometer, laser hypsometer or telescoping height pole²²⁷;
- measuring diameter at breast height (DBH) using diameter tape or calliper for measuring tree diameter 1.3 m above ground level²²⁸;
- assessing survival rates by counting surviving trees in permanent sample plots over time²²⁹;
- quantifying regeneration rates by counting seedlings and saplings in fixed-area subplots within main sample plots and tracking changes over time²³⁰;
- estimating understory vegetation using quadrat sampling to estimate biomass of understory plants within sample plots²³¹;
- determining dead wood by using line intersect sampling for fallen dead wood and fixed-area plots for standing dead trees²³²;
- assessing litter by collecting samples of all litter within small fixed-area frames, drying and weighing²³³; and
- conducting soil sampling using soil cores or pits to collect samples at standardised depths, analysing for bulk density and carbon content²³⁴.

Noteworthy for the area-based approach is the necessity of a baseline estimation and re-evaluation — to occur every verification. Assessing the amount of nitrogen fertiliser applied and if fires occurred and the amount of burnt biomass is necessary for determining project emissions. This is also required for the census-based approach, however, only AGB and BGB

²²⁶ Cochran WG. (1977). *Sampling Techniques*, 3rd Edition. John Wiley & Sons.

²²⁷ Total Height: Use a clinometer, laser hypsometer or telescoping height pole to measure tree height from base to top. Source: Avery TE and Burkhart HE. 2015. *Forest Measurements*, 5th Edition. Waveland Press.

²²⁸ IPCC. 2003. *Good Practice Guidance for Land Use, Land-Use Change and Forestry*.

²²⁹ Sheil D, *et al.* 1995. The Interpretation and Misinterpretation of Mortality Rate Measures. *Journal of Ecology*, 83(2):331–333.

²³⁰ FAO (2015). *Global Forest Resources Assessment 2015: Desk Reference*.

²³¹ Mueller-Dombois D and Ellenberg H. 1974. *Aims and Methods of Vegetation Ecology*. John Wiley & Sons.

²³² Harmon ME and Sexton J. 1996. *Guidelines for Measurements of Woody Detritus in Forest Ecosystems*. US LTER Network Office.

²³³ Wieder RK and Lang GE. 1982. A Critique of the Analytical Methods Used in Examining Decomposition Data Obtained from Litter Bags. *Ecology*, 63(6):1636–1642

²³⁴ Intergovernmental Panel on Climate Change (IPCC). 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry and Other Land Use, Chapter 3: Consistent Representation of Lands. Prepared by the National Greenhouse Gas Inventories Programme, Eggleston HS, Buendia L, Miwa K, Ngara T and Tanabe K. (eds). Published: IGES, Japan.



carbon pools are included. In this case, monitoring will involve annual direct measurements of planting unit numbers, height and DBH along with annual survival rates, using similar techniques as discussed for the area-based approach. The monitoring tasks for each project activity are described below.

- **Agroforestry in croplands:** Monitoring will use the census-based approach described above with the project participants and project team conducting these measurements. The benefits-sharing mechanism will pay project participants to aid and monitor tree growth of each project tree on the land they have rights to — forming a citizen science initiative that makes use of technology for collecting, storing and sharing data. Monitoring by the project team will be random and used as verification. While not directly part of the carbon accounting, the project will also monitor, *inter alia*, crop yields, soil erosion rates, siltation, river flow and water quality to assess the overall climate impact of the agroforestry practices. Crop yields are measured by harvest sampling in representative plots or surveys. Soil erosion rates are assessed using erosion pins or sediment traps. Siltation is monitored with sediment load measurements in water bodies. River flow is gauged using flow meters or weirs at select points. Water quality parameters such as turbidity, pH, and nutrient amounts are analysed using portable water quality test kits or by using laboratory analysis of collected samples. These techniques would provide an assessment of the agroforestry practices' broader environmental impacts.
- **Agroforestry in rural residential areas:** Monitoring will be similar to the method used for agroforestry in croplands but include assessments on the impact of homestead activities and tree care practices on tree growth and health, fruit yields and income generation. These will be undertaken as surveys and will help evaluate the overall impact of the agroforestry practices in rural residential contexts.
- **Rangelands monitoring:** The project will employ different monitoring approaches for woodland, savanna and grassland areas within the rangelands. For woodlands, the area-based monitoring approach will be used while the census-based approach will be used in savanna and grassland. Depending on land tenure within the woodlands, savanna and grasslands, either the project team or project participants will conduct the monitoring tasks. For each of the areas — while not directly part of the carbon accounting — the project will also conduct additional monitoring activities. These will include evaluating changes in overall vegetation cover, monitoring grazing patterns and assessing soil erosion rates and siltation. Vegetation cover changes will be assessed using Normalized Difference Vegetation Index (NDVI) analysis of satellite imagery or ground-based quadrat- or line-intercept surveys. Grazing patterns will be monitored by using GPS collars on select animals, visual observations and vegetation-use assessments in sample plots. Soil erosion rates will be quantified using erosion pins, sediment traps or photogrammetric measurements of soil surface changes. Siltation will be evaluated by measuring sediment accumulation and water turbidity in water bodies. These additional assessments will help evaluate the overall impact of the project activities on the rangeland ecosystem.
- **Forest monitoring.** If reforestation activities are implemented, monitoring will follow the area-based approach. The project team will conduct regular inventories to track changes in forest structure and carbon stocks.

The project will implement a biodiversity monitoring programme across all land use types. This programme will include annual species surveys focusing on main indicator species identified in consultation with local ecologists. Camera traps will be strategically placed to monitor wildlife presence and behaviour. Vegetation transects will be established to track changes in plant diversity and structure. These efforts will provide valuable insights into the project's impact on local ecosystems and biodiversity.

Regular community surveys and stakeholder interviews will be undertaken to assess the project's socio-economic impacts. These will track changes in household income, employment rates, food security and overall quality of life. Particular attention will be paid to understanding



how the introduction of trees and associated agroforestry practices affect local livelihoods and community well-being.

12.4. Quality assurance and quality control

A robust QAQC system is necessary for ensuring the accuracy and reliability of a monitoring plan. This system should include standardised data collection protocols, regular calibration of both field instruments and laboratory equipment, and ongoing training of field personnel to minimise observer bias and ensure consistent application of methodologies. Data entry processes should involve double-entry verification or automated error-checking systems to detect and correct transcription errors. Regular internal audits of the monitoring process should be undertaken, with periodic external audits to provide independent assessments at defined intervals. Data analysis should incorporate statistical checks for outliers and anomalies, with a procedure for investigating and documenting any unusual findings. A chain of custody for samples and data should be maintained, supported by secure data storage, backup systems and extensive metadata documentation with version control. Additionally, the monitoring plan should include provisions for the periodic review and updating of methodologies to incorporate new technologies or best practices. By implementing these QAQC measures, the project ensures high-quality, defensible data that accurately reflects the project's impacts and supports credible reporting to stakeholders and verification bodies.

12.5. Data archiving

The data archiving procedures are designed to ensure the secure storage, accessibility and long-term preservation of all relevant data, including QAQC records. Under these protocols, all data collected during the monitoring process — such as sample records, sample locations, and corresponding results — will be systematically archived in electronic format. This process ensures that all information remains accessible for at least two years after the conclusion of the final project crediting period. Data will be securely stored on a dedicated, backed-up drive, with redundancy measures in place to prevent data loss and ensure reliable access for stakeholders.

Transparency is prioritised by granting stakeholders appropriate access to archived data, with security measures in place to protect sensitive information. This approach enhances accountability and supports ongoing evaluation and analysis, thereby improving the overall effectiveness and integrity of the monitoring process. Additionally, provisions are made for potential updates to electronic file formats, ensuring the continued compatibility, version control and usability of archived data over time.

12.6. Roles and responsibilities

The roles, responsibilities and capacities of the monitoring team and management are delineated as follows, ensuring the effective implementation and management of the monitoring plan.

- **Project Manager:** Sand Catchment (Pty) Ltd. (SC), acting as the project manager, is responsible for overseeing the entire monitoring process. This includes conducting baseline assessment to establish initial carbon stock, managing sampling processes and coordinating retrospective analyses to assess long-term trends in carbon dynamics. They ensure that all activities are aligned with project objectives, adhere to established protocols and are executed in a timely manner. The Project Manager also facilitates coordination between several stakeholders, ensuring seamless communication and efficient project execution.
- **Monitoring Coordinator:** The monitoring coordinator within SC manages the day-to-day monitoring activities. This includes overseeing the actual sampling process, adhering to the protocols and guidelines. The coordinator ensures that all fieldwork is undertaken



accurately and consistently, and that data collection aligns with the QAQC procedures. Additionally, they support field technicians by providing guidance and addressing any challenges that arise during the monitoring activities.

- **Technical Trainer:** C4 EcoSolutions (Pty) Ltd. (C4) provides technical expertise in sampling methodologies. Their role includes conducting training workshops for field technicians to ensure proper sampling techniques are applied. C4 collaborates closely with SC to ensure that all sampling activities are carried out efficiently and accurately, according to the established protocols.
- **Field Technicians:** Field technicians, under the guidance of SC, are responsible for executing the data collection activities. They apply the sampling techniques taught by C4 and follow the established protocols to collect accurate and reliable data. Their duties include recording observations, collecting samples and ensuring data integrity by adhering to QAQC procedures. Field technicians also report any fieldwork challenges to the monitoring coordinator.
- **Data Manager:** The data manager at SC is tasked with managing and archiving all data generated during the monitoring process. This includes overseeing data entry, implementing error-checking procedures and ensuring secure storage of data. They are responsible for maintaining data backups, version control and documentation of metadata to ensure data traceability and long-term accessibility.
- **QAQC Officer:** The QAQC Officer within SC ensures that all monitoring activities comply with quality assurance and control protocols. They conduct regular audits, review data for accuracy and identify potential sources of error or bias. The QAQC Officer plays a crucial role in maintaining the credibility of the data and providing feedback to improve the monitoring process.
- **External Auditor:** An external auditor provides independent verification of the monitoring plan's implementation. They conduct periodic audits to confirm compliance with required standards and methodologies. The external auditor assesses the data's integrity and the effectiveness of QAQC measures, offering an objective evaluation that supports credible reporting to stakeholders and verification bodies.
- **Stakeholder Liaison:** The stakeholder liaison, also part of SC, manages communication and engagement with stakeholders. They ensure transparency by providing regular updates on monitoring activities, addressing stakeholder concerns and facilitating access to monitoring data. The liaison also gathers stakeholder feedback to inform future adjustments to the monitoring plan.

13. Conclusion

This Feasibility Study for the Afforestation, Reforestation and Revegetation (ARR) project in the Sabie-Sand River Catchment demonstrates potential for addressing environmental degradation, increasing carbon sequestration and improving community livelihoods. The project's strategic approach — combining agroforestry practices, targeted reforestation and community development initiatives — aligns with both local requirements and global climate change mitigation goals.

The main findings are described below.

- **Carbon sequestration potential:** The project shows carbon sequestration capacity across different land use types, with initial estimates indicating potential for generating Verified Carbon Units (VCUs).
- **Non-carbon climate benefits:** The project is expected to deliver environmental improvements beyond carbon sequestration. These include, *inter alia*, reduced soil erosion, decreased siltation of water bodies, improved soil health and water retention. Such benefits contribute to increased land productivity capacity and climate resilience for both ecosystems and local communities.



- **Biodiversity conservation:** Being located within a biodiversity hotspot and its focus on indigenous species, the project provides opportunities for improving the resilience of local ecosystems and supporting endangered species.
- **Community benefits:** The integrated approach to community development including education, training and alternative livelihood creation, offers potential for long-term socio-economic improvements in the region.
- **Climate, Community and Biodiversity (CCB) Standard certification potential:** The project demonstrates eligibility for CCB certification — with possible qualification for Gold Level status — in climate change adaptation, community involvement and biodiversity conservation.
- **Implementation challenges:** The study identifies several challenges, including, *inter alia*, complex land tenure systems, potential resource conflicts and the need for sustained community engagement, which will require careful management and mitigation strategies.
- **Monitoring and Verification:** The proposed monitoring plan provides a robust framework for tracking project outcomes and ensuring accountability.

While the project shows promise, its success will depend on effective stakeholder engagement, adaptive management and the capacity to navigate the complex socio-economic and environmental landscape of the Sabie-Sand River Catchment. The phased implementation approach, starting with pilot projects, offers a prudent strategy for refining methodologies and building community support.

Recommended next steps include:

- detailed stakeholder mapping and engagement plan;
- refinement of carbon sequestration estimates based on pilot project data;
- development of a comprehensive risk mitigation strategy;
- elaboration of long-term funding and benefit-sharing mechanisms; and
- establishment of partnerships with local and national institutions for project support.

In conclusion, the ARR project in the Sabie-Sand River Catchment presents a viable and potentially impactful intervention for addressing climate change, biodiversity loss and community development challenges. With careful planning, sustained engagement and adaptive management, the project has the potential to serve as a model for integrated landscape restoration and sustainable development in similar contexts globally.

14. Appendices

14.1. Appendix 1: Summary of the risk assessment methodology

The non-permanence risk tool calculates a risk rating to determine the number of buffer carbon credits per project — a requirement for all agriculture, forestry and other land use (AFOLU) projects. This risk rating is based on three primary categories: internal, external and natural risks. Each primary category contains several secondary categories, which, when summarised, constitute the risk rating. Mitigation methods should be used to help offset considerable risk scores. Below, we summarise the main factors in the secondary categories that contribute to a low-risk rating. We also indicate the potential risk score per factor in brackets. In instances where the risk is not applicable, it is assigned a score of 0.

Internal risks

Internal risks refer to factors related to project management, financial viability, opportunity cost and project longevity. These are listed below with risk rating provided in brackets.



Project management

If the project does not have an adaptive management plan in place that includes a monitoring plan (the project fails).

- By planting species that are not native or ill adapted to the area (2).
- When ongoing enforcement is required to prevent encroachment by outside actors (2).
- When the management team are not present in the country (2).
- When the management team have experience with project design and implementation, carbon accounting and reporting (-2).
- When there is an experienced management team under VCS and approved GHG programs (-2).
- By having a comprehensive training plan for all participating farmers (-2).

Financial viability

If the payback period is greater than 20 years from the current risk assessment (the project fails).

- The time to reach a cash flow break-even point 10 years > 20 years (3).
- The percentage funding secured to cover the cash-out before the break-even point (3).
- If the project has access to at least 80% of the cash required (-2).

Opportunity cost

- The Net Present Value (NPV) analysis indicates that alternative land-use activities are up to 100% more profitable compared to the current project activities (8).
- The net positive community impacts of project activities are not demonstrated (8).
- The project is protected by a legally binding commitment to continue management practices for at least 100-years (-4).
- The project has additional financial support to overcome expected revenue loss (-2)

Project longevity

If the project has no management, financial and monitoring plan for the entire project longevity or a project longevity of less than 40 years (the project fails).

- Any project with a legally binding agreement that covers at least a 100-year period from the project start date will be assigned a score of zero.

External risks

Land tenure and resource access or impact, community engagement and politics influence external risks. These are listed below with risk rating provided in brackets.

Land tenure and resource accessibility

- Ownership and resource access/use rights held by different entities (2),
- Government has previously expropriated substantial areas of land (for example, 10% or more) in the project area in the past 20 years (10),
- Disputes over land tenure or ownership in more than 5% of the project area (10),
- Disputes over land access or usage rights (5).
- Protection by a legally binding commitment to continue management practices that protect carbon stocks over the length of the project crediting period (-2).

Stakeholder engagement

- Less than 50% of households living within the project area, who are reliant on resources derived from the project area, have been consulted (10).
- Less than 20% of households living within 20 km of the project boundary outside the project area and who are reliant on the project area, have been consulted (5).



Political risk

- The governance score, averaged over the six World Bank Institute's Worldwide Governance Indicators for the most recent five years, is less than -0.79 (6).
- The country is: 1) party to the Paris Agreement and has submitted an NDC to the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat in the last five years; 2) includes AFOLU commitments (conditional or unconditional) in its NDC; and 3) has a documented and active climate change plan that includes the project activity (-2).

Natural risks

Natural risks are calculated based on: i) the frequency of an event; ii) the significance of the damage caused by the event; and iii) whether potential mitigation protocols are in place. Risks range from 1% to 30% depending on the combination of these factors. Implementing preventative measures and a proven history of containing natural risks will reduce the risk score by up to 50%. Natural risk categories include fire, pest and disease outbreaks, extreme weather, geological hazards and other natural disasters and risks, future climate impact and sea level rise risks.

Natural risks

- A natural risk that occurs more than once every ten years and causes 70% or more damage to the project area will result in project failure.
- If the likelihood of an event occurring is only once every 100 years or less frequently or not applicable to project area, it is considered to pose no risk.
- Where an event occurs more than once every 10 years:
 - carbon stock losses of 70% and greater will fail;
 - carbon stock losses of 50–69% will have a risk score of (30);
 - carbon stock losses of 25–49% will have a risk score of (20);
 - carbon stock losses of less than 5–24% will have a risk score of (5); and
 - full recovery of carbon stock expected within 10 years of any event (4).

Mitigation score:

- prevention measures applicable to the risk factor are implemented (0.50);
- demonstrated history of effectively containing natural risk (0.50);
- both of the above (0.25); and
- none of the above (1).

Projected future climate change impact on natural risk:

- natural risk associated with climate change impact (NR-c) (1 – 1.4); and
- natural risk not associated with climate change impact (NR-nc) (1).