MJUMITA COMMUNITY FOREST PROJECT (LINDI)

PROJECT DESCRIPTION

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Prepared By	MJUMITA (Tanzania Community Forest Network) and TFCG (Tanzania Forest Conservation Group)
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The project has been designed by the citizens of the ten participating villages: Kinyope, Kiwawa, Likwaya, Makumba, Milola Magharibi, Mkanga 1, Mkombamosi, Muungano, Nandambi and Ruhoma. The Village Councils, Village Natural Resources Committees, Village Land Use management committees, REDD special committees, MJUMITA local networks, elders and ordinary citizens have invested their time, hard work and knowledge in designing this project.

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The design has been made possible through a partnership between the Tanzania Forest Conservation Group and the Mtandao wa Jamii wa Usimamizi wa Misitu wa Tanzania in collaboration with the Institute of Resource Assessment, the Regional Community Forestry Training Centre for South-East Asia, CARE International in Tanzania, the Clinton Climate Initiative, the Valuing the Arc project of WWF and Sokoine University of Agriculture.

The design of the 'MJUMITA Community Forest Project (Lindi)' was facilitated by the Making REDD Work project team:

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With the support of Lindi District Council and Lindi Municipal Council:

Name	Department	Title
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The Project Document was written by Theron Morgan-Brown, MJUMITA Technical Advisor.

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Ronnakon Triraganon, Regional Community Forestry Training Centre

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Additional technical input has been provided by:

Kate Forrester-Kibuga on the stakeholder analysis;

Tuyeni Mwampamba and Forest Trends on the Social Impact Assessment and theory of change development;

Forest Trends and CARE International on the carbon enterprise design;

Roy Gereau and Moses Mwangoka on the botanical values of the project area;

The following VNRC members for their assistance with the botanical surveys:

Name	Title
Mohamed Makunda	Ruhoma Village Natural Resource Committee member

Said Liochocho	Kiwawa Village Natural Resource Committee member
Ismail Mmonyomonyo	Kiwawa Village Natural Resource Committee member
Fadhili J Mtambule	Kiwawa Village Natural Resource Committee member
Said Issa Mawala	Mkanga Village Natural Resource Committee member
Bakari A.Lyiumu	Mkanga Village Natural Resource Committee member
Said Likwena	Mkomba Village Natural Resource Committee member
Mohamed Mandutta	Mkombamosi Village Natural Resource Committee member
Rajabu Mohamed Mtopella	Muungano Village Natural Resource Committee member
Said Mussa Ngapaliji	Muungano Village Natural Resource Committee member
Bakari Mfaume Nangonji	Ruhoma Village Natural Resource Committee member

Andrew Perkin and Katarzyna Nowak on the vertebrate fauna of the project area; and

Elia Mulungu on the birds of the project area.

The National REDD Task Force have provided valuable oversight to the project development process.

ACRONYMS

AFOLU Agriculture, Forestry and Other Land Use

AUDD Avoided Unplanned Deforestation and Degradation

CCB Climate, Community, and Biodiversity Standardard

GHG Greenhouse Gas

lat/lon Latitude and Longitude

MCFPL MJUMITA Community Forest Project (Lindi)

MJUMITA Mtandao Wa Jamii Usimamizi Misitu Tanzania (Tanzania Community Forest Network)

NGO Non-Governmental Organization

PD Project Description

PDD Project Design Document

REDD Reducing Emissions from Deforestation and Forest Degradation

tCO2e Metric ton of carbon dioxide equivalent

TFCG Tanzania Forest Conservation Group

VCS Verified Carbon Standard

VM Verified Methodology

VNRC Village Natural Resource Committee

WGS World Geodetic System

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1.1 Summary Description of the Project

This project seeks to reduce green house gas emissions caused by unplanned deforestation on 41,924 ha of communal village land, while simultaneously promoting rural economic development and biodiversity conservation in Lindi Rural District in Tanzania. Deforestation in villages in Lindi District is primarily the result of the expansion of small-holder cultivation of cash and subsistence crops, with unsustainable charcoal harvesting also contributing to deforestation in some areas. Prior to the project start, forest areas within the project area were open access without secure tenure for individuals or communities. Communal forest land could be converted to customary household ownership through clearing and cultivation. The annual gross deforestation rate in the region encompassing the project area was 1.99% from 2001 to 2012.

The primary project activities included land-use planning and establishing village forest reserves, which gives village governments secure tenure and regulatory authority over the forests within their boundaries. Communities have put 67% of their remaining forest areas under protection, including 75% of forest with higher carbon stocks. Additionally, the project has promoted new agricultural practices which will help them avoid pests, maintain fertility and increase their crop yields, and thereby reduce the need to clear more forests for agriculture. The project has also supported community members to develop new forest friendly livelihoods like bee-keeping, and improved credit accessibility for community members looking to establish small businesses. Finally, village earnings from the sale of verified GHG emissions reductions and royalties charged for sustainable forest use, will help to offset the opportunity costs of REDD. The project has helped villages develop an innovative benefit sharing mechanism that pays dividends to every village member and allows community members to contribute to and plan for their own village development projects such as schools, clinics, wells, etc.

The project is located in Lindi District, Lindi Region approximately 30 km inland from the Indian Ocean in south-eastern Tanzana. The project area initially includes 10 villages: Kinyope, Kiwawa, Likwaya, Makumba, Milola Magharibi, Mkanga 1, Mkombamosi, Muungano, Nandambi and Ruhoma. The project area may be expanded to include other villages adjacent to the participating villages if startup funding becomes available.

The project area lies within the Eastern African Coastal Forest biodiversity hotspot and was one of the last unprotected fragments of coastal forest in Tanzania prior to the project start. This mosaic of forest, woodland and thicket is considered of exceptional importance due to the high concentrations of endemic species. The project area is home to one critically endangered primate, the Rondo Dwarf Galago and at least three plants categorized as endangered on the IUCN Redlist. Within the project area, 12 East African Coastal Forest endemic plant species have also been recorded (Doggart et al. 2013a).

The project is anticipated to reduce net GHG emissions from the initial 10 project villages by an average of about 45,000 tons of CO2 per year or by 1,350,000 tons of CO2 during the 30 year project crediting period. If startup funding becomes available, the project may also expand to include more villages within Lindi district.

1.2 Sectoral Scope and Project Type

The project's sectoral scope is Agriculture, Forestry and Other Land Use (AFOLU) and its project category is Reduced Emissions form Deforestation and Degradation (REDD). The primary project activity is avoiding unplanned deforestation and degradation (AUDD).

The project is a grouped project with each participating village being a project instance and each village government being a project proponent. New villages within the same reference region may be added in the future as project instances and proponents as per the requirements for grouped projects in the VCS standard and AFOLU requirements.

1.3 Project Proponent

As all of the project area is on communally owned village land, the project proponents are the participating project village councils who have overall control over the project area and responsibility for implementing the project's core activities (see section 12 of project details for more information). However, all of the project proponents have signed an MoU with MJUMITA empowering MJUMITA to undertake a variety of activities on their behalf (see next section).

No.	Name of Village	Name of Chairperson	Name of Village Executive Officer	Village Postal Address	Phone Numbers*	
					Chairperson	Village Executive Officer
1	Muungano	Juma M. Njangari	Rashid S. Rashid	P. O. Box 328 Lindi, Tanzania	0682 400547	0682593698
2	Mkombamosi	Rashid Mwishaweji	Chande A. Khalifa	P. O. Box 328 Lindi, Tanzania	-	0787370207
3	Makumba	Yusuph S. Pangani	Rashid B. Mpwili	P. O. Box 328 Lindi, Tanzania	-	0685296221
4	Likwaya	Mwalim K. Tanga	Hereswida Mathew	P. O. Box 328 Lindi, Tanzania	0783 270129	0782592267
5	Mkanga 1	Athumani Kimete	Anzigar Lilai	P. O. Box 328 Lindi, Tanzania	0689 618090	0787311753
6	Nandambi	Rashid S. Kibaba	Selemani Kitenge	P. O. Box 328 Lindi, Tanzania	0789 872884	0786048736
7	Kinyope	Musa Athumani Pilanga	Hamis A. Mwinyimmad	P. O. Box 328 Lindi, Tanzania	0689 306008	0782591072
8	Ruhoma	Said H. Katambi	Curben A. Chitanda	P. O. Box 328 Lindi, Tanzania	-	0686167333
9	Milola Margharibi	Issa Abdallah Pilipili	Hamis J. Mzee	P. O. Box 328 Lindi, Tanzania	0788 951190	0688347913
10	Kiwawa	Said M Manyanya	Ally M. Akalola	P. O. Box 328 Lindi, Tanzania	0684 977834 neighbor	0787753990

* Dialling instructions: Outside of Tanzania - replace the zero at the beginning of the number with +255. Inside Tanzania – dial as written.

At community level, the project is aligned with the Local Government (District Authorities) Act (1982). The governance structures and roles and responsibilities of the Village, Ward and District authorities are defined by this Act and are summarised below in terms of how they relate to the project. While the village councils are listed as the project proponents due to their executive powers, there are many other institutional bodies within the village that have responsibilities within the REDD project.

The ***Village Assembly*** is the supreme authority on all matters of general policy-making in relation to the affairs of the village. A village assembly comprises all women and men ordinarily resident in the village and who has attained the apparent age of eighteen years. Meetings of the village assembly are supposed to be held at least every three months. In the context of the project, the village assembly have the power to accept or refuse the REDD project. The Village Assembly is also responsible for reviewing village by-laws including those pertaining to the village forest reserve, village land use plan and REDD revenue distribution. Although not required by law, the project has required the approval of the village assembly for the Village Forest Reserve, Village land use management and REDD by-laws. The village assembly elect and hold accountable the village council.

The ***Village Council*** is the organ in which is vested all executive power in respect of all the affairs and business of a village. This specifically includes power to 'plan and co-ordinate the activities of and render assistance and advice to the residents of the village engaged in .... forestry or other activity or industry of any kind'. Village councils are elected by the village assembly. Elections are held every three years. It is customary, although not stated in law, that the committee includes at least one representative from each sub-village. Where a village council proposes to make by-laws, they are required to convene a meeting of the village assembly to review the by-laws. The Village Council is then responsible for making amendments based on comments from the Village assembly; and to submit to the District Council. The Village Council is then responsible for enforcing the by-laws. In the context of the project, the Village Councils therefore play a key role in enforcing the village land use plan and by-laws; the village forest reserve management plan and by-laws; and the REDD by-laws. According to the MoUs with MJUMITA, the Village Councils are responsible for the implementation of the strategies intended to reduce emissions. The Village Councils also have the power to establish village committees and to delegate some of their power and responsibilities to those committees. In each of the project villages, the Village Councils have established three committees:

Village Natural Resources Committees: responsible for the management of all forests on village land including those inside the village forest reserves, implementing deforestation and carbon monitoring activities; and reporting to the village assembly on land use issues;

Village Land Use Management Committees: responsible for the implementation of the village land use plans and by-laws, and reporting to the village assembly on land use issues;

Village REDD Committees: responsible for maintaining a register of eligible recipients of REDD payments subject to public review; overseeing the REDD payment mechanism including facilitating a participatory decision making process on the use of the REDD payments; and reporting to the village assembly on issues related to the REDD payments.

1.4 Other Entities Involved in the Project

Organization name	Mtandao wa Jamii Usimamizi Misitu Tanzania (MJUMITA) or The Tanzania Community Forest Network
Role in the project	Authorized representative for the project proponents, providing technical assistance to proponents regarding REDD activities, facilitating project validation and verification, and marketing VCUs.
Contact person	Rahima Njaidi
Title	Director
Address	Plot No. 323 Msasani Village, Old Bagamoyo Road P.O. Box 21522 Dar es Salaam, Tanzania
Telephone	+255 22 2669007
Email	mjumitaorg@mjumita.org

Organization name	Tanzania Forest Conservation Group
Role in the project	Providing technical assistance to proponents regarding REDD activities, social and biodiversity monitoring.
Contact person	Charles Meshack
Title	Executive Director
Address	Plot 323, Msasani Village, Old Bagamoyo Road PO Box 23410 Dar es Salaam, Tanzania
Telephone	+255 22 2669007
Email	tfcg@tfcg.or.tz

Mtandao wa Jamii Usimamizi wa Msitu Tanzania (MJUMITA or Tanzania Community Forest Network) in partnership with the Tanzania Forest Conservation Group (TFCG) and with financial support from the Royal Norwegian Embassy of Tanzania, provided technical expertise to the project proponents since the beginning of the project. MJUMITA and TFCG have helped participating villages establish land-use plans, village forest reserves, and implement strategies for reducing emissions from deforestation and degradation.

The ten participating villages have signed MoUs with MJUMITA, witnessed by the District Government, which empower MJUMITA to provide the proponent villages with the following services to facilitate access to the voluntary carbon market:

a) Remote monitoring of forest cover and carbon stocks

b) Coordinating ground monitoring of carbon stocks by participating villages

c) Identifying and contracting a VCS and CCBA approved project validator

d) Identifying and contracting VCS and CCBA approved project verifiers as needed

e) Preparing and submitting the project design document for validation

f) Preparing and submitting project monitoring reports for verification

g) Marketing and selling verified emissions reductions to buyers in the voluntary carbon market

h) Receiving payment from buyers in the voluntary carbon market on behalf of the village and other proponent villages

i) Retiring sold emissions reductions according to the VCS and CCBA requirements

j) Forwarding revenue from the sale of verified emissions reductions to the village subject to the stipulations specified in this agreement.

k) To avail information about carbon credit emissions and fulfil any other requirements by VCS and CCBA registries.

l) Provide capacity building to communities on any matter emerging related to REDD+, good governance, and carbon trading for improvement of their performance.

m) Facilitate village government to have operational plans in the format required by the project and any other need that may arise.

n) To facilitate participatory social and ecological assessment and monitoring and submit the results to any different stakeholders as the need may be.

o) To facilitate the Community Carbon Enterprise on any other technical requirement needed to meet conditions for REDD+.

Signed copies of each villages MoU have been provided to the Auditors.

The participating villages will collectively retain rights to the GHG reductions achieved by the project, but MJUMITA will be entitled to compensation from the project proponents to cover the costs of implementing its responsibilities. MJUMITA is responsible for dividing up the benefits derived from the sale of GHG reductions between the project proponents based on the agreed system of tracking each project proponents relative contribution to the overall GHG reductions achieved by the project.

The system for dividing GHG reductions between the proponent villages is based on the stock-flow REDD mechanism[1] proposed by the Woods Hole Research Center (WHRC) and Amazon Institute for Environmental Research (IPAM) to the UNFCCC, which places weight on both reductions in emissions compared to baseline emissions and forest carbon stock conservation. Under the system used by the project, 70% of the GHG emissions reductions generated by the project are divided between villages based on each villages performance relative to their individual portion of the project baseline emissions. The remaining 30% is divided amongst villages based on the relative proportion of total carbon stocks in the project area falling within each village. However, if any village exceeds their baseline emissions then the excess emissions above the baseline are subtracted from their portion of the carbon stock based credits and redistributed as carbon stock payments to actors who did not exceed their baselines. The intent of the system is to provide villages with lower than average baselines and a significant portion of the project areas carbon stocks an increased incentive to participate in REDD activities which may be necessary to prevent leakage from villages with higher historical baselines.

1 http://www.whrc.org/policy/pdf/cop14/Stock_Flow_Mechanism.pdf

In interactions with MJUMITA, communities will be represented by their village chairperson and two other representative chosen in village assembly meetings, of whom one will be a woman. These three representatives from each village will form the core of the P*roject Executive Committee* in charge of overseeing the implementation of the MOU between MJUMITA and the participating villages. The village members of the committee will review, change, and approve budgets proposed by MJUMITA to cover costs associated with MRV and marketing. The committee will also review the monitoring reports compiled by MJUMITA and the village level performance reports and portions of REDD revenue awarded to each village. In the event that a significant amount of leakage is detected outside of the project area, as per the MOU, the committee will identify the responsible village so that the leakage can be included in estimates of their performance. The village representatives on the executive committee will also be responsible for presenting this information to their village assemblies.

The executive committee will also include members with an advisory role, including representatives from the districts chosen by the district executive director, the executive director from TFCG, a representative from the Forestry and Nature Conservation department of Sokoine University of Agriculture, and a representative from the Vice President's Office dealing with national level REDD issues. To enable the committee to be able to make informed decisions, all of the executive committee members will receive training on REDD MRV, including basics of remote sensing and GIS that will be used by MJUMITA to monitor performance and report to VCS and CCB. The committee will also receive copies of MJUMITA's annual financial audit and carbon sales information to confirm that MJUMITA is accurately reporting income and using it as instructed.

Additional stakeholders

Organization name	Lindi District Council
Role in the project	Providing skilled staff members for land-use and forest management planning, agricultural extension services and overseeing community development projects. Districts must approve all village land-use and forest management plans.
Contact person	Charles Mwaipopo
Title	District Forest Officer
Address	P. O. Box 328 Lindi, Tanzania
Telephone	
Email	charlesmwaipopo@gmail.com

Organization name	Lindi Municipal Council
Role in the project	Providing skilled staff for land-use and forest management planning, agricultural extension services and overseeing community development projects in villages in Lindi Municipality. Districts must approve all village land-use and forest management plans.
Contact person	Apiyo Ezra

Title	Municiple Forest Officer
Address	P. O. Box 328 Lindi, Tanzania
Telephone	+255655482050
Email	ezraapi@yahoo.co.uk

Village Councils report to the Ward Development committees and to the District Council.

The Ward Development Committee is responsible for ensuring the implementation of the decisions and policies of the district council, and of development schemes. The Ward Development Committee reports to the District Council.

The District Council is responsible for the implementation and monitoring of development projects throughout the District; and therefore plays a key role in supporting the villages in the implementation of the project's activities.

The project has worked closely since its beginning with the Lindi District Council. The district provided man power to facilitate the implementation of many key project activities including land-use and village forest reserve planning, and agricultural extension services to promote sustainable agricultural practices. Additionally, the land-use and forest management plans of the participating villages have been reviewed and approved by the Lindi District Council. The district will continue to provide support for ongoing project activities including agricultural extension activities and assistance with enforcing land-use and village forest reserve by-laws when needed. In exchange for these services, the participating villages will pay a cess of 5% of their revenue from REDD to the district council.

1.5 Project Start Date

The project start date is May 28, 2011, which is the date that the first project village (Mkanga 1) passed its forest management plan and supporting by-laws in a village assembly meeting. This represents the start of the implementation of new forest management practices aimed at reducing greenhouse gas emissions in the project area.

1.6 Project Crediting Period

The project crediting period will be for 30 years from April 21st, 2012 to April 20th, 2042. The start of the project crediting period corresponds to the last Landsat imagery used in the baseline deforestation analysis. This imagery was selected because it was the cloud free, wet season Landsat imagery that was temporally closest to the project start date. The methodology used by this project allows for using satellite imagery that was captured within two years of the project start date to establish the forest cover benchmark map for the project area at the start date.

1.7 Project Scale and Estimated GHG Emission Reductions or Removals

The project is expected to generate less than 300,000 tons of CO2 in emissions reductions per year and is thus not considered a large project as per VCS Standard 3.4.

Project Scale	
Project	X
Large project	

The estimated project GHG emission reductions shown in the following table were estimated using the selected methodology. They represent expected reductions after accounting for unavoidable deforestation in the project area and leakage, but not withholding for the risk buffer. Only the emissions reductions for the first fixed baseline period (10 years) are shown. See VM Table 36 in Part 2, Section 9.3 of the methodological annex for details.

Year	Estimated GHG emission reductions or removals (tCO_2e)
2012-2013	33,752
2013-2014	35,462
2014-2015	40,062
2015-2016	45,233
2016-2017	47,948
2017-2018	50,937
2018-2019	52,846
2019-2020	53,594
2020-2021	51,924
2021-2022	50,873
Total estimated ERs	462,631
Total number of crediting years	10
Average annual ERs	46,263

1.8 Description of the Project Activity

The following activities were developed through a consultative process involving meetings in all project villages and at landscape level with a wide range of stakeholders as part of the Social Impact Assessment. The activities reflect the priorities outlined by the communities. The activities were developed using a theory of change approach (Richards and Panfil 2010 a and b). Details of this process are provided in Mwampamba *et al*. 2011 at www.tfcg.org/MakingREDDwork.html. None of the activities are within an area covered by a jurisdictional REDD+ program.

Activity description	Expected outcomes	Relevance to project's objectives
Activity 1. Improve governance at village level. Based on training and awareness raising supported by the project, village councils and their Natural Resources, Land	More effective and equitable implementation of forest management and sustainable land management by-laws and plans thereby resulting in emission reductions; a more permanent basis for maintaining	Ensures that local councils and civil society participate fully in providing the local conditions necessary to achieve REDD objectives. Provides necessary supporting

Activity description	Expected outcomes	Relevance to project's objectives
Use Management and REDD committees will be democratically established and will implement their roles and responsibilities in accordance with good governance principles. They will raise awareness amongst other community members on governance issues. Based on training and awareness raising supported by the project, MJUMITA members will also raise awareness amongst the communities regarding good governance; and will help communities to hold village leaders accountable. Training and awareness raising on good governance was / will be provided by TFCG and MJUMITA between 2010 – 2014 to the villages managing the project area. Village Natural Resources, Land Use Management and REDD Committees were elected where they were absent or incomplete. Local MJUMITA networks have been established as a forum for resolving governance issues between and within communities. TFCG and MJUMITA have also constructed village offices for the ten villages in order to provide a more conducive environment for the implementation of governance functions. Reinforcement training on good governance principles and practices will be	forest cover; and carbon sequestration through natural regeneration. Village council provide a more effective and equitable service to the communities as a result of improved knowledge on their roles and responsibilities and greater accountability. Public services and community-owned infrastructure are managed in a more equitable, effective and efficient way. Improved governance at village level will underpin strategies to adapt to climate change including through improved land and natural resources management and improved conflict resolution. There is equitable and well-governed access to water and natural resources for communities during droughts and other times of climate change-related stress.	conditions for equitable benefit sharing including in relation to more equitable gender-relations and for sustaining free, prior and informed consent. Provides a stronger foundation for the implementation of community based forest management; sustainable land management; and for REDD payments to incentivise practices that reduce emissions. Improved governance brings cross sectoral benefits at village level that will also contribute to more secure tenure; improved public services including in relation to health, education, land tenure and the local economy; more resilience to climate change; and better management of infrastructure intended for community benefit.

Activity description	Expected outcomes	Relevance to project's objectives
provided to Village Council, Village Natural Resources Committee and REDD Committee members by MJUMITA and Lindi District Council prior to each round of REDD payments. Training has been provided to local government staff on conflict resolution. MJUMITA and the Lindi District Council will continue to provide backstopping to the MJUMITA networks and village leaders on governance issues. **Timing:** Training provided by TFCG and MJUMITA 2010 – 2013; improved governance to be practiced throughout project lifespan.		
Activity 2. Implement sustainable land management Each village will prepare a village land use management plan in a participatory way and modelling the integrated approach to land use planning and community based forest management planning that has been practiced by the project. See Luwuge *et al*. 2011a for guidelines on the project's approach. The planning process will be facilitated by the District Participatory Land Use Management team. The plans specify the geographical distribution of land uses for the community and the mechanisms	All villages have developed and are implementing village land use plans which guide the community on the agreed location for different land uses including forests and agricultural land. Communities will benefit because water and other ecological services are maintained as a basis for more sustainable livelihood activities. Land tenure is strengthened and conflicts over land are reduced. More effective, equitable and sustainable management of forest resources will reduce emissions of greenhouse gases and protect high conservation	The boundary mapping process that is integrated into the village land use planning provides an accurate basis for defining the village boundaries. Provides the precondition for delineating areas for participatory forest management and for improving the security of land tenure at community and individual levels. Zonation of village land into different land uses makes clear the agreed locations for agriculture, public services, residential areas, sensitive ecological zones including water sources and forests.

Activity description	Expected outcomes	Relevance to project's objectives
to ensure implementation. The plans are reviewed and approved by the District Council. Through awareness raising amongst the community; training to village leaders; and installation of sign boards in key locations, the plans are widely communicated within the community. The village land use management committee will oversee the implementation of the plans with oversight from the Village Council and accountable to the Village Assembly. Lindi District Council will provide backstopping where resources allow. Additional training will be provided to village natural resources committee on fire prevention activities combined with widespread awareness raising on the causes of fire; the risks of fire; and ways of preventing and tackling fire. For the ten project area villages, each village has prepared a village land use plan and by-laws in a participatory way and in accordance with national guidelines. **Timing:** VLUP training and development between 2010 and 2012; implementation throughout project lifespan.	values. Through training and awareness raising on wildfire prevention, there will be less fire damage to forests even during periods of climate change-related drought.	On the basis of the village land use plans, villages can begin to issue customary rights of occupancy.
Activity 3. Community based forest management.	The effective management of the village forest reserves will significantly reduce	Community based forest management is relevant to all of the climate, community and

Activity description	Expected outcomes	Relevance to project's objectives
Following widespread awareness raising to all community groups, each village will establish village forest reserves. This involves agreeing the location of the village forest reserve; and preparation of a management plan and by-laws following a participatory approach facilitated by the District. The plans and by-laws are presented to the village assembly for approval; and from there they are presented to the District Council for review and approval. Once approved at District level the communities will implement their Village Forest Reserve management plans and by-laws according to the rules that they have agreed amongst themselves and as stipulated in their plans and by-laws. These include some sustainable use. As part of REDD readiness, each village has established a forest reserve and has prepared and approved management plans and by-laws for the Village Forest Reserves. REDD revenues will be used to contribute to, or cover in their entirety, management costs. The Village Natural Resources Committees are responsible for overseeing the implementation of the plans with oversight from the Village Council and accountable to the Village Assembly. Lindi District Council will provide	deforestation in the reserves and therefore will also reduce emissions of greenhouse gases. The management objectives for the reserves include maintaining natural forest cover. By conserving the natural habitat, so the biodiversity and other high conservation values will also be protected. Communities will benefit by having access to sustainably managed forest products, even during times of climate-change induced stress; by avoiding degradation of water sources and soil erosion that would otherwise result from deforestation; and by earning revenues from REDD. By seeking to avoid forest fragmentation by having mostly contiguous village forest reserves, the project aims to reduce the risk of forest damage as a result of high winds associated with climate change.	biodiversity objectives of the project. CBFM will help communities to conserve the ecosystem services that they depend on; and ensure a sustainable supply of forest products.

Activity description	**Expected outcomes**	**Relevance to project's objectives**
backstopping where resources allow. Awareness raising activities will be conducted on wild fires; and training will be provided on preventing wildfires. For the ten project area villages, each village has established a village forest reserves and is implementing its management plan. **Timing:** CBFM training and development between 2010 and 2012; implementation throughout project lifespan.		
Activity 4. Channel REDD payments to communities. As part of the REDD readiness activities, MJUMITA and TFCG have modelled a payment mechanism based around making individual payments to all women, men and children registered as residents of a village. Residents are treated as shareholders in the REDD enterprise and are entitled to dividends in the form of REDD payments. Each village has developed by-laws to govern the REDD payments; have established REDD committees who have been trained on how to implement the payments; and have been through two rounds of payments. The REDD committees will take on responsibility for distributing payments from the sale of the voluntary emission reductions.	The REDD payments will provide an incentive to communities to maintain forest cover; and will cover the direct costs of managing the village forest reserves. As such the payments are critical for ensuring the longer term climate, community and biodiversity benefits. The payments will be paid equally to women, men and children; and to all households regardless of wealth. REDD payments will provide funds for community development projects including improved infrastructure and social services. REDD payments will provide a direct income to individuals.	The payments contribute to the project's climate and biodiversity objectives by providing an incentive for communities to manage their forests sustainably and by covering the costs of forest management. They contribute to the community objectives by providing an income to individuals and / or, depending on the decision of the communities, to pay for community development activities including public services. The payment system is designed to avoid elite capture by making every woman, man and child (collected by their mothers) eligible thereby ensuring that poorer households and women benefit.

Activity description	**Expected outcomes**	**Relevance to project's objectives**
This will involve maintaining a register of residents; liaising with MJUMITA regarding the emission reductions and earnings; and ensuring that the budget allocation process is in line with the village's by-laws. The model allows for communities to decide whether / how much to allocate to individual payments and / or to allocate to community development projects. Village Councils must present detailed plans and budgets to the Village Assembly for any community development projects and the Village Assembly can then vote whether they agree to support the project. The MJUMITA Community Liaison officer will assist with the process and Lindi District Council will provide backstopping where resources allow. **Timing:** throughout project lifespan.		
Activity 5. Improve profitability, ecological sustainability and climate change resilience of agriculture. As part of the REDD readiness activities, the project developed an agricultural strategy (TFCG 2012). On the basis of this strategy, and working closely with the District, TFCG has been training women and men small-scale farmers on conservation agriculture and reducing crop	It is expected that by adopting conservation agriculture, farmers can improve the profitability of their agricultural practices. It is expected that by improving practices, farmers can move away from shifting cultivation and deforestation. . It is expected that REDD payments will enable farmers to invest in improved agriculture and thereby generate more profit; be more ecologically	In terms of relevance to climate and biodiversity objectives, as agriculture is the main deforestation driver in this area, it is critical that communities adopt improved agricultural practices that will allow farmers to improve their livelihoods without bringing forest areas into agriculture. In terms of the relevance to the community objectives, improved agricultural practices aim to increase the profitability of farming practices. By adopting agricultural

Activity description	Expected outcomes	Relevance to project's objectives
losses from crop-raiding animals. The agricultural strategy promotes conservation agriculture techniques that avoid shifting cultivation; and generate more value from less land. The techniques now being practised also enhance soil moisture management, soil nutrient conservation and improved seed selection thereby also contributing to climate change adaptation. The project's agricultural strategy is available at www.tfcg.org/MakingREDDwork.html More in-depth training is provided to community-based trainers. The community-based trainers are expected to provided technical backstopping for other farmers in their village. Farmer field schools also serve as demonstration plots for other farmers to observe the benefits of conservation agriculture. Open days where everyone is invited to visit the demonstration plots and meet with the Farmer Field School members have been used to promote the approach. Radio is used to raise awareness about conservation agriculture and training materials are provided in each village. It is expected that farmers trained in conservation agriculture will work with local	sustainable; and avoid deforestation outside of the village forest reserves. By introducing improved agricultural activities that are designed to increase farmers' resilience to climate change, it is anticipated that farmers will be able to withstand the shift in growing season; increase in crop pests and diseases; increase in weeds; and decrease in crop productivity that are anticipated as a result of climate change.	practices that are more resilient to climate change, farmers will be less vulnerable to climate change.

Activity description	**Expected outcomes**	**Relevance to project's objectives**
government staff, ward extension officers and community based trainers to implement improved agricultural practices and to support other farmers in their respective villages to adopt improved agricultural practices. Lindi District Council will provide backstopping where resources allow. REDD payments will provide a source of cash for farmers to invest in agricultural inputs including improved seed varieties. **Timing:** Most training provided between 2010 – 2014 in project villages; and in leakage belt villages in 2014 with District and Community Based Trainers providing ongoing support post-2014. Additional funds are being raised in order for TFCG to continue to support farmers on conservation agriculture in the project area villages.		
Activity 6. Improve access to microfinance services for community members. Training is provided to women and men on establishing and operating village savings and loans associations. The VSLAs provide a mechanisms for community members to access loans d to save. The VSLAs are linked with the training on improved agriculture and with the training on enterprise development.	This activity is closely linked with Activities 4 and 5. The village savings and loans associations are intended to help farmers and those with small enterprises to have access to capital to help with enterprise development and purchasing inputs relevant to adopting improved agricultural practices. Farmers will have access to microfinance facilities that will help them to invest in more climate-resilient agricultural	This activity aims to provide a mechanism whereby the REDD payments can be linked with improved livelihood activities.

Activity description	Expected outcomes	Relevance to project's objectives
The VSL Associations are intended to link with the REDD payments by providing a mechanism by which community members can save their REDD incomes until it can be invested. Lindi District Council will provide backstopping where resources allow. **Timing:** Most training provided between 2010 – 2014 with District and Community Based Trainers providing ongoing support post-2014.	practices; and to survive and recover from climate change-related stress. Loans can also be used to help farmers switch to other enterprises.	
Activity 7. Generate incomes from the sale of bee products. Beekeepers within the communities will produce honey and other bee products with some of their hives being placed within the village forest reserves. As part of the REDD readiness activities, over 200 beekeepers were trained in beekeeping and were provided with equipment. Beekeepers are expected to work with closely with the Village Natural Resources Committees providing support in reserve management. Lindi District Council will provide backstopping where resources allow. **Timing:** Most training provided between 2010 – 2014 with District providing support post-2014.	Revenues to the beekeepers from the sale of honey and other bee products is expected to improve the livelihoods of the bee keepers. Benefits from beekeeping are expected to include additional support to the Village Natural Resources Committees from the beekeepers in relation to effective management of the village forest reserves. This will help to reduce deforestation and emissions of greenhouse gases.	This is relevant to the community objectives by contributing to improved incomes and by providing an alternative income to agriculture thereby improving climate change resilience and adaptation by providing households with a broader spread of economic activities to rely on. This is relevant to the climate and biodiversity objectives by incentivising effective reserve management.
Activity 8. Growing and harvesting trees on woodlots	Farmers will have easy access to trees for fuelwood and	This will contribute to the climate and biodiversity impacts by

Activity description	Expected outcomes	Relevance to project's objectives
and through agroforestry. Farmers in the project villages will grow and harvest trees in woodlots and through agroforestry. This is based on the training provided to farmers during the REDD readiness phase. The local MJUMITA networks will promote tree planting and providing training where resources allow. Lindi District Council will provide backstopping where resources allow. **Timing:** Most training provided between 2010 – 2014 with District providing ongoing support post-2014.	building materials from their woodlots. There will be less pressure on the natural forests to supply fuel wood and building materials. Farmers can generate an income from the sale of their trees.	reducing pressure on the forest from tree cutting for fuel wood and construction. It will contribute to the community objectives by providing fruits and wood products for domestic consumption; by providing an income from the sale of timber; and by diversifying household incomes thereby contributing to climate change adaptation.
Activity 9. Improve social services and infrastructure Communities will have the option of allocating some or all of their REDD revenues to pay for better social services and infrastructure. This is closely related to Activities 1 and 4. **Timing:** throughout project lifespan.	Expected impacts include better health care, education and infrastructure for community members. Other expected impacts include more positive attitudes and practices in relation to sustainable forest management by the majority of community members.	This will contribute to climate and biodiversity impacts by increasing the incentive to maintain forest cover as communities see the benefit of the REDD revenues in terms of better schools, clinics and roads. It will contribute to the community objectives by providing better public services including education, health care and governance.

1.9 Project Location

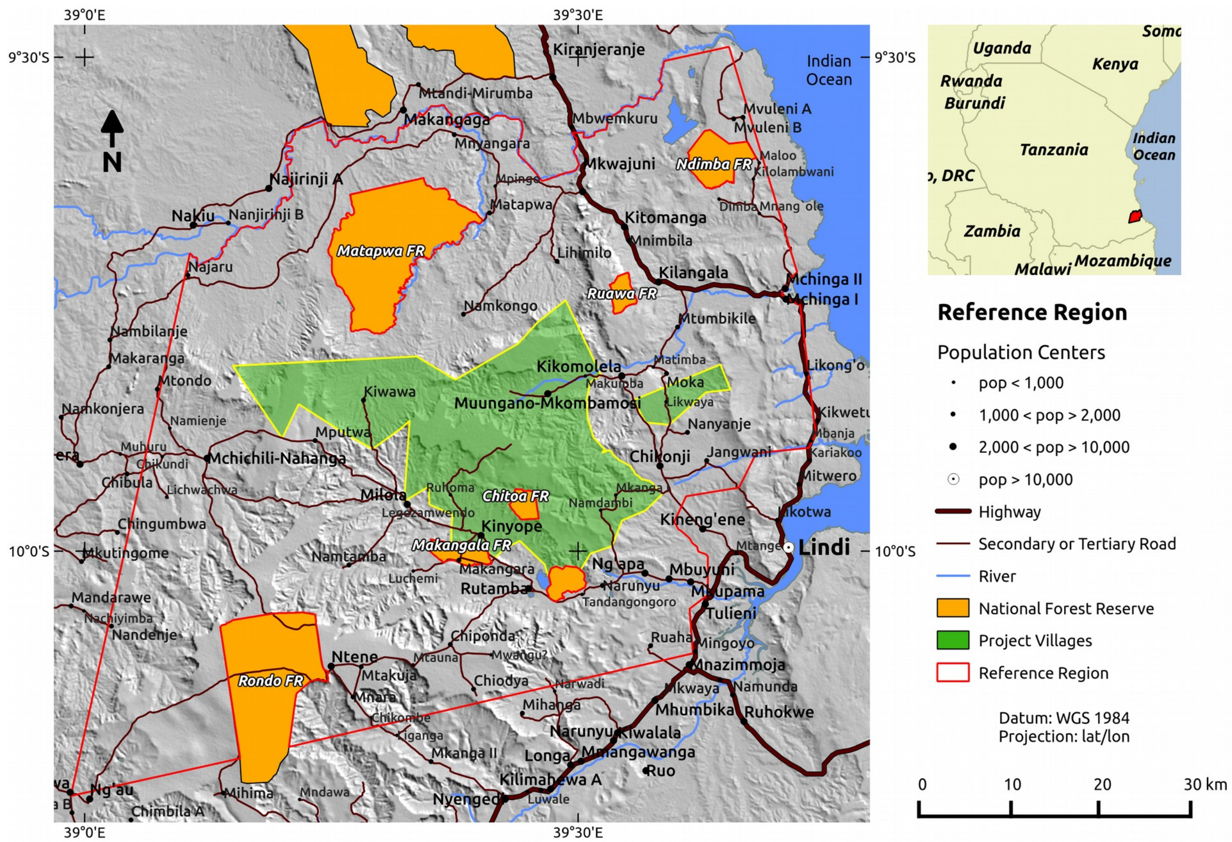

Figure 1: Initial project area villages and potential expansion areas (Reference Region)

The project area is on village land located in Lindi District, Lindi Region approximately 30 km inland from the Indian Ocean in south-eastern Tanzana (Figure 1). The initial project area consists of all forest areas (41,924 ha) at least 10 years old within the 10 initial participating project villages: Kinyope, Kiwawa, Likwaya, Makumba, Milola Magharibi, Mkanga 1, Mkombamosi, Muungano, Nandambi and Ruhoma. If funding becomes available, the project area may expand to include the forests in villages directly bordering the initial project area, including, but not necessarily limited to Namkongo, Lihimilo, Moka, Mtimba, Kikomolela, Rutamba, and Mputwa. GIS files have been shared with the validator covering the initial participating project village boundaries, the reference region and the forest areas within these boundaries.

Figure 2 is a close up of the initial project villages showing the boundaries of each village and their forest areas. Full page versions of Figure 1 and Figure 2 are presented in Part 2, Step 1 of the Methodological Annex.

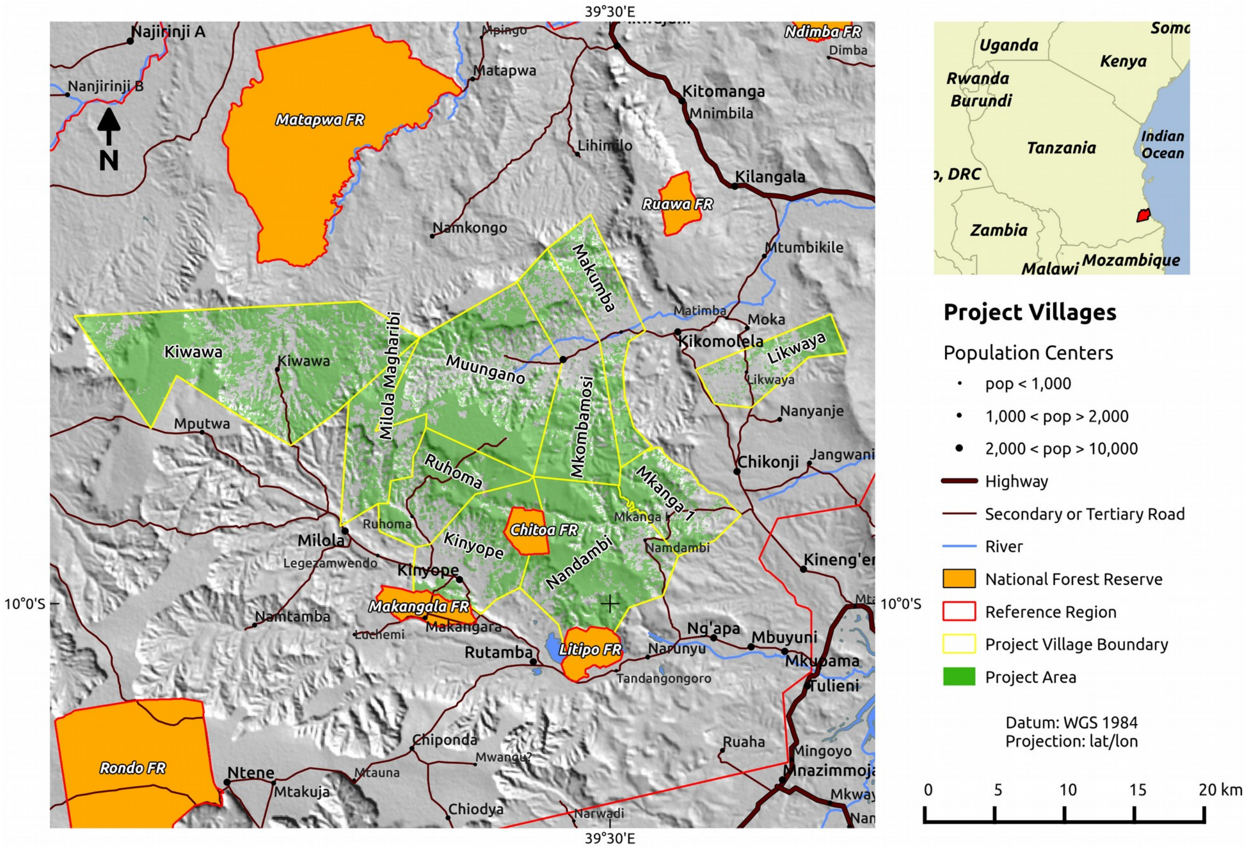

Figure 2: Initial project villages and forest area

1.10 Conditions Prior to Project Initiation

The conditions existing prior to project initiation were the same as the baseline scenario presented in Section 2.4. Thus, as per the instructions, in this section, we describe only the general environmental conditions of the project area including information on climate, hydrology, topography, soils, and vegetation.

Climate

The climate of the Eastern African Coastal Forests is 'characterised by high temperatures and incident sunlight with little seasonal or annual variation, combined with very variable rainfall patterns (Burgess and Clarke 2000).'

The position of the Inter-Tropical Convergence Zone (ITCZ) determines the direction of the prevailing winds and rainfall patterns in the project area. Between October / November to February / March when the ITCZ lies to the south of the project area, the north-easterly trade winds prevail whilst between May and September when the ITCZ lies to the north, south-easterly winds prevail (Burgess and Clarke 2000).

Meteorological data from the project area are scarce, particularly from the plateau tops. The closest meteorological station is in Lindi at 37 576624E 88940221S at 41 m asl (Burgess and Clarke 2000). A rainfall station was operational at Rondo Ntene (10°08'S, 39°15'E, 758 m altitude) on the nearby Rondo plateau from 1954 – 1973; at the Ngurumahamba Estate (12 km east of Litipo) between 1932 – 1962; at the Rutamba Tanganyika Refugee Service (10°02'S, 39°30'E, 300 m) from 1969 – 1973; and at the Naitivi Plantation (10°02'S, 39°33'E, 90 m altitude) from 1934 – 1957 (Clarke 1995)

Across the District, annual mean rainfall varies from 800 mm in the lowlands to an estimated 1200 mm on the plateau. Over the time that they were operational, the various rainfall stations described the above recorded annual mean rainfalls that ranged from 1074 mm at Rutamba; 1096 mm at Naitivi Plantation; and 1215 mm at Rondo Ntene. There is considerable variation in the total annual rainfall. For example the Ngurumahamba Estate rainfall station, recorded a peak annual rainfall of 1418 mm and a minimum of 667 mm over the 30 years that it operated between 1932 and 1962 (Clarke 1995).

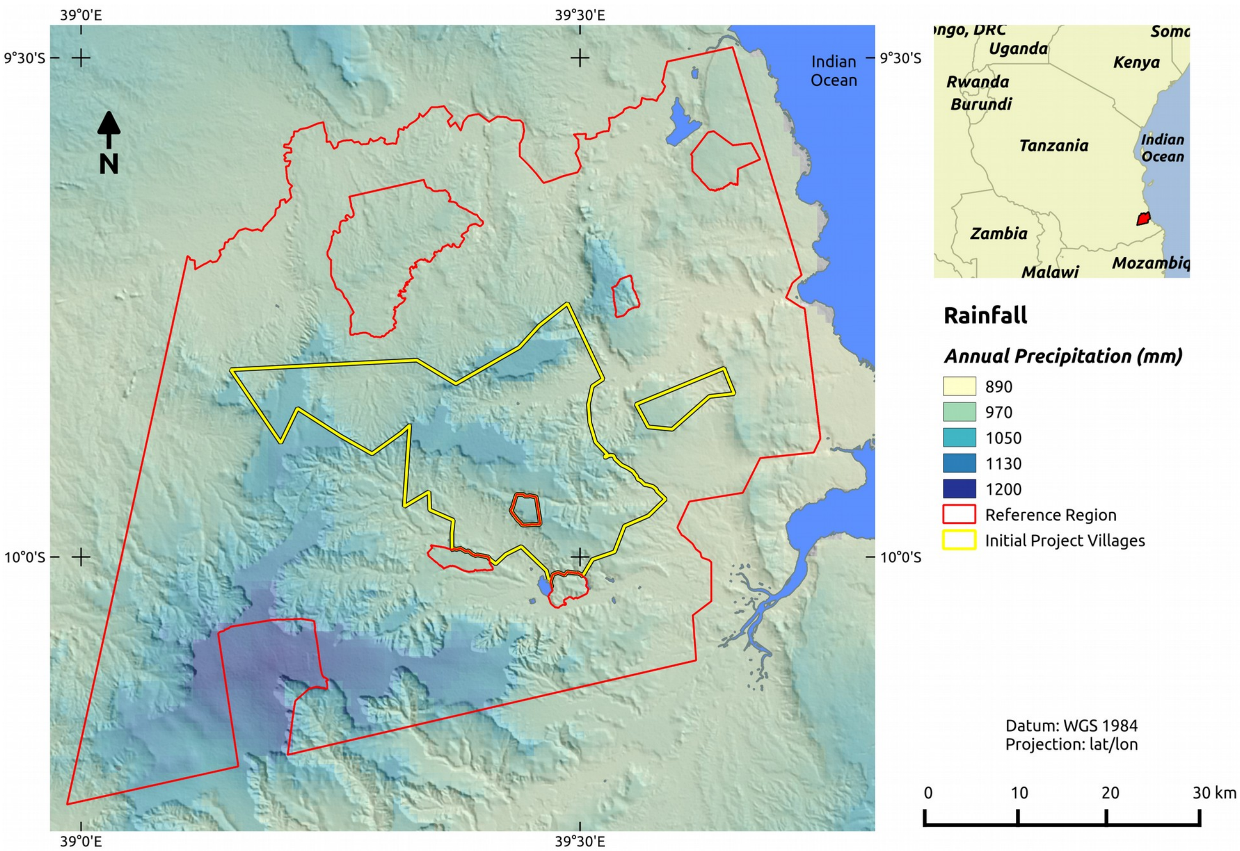

Figure 3: Average annual rainfall in the initial project area and potential expansion areas (reference region)

The rainfall pattern in Lindi is bimodal with rains between November and January (vuli) and between March and May (masika). Clarke (1995) reports that the rainfall stations at the Rutamba Tanganyika Refugee Service; at the Naitivi Plantation and at Rondo Ntene all recorded an average monthly rainfall of less than 50 mm between June and October. The seasonal pattern of precipitation varies annually.

Loveridge (1944) describes a significant occult precipitation effect from both the morning and evening mists that gather over the Rondo plateau and a similar phenomenon may also affect the Noto, Chitoa and Likonde plateaux.

The mean annual temperature across the District ranges from 24°C - 28°C.

Tropical storms are rare in the coastal forest belt although high winds occationally cause tree falls.

Topography and Hydrology

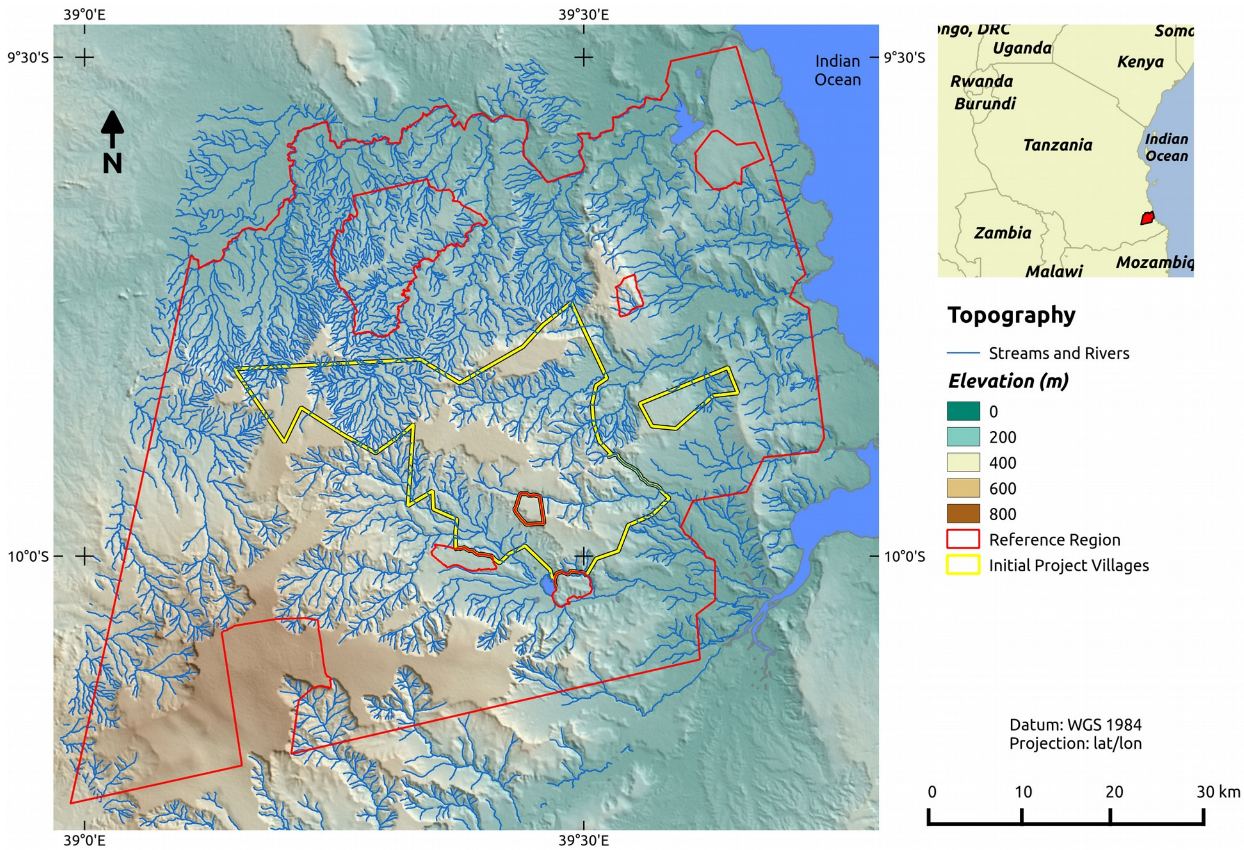

Figure 4: Topography and hydrology of initial project villages and potential expansion areas (reference region)

The initial project area extends for 40 km from North to South and 54 km from East to West. At the centre of the landscape, the Mnanguru River has cut down into the Pliocene surface leaving a 3 km wide valley, now the site of Muungano, Mkombamosi, Makumba and Kikomolela Villages. To the north, the Likonde plateau rises up the steep escarpment from the valley floor at around 215 m asl to the plateau top at 300 – 380 m asl. The Likonde plateau undulates gently descending in the east towards the coastal plain. To the west the Likonde plateau meets with the Jurassic surface at Kiwawa and along the watershed between the Mnanguru and Milola basins.

South of the Mnangaru Valley, the Noto plateau rises up, steeply in the west and more gently in the east. The highest point in the landscape lies at the north western edge of the Noto plateau at 534 m asl. From north-west to south east the plateau descends gently down towards the coastal plain. To the south the narrow Mkomole Valley divides the Noto plateau in the north from the Chitoa plateau in the South. The Chitoa plateau is lower than the Noto plateau extending up to only 340 m asl on its western edge. As with the Noto plateau, its western escarpment rises steeply from the Milola Valley whilst the eastern side descends gently down to the coastal plain. To the south of the Chitoa plateau are a series of shallow lakes.

With the exception of the streams and rivers in the valley floors, most of the streams are seasonal and many only have surface water during heavy rains.

Soils

The landscape is characterised by a gradation or 'catenary succession' of soils from the well-drained, sandy loams and loamy sands of the plateau tops down to the dark cracking clays and sandy clays formed from lacustrine and riverine alluvium in the valleys and floodplains (Burgess and Clarke 2000). Typical of many parts of coastal Tanzania, there is high local variability in the soils reflecting different substrates, slope angles, vegetation and drainage. Broad-scale maps are therefore misleading.

Clarke 1995 describes the soils of Chitoa Forest Reserve, on the south-western edge of the Chitoa plateau as 'Red brown sandy soils prone to retreating scarp erosion at the plateau edge' whilst he describes soil samples from Litipo Forest Reserve, at the southern edge of the landscape as having 'a pH that ranges from slightly acidic to neutral. The texture of the soil is sandy and the moisture content low. The leaf litter is fairly shallow and there is no fermentation layer due to the quick turnover of minerals and ions. Soil profiles from the riverine forest show more of a mineral horizon.

Vegetation

Like many parts of the Eastern African coastal forest ecoregion, the project landscape includes a mosaic of different vegetation types. The project area is centred on coastal forest of the Chitoa and Noto plateaux and the Likonde escarpment. These are characteristic of the East African Coastal Dry forests; are botanically diverse; and are home to several endemic and threatened plant species. The coastal forests are bordered by miombo woodland to the west and shorter coastal scrub forest to the east interspersed with agricultural land, agroforestry, fallows and regenerating areas. There is a smooth transition between forests and woodlands in the region, with coastal forest species existing in closed woodland formations with grassy understories in some areas.

The project area and immediately surrounding areas are part of the Zanzibar-Inhambane regional mosaic (sensu White 1983a and b). As its name suggests, this is a mosaic of different vegetation types. Within the Zanzibar-Inhambane regional mosaic, Burgess and Clarke (2000) define the East African Coastal Forests as an 'archipelago-like regional sub-centre of endemism'. They are forests dominated by Swahilian near endemic tree species. Burgess and Clarke (2000) identified the typical formation as East African Coastal Forest with five variants, of which four have been recorded within the project landscape: Coastal Dry Forest, Coastal Scrub Forest, Coastal Brachystegia Forest, and Coastal Riverine/Groundwater/Swamp forest. The fifth variant, the Coastal Afromontane Forest was not recorded in the project area.

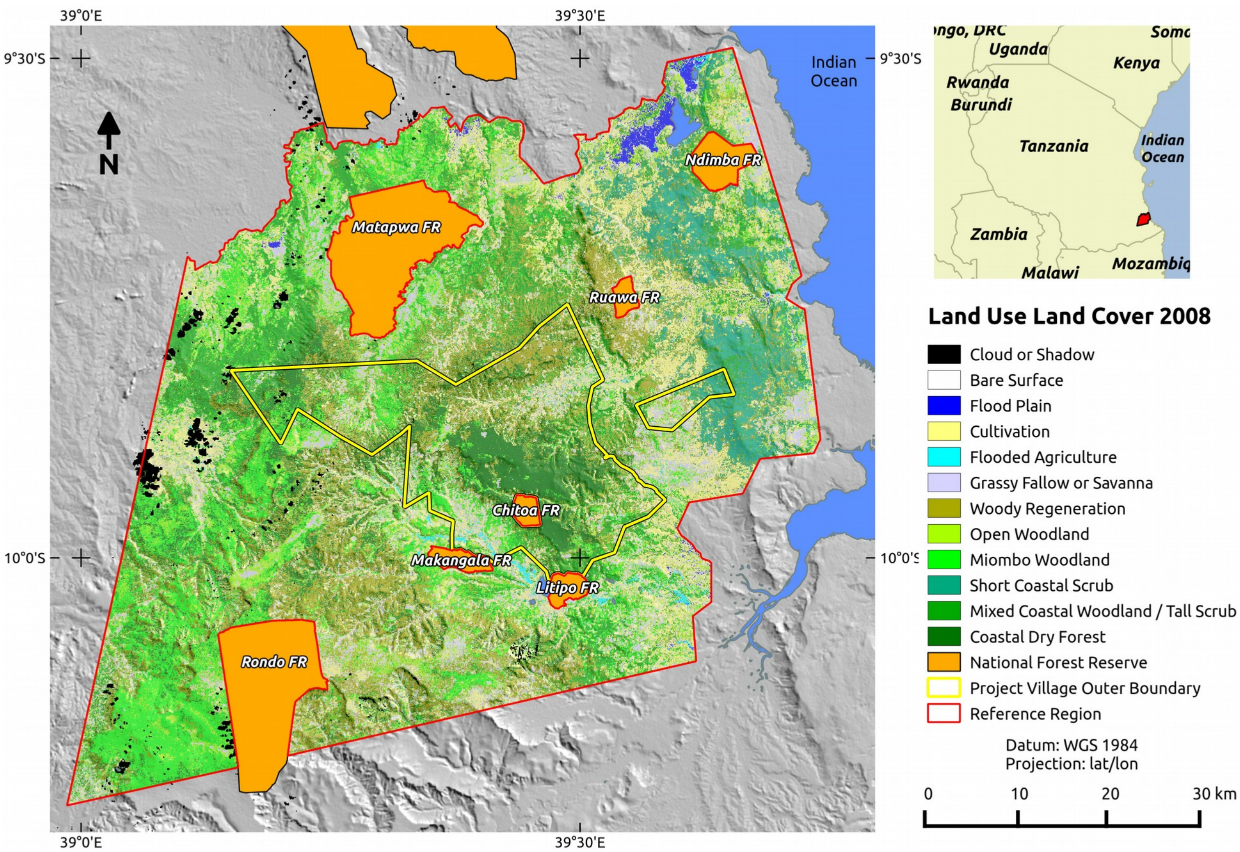

Figure 5: Classification of land use land cover in initial project area and potential expansion areas (reference region).

1.11 Compliance with Laws, Statutes and Other Regulatory Frameworks

Relevant national laws include the following:

- Local Government (District Authorities) Act 1982 – The principle legislation in the country establishing and regulating local governments including district and village governments.
- The Land Act 1999 – The principle legislation in the country establishing and regulating land tenure.
- The Village Land Act 1999 – The principle legislation in the country establishing and regulating village land tenure.
- The Forest Act 2002 – The principle legislation in the country establishing and regulating forest management and use rights.
- Land Use Planning Act 2007 – The principle legislation establishing and regulating land use planning on village land in Tanzania.

The project complies with these acts. At the beginning of the project, the project developed a field manual (see Luwuge et al. 2011a) to establish a single process that integrates the land-use planning guidelines from the 2007 Land Use Planning Act and the guidelines for establishing community based forest management associated with the 2002 Forest Act. As per the guidelines, the land-use and forest management planning process was participatory involving village residents, village government authorities, and district government authorities. MJUMITA and TFCG staff members facilitated the process and provided guidance to communities regarding the compatibility of their plans with REDD. For each participating village, the resulting management plans and bylaws were reviewed, revised, and subsequently approved by the village assembly. The plans and bylaws were then submitted to and approved by the Lindi District Council. For more details on the process and how it conforms with the established guidelines, see the field manual. Copies of the approved management plans and bylaws have been shared with the validating organization.

1.12 Ownership and Other Programs

Right of Use

The project proponents (participating project villages), under law, have the right of use of 100% of the land where the GHG emissions reductions will be produced and thus meet the VCS requirements for the right of use.

The project area is defined as village land as per the 1999 Land Act and 1999 Village Land Act definitions of Land. As per section 7 of the Village Land Act, the project areas are on '(a) land within the boundaries of villages registered in accordance with the provisions of section 22 of the Local Government (District Authorities) Acts ' where ' (d) land, the boundaries of which have been agreed upon between the village council claiming jurisdiction over that land and (i) where the land surrounding contiguous to that village is village land, the village councils of the contiguous village; or (iii) where the land surrounding or contiguous to tat village is reserved land, the official or public organization for the time being responsible for that reserved land.' The boundaries between the participating villages and surrounding villages were clarified and mapped as part of the land-use planning process facilitated by the project (see the description of process to resolve all village boundary conflicts in the project area at the end of this section). The boundaries of reserved land (national forest reserves) were already established. The village boundary maps have been approved by the participating villages and the district council, and have been sent by the district land officer to the ministry of lands.

Section 8 of the Village Land Act empowers the village council to manage all village land and makes specific reference to the management of natural resources and the environment. As per section 4 of the 2002 Forest Act, the project area is defined as '(c) village forests which consist of: (i) village land forest reserves; and (ii) forests which are not reserved which are on village land and of which the management is vested in the village council'. While, the village land act give village councils authority over all land in the village, this authority becomes more formalized and effective when villages have established clear boundaries, conducted land-use planning, established forest management plans, and created village land forest reserves, as all of the participating villages have as part of the project startup activities. The process to create forest management plans is established in sections 11-14 of the Forest Act, while the process to declare a village land forest reserve is established in sections 32-34. The forest by-laws approved by each village assembly place forest areas within the village forest reserves and on village land outside of village forest reserves under the authority of the village natural resource committees, which are elected by community members to represent their interests and serve as an extension of the village council. Thus, 100% of the forest within the project area is under the control of the project proponents.

Village boundary conflict resolution

During the social impact assessment, stakeholders were asked to identify any ongoing or unresolved conflicts over rights to lands, territories and resources. Stakeholder identified a number of village boundary conflicts within the project area. Other boundary conflicts were identified during the village land use planning exercises. Village boundary disputes are common in Tanzania and are part and parcel of the national process of formalizing village boundaries which were historically unclear in some areas, particularly in unsettled areas such as forests. Between 2007 – 09 the Ministry of Lands undertook a mapping exercise to determine village boundaries across the country. With more than 10,000 villages in Tanzania many of which were unclear on their boundary location, and with a limited budget, many boundaries were decided hurriedly and beacons were often placed in a different location than was recorded on the map. This has caused boundary disputes between many villages.

Procedures are in place to resolve such boundaries. These involve consultation between representatives from the concerned villages facilitated by the District Government. Once agreement is reached between the community representatives, the resolution is presented to the respective village assemblies for review and approval. From there the District is responsible for requesting a change to the national cadastral map of village boundaries from the Ministry of Lands. The project supported various boundary resolution processes following these procedures.

The following disputes were identified and resolved:

Kiwawa village had a border dispute with neighboring Mputwa village with the latter claiming that a large area of Kiwawa village belonged to Mputwa. This conflict started in 2006. This conflict was resolved in January 2011 in the process of developing the LUP for Kiwawa Village.

Muungano Village had boundary conflicts with two neighbours, Ruhoma and Milola Magharibi villages (both project villages). Following the normal conflict resolution process mediated by District staff, the issue was resolved in December 2010.

Likwaya, Moka, Matimba and Kikomolela had a boundary conflict regarding the location of Beacon Number 854. In order to resolve this conflict, a meeting was held on 8th April 2013 involving 8 members from each village including Village leaders (Chairperson and Village Executive Officer), four elders and two members from Village Land use Management Committee (VLUM) making it 32 (including 1 woman) community members. Three District staff also participated including the District surveyor. After reviewing the steps that had been taken during participatory land use planning process in the respective villages and after each village had the opportunity to present their perspective, the participants looked at the satellite image for the areas and it was agreed that the beacon was in the correct place and each of the four villages agreed that its location should be respected.

Milola Magharibi and Ruhoma, Muungano, Kiwawa and Milola 'B' had a boundary conflict regarding two sub-villages. The conflicts arose because some families who consider themselves to be residents of Milola Magharibi are living within the borders of Muungano (Kipunga sub-village) and Ruhoma.. A related conflict was between Milola B and Milola Magharibi. Milola B was formerly part of Milola Magharibi and there was still some uncertainty regarding the boundary between the two villages following the Ministry survey of Village lands when the two villages were formed. These two conflicts were resolved in March 2013 following a re-survey. The resurvey involved members from the five villages i.e. Milola Magharibi, Milola B, Kiwawa, Muungano and Ruhoma. Meetings were held between Milola Magharibi and Milola B; and Milola magharibi and Kiwawa, Muungano and Ruhoma. A follow up meeting was also held between Milola Magharibi, Milola B and Kiwawa to agree on one of the proposed boundary amendments. The Divisional Secretary from both Milola and Nangaru and the WEO from Nangaru also participated. New boundary points were agreed between Milola Magharibi and each of the other four villages and beacons were installed.

The project facilitated village assembly meetings in 19 project zone villages: Kiwawa, Mputwa, Milola Magharibi, Milola B, Ruhoma, Kinyope, Rutamba, Mkanga 1, Nandambi, Chikonji kaskazini, Likwaya, Nanyanje, Moka, Komolo, Makumba, Muungano, Mkombamosi and Lihimilo. These VA meetings were meant: to explain the village boundary amendments made subsequent to the land use planning in all project villages and non project villages that share the disputed boundary beacons; and to obtain a copy of the meeting minutes of the VA indicating that all villages accepted the changes. The meetings were held between 27th August - 5th September 2013. Two village assembly meetings were done per day using a music system to attract the villagers to attend the meeting. The proposed boundary amendments have been submitted to the Ministry of Lands and Human Settlements for approval. A new issue raised during these meetings related to the location of Mtele sub-village in Nandambi Village. The project shall proceed with the normal boundary resolution process for this case and will report on progress in the 2nd Project Implementation Report. This last remaining unresolved conflict involves approximately 600 ha of forest, which is far less than 5% of the project area.

Emissions Trading Programs and Other Binding Limits

The project activities are not included in any emissions trading program.

Other Forms of Environmental Credit

The project has not sought and has no plans to seek out any other form of GHG related environmental credits. The project is only reducing emissions via reduced emissions from deforestation and degradation (REDD) and is therefore not eligible to participate in any other program to create another type of GHG related environmental credit.

Participation under Other GHG Programs

The project is not registered or seeking to be registered under any other GHG programs.

Projects Rejected by Other GHG Programs

The project has not been rejected by any GHG programs.

1.13 Additional Information Relevant to the Project

Eligibility Criteria

If funding becomes available, the project may expand to include new project instance (villages). Potential expansion villages must be within the reference region (see Part 2, Step 1.1.1 of the Methodological Annex), must have a leakage belt which does not fall outside the reference region (see Part 2, Step 1.1.3 of the Methodological Annex), and must pass a resolution agreeing to participate in REDD activities in the village assembly after engaging in a process of free, prior, and informed consent as described in Forrester-Kibuga et al. 2011.

Additionally, as per VCS requirements, expansion villages must meet the methodology applicability conditions of VM0015 as described in Part 1 Section 2 of the methodological annex, be subject to the same additionality conditions as described in Part 1 Section 3 of the methodological annex, and be appropriate locations for the same project activities described in this PD. Given that the reference region was carefully constructed to resemble the project area (see Part 2 Step 1 of the methodological annex) in terms of environment, drivers of deforestation, and forest tenure, any village within the reference region should meet these conditions. As part of the reference region, the baseline for these villages is already established through the same process used to establish the baseline for the initial project villages (see Part 2 Step 4 of the methodological annex). Thus monitoring emissions in expansion villages will follow the same process as described in Part 3 Task 1 of the methodological annex.

Leakage Management

The project's main leakage management/prevention activity is activity 5 - improve profitability and ecological sustainability of agriculture, which is described in detail in section 8. The aim of these activities is to improve yields and the sustainability of farming in the project area so that villages can produce more on less land. Under the current farming practices in the project area, soil fertility is quickly exhausted and yields are generally low. Agricultural land use is typically expansive rather than intensive. The strategies employed under activity 5 were developed based on the results of an in depth study of farming practices in the project area commissioned by the project (TFCG 2012). As part of the selected VCS methodology, the project will monitor for leakage using remote sensing (see Methodological Annex Part 3). If a substantial amount of leakage is detected, the project will target greater efforts under activity 5 to the actors (both residents of the project area and residents in neighboring villages) who are responsible for the leakage. Any plans for project area expansion will also take leakage mitigation into consideration so that neighboring communities where leakage occurs will be the first to be invited to join the project.

Commercially Sensitive Information

The project was started with public funds and is intended to be a pilot project that will provide lessons learned for future REDD initiatives. As such, no information has been withheld from the public version of this document.

Further Information

Numerous study reports and other documents related to this project can be found at *http://www.tfcg.org/makingReddWork.html*.

See the CCB project design document for details on numerous social and environmental benefits that the project will generate in addition GHG emissions reductions. The CCB PDD for this project is available from *http://www.tfcg.MakingREDDwork.html* or from the CCB website.

On the next page, the project presents the risk monitoring and mitigation plans developed for the CCB PDD and Monitoring Plan, but also relevant to understanding the project plans for mitigating risks related to the project's GHG benefits.

Risk monitoring plan

Through an exhaustive consultative process with stakeholders (described in section 6 of this PD) the project identified ten potential risks to the project. The project will monitor the indicators specific to each risk. In addition the project will monitor progress in relation to the mitigation measures proposed. The plan to monitor these risks is presented in the following table.

Risk	Indicator	Method	Frequency of monitoring and reporting	Means of Verification	Responsible	Costs of monitoring	Reference for baseline value
Risk 1. Conflicts over village boundaries cause delays to land use planning and the issuing of village land certificates; and revised boundaries are not accepted by all farmers with some farmers continuing to clear forest in an adjacent village's land.	R 1.1 Status of village land use plans and village land certificates for all villages.	Review of village land use plans and by-laws through consultation with VLUM Committees and Village Councils.	Monitoring annually. Reporting at each verification.	Project implementation reports, monitoring reports and copies of VLUPs and Village Land Certificates	VLUM Committees for collation by Carbon Enterprise Coordinator	MJUMITA personnel time and transport costs to visit participating villages.	Project Design Document.
	R 1.2 Number and status of village boundary conflicts.	Consultation with VLUM Committees, Village Councils and VNRCs.	Monitoring annually. Reporting prior to each verification.	Project implementation reports, Monitoring reports and boundary resolution documentation.	VNRCs, VLUM Committees and Village Councils for collation by Carbon Enterprise Coordinator	MJUMITA personnel time and transport costs to visit participating villages.	Project Design document.
Risk 2. Increase in human-wildlife conflict associated with increase in forest cover and forest enhancement.	R 2.1 % of communities in which an increase in H-W Conflict is recorded.	Consultation with CA CBTs and Village Councils.	Monitoring annually. Reporting prior to each verification.	Project implementation reports, monitoring reports.	CA CBTs, Village Councils for collation by Carbon Enterprise Coordinator	MJUMITA personnel time and transport costs to visit participating villages.	Project Design document.
Risk 3. Private investors purchase	R 3.1 Number of sales of village	Consultation with Village	Monitoring and reporting prior to	Project implementation	Village Councils for collation by	CEC Time	Project Design

Risk	Indicator	Method	Frequency of monitoring and reporting	Means of Verification	Responsible	Costs of monitoring	Reference for baseline value
forests within the project area and clear them for agriculture	land to external investors.	Councils; review of community records, site visits and maps.	each verification	reports and monitoring reports	Carbon Enterprise Coordinator		Document. SIA report
	R 3.2 Area of forest within the project area sold to private investors for non-forest land uses.	Review of community records, site visits and maps.	Monitoring and reporting prior to each verification	Project implementation reports and monitoring reports	Village Councils for collation by Carbon Enterprise Coordinator	CEC Time	Project Design Document. SIA report
Risk 4. Internal conflict within communities over forest access rights.	R 4.1 Number of conflict events over forest access rights per village per year.	Review of community records, consultation with VC, VLUM Communittees and VNRCs	Monitoring and reporting prior to each verification	Project implementation reports and monitoring reports	VNRCs (for VFRs), VLUM Committees and Village Councils for collation by Carbon Enterprise Coordinator	CEC Time	Project Design Document. SIA report
Risk 5. Forest fires cause deforestation within the project area.	R 5.1 Area of forest converted to non-forest as a result of fire within the project area.	Review of community records of forest fire events Deforestation analysis using remote sensing images.	Monitoring and reporting prior to each verification	Project implementation reports and monitoring reports	VNRCs (for VFRs) and VLUM Committees for collation by the Carbon Enterprise Coordinator. MJUMITA TA for remote sensing analysis.	GIS Officer and MJUMITA TA time. Image cost shared with deforestation monitoring.	Project Design document.
Risk 6. Reluctance to	R 6.1 and CM	Consultation	Monitoring and	Project	CA CBTs and	MJUMITA	Project

Risk	Indicator	Method	Frequency of monitoring and reporting	Means of Verification	Responsible	Costs of monitoring	Reference for baseline value
adopt alternative land-use practices to shifting agriculture, due to deeply ingrained and long land-use management traditions, as well as capacity and financial barriers to adoption of alternative techniques.	8.2 Number of women and men farmers who adopt improved agricultural practices, value addition and / or other enterprises within the project villages.	with CA CBTs and Village Councils.	reporting prior to each verification	implementation reports and monitoring reports	Village Councils for collation by Carbon Enterprise Coordinator	personnel time and transport costs to visit participating villages.	Design Document
Risk 7. Corruption in relation to the REDD payments undermines the effectiveness and equitability of REDD	R 7.1 Number of corruption events involving REDD payments per year; value of resources involved; and follow up action taken.	Review of community records, consultation with VC, REDD Committee members and MJUMITA members.	Annually	Project implementation reports and monitoring reports supported by REDD payment records and REDD payment Report	REDD Committees, Village Councils for collation by Carbon Enterprise Coordinator	CEC Time	Project Design Document. SIA report
Risk 8. Corruption in relation to forest reserve management results in forest clearance	R 8.1 Number of corruption events in relation to village forest reserve management.	Review of community records, consultation with REDD Committees, VCs and MJUMITA	Annually	Project implementation reports supported by REDD payment records and REDD payment	REDD Committees, Village Councils for collation by Carbon Enterprise Coordinator	CEC Time	Project Design Document. SIA report

Risk	Indicator	Method	Frequency of monitoring and reporting	Means of Verification	Responsible	Costs of monitoring	Reference for baseline value
		members.		Report			
Risk 9. Political support for REDD in Tanzania is withdrawn or legislation is changed to prevent communities accessing REDD revenues directly	R 9.1 Policy statements supportive of / obstructive of community access to REDD revenues.	Review of national policy and legislation	Monitoring and reporting prior to each verification	Project implementation reports	Carbon Enterprise Coordinator	CEC Time	Project Design Document. SIA report
Risk 10. REDD revenues are insufficient to incentivise sustainable forest management	R 10.1 Number of communities who opt out of the project due to insufficient revenues.	Community consultation	Annual	Project implementation reports	Carbon Enterprise Coordinator	CEC Time	Project Design Document. SIA report

Risk Mitigation Plan

Through the same stakeholder consultation process as well as contributions from expert consultants and in house analysis of the risk by MJUMITA and TFCG, the following mitigation measures were developed.

Risk description	Probability and potential impact of risk	Mitigation measures
Risk 1. Conflicts over village boundaries cause delays to land use planning and the issuing of village land certificates; and revised boundaries are not accepted by all farmers with some farmers continuing to clear forest in an adjacent village's land.	Probability: medium / high. Potential impact: high.	Mitigation measures: seek consensus from all affected villages on the location of village boundaries through joint meetings; boundary visits; and participatory mapping. Raise awareness on the location of the new boundaries within the affected villages. Support the District Lands Office to apply for a village boundary amendment from the Ministry of Lands and ensure that all required documents and other evidence is submitted. Provide training to District staff on Conflict Management in the context of Climate Change.
Risk 2. Increase in human-wildlife conflict associated with increase in forest cover and forest enhancement. Existence of wild animals in the area (and possible increase in wildlife due to forest enhancement) could threaten safety of communities and agricultural efforts (through crop destruction).	Medium. Potential impact: medium	Training to farmers on techniques to avoid crop losses due to wild animals. Shifting to more permanent agricultural techniques in fields that are further from the forests.
Risk 3. Private investors purchase forests within the project area and clear them for agriculture	Probability: low / medium Potential impact of risk: high	Mitigation measures already taken include: awareness raising on land rights; strengthening the tenure of the village land through village land use planning; boundary resolution; and obtaining the village land certificates; and providing an incentive to communities to retain ownership of their forests through REDD

Risk description	Probability and potential impact of risk	Mitigation measures
		payments. The local MJUMITA networks are also ready to advise communities on the risks of selling land to private investors. Through their membership of the national MJUMITA network, they have access to legal and political support.
Risk 4. Internal conflict within communities over forest access rights.	Probability: medium Potential impact of risk: high	The REDD readiness activities were implemented with a commitment to free, prior and informed consent. Through the participatory planning and social impact assessment work, community members have directed the design of the REDD implementation phase. They were also given opportunities to opt out of the project at various stages. Those communities with groups of individuals who were not happy to continue with REDD implementation are not included. All of the villages that are included in this PDD have chosen to continue with the project through their village assembly meetings. The Village Assembly meetings have passed by-laws on REDD and have signed a Memorandum of Understanding with MJUMITA outlining their commitment to the REDD process. In addition, a conflict resolution mechanism is in place, to ensure that conflicts that do arise can be addressed in a fair way. By engaging with a wide range of stakeholders during the project design phase, there is also a broad network of support for the initiative at local and national level including from local MPs, the District Council and the Ward Development Committees. The project also provided training to District staff on Conflict Management in the context of Climate Change.
Risk 5. Forest fires cause degradation within the project area.	Probability: medium Potential impact of risk: medium	Awareness raising on fire prevention and fire fighting. By-laws that prohibit the use of fire to clear forests; or the starting of fires within village forest reserves for any other reason. Training farmers on alternative agricultural methods to reduce dependence on ‘slash and burn’ agriculture.
Risk 6. Reluctance to adopt alternative landuse practices to shifting agriculture, due to deeply ingrained and long landuse management	Probability: medium Potential impact of risk: medium	Farmer field schools will be used to demonstrate the direct benefits of conservation agriculture and other improved techniques. Farmers days will be organized in order to attract people to come and see the new approaches. By providing training to community based trainers it is intended that there will technical backstopping available within the communities for farmers. Access to microfinance for agricultural

Risk description	Probability and potential impact of risk	Mitigation measures
traditions, as well as capacity and financial barriers to adoption of alternative techniques.		investment will be increased as a result of the project supporting the establishment of village savings and loans associations. The agricultural strategy has been carefully designed to focus on locally-appropriate strategies. REDD finance will provide an incentive to adopt practices that do not result in deforestation. TFCG will seek additional funds to provide continued agricultural support following the close of the Norwegian-funded project.
Risk 7. Corruption in relation to the REDD payments undermines the effectiveness and equitability of REDD	Probability: medium Potential impact of risk: low / medium	The individual payment mechanism modeled by this REDD project is designed to maximize accountability around REDD payments. It is based on the premise that individuals are more likely to demand accountability where they have a direct stake in the outcome of transactions. As part of the REDD readiness activities, there has been widespread awareness raising in relation to the model and two rounds of payments have been made in all villages so that a majority of people are familiar with the process and the roles and responsibilities of different stakeholders. The MJUMITA networks have also been trained to provide support to communities to prevent and where necessary address any governance shortfalls in relation to the REDD payments. The presence of civil society organizations is known to moderate the risk of elite capture in participatory forest management (Persha and Andersson 2014). The highest risks relate to the use of any funds allocated for community development projects. Where communities do not trust their leaders, they have the option of not entrusting any money to them.
Risk 8. Corruption in relation to forest reserve management results in forest clearance	Probability: medium Potential impact of risk: medium	Over the last decade there has been growing awareness on the scale of corruption within the forest sector in Tanzania and its impact on national development. As such various efforts are now underway at local and national levels to mitigate these risks. Many of these initiatives such as the Mama Misitu (Mother Forest) Campaign and the Forest Justice Project have invested in building the capacity of communities to address governance shortfalls. As part of the REDD readiness activities, TFCG and MJUMITA have provided training to village leaders on good governance. They have also provided training and

Risk description	Probability and potential impact of risk	Mitigation measures
		support to community based advocacy groups so that they can address governance shortfalls directly at village level. These local MJUMITA networks are now in place and will monitor and expose any corruption in relation to reserve management.
Risk 9. Political support for REDD in Tanzania is withdrawn or legislation is changed to prevent communities accessing REDD revenues directly	Probability: low Impact of risk: high	With support from the Norwegian government, the UN REDD program and the Forest Carbon Partnership Facility, there is widespread awareness about REDD and support for it within Tanzania. The National REDD strategy was published in 2013 documenting the government's commitment to continue with REDD. By raising awareness amongst communities and MPs about the potential benefits that REDD could offer rural communities, the issue also has political support.
Risk 10. REDD revenues are insufficient to incentivise sustainable forest management	Probability: medium Impact of risk: high	By seeking CCB and VCS validation, the project aims to secure a price for REDD credits that will provide sufficient incentives to communities to reduce deforestation. In addition, during the REDD readiness activities, TFCG and MJUMITA emphasized the other benefits to communities of maintaining forest cover and will continue to look at ways to secure other revenues for communities that support and are compatible with REDD.

2 APPLICATION OF METHODOLOGY

2.1 Title and Reference of Methodology

The project uses the "Methodology for Avoided Unplanned Deforestation" (VM0015, Version 1.1) approved by VCS on December 3rd, 2012. The methodology provides its own template for demonstrating compliance with the methodology. This completed template is presented in the VM0015 Methodological Annex to this project document. Thus, for most parts of this section, the reader is referred to the relevant part of the methodological annex.

As per the methodology, the additionality of the project is assessed using the most recent version (3.0) of VT0001 Tool for the Demonstration and Assessment of Additionality in VCS AFOLU Project Activities.

2.2 Applicability of Methodology

Refer to Part 1, Section 1 and 2 of the Methodological Annex.

2.3 Project Boundary

The project's spatial boundaries are the boundaries of participating villages. As a REDD project, the core project areas, where emissions reductions will occur, are forest areas older than 10 years within the participating project villages. A map of forest areas older than 10 years in the initial project villages and the initial project village boundaries is provided in Figure 2 of Section 1.9 of this Project Description. Some project activities take place in participating villages outside of forests, such as promoting conservation agriculture, but none of these activities create significant emissions and are thus excluded (see Step 1.4 of Part 2 of the Methodological Annex). Additional information about the project's spatial boundaries can be found in Step 1.1.2 of Part 2 of the Methodological Annex. Maps of the reference region and leakage belt are provided in figures 1 and 9 respectively of Part 2 of the Methodological Annex.

The following table shows the relevant sources of greenhouse gas emissions in the baseline scenario. There are no significant emissions associated with project activities. For further details, see Steps 1.3 and 1.4 of Part 2 of the Methodological Annex.

Source		Gas	Included?	Justification/Explanation
Baseline	Deforestation	CO_2	Yes	Caused by the loss of above and below ground standing tree biomass caused by conversion of forested land-covers to non-forest land-covers. All other carbon pools are conservatively excluded.
		CH_4	Yes	Created by burning above ground tree biomass during the conversion of forest land-covers to non-forest land-covers.
		N_2O	No	Always considered insignificant as per VCS rules

2.4 Baseline Scenario

The baseline scenario is continued conversion of forest on village land to small scale farming for a variety of cash and subsistence crops. A summary of the scenario is provided below. Refer to Part 2, Step 3 of the Methodological Annex for a complete description of the scenario and the basis for its selection.

Rural population growth in Lindi provides both the means (increased labor supply) and the necessity (increased need for subsistence and cash crops) for the expansion of permanent and shifting cultivation associated with deforestation, while urban population growth increases demand for charcoal. Due to the lack of alternative economic opportunities and low skilled population, farming is the only economic activity available to the vast majority of the regions inhabitants. Furthermore, due to the complete absence of land-use restrictions, intensification-related financial and technical hurdles, expanding the area of cultivation through deforestation is preferred to expanding yields through agricultural intensification.

Crop choice affects rates of deforestation in the region. When economic conditions favor maize cultivation, deforestation is higher because maize requires higher soil fertility, which can be obtained by clearing mature forest. Cash crops are a substitute for food crops. Therefore, farmers likely decide to grow one crop or another based on the prices of both cash and food crops. The region is the second biggest producer of cashews and when market conditions favor cashew cultivation over maize, deforestation declines because farmers devote more of their labor to tending to their existing cashew trees.

Future Trends of Underlying Causes

In the absence of REDD, most of these conditions would continue to persist and drive deforestation. Education is slowly improving in the region, which will make it easier for young people from the area to move to urban areas in search of economic opportunities. However, it seems unlikely that population growth in the region will actually decline over the next decade. Furthermore, Lindi is less isolated today. Some areas of Lindi region are experiencing migration from outside the region, and this could eventually effect the leakage belt and project villages as well. Another possible phenomenon, is that men born in the region may return to the region if new economic opportunities present themselves. Over the past decade, the Tanzanian government has constructed a bridge over the Rufiji River that previously separated Lindi Region from the northern Tanzania Coast and Dar es Salaam, and has also slowly improved the highway linking Lindi town to Dar es Salaam and Mtwara. Furthermore, these infrastructure improvements are on going, with about 60 km of the highway from Dar es Salaam still unpaved in Kilwa district. Unfortunately, there is no appropriate location in Tanzania that could be used as a proxy to estimate the effects of this improved infrastructure on future deforestation in Lindi. Therefore, as the future pattern and timing of these events is uncertain, migrants and returning residents are not included as deforestation agents for this baseline period.

Agriculture - Future Trends

Given the complicated interactions between weather, cash crops, food crops, and deforestation, predicting the future of deforestation in the region with any certainty is difficult. However, evidence suggests that the historical baseline is conservative and deforestation is likely to increase in the near future. Lindi Region is the least densely populated region in the country and the theory of labor swapping between cash and food crops resulting in changes in deforestation only holds true so long as the farm labor supply in Lindi is constrained. As described in section 3.1 of the methodolocial annx, census data from 2002 to 2012 does suggest that the labor supply in Lindi was historically constrained. However, this beneficial relationship between increased cash crop farming and reduced deforestation could very easily evaporate if the region becomes attractive to migrants from elsewhere in the country, which is a real possibility given the increased returns to agriculture that improvements to the transportation infrastructure in the region over the past decade might bring.

However, regardless of changes in migration patterns, it should be noted that in response to the 2002/2003 cropping season drought, the government of Tanzania imposed a ban on maize exports and this ban remained in place until the end of 2010, with the exception of 1 month in 2006[2]. A new ban was then put in place again for a few months in 2011, and then lifted. Thus, the only observation periods in the baseline where a maize export ban was not in place were from 2001 to 2002 and parts of 2010 to 2012, which were the two periods with the highest deforestation rates. In 2012, in response to studies conducted by USAID and the World Bank that showed export bans did not improve food security and increased rural poverty, the Tanzanian government made a commitment not to impose crop export bans

2 Ahmed, S. A., Diffenbaugh, N. S., Hertel, T. W., & Martin, W. J. (2012). Agriculture and trade opportunities for Tanzania: past volatility and future climate change. Review of Development Economics, 16(3), 429-447.

in the future[3]. At the same time, export taxes on cashew nuts have been increased, and the new warehouse receipt system introduced in 2008, which was designed to provide cashew farmers with a guaranteed price at the beginning of the cropping season has proved highly dysfunctional[4] - even leading to riots by disgruntle cashew farmers in Lindi region[5]. Thus, the future policy environment will most likely favor maize production, and therefore deforestation, much more than the historical policy environment.

Wood Products – Future Trends

While rural population growth in the reference region over the past decade was relatively slow (0.59%), urban population growth was rapid. The population of Lindi Urban District (Lindi Town) grew from 41,075 to 78,841 from 2002 to 2012. Urban population growth is likely to continue to be strong and thus demand for charcoal will likely increase and reach further into the project area and reference region in the future.

Conclusion

The preponderance of evidence suggests that deforestation rates in the region will increase in the near future. However, given that the historical baseline does not show a clear upward trend and that there is no appropriate proxy area that could be used to quantify the exact effects of the new policy environment and improved infrastructure on the future rates of deforestation in the region, we have conservatively decided to use the historical average deforestation rate.

2.5 Additionality

As per the methodology, the additionality of the project is assessed using the most recent version (3.0) of VT0001 Tool for the Demonstration and Assessment of Additionality in VCS AFOLU Project Activities. Refer to Part 1, Section 3 of the Methodological Annex for the step by step application of the tool.

2.6 Methodology Deviations

In Part 2 Step 1.1.1 of VM0015, in the footnotes, the methodology says that Brown et al. 2007 suggest as a rule of thumb that for a project area greater than 100,000 ha, the reference region should be 5-7 times larger than the project area and that the reference region for a project area less than 100,000 ha should be 20 to 40 times the size of the project area. The same footnotes also say that these numbers are “indicatives” and that the exact ratio between the two areas depends on the particular regional and project circumstances.

The forested part of the reference region for this project is 6.4 times larger than the project area, though, in the Brown et al, 2007 they are referring to total reference region area, not just forested area, in which case the reference region chosen by this project is 9.6 times larger than the project area. This is still significantly less than 20 times larger, and while the language of the methodology suggests that the

3 Saiboko, A. 2013. Food export ban move a failure, reports Chiza. Daily News, Dar es Salaam. Available at: http://www.dailynews.co.tz/index.php/local-news/22936-food-export-ban-move-a-failure-reports-chiza

4 Domasa, S. 2013. Cashew farmers petition against warehouse receipts system. The Guardian, Dar es Salaam. Available at: http://www.ippmedia.com/frontend/?l=53929

5 Daily News. 2013. Police team formed to arrest Lindi chaos. Daily News, Dar es Salaam. Available at: http://www.dailynews.co.tz/index.php/local-news/16758-police-team-formed-to-arrest-lindi-chaos

project area to reference region ratio recommendations are only suggestions, the validator has requested that the choice to use a smaller than suggested reference region size be listed as a deviation.

As stated in the methodological annex, the reference region size was limited due to the unique location of the project area with respect to forest types, forest tenure, and geography. Most of the coastal plateau forest areas to the north of the chosen reference region are in forest reserves. To the south of the reference region almost all of the coastal forests have been replaced with heavily managed woody fallows, while areas to the west are dominated by drier woodlands and also much further from the coast than the project area.

The western boundary of the reference region corresponds to the Landsat scene used in the baseline analysis with the shortest western extent. The northern boundary is marked by the Mbwemburu river, which forms the boundary between Lindi Rural and Kilwa districts. The southern boundary corresponds to the southern most extent of PALSAR scenes used in the baseline analysis. Finally, the eastern boundary was drawn along the coast to avoid mangrove and coastal thicket that are not found in the project area. To ensure that the reference region only included forests under the same tenure regime as the project area, five national forest reserves were excluded from the reference region, as was Lindi municipality based on the ministry of lands 2007 survey map of the area.

Thus, with the exception of the eastern boundary, the reference region boundary choices correspond to satellite path and political boundaries, which is considered good practice as it avoids potentially drawing biased boundaries that include areas of deforestation while avoiding areas of forest persistence. At the same time, the reference region and project area villages are very similar with regards to historical deforestation rates, which is what the project has chosen as its baseline approach to predict future quantities of deforestation. The deforestation rate from 2001 to 2012 within project area villages was 1.9% per annum, while the deforestation rate within the reference region was 1.99% per annum.

Also, the validation results of the deforestation model suggest that the model of deforestation for the entire reference region results in very accurate projections of deforestation within the project area villages. The quantity of deforestation predicted by the model to occur within the project area villages for the validation period (2006 to 2010) was 96% of what was observed.

Thus, the choice of a smaller reference region helps to ensure that the reference region and project area are very similar and does not appear to negatively affect the conservativeness of the estimates.

In Part 2, Step 8.2 of the methodology, it states that *ex ante* activity displacement leakage should be calculated, “by multiplying the estimated baseline carbon stock changes for the project area by a displacement leakage factor (DLF)” and then suggests in the footnotes that the DLF should be set to the proportion of the project area deforestation agents who do not participate in leakage prevention or other project activities. However, this would result in double counting unavoided baseline deforestation since the project does not anticipate 100% effectiveness of avoided deforestation activities. By definition, deforestation activities that continue in the project area, cannot leak to outside the project area. Thus, rather than multiplying the DLF by the baseline carbon stock changes, we multiplied the DLF by the difference between the baseline and the *ex ante* estimates of project scenario carbon stock changes (which changes over time as anticipated effectiveness changes). Therefore, as the participating project villages become more effective at preventing deforestation, leakage would also rise since a greater number of deforestation agents will be displaced.

For the reasons provided, this is a much more realistic means of estimating leakage ex ante. However, as this has no effect on the calculation of emissions ex post, it does not negatively affect the conservativeness of estimates.

3 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

3.1 Baseline Emissions

Refer to Part 2, Steps 2 through 6 of the Methodological Annex.

3.2 Project Emissions

Refer to Part 2, Step 7 and Part 3 of the Methodological Annex.

3.3 Leakage

Refer to Part 2, Step 1.1.3, Part 2, Step 8, and Part 3 of the Methodological Annex.

3.4 Net GHG Emission Reductions and Removals

A summary of estimated GHG emissions reductions for the first fixed baseline period (2012-2022) is shown in the following table. Refer to Part 2, Steps 6 through 9 of the Methodological Annex for the details on the quantification of net GHG emission reductions.

Year	Estimated baseline emissions or removals (tCO_2e)	Estimated project emissions or removals (tCO_2e)	Estimated leakage emissions (tCO_2e)	Estimated net GHG emission reductions or removals (tCO_2e)
2012-2013	135,552	-94,886	-6,913	33,752
2013-2014	122,073	-79,347	-7,263	35,462
2014-2015	120,668	-72,401	-8,205	40,062
2015-2016	121,105	-66,608	-9,265	45,233
2016-2017	115,537	-57,768	-9,821	47,948
2017-2018	111,582	-50,212	-10,433	50,937
2018-2019	106,116	-42,447	-10,824	52,846
2019-2020	107,618	-43,047	-10,977	53,594
2020-2021	104,265	-41,706	-10,635	51,924
2021-2022	102,154	-40,862	-10,420	50,873
Total	1,146,670	(589,284)	(94,756)	462,631

4 MONITORING

4.1 Data and Parameters Available at Validation

Data / Parameter	Forest cover benchmark map 2001
Data unit	ha
Description	Digital map of forest cover in the reference region, leakage belt, and project area at the beginning of the reference period (2001).
Source of data	Remote sensing analysis involving Landsat 5 and Landsat 7 data from path 165, row 67.
Value applied:	N/A
Justification of choice of data or description of measurement methods and procedures applied	Landsat data is the most easily accessible data. It is systematically gathered year round and at an appropriate resolution for this type of analysis. The analysis was carried out by MJUMITA. See Part 2, Section 2.4 of the Methodological Annex for a complete description of the procedures used to create the map.
Purpose of Data	This data was used as the starting point for the deforestation analysis used to determine the baseline scenario.
Comments	Geotiff raster – 30m resolution – projection UTM Zone 37S – datum WGS84

Data / Parameter	Map of 2001 to 2012 deforestation
Data unit	ha
Description	Digital map of deforestation and forest persistence in the reference region from 2001 to 2012.
Source of data	Remote sensing analysis involving Landsat 5 and Landsat 7 data from path 165, row 67. Training and accuracy assessment data for the analysis were derived from high resolution imagery available of google earth, Spot 5 imagery and ground truthing.
Value applied:	N/A
Justification of choice of data or description of measurement methods and procedures applied	Landsat data is the most easily accessible data. It is systematically gathered year round and at an appropriate resolution for this type of analysis. The analysis was carried out by MJUMITA. See Part 2, Section 2.4 of the Methodological Annex for a complete description of the procedures used to create the map.
Purpose of Data	This data was used to calculate historical deforestation rates used to determine the baseline deforestation rate (historical average). See Table B of the Methodological Annex for the deforestation rates calculated from this map.
Comments	Geotiff raster – 30m resolution – projection UTM Zone 37S – datum WGS84

Data / Parameter	Forest cover benchmark map 2012
Data unit	ha
Description	Digital map of forest cover in the reference region, leakage belt, and project area at the beginning of the project crediting period (2012).
Source of data	Remote sensing analysis involving Landsat 5 and Landsat 7 data from path 165, row 67. Training and accuracy assessment data for the analysis were derived from high resolution imagery available of google earth, Spot 5 imagery and ground truthing.
Value applied:	N/A
Justification of choice of data or description of measurement methods and procedures applied	Landsat data is the most easily accessible data. It is systematically gathered year round and at an appropriate resolution for this type of analysis. The analysis was carried out by MJUMITA. See Part 2, Section 2.4 of the Methodological Annex for a complete description of the procedures used to create the map.
Purpose of Data	This map was used as the starting point for projecting baseline deforestation. This map will also serve as the starting point for monitoring future deforestation.
Comments	Geotiff raster – 30m resolution – projection UTM Zone 37S – datum WGS84

Data / Parameter	Land use, land cover map 2012
Data unit	ha
Description	Digital map of forest cover types in the reference region, leakage belt, and project area at the beginning of the project crediting period (2012).
Source of data	Remote sensing analysis involving Landsat 5 and Landsat 7 data from path 165, row 67. Training and accuracy assessment data for the analysis were derived from high resolution imagery available of google earth, Spot 5 imagery and ground truthing.
Value applied:	N/A
Justification of choice of data or description of measurement methods and procedures applied	Landsat data is the most easily accessible data. It is systematically gathered year round and at an appropriate resolution for this type of analysis. The analysis was carried out by MJUMITA. See Part 2, Section 2.4 of the Methodological Annex for a complete description of the procedures used to create the map.
Purpose of Data	This map is used together with the map of projected baseline deforestation to determine baseline annual areas of deforestation of different forest types in the project area and leakage belt during the first fixed baseline period from 2012 to 2022. This map will also be used in combination with change detection to determine the annual areas of observed deforestation during the crediting period.

Comments	Geotiff raster – 30m resolution – projection UTM Zone 37S – datum WGS84

Data / Parameter	Map of projected baseline deforestation 2012-2022
Data unit	ha
Description	Digital map of projected deforestation and forest persistence in the reference region, leakage belt, and project area from 2012 to 2022.
Source of data	Spatial model based on the relationships between historical deforestation and factor maps.
Value applied:	N/A
Justification of choice of data or description of measurement methods and procedures applied	The historical average deforestation rates for high carbon forest and low carbon forests obtained from the analysis of the Map of 2001 to 2012 deforestation were applied to a deforestation risk map generated from a spatial model. The analysis was carried out by MJUMITA. See Part 2, Section 4 of the Methodological Annex for a complete description of the procedures used to create the map.
Purpose of Data	This map is used together with the 2012 land-use land-cover map to determine annual areas of baseline deforestation from different forest types in the project area and leakage belt during the first fixed baseline period from 2012 to 2022.
Comments	Geotiff raster – 30m resolution – projection UTM Zone 37S – datum WGS84

Data / Parameter	$ABSLPA_{t,icl}$
Data unit	ha / y-1
Description	Area of baseline deforestation in the project area in year *t* per forest class *icl.*
Source of data	Spatial model based on the relationships between historical deforestation and factor maps.
Value applied:	See VM Table 11.b in the Methodological Annex for values
Justification of choice of data or description of measurement methods and procedures applied	Crosstab analysis of the map of projected baseline deforestation from 2012-2022 and the land-use, land-cover map of 2012 in the project area. For futher details see Part 2, Steps 2, 4 and 5 of the Methodological Annex.
Purpose of Data	Data is used in the calculation of baseline emissions from the project area.
Comments	None

Data / Parameter	$ABSLLK_{t,icl}$
Data unit	ha
Description	Area of baseline deforestation in the leakage belt in year *t* per forest class *icl.*
Source of data	Spatial model based on the relationships between historical deforestation and factor maps.
Value applied:	See VM Table 11.c in the Methodological Annex for values
Justification of choice of data or description of measurement methods and procedures applied	Crosstab analysis of the map of projected baseline deforestation from 2012-2022 and the land-use, land-cover map of 2012 in the leakage belt. For further details see Part 2, Steps 2, 4 and 5 of the Methodological Annex.
Purpose of Data	Data is used in the calculation of baseline emissions from the project area.
Comments	None

Data / Parameter	$\Delta Cab_{icl,t}$
Data unit	t CO_2e/ha
Description	Above ground carbon stock change factor for intial forest class *icl* in year *t* in the project area or leakage belt.
Source of data	Allometric equations applied to field measurements
Value applied:	High Carbon Forest: -159.23 in year t Low Carbon Forest: - 107.03 in year t
Justification of choice of data or description of measurement methods and procedures applied	Mandatory carbon pool. See Part 2, Step 6.1 of the Methodological Annex for details of field measurements and the allometric equations applied.
Purpose of Data	This data is used to calculate the carbon stock changes associated with deforestation in different forest types.
Comments	Also see VM Table 20.a.1-2 in the Methodolgical Annex for values. These values may change due to periodic carbon stock monitoring.

Data / Parameter	$\Delta Cbb_{icl,t}$
Data unit	t CO_2e/ha
Description	Below ground carbon stock change factor for initial forest class *icl* in year *t* in the project area or leakage belt.
Source of data	Allometric equations applied to field measurements
Value applied:	High Carbon Forest: -4.98 per year from year t to year t+9 Low Carbon Forest: -3.74 per year from year t to year t+9

Justification of choice of data or description of measurement methods and procedures applied	Mandatory carbon pool. See Part 2, Step 6.1 of the Methodological Annex for details of field measurements and the allometric equations applied.
Purpose of Data	This data is used to calculate the carbon stock changes associated with deforestation in different forest types.
Comments	Also see VM Table 20.a.1-2 in the Methodological Annex for values. These values may change as a result of periodic carbon stock monitoring.

Data / Parameter	$\Delta Cab_{fcl,t}$ (project area)
Data unit	t CO_2e/ha
Description	Above ground carbon stock change factor for final post-deforestation class *icl* in year *t* in the project area.
Source of data	Allometric equations applied to field measurements
Value applied:	High Carbon Forest: 2.72 per year from year t to year t+9
Justification of choice of data or description of measurement methods and procedures applied	Significant carbon pool. See Part 2, Step 6.1 of the Methodological Annex for details of field measurements and the allometric equations applied. Values for project area and leakage belt are different due to methodology rules for dealing with measurement uncertainty.
Purpose of Data	This data is used to calculate the carbon stock changes associated with deforestation in different forest types in the project area.
Comments	Also see VM Table 20.b.1 in the Methodological Annex for values.

Data / Parameter	$\Delta Cbb_{fcl,t}$ (project area)
Data unit	t CO_2e/ha
Description	Below ground carbon stock change factor for final post-deforestation class *icl* in year *t* in the project area.
Source of data	Allometric equations applied to field measurements
Value applied:	High Carbon Forest: 0.82 per year from year t to year t+9
Justification of choice of data or description of measurement methods and procedures applied	Significant carbon pool. See Part 2, Step 6.1 of the Methodological Annex for details of field measurements and the allometric equations applied. Values for project area and leakage belt are different due to methodology rules for dealing with measurement uncertainty.
Purpose of Data	This data is used to calculate the carbon stock changes associated with deforestation in different forest types in the project area.
Comments	Also see VM Table 20.b.1 in the Methodological Annex for values.

Data / Parameter	$\Delta Cab_{fcl,t}$ (leakage belt)
Data unit	t CO_2e/ha
Description	Above ground carbon stock change factor for final post-deforestation class *icl* in year *t* in the leakage belt.
Source of data	Allometric equations applied to field measurements
Value applied:	High Carbon Forest: 0.97 per year from year t to year t+9
Justification of choice of data or description of measurement methods and procedures applied	Significant carbon pool. See Part 2, Step 6.1 of the Methodological Annex for details of field measurements and the allometric equations applied. Values for project area and leakage belt are different due to methodology rules for dealing with measurement uncertainty.
Purpose of Data	This data is used to calculate the carbon stock changes associated with deforestation in different forest types in the leakage belt.
Comments	Also see VM Table 20.b.2 in the Methodological Annex for values.

Data / Parameter	$\Delta Cbb_{fcl,t}$ (leakage belt)
Data unit	t CO_2e/ha
Description	Below ground carbon stock change factor for final post-deforestation class *icl* in year *t* in the leakage belt.
Source of data	Allometric equations applied to field measurements
Value applied:	High Carbon Forest: 0.28 per year from year t to year t+9
Justification of choice of data or description of measurement methods and procedures applied	Significant carbon pool. See Part 2, Step 6.1 of the Methodological Annex for details of field measurements and the allometric equations applied. Values for project area and leakage belt are different due to methodology rules for dealing with measurement uncertainty.
Purpose of Data	This data is used to calculate the carbon stock changes associated with deforestation in different forest types in the leakage belt.
Comments	Also see VM Table 20.b.2 in the Methodological Annex for values.

Data / Parameter	$EBBtot_{icl}$
Data unit	t CO_2e/ha
Description	Factor for non-CO_2 emissions from forest burning per forest class *icl*.
Source of data	Field observations and IPCC default values.
Value applied:	High Carbon Forest: 11.38 Low Carbon Forest: 7.65
Justification of choice of	Optional emissions monitoring. See Part 2, Step 6.2 of the

data or description of measurement methods and procedures applied	Methodological Annex for details and equations applied.
Purpose of Data	This data is used to calculate the CO_2 equivalent of emissions from burning forest biomass during the process of deforestation.
Comments	Also see VM Table 23 in the Methodological Annex for values.

4.2 Data and Parameters Monitored

This section presents the data that will be collected as part of monitoring for verification. This data will in turn be used to update a series of tables as described in Part 3 of the methodological annex in order to calculate the net GHG reductions that occur during the crediting period.

Data / Parameter	Deforestation Map (2013 – 2022)
Data unit	ha
Description	A map of areas of deforestation and forest persistence in the project area and leakage belt during the project crediting period.
Source of data	Landsat 7, Landsat 8 and ALOS PALSAR data as needed, with high resolution imagery or field observations for ground truthing
Description of measurement methods and procedures to be applied	See Part 3, Task 1.1.2 of the Methodological Annex for a description of the procedures to create this map.
Frequency of monitoring/recording	Every 1 to 2 years depending on satellite image availability
Value applied:	N/A
Monitoring equipment	See Part 3, Task 1.1.2 of the Methodological Annex for a description of the tools used to create this map.
QA/QC procedures to be applied	High resolution satellite imagery and ground monitoring data will be used for ground truthing. The minimum accuracy of the deforestation map will be 80%.
Purpose of data	Deforestation detected in this map will be used as the basis for determining where deforestation has occurred in the project area and leakage belt during the crediting period.
Calculation method	N/A
Comments	none

Data / Parameter	$ABSLPA_{t,icl}$ *(ex post)*
Data unit	ha
Description	Annual area of ex post (observed) deforestation in initial forest class *icl* in the project area in year *t* of the crediting period.
Source of data	Deforestation Map (2013-2022) and Land-use land-cover map

	2012
Description of measurement methods and procedures to be applied	R script generates a crosstab table showing the number of hectares deforested in each forest type in the project area.
Frequency of monitoring/recording	Every 1 to 2 years depending on satellite image availability
Value applied:	N/A
Monitoring equipment	See Part 3, Task 1.1.2 of the Methodological Annex for a description of the tools used to create the maps used in the analysis.
QA/QC procedures to be applied	High resolution satellite imagery and ground monitoring data will be used for ground truthing. The minimum accuracy of the deforestation map will be 80%.
Purpose of data	This data is used in the calculations of emissions from the project area during the crediting period.
Calculation method	N/A
Comments	These figures will appear in the verification report in the ex post versions of VM Table 11.b from the Methodological Annex.

Data / Parameter	$ABSLLK_{t,icl}$ *(ex post)*
Data unit	ha
Description	Annual area of ex post (observed) deforestation in initial forest class *icl* in the leakage belt in year *t* of the crediting period.
Source of data	Deforestation Map (2013-2022) and Land-use land-cover map 2012
Description of measurement methods and procedures to be applied	R script generates a crosstab table showing the number of hectares deforested in each forest type in the leakage belt.
Frequency of monitoring/recording	Every 1 to 2 years depending on satellite image availability
Value applied:	N/A
Monitoring equipment	See Part 3, Task 1.1.2 of the Methodological Annex for a description of the tools used to create the maps used in the analysis.
QA/QC procedures to be applied	High resolution satellite imagery and ground monitoring data will be used for ground truthing. The minimum accuracy of the deforestation map will be 80%.

Purpose of data	This data is used in the calculations of emissions from the leakage belt during the crediting period.
Calculation method	N/A
Comments	These figures will appear in the verification report in the ex post versions of VM Table 11.c from the Methodological Annex.

Data / Parameter	$\Delta Cab_{icl,t}$
Data unit	t CO_2e/ha
Description	Above ground carbon stock change factor for intial forest class *icl* in year *t* in the project area or leakage belt.
Source of data	Allometric equations applied to field measurements
Description of measurement methods and procedures to be applied	See Part 2, Step 6.1 of the Methodological Annex for details of field measurements and the allometric equations applied.
Frequency of monitoring/recording	First re-measure will occur in 2015 and then every 2 to 5 years depending on detected rate of growth (only measured at intervals where significant change is likely to be observed).
Value applied:	Starting Values: High Carbon Forest: -159.23 in year t Low Carbon Forest: - 107.03 in year t
Monitoring equipment	Measurements will be made by already trained community members with support from a MJUMITA staff member. Each village already has their own GPS, measuring tape, and calipers necessary to make the field measurements.
QA/QC procedures to be applied	Monitoring data will be fed into the same database used for storing and organizing the initial carbon plot data. Anomalous values will be detected using queries and checked against paper forms and possibly revisited in the field.
Purpose of data	This data will be used to update VM Table 20.a.1-2 for both baseline and project emissions estimates from the time of measurement going forward.
Calculation method	See Part 2, Step 6.1 of the Methodological Annex for calculation details. The significance of detected changes in carbon stocks will be evaluated using a matched-pair t-test.
Comments	When measured, updated versions of VM Table 15.b from the Methodological Annex will be presented in the verification report.

Data / Parameter	$\Delta Cbb_{icl,t}$
Data unit	t CO_2e/ha

Description	Below ground carbon stock change factor for initial forest class *icl* in year *t* in the project area or leakage belt.
Source of data	Allometric equations applied to field measurements
Description of measurement methods and procedures to be applied	See Part 2, Step 6.1 of the Methodological Annex for details of field measurements and the allometric equations applied.
Frequency of monitoring/recording	First re-measure will occur in 2015 and then every 2 to 5 years depending on detected rate of growth (only measure at intervals where significant change is likely to be observed).
Value applied:	Starting Values: High Carbon Forest: -4.98 per year from year t to year t+9 Low Carbon Forest: -3.74 per year from year t to year t+9
Monitoring equipment	Measurements will be made by already trained community members with support from a MJUMITA staff member. Each village already has their own GPS, measuring tape, and calipers necessary to make the field measurements.
QA/QC procedures to be applied	Monitoring data will be fed into the same database used for storing and organizing the initial carbon plot data. Anomalous values will be detected using queries and checked against paper forms and possibly revisited in the field.
Purpose of data	This data will be used to update VM Table 20.a.1-2 for both baseline and project emissions estimates from the time of measurement going forward.
Calculation method	See Part 2, Step 6.1 of the Methodological Annex for calculation details. The significance of detected changes in carbon stocks will be evaluated using a matched-pair t-test.
Comments	When measured, updated versions of VM Table 15.b from the Methodological Annex will be presented in the verification report.

4.3 Monitoring Plan

In addition to the description of the data and parameters described in the previous section, Part 3 of the Methodological Annex provides a detailed monitoring plan including the process and schedule for obtaining, recording, compiling and analyzing monitoring data and parameters. Here we provide information on the parties responsible for different parts of the monitoring plan and the plan for data management.

Responsible Parties

- TFCG GIS Officer – responsible for obtaining and analyzing the satellite data as described in Part 3, Task 1.1.2 of the Methodological Annex, updating all ex post tables described in Part 3, Task 1 of the Methodological Annex, and compiling verification reports.

- MJUMITA Carbon Monitoring Officer – responsible for organizing the collection, recording, and analyzing of carbon stock data as described in Part 3, Task 1.1.3 and Part 2, Step 6.1 of the Methodological Annex. Also responsible for entering data from village natural resource committee forest patrol reports into excel to be used for ground truthing and monitoring of project activity implementation.

- MJUMITA Enterprise Officer – responsible for documenting REDD dividend payment books, village assembly meetings, and photographic evidence of the village development projects funded by REDD revenue.

- MJUMITA Technical Adviser – responsible for providing technical backstopping to the TFCG GIS Officer and MJUMITA Carbon Monitoring Officer.

Plan for data storage and management

- All gis data described in this project document and the methodological annex, and any gis data generated as part of monitoring activities will be stored on a network drive and at least one external drive in the TFCG/MJUMITA head office.

- New gis data generated on individual computers will be backed up to an external drive within 1 week of being created and will be backed up to the network drive within 1 month.

- New result data (tables and figures) from the analysis of gis data and any updates to the mysql carbon stock database will also be backed up to a cloud server within 1 week of being created, in addition to being stored on network and external drives.

- Paper copies of field data forms will be stored at the TFCG/MJUMITA head office.

5 ENVIRONMENTAL IMPACT

The core project activities center around the conservation of natural forests and are provided for in the Forest Act 2002, are not subject to requirements for an environmental impact assessment. The project anticipates substantial net positive environmental impacts and is seeking to verify these impacts through the Climate, Community, and Biodiversity (CCB) project standards. The CCB PDD for this project is available from www.tfcg.org/MakingREDDwork.html or from the CCB website.

6 STAKEHOLDER COMMENTS

Stakeholder identification has been carried out and reviewed at various stages of the REDD readiness process in order to ensure that all key stakeholders have been identified and consulted. The stakeholder consultation process broadly followed the steps recommended by Forest Trends in relation to social impact assessment of land based carbon projects (Richards and Panfil 2010 a and b). At the project outset, a stakeholder analysis was conducted with the aim of identifying and understanding the stakeholders within and external to the communities (Forrester-Kibuga and Samweli 2010). This is available at www.tfcg.org/MakingREDwork.html. During the social impact assessment workshops at village and landscape level, this list of stakeholders was reviewed and validated by the participants (Mwampamba et al. 2011). Participants in the SIA process included representatives of the communities, community groups and other stakeholders identified by the initial consultancy. In addition the REDD readiness process was well publicized at local level through newsletters and local media thereby ensuring that all local stakeholders had the opportunity to engage with the project during the design phase.

The initial consultation with the communities at sub-village and village level is described in Forrester-Kibuga *et al.* 2011; records of the village level consultation on project design are recorded in Mwampamba *et al*. 2011 and Nguya 2011; and the stakeholder workshop to present the PDD is described in Mbegu 2014. MoUs have been signed between MJUMITA and the communities further documenting their consent to participate. Copies of the MoUs signed by each community have been provided to the Validators.

In terms of stakeholder involvement in project design through effective consultation, a multi-step process was implemented reflecting the project's commitment to free, prior and informed consent. These steps are outlined below with more information available in Luwuge *et al*. 2011, Luwuge *et al*. 2011a and in Mwampamba *et al*. 2011. The process aimed to ensure that as many people as possible were informed about REDD and the REDD readiness initiatives; that they had more than one opportunity to confirm their consent for REDD as the process continued, or withdraw from the process; and that marginalized groups including poorer households, women and those living in more remote sub-villages were included. Local government staff participated at each stage and elected officials including the MP and Ward councilors were involved at key points.

Changes to the project design included the withdrawal of six villages from the process: Kikomolela, Moka, Chikonji, Rutamba ya Sasa, Lihimilo and Namkongo Villages. In each of these villages there were groups who did not consent to the REDD readiness or REDD implementation activities proceeding. In keeping with our commitment to free, prior and informed consent as a per-requisite for participating in REDD, these villages are not included in the project area for this PDD. The project's desired impacts and the strategies to achieve those impacts are a culmination of stakeholder comments.

Communication between the project was helped by identifying community communicators who were given responsibility for liaising between the project and their respective community. Each communicator was provided with a mobile phone and airtime each month during the REDD readiness phase.

Community Stakeholder Consultation Process
Introductory meetings with Village Councils Introductory meeting to all Village Councils were held to introduce TFCG and MJUMITA and explain about REDD, climate change and participatory forest management. Village councils were asked whether they would like to continue with REDD readiness activities.
Community level awareness raising and consultation at sub-village level Consultation and awareness raising meetings were held at sub-village level. All sub-villages were visited and people had the opportunity to learn about REDD, climate change and participatory forest management; discuss any concerns; and express their support or objection to REDD readiness activities proceeding. The outreach at sub-village level aimed to ensure that even those living in more remote parts of the village including poorer households and women, who often do not attend village assembly meetings, could be contacted. See Forrester-Kibuga et al. 2011.

Community level awareness raising, consultation and request for consent to proceed at village level Village assembly meetings were held in each village including drama and discussions to raise awareness on REDD and to document the consent of the village to proceed with the project. All adult residents of a village are members of the village assembly. Many children also participated. Members of the village natural resources committee were confirmed, ensuring that at least 1/3 of members were women. The village assemblies were requested to decide whether they wanted to proceed with the REDD readiness. All villages included in this PDD chose to accept the REDD readiness project and to proceed towards REDD implementation. See Forrester-Kibuga et al. 2011.
Community level, participatory project design and social impact assessment workshops with community representatives Three–day social impact assessment workshops were held in all villages involving an average of 29 people per village including representatives from all sub-villages, village elders, village leaders, at least one village natural resources committee member and different forest users including herbalists. On average 9 out of the 30 participants were women.The workshops initiated a theory of change approach to social impact assessment. Steps taken during these meetings included: participatory mapping of high conservation values; development of with and without REDD scenarios; identification of REDD project objectives and activities; validation of lists of internal and external stakeholders; community recommendations on a conflict resolution mechanism. The results of the workshops are synthesised in Mwampamba et al. 2011.
Participatory social impact assessment workshop at landscape level involving community representatives and other stakeholders The village level workshops were followed by a workshop at District level involving representatives from all villages plus other stakeholders. The objective of the workshop was to a) verify the information gathered at the village workshops and validate the post-workshop synthesis and analyses, b) identify key project activities needed to fulfil the long-term social objectives i.e., Phase 2 of the REDD project, c) agree on the conflict resolution mechanism and communication strategy; d) document plans by stakeholders external to the communities on relevant initiatives, including local government plans, to feed into the with and without project scenarios; and e) with workshop participants, identify the intended and unintended social consequences of project activities. The principal approach for conducting Stage 4 of the SIA was the Open Standards for the Practice of Conservation's theory of change (or causal model) approach. Open Standards (OS) are a set of standards that "provide the steps and guidance necessary for successful implementation of conservation projects" (CMP, 2007). The objectives and activities agreed upon by stakeholders during these planning workshops form the basis for the design of the REDD implementation process as outlined in Sections G 3.1 and G 3.2. The workshop report is available as supplementary material (Luwuge et al., 2011) and the results are synthesised in Mwampamba et al. 2011.
Consultation meetings with community leaders on village land use planning, participatory forest management and REDD A process of integrated village land use planning, establishment of community based forest management and REDD readiness was initiated in all villages. This involved introductory meetings with the Village Land Use Management (VLUM) committees, the Village Natural Resources Committees

(VNRC), the Village Councils and elders on potential REDD revenues, principles of REDD and climate change, natural resources policies, land use planning principles and procedures, community based forest management principles and procedures and REDD benefit sharing by-laws.
Community consultation meetings on proposed REDD readiness activities Meetings were then held in each village with the Village Assembly on linkages between REDD, village land use planning and community based forest management; and signing of an MoU between the community and the project to document roles and responsibilities in relation to REDD readiness. This was another key step in ensuring free, prior and informed consent. All villages included in this PDD agreed to proceed and signed an MoU with the project consenting to proceed with REDD readiness activities. These are available as supplementary material.
Community-led land use planning, village forest reserve establishment and REDD by-law development The village land use planning and CBFM establishment processes then proceeded. The approach taken aimed to ensure that all of the required steps were followed as per government guidelines. An integrated approach was adopted whereby the two processes, which are often implemented separately, were well integrated. In each village the process was led by the community representatives with technical support from local government staff and facilitated by TFCG and MJUMITA field teams (see Luwuge et al 2011a for a detailed description of this process). Steps that were taken included:village boundary review, participatory rural appraisal, forest utilization assessmentdevelopment of community action plan.Verification of village boundary beaconsReach consensus with neighbouring villages on location of village boundaries.Data collection to map the current land usesForest walks and forest sample plot assessmentMeeting to prepare drafts of the village land use plan and by-laws, village forest reserve plan and by-laws and the REDD benefit sharing by-laws.Draft REDD, VLUP, VFR plans and by-laws presented at sub-village level for consultation.VNRC, VLUM and Village Council REDD meeting to address issues raised at sub-village level and revise by-laws and plans accordingly.Village Council meeting to present draft village land use plan and by-laws; draft VFR management plan and by-laws; draft REDD benefit sharing mechanism by-laws; and service provider agreement between community and MJUMITA.Mapping of village forest reserve boundary, forest management units and land use classes for incorporation in final land use plan and VFR maps involving selected members of the VLUM and the VNRC.Village assembly meeting to present REDD benefit sharing by-laws; select REDD benefit sharing committee; present the draft VFR management plan, by-laws and map; present the draft Village Land Use plan and by-laws; and present and sign the MJUMITA - Village service provision agreement; describe the payment procedures for initial payment; and identify community development projects from initial payment. Based on comments at the village assembly meetings, corrections were then made to the maps. In some cases this was quite a lengthy process. Similarly, in some cases the project facilitated a more extensive consultation and conflict resolution process regarding the village boundaries.Once approved at the village level and once the maps were finalised, The documents were presented to the Ward Development Committee; the District Lawyer and the District CMT. Additional comments were then incorporated. These mainly related to the maps. From there they were submitted to the District Council for approval. Once approved they were submitted for signing by the District Commissioner and once signed were returned to the respective villages.

Community consultation and planning on REDD payment mechanism and piloting of the REDD payment mechanism Once the plans and by-laws had been approved at village level, training was provided to the REDD special committee on the REDD payment procedures. This included calculating the dividend to be paid to each resident. The total sum to be paid to each village was based on the calculations of potential emission reductions, proportional to the area of forest to be conserved and the historical deforestation rate and based on a conservative per ton price. This was then divided by the number of residents. The REDD committees were then responsible for ensuring that a complete list of the residents of the village was in place; and that proposals on community development projetcs were prepared. On the payment day, further information on REDD was provided and communities again had an opportunity to provide or withdraw their consent to proceed towards REDD implementation. At the time of the first payment Kiwawa Village withdrew their consent at this stage. However following further consultation over a four month period and a conflict resolution process related to the village forest reserve boundary, the village consented to proceed and a REDD payment was made. In each village, people were required to make a contribution from their REDD payment to forest management costs and, in some cases, community development projects based on a vote by the Village Assembly. In each village, the REDD payment was followed by a participatory evaluation of the process involving village representatives and the results of that consultation were integrated in a revised REDD model. Changes made were to ensure that some funds be set aside to pay for forest management activities by the Village Natural Resources Committee and to pay for the work of the REDD committees in preparing for the payments. A more detailed description of the REDD payment model is available in GL 2.6.
Stakeholder consultation and evaluation involving community representatives and other stakeholders Following the trial REDD payments, a stakeholder workshop was held to generate feedback on the REDD readiness activities and on the proposed REDD implementation model. This was attended by community representatives, local government officials, Ward Councillors and the Member of Parliament. Key issues raised during the meeting included the need for the local government to accelerate the process of approving the by-laws and plans developed by the communities; and the need for greater cooperation in resolving village boundary conflicts. Comments were also provided regarding the REDD model including the need to clarify the role of the District. The project also faciliated the Lindi District Council Economic and Environment Committee members to visit six of the project villages in November 2012 in order to ensure that local government leaders were informed and had the opportunity to provide input into the process.
Strengthening community land tenure by securing village land certificates Requests for village land certificates were submitted to the Ministry of Lands and requests for boundary revisions were also submitted where resolutions had been made to change village boundaries following extensive consultation with the affected villages. The project has been making close follow-up on this.
Community level awareness raising on implementation of village land use and forest management plans. Awareness raising events to remind people about the land use plan and the village forest reserve.
Community consultation and participatory development of MoU between MJUMITA and the

communities Meet with the Village Council and REDD special committee to develop an MoU between the village and MJUMITA outlining the roles and responsibilities of the two parties in relation to the REDD implementation phase including allowing MJUMITA to represent the communities in the CCB and VCS validation and verification processes; and in negotiations with potential buyers of the verified emission reductions.
Community training on roles and responsibilities Training to VLUM and VNRC (plus V Chair and VEO) on implementation of CBFM and VLUP (3 days) including training on roles and responsibilities of different stakeholders; training on relevant policies and laws; familiarisation with VLUP and VFR plan; preparation of monitoring plan, budget and work plan for CBFM; preparation of monitoring plan, budget and work plan for village land use management; and field visit to selected land use boundaries. And distribute relevant training materials.
Community consultation and request for written consent to proceed with REDD implementation The memoranda of understanding were presented to the Village Assembly and where approved, the MoUs were signed in May 2013. These are available as supplementary material.
Stakeholder meeting in Lindi to present PDDs On 4th February 2014 a stakeholder meeting was held in Lindi involving 91 participants including Village leaders from 10 villages, ward and divisional leaders, Ward Councillors, district and Municipal officials, Executive Directors from the District and Municipal councils, the District Commissioner and Member of Parliament, journalists and project officers. During the meeting presentations were made on the CCB and VCS PDDs; hard copies of summary documents were circulated; and there was an opportunity for comments and discussion (see Mbegu, 2014).

The processes described above focuses on the consultation at community and project area level. TFCG and MJUMITA have also been consulting with national level stakeholders including the National REDD task force, representatives of the National Carbon Monitoring Centre, the Land Use Planning Commission and the Tanzania Forest Service. A project advisory committee with representatives from the Vice-President's office, Ministry of Natural Resources and Tourism, Sokoine University of Agriculture, Prime-Minister's Office for Regional and Local Government, Lindi District Council, Lindi Regional Natural Resources Office and other civil society organization including CARE, WWF and the Mpingo Conservation and Development Initiative have met on a biannual basis to review progress on REDD readiness activities. Their comments and advice have also been included in the project design.

Consultations and participatory process have involved village assembly meetings open to all adult residents of a village; meetings with elected village councils and village natural resources committees; meetings at sub-village level; and meetings with specific groups including women and charcoal producers. The Village Assembly and the Village Council are considered to be the legitimate forums for community consultations based on Tanzanian tradition and the Local Government (District Authorities) Act, 1982 which states that:

'*141. A village assembly is the supreme authority on all matters of general policy-making in relation to the affairs of the village as such, and shall be responsible for the election of the village council and the* *removal from the council of any or all of the members of the council, and for the performance of any other functions conferred upon it by or under this Act or any other written law.*

142.-(l) A village council is the organ in which is vested all executive power in respect of all the affairs and business of a village.

(2) In addition to any functions conferred upon it by or under this Act or any other written law, a village council shall

(a) do all such acts and things as are necessary or expedient for the economic and social development of the village;

(b) initiate and undertake any task, venture or enterprise designed to ensure the welfare and well being of the residents of the village;

(c) plan and co-ordinate the activities of and render assistance and advice to the residents of the village engaged in agricultural, horticultural, forestry or other activity or industry of any kind;

(d) encourage the residents of the village in undertaking and participating in communal enterprises;

(e) to participate, by way of partnership or any other way, in economic enterprises with other village councils.'

Where consultation has been through community representatives, the project has involved the Village Chair and / or the Village Executive officer with a preference for the Village Chairperson as the elected representative. The project has also involved the Ward Councilors as the elected community representatives on the District Council; and the Member of Parliament. During the village land use planning and village forest reserve planning, the project worked with the elected village natural resources committees and village land use management committees. For the REDD payments and by-law development and implementation, the project has worked with the elected, village REDD committees.

The project has also used a suite of communication tools including radio, video shows, project newsletters, posters, meetings and leaflets in Swahili to ensure adequate levels of information sharing with different stakeholders. These have included posters describing the MJUMITA Carbon Enterprise model which have been distributed in all villages; a documentary in Swahili explaining about the principles of REDD and presenting different community perspectives on REDD; regular radio programs on conservation agriculture; summaries of the CCB PDD, monitoring plan and 1st Project Implementation Report.

It is important that measures are in place to enable effective participation of all communities, including all the Community groups beyond the project design phase. Annual village assembly meetings will be held in each village involving all adult residents to review progress towards achieving the projects climate, community and biodiversity benefits; and to decide on the distribution of REDD revenues. As village assembly meetings are open to all residents of a village, these meetings will be open to all community groups within the respective villages including women.

In interactions with MJUMITAg going forward, communities will be represented by their village chairperson and two other representative chosen in village assembly meetings, at least one of whom will be a woman. These three representatives from each village will form the core of the project executive committee in charge of overseeing the implementation of the MOU between MJUMITA and the participating villages. The village members of the committee will review, change, and approve budgets proposed by MJUMITA to cover costs associated with MRV and marketing. The committee will also review the monitoring reports compiled by MJUMITA and the village level performance reports and portions of REDD revenue awarded to each village. In the event that a significant amount of leakage is detected outside of the project area, as per the MOU, the committee will identify the responsible village so that the leakage can be included in estimates of their performance. The village representatives on the executive committee will also be responsible for presenting this information to their village assemblies.

The executive committee will also include members with an advisory role, including representatives from the districts chosen by the district executive director, the executive director from TFCG, a representative from the Forestry and Nature Conservation department of Sokoine University of Agriculture, and a representative from the vice president's office dealing with national level REDD issues. To enable the committee to be able to make informed decisions, all of the executive committee members will receive training on REDD MRV, including basics of remote sensing and GIS that will be used by MJUMITA to monitor performance and report to VCS and CCB.

Additionally, during the startup phase of the project and continuing through out the project implementation phase, MJUMITA has and will continue to rely on phone conversations between the MJUMITA carbon enterprise coordinator and village leaders, MJUMITA members, and elected community communication agents (who are provided with a phone and airtime by MJUMITA) to gather information about project implementation progress and challenges.

TFCG and MJUMITA have and will continue to use a series of different communication channels to share full and summary project documentation. These are described below:

Internet –website the project design document has been submitted to the Climate, Community and Biodiversity Project Standards for posting on their website for public comment. It is also posted on the TFCG website. TFCG and MJUMITA will circulate an e-mail through the REDD pilot projects and the Tanzania Forest Working Group list serves to publicize the public comment period. Several of the supplementary documents are already available on the project's website including the project's policy on GMOs; the biodiversity survey report for the area; the social impact assessment; and the project's agricultural strategy.

Meetings with local stakeholders – the project model as outlined in this document has been presented to communities through various forums including the landscape level social impact assessment workshop; the landscape level participatory evaluation workshop held in November 2012; and the village assembly and village council meetings to present the REDD model in each village. During each of these events, there has been opportunity to discuss the proposed model for REDD. In addition a stakeholder meeting was held on 4th February 2014 in Lindi with representatives from all of the participating villages as well as local government staff and leaders at which the PDD was presented and there was an opportunity for questions and comments. Community stakeholders will continue to have an opportunity to make input in the project during village assembly meetings to discuss the use of REDD revenue and through their elected representatives to the executive committee. All meetings were and will continue to be conducted in Swahili.

Printed materials – the project has distributed posters in all participating villages that document the project's REDD model. A summary in Swahili of the CCB PDD was presented to communities during the stakeholder meeting on 4th February 2014. Representatives from all villages as well as Ward Councillors and District Officials including the District Commissioner and District Executive Director were presented with a hard copy summary. The hard copy summary included a translation of Sections G1.1-9 plus summaries of sections G 2, 3, 5 and 8; CM 1 – 3; B 1 – 2; GL 1- 3. Similarly a summary of the 1st project implementation report was presented in hard copy and as a presentation followed by discussions on 04/02/2014. Please refer to the PDD Stakeholder Consultation Workshop report (Mbegu, 2014). Hard copies of the full PDD were presented to the District Executive Directors for Lindi and Lindi Municipal; and were available for stakeholders to access at the TFCG Project Office in Kinyope Village as well as at the TFCG Head Office in Dar. Registers for recording comments will be made available and comments will be provided to the Validators.

Conflict resolution and Grievance redress procedure

Through consultation with stakeholders at village and landscape level (see Nguya 2011 and Mwampamba *et al.* 2011) conflict resolution mechanisms and grievance redress procedures were identified. MJUMITA aimed to find mechanisms that are fast; easy to understand; transparent; accessible; and without risk of retribution. Given that REDD will be community-led, it was recommended that the conflict resolution procedures for REDD should follow the same procedures as are in place for other conflicts within the District. It was agreed that the normal procedures should be applied in case of any conflicts within communities or between communities. This will ensure that community members are familiar with the processes.

Within communities conflicts are addressed either by the Village Council or one if its committees. In the case of land disputes within communities, the Village Lands Tribunal is responsible; whilst issues related to natural resources management are the responsibility of the village natural resources committees. If the committees are unable to resolve the issue, or for other issues, then the conflict can be presented to the Village Council, Village Elders and / or the Village Assembly. If the Village Council is unable to resolve it, then issues can be taken to the Ward Development Committee.

For conflicts between communities, the District Council is responsible for intervening. Again the office responsible will vary depending on the nature of the conflict. Where government staff are unable to resolve a conflict, it may either be taken to the District Executive Director or to the District Commissioner to resolve.

Whilst these mechanisms apply to conflict resolution within and between stakeholders, it was recognized that clear feedback and grievance procedures are also needed to address grievances between the communities and MJUMITA.

The first stage of the grievance procedure is for communities or other stakeholders to raise an issue of concern with MJUMITA either by writing to the Site Leader; or the MJUMITA Executive Director; or by communicating with them verbally. At this stage an amicable resolution is sought and a response is provided in writing by the project. The process should not extend beyond two months.

For stage two of the grievance procedure, communities were asked to identify a neutral third party who is well-respected, trusted and freely available, to act as a mediator and to facilitate a resolution process in situations where the first stage has failed to reach a solution. Proposals included the Ward Development Committee, the District Commissioner, the Court and the District Executive Director. The participants in the landscape level SIA workshop in 2011 agreed that the District Executive Director should be the independent third party with the final say in the resolution of any conflicts between a community and the project. However it was acknowledged that, where possible, conflicts could also be mediated by the Ward Development Committee, or the Court. The procedures are detailed in the MoU between MJUMITA and the communities (see Annex 2). This procedure was presented at the workshop on 04/02/2014.

If the second stage of the grievance procedure fails then the issue would be referred to the District Court.

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MJUMITA COMMUNITY FOREST PROJECT (LINDI)

METHODOLOGICAL ANNEX

This is the main methodological annex to the Verified Carbon Standard Project Description of the MJUMITA Community Forest Project (Lindi). The project uses the "Methodology for Avoided Unplanned Deforestation" (VM0015, Version 1.1) approved by VCS on December 3rd, 2012. The methodology provides its own template for demonstrating compliance with the methodology, which the project has completed in the following methodological annex.

Version: 1.2 (20-February-2015)

ACRONYMS

AFOLU	Agriculture, Forestry and Other Land Use
AUDD	Avoided Unplanned Deforestation and Degradation
CDM	Clean Development Mechanism
CGIAR	Consultative Group on International Agricultural Research
DEM	Digital Elevation Model
DLF	Displacement Leakage Factor
EI	Effectiveness Index
GHG	Greenhouse Gas
GIS	Geographic Information System
IFM	Improved Forest Management
IFM-RIL	Improved Forest Management - Reduced Impact Logging
lat/lon	Latitude and Longitude
MCDI	Mpingo Conservation and Development Initiative
MCFPL	MJUMITA Community Forest Project (Lindi)
MJUMITA	Mtandao Wa Jamii Usimamizi Misitu Tanzania (Tanzania Community Forest Network)
NGO	Non-Governmental Organization
PD	Project Description
REDD	Reducing Emissions from Deforestation and Forest Degradation
SRTM	Shuttle RADAR Topography Mission
tCO2e	Metric ton of carbon dioxide equivalent
TFCG	Tanzania Forest Conservation Group
UNFCCC	United Nations Framework Convention on Climate Change
VCS	Verified Carbon Standard
VM	Verified Methodology
VNRC	Village Natural Resource Committee
WGS	World Geodetic System

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* Tables used in the VM0015 v1.1 methodology template are labeled as VM Table (number), while supplementary tables not part of the template are labeled as Table (letter).

ADDITIONAL TABLES

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LIST OF EQUATIONS*

* Equations from the methodology template are referred to as equation VM (number) and follow original numbering in the template. New equations not in methodology template are referred to as equation (letter).

ADDITIONAL EQUATIONS

PART 1 – SCOPE, APPLICABILITY CONDITIONS AND ADDITIONALITY

1 SCOPE OF THE METHODOLOGY

VM0015 is for estimating and monitoring GHG emissions of project activities that avoid unplanned deforestation. It does not include accounting for avoided degradation. The MJUMITA Community Forest Project (Lindi) falls within this scope as an AFOLU project in the Avoided Unplanned Deforestation and/or Degradation (AUDD) category that does not intend to account for avoided degradation.

Baseline activities, which include deforestation of old-growth and secondary forests with highly limited logging and project activities, which include protection with controlled logging (highly limited), and charcoal production (highly limited) fall within the scope categories D and H of the methodology (see VM Table 1).

VM Table 1. Scope of the methodology

			Project Activity	
			Protection with logging, fuel wood collection or charcoal production	Protection with controlled logging, fuel wood collection or charcoal production
BASELINE	Deforestation	Old-growth without logging	A	B
		Old-growth with logging	C	D
		Degraded and still degrading	E	F
		Secondary growing	G	H
	No-deforestation	Old-growth without logging	No change	Degradation
		Old-growth with logging	IFM	IFM-RIL
		Degraded and still degrading	IFM	IFM
		Secondary growing	No change	Degradation

2 APPLICABILITY CONDITIONS

The project meets the applicability conditions of the methodology:

a) Baseline activities include unplanned deforestation as per the most recent VCS AFOLU requirements.

b) Project activities include eligible categories defined in VM Table 1.

c) All of the project area meets the Tanzanian definition of forest as submitted by the Tanzanian DNA to UNFCCC.

d) All of the project area has met the Tanzanian definition of forest at least 10 years prior to the project start date.

e) The project area does not include forested wetlands growing on peat.

3 ADDITIONALITY

As per the methodology, the additionality of the project is assessed using the most recent version (3.0) of VT0001 Tool for the Demonstration and Assessment of Additionality in VCS AFOLU Project Activities.

The tool requires 4 four steps to be applied:

a) Step 1. Identification of alternative land use scenarios to the AFOLU project activity

b) Step 2. Investment analysis to determine that the proposed activity is not the most economically or financially attractive of the identified land use scenarios; or

c) Step 3. Barrier analysis; and

d) Step 4. Common practice analysis

Step 1. Identification of alternative land use scenarios to the proposed VCS AFOLU project activity

In this step, alternative land use scenarios to the proposed VCS AFOLU project activities that could be the baseline scenario are identified through the following sub-steps:

Sub-step 1a. Identify credible alternative land use scenarios to the proposed VCS AFOLU project activity

Four credible alternative land use scenarios have been identified in line with the guidelines presented in the tool.

1. Continued conversion of communally owned village forest land to small-scale agriculture, primarily for annual cash or subsistence crops.
2. Conservation resulting from an NGO raising the funds necessary to implement all of the proposed project activities, including CBFM, from sources not related to carbon markets.
3. Conservation resulting from the establishment of a new national forest reserve.

Scenario 1 is the continuation of the pre-project (or business as usual) land uses. See Step 3 of Part 2 of this methodology annex for a complete description of this scenario. The other two scenarios require external sources of funding to support conservation activities and are things that have happened elsewhere in Tanzania within the past 10 years.

Sub-step 1b. Consistency of credible land use scenarios with enforced mandatory applicable laws and regulations

Prior to the project, none of the villages in the project had established village forest reserves or conducted land-use planning. Thus, conversion of forest to small holder agriculture was legal, except in the case of conversion of forest land to agriculture within 30 meters of a stream and farming on extremely steep slopes (hazard lands), which are illegal land-uses under the 2002 Forest Act and 1999 Land Act respectively. However, there is not a single documented case of these acts being enforced in the participating project villages prior to the start of the project and numerous examples of farmers clearing in stream valleys and on hazard lands. In fact, the historical deforestation analysis (see Step 2 of Part 2 of this annex) suggests that stream valleys are the preferred location for small holder farmers deforesting in the the vicinity of the project area.

In such cases when a potential land-use scenario does not comply with applicable laws and regulations, VT0001 requires that non-compliance with those legal requirements be prevalent in at least 30% of the smallest administrative unit that encompass the project area in order for the land-use to be considered plausible. In this case, the smallest administrative unit would be Lindi Region since the project area spans Lindi Rural and Lindi Urban districts. To access the prevalence of deforestation along streams, some reasonable sampling had to be done as there is no map of all of the streams in Lindi Region. Therefore, the analysis of deforestation within 30 m of a stream was limited to major streams, for which a GIS shapefile was available. This is reasonable because if this rule is not enforced along major water ways, it is even more likely that the rule is not enforced for minor water ways. Additionally, not all of the Region is inhabited, so it is difficult to access the enforcement of a rule where there is no threat. Instead, the sampling was done at the scale of wards. There ware 119 wards in Lindi Region and 61 of them overlap a major stream. High resolution imagery available from Google Earth was used to locate agricultural within 30 meters of major streams. If a farm was found, then the search shifted to a new ward. The search was not systematic and did not cover all of the wards. Once a sufficient number of clearings were detected to demonstrate that the law regarding cultivation near streams is not enforced across most of the region, the search stopped. The search revealed agricultural clearings within 30 meters of a major stream in 32 wards with a combined area equal to 50% of the region. Examples of agricultural encroachment in streams were found in all 6 of the region's districts. Shapefiles of the locations of agricultural encroachment in waterways, ward and district boundaries were shared with the validation body.

The 2002 Forest Act allows for the conservation activities in scenarios 2 and 3 to be established. Thus, all of the scenarios are consistent with enforced mandatory applicable laws and regulations.

Sub-step 1c. Selection of the baseline scenarios

Scenario 1, which is the continuation of the land-use trends of the 10 years prior to the project is the most plausible alternative land use scenario in the absence of this REDD project. While some of the land-use conversions are illegal under national Tanzanian law, these laws were in place during the 10 years prior to the project and the historical deforestation analysis demonstrates that they were not enforced. To justify the selection of Scenario 1 as the baseline scenario, the relative likelihood of each scenario is briefly considered.

Scenario 1: Continued conversion of communally owned village forest land to small holder agriculture, primarily for annual cash or subsistence crops.

All of the land in the project area prior to the establishment of the project was de facto open access village land. Village residents in the project area and in the rest of the reference region were free to clear as much forest as they were able to establish their farms. Furthermore, only through clearing forests could residents obtain customary ownership over the land, since they could not simply claim forested land as their own. Farmers in the participating project villages and in the wider reference region frequently clear new farms from the forest to avoid pests and weeds, and access more fertile soil. Due to the lack of capital and knowledge, farmers in the region do not engage in intensive forms of agriculture and are unlikely to come to adopt them in the future in the absence of the project.

The underlying drivers of deforestation are population growth and improved market access, both of which are likely to continue in the future. See Part 2, Step 3 of this methodological annex for a complete description of the drivers of deforestation in the region and a justification of their likely future trajectories.

Scenario 2: Conservation resulting from an NGO raising the funds necessary to implement all of the proposed project activities from sources not related to carbon markets (see section 1.8 of the project description for a complete description of project activities).

NGO's in Tanzania, including MJUMITA and TFCG, have been successful in obtaining funding for a wide range of conservation activities related to establishing community based forest management (CBFM) in the absence of REDD. However, prior to REDD, CBFM in Tanzania has been about protecting and managing forest resources and environmental services that are important to communities and not carbon resources. Although sometimes traditional CBFM could accomplish REDD, usually it does not. When given the opportunity to establish a village forest reserve, communities typically decide to protect forests that they rely on for water, building supplies, cooking fuel, or medicinal plants. Communities that possess larger areas of forests than they need to secure these services prefer to leave most of their forest area available for future conversion to farming as that is the most economically viable use. A few large village forest reserves have been established in Tanzania, but all of them were established in areas with limited or no pressure for agriculture and substantial expected timber and or charcoal values. Finally, national land-use planning guidelines encourage reserving small percentages of village land as forest by recommending a formula to calculate a community's future agricultural land needs when planning how much forest to reserve. Thus, in the absence of the incentives from REDD, CBFM typically either causes substantial internal leakage within a village or results in protecting forests that were not under threat of deforestation in the first place. The experience of the project during establishment agrees with these findings. The project found that participating communities could only be convinced to put a majority of their remaining forest, and in particular forest areas that they would otherwise prefer to farm, under sustainable management after they learned about their potential earnings from REDD.

Scenario 3: Conservation resulting from the establishment of a new national forest reserve.

The government of Tanzania does occasionally establish new national forest reserves. However, the process of establishing new reserves in Tanzania is time consuming and expensive. To the knowledge of the authors of this project description, there has been only one new forest reserve (Derema Forest Reserve) created in the past 10 years in Tanzania and discussions about that forest within the government and conservation community preceded its creation by at least 10 years. Several new nature reserves were created during that time, but they were all created from existing forest reserves. To the knowledge of the authors of this project description, there have been no discussions within the national government about the creation of a new forest reserve or nature reserve in the project area.

Furthermore, even if a new protected area was established, it would not have resulted in the level of forest conservation anticipated to result from the project since leakage prevention activities do not accompany protected area creation in Tanzania.

Step 3. Barrier analysis

Following Step 1, VT0001 allows for either conducting an investment analysis or a barrier analysis. We elected for a barrier analysis. The analysis is used to establish whether the type of proposed project activity faces barriers that:

a) Prevent the implementation of this type of proposed project activity without the revenue from the sale of GHG credits; and

b) Do not prevent the implementation of at least one of the alternative land use scenarios.

Sub-step 3a. Identify barriers that would prevent the implementation of the type of proposed project activity.

a) Investment barriers

There are numerous barriers to implementing the proposed project activities in the particular project site. Chief among these barriers are the limited value of the forests in the project area other than in terms of REDD and the high pressure for expanding agricultural land. While these barriers would make it extremely difficult to convince the participating communities to engage in the proposed activities in the absence of REDD, they also mean that there would not have been a business case to make to donors for the funding necessary to even start the project. The donor money used to establish this project was specifically provided to launch a REDD project that would generate revenue for local communities through the sale of REDD credits.

b) Ecological conditions barriers

Another significant barrier to convincing communities to implement AFOLU activities is that communities in the project area are not currently experiencing any scarcity of forest resources on which they depend. The projected baseline scenario (see Step 4 of this methodological annex) would still leave each participating village with more than 500 ha of forest after 20 years of deforestation. It seems reasonable to conclude that the baseline scenario is unlikely to seriously disrupt ecosystem services and local subsistence use of the forest during the time scale of the project. Thus, in the absence of REDD, there is little upside for communities to engage in the project activities and in particular to commit large portions of their remaining forest areas to conservation.

c) Social conditions and land-use practice barriers

The abundance of forest land in the project area also means that community members would be unlikely to adopt the agricultural interventions promoted by the project since there is no need to engage in intensive agriculture when the expansive agriculture techniques that community members are already accustomed to can still be implemented.

Sub-step 3b. Show that the identified barriers would not prevent the implementation of at least one of the alternative land use scenarios (except the proposed project activity).

The barriers described in sub-step 3a actually facilitate rather than hinder scenario 1. The lack of a business case for community based forest management in the area both in terms of commercial and subsistence use means that it would have been unlikely for an NGO to receive the funding necessary to start the project and introduce the project activities. Thus, the business as usual scenario would have continued.

Meanwhile, the ecological conditions (abundant forests), tenure regime (open access), and traditional agricultural practices (low yield expansive slash and burn agriculture) would jointly prevent the adoption of land sparing intensive agriculture practices promoted by the project in the absence of REDD. With the incentives provided by REDD, communities have decided to change the forest tenure regime and limit the availability of open access forest land for agriculture, thereby generating demand for knowledge of more intensive agricultural practices. Therefore, none of the barriers described in sub-step 3a would prevent the implementation of scenario 1.

Step 4. Common practice analysis

A few large scale CBFM projects have been established by NGOs elsewhere in the country, but these NGOs targeted forest areas where there was little if any pressure for conversion to agriculture and there were substantial anticipated timber values. The two most successful examples of large scale CBFM projects (both of which have taken more than 10 years to establish and still have yet to earn substantial revenue from timber sales) are the Suledo project in Kiteto District and the Mpingo Conservation and Development Initiative (MCDI) in Kilwa district. The Suledo project is based in communities that are primarily pastoral and thus have little interest in converting the forest to agriculture[1]. The MCDI project works with villages that have very low population densities and large forest areas, and has specifically avoided trying to convince communities to protect forest areas that they plan to clear in future for agriculture[2]. At the same time, both of these areas are reported to have large stocks of *Dalbergia melanoxylon,* one of the most valuable woods in the world, as well as other valuable hardwood species. In sharp contrast, in the MCFPL area, most of the valuable timber has already been removed (see Step 1.3 of the methodological annex) and there is strong pressure to clear forest for agriculture (see Step 3 of the methodological annex).

Thus, the proposed AFOLU project activities do not represent common practice.

PART 2 – METHODOLOGY STEPS FOR EX-ANTE ESTIMATION OF GHG EMISSION REDUCTIONS

STEP 1: DEFINITION OF BOUNDARIES

1.1 Spatial Boundaries

1.1.1 Reference Region

At present, the Tanzanian government has no jurisdictional baseline or definite plans for the basis of possible future jurisdictional accounting. Therefore, we have elected to create our own reference region following the guidance of the methodology. The reference region (267,583 ha) consists of all woody cover within the reference region polygon (402,741 ha) (see Figure 1) continuously meeting the definition of forest from 1991 to 2001. Although the current Tanzanian definition of forest would have allowed short regenerative forests common in fallow lands in the reference region to be included, forests less than 10 years old at the start of the reference period were excluded from the reference region in order to make the reference region consistent with the project area, which by definition cannot include forests less than 10 years old at the start of the project. This is a conservative approach because the deforestation rates in fallows meeting the Tanzanian definition of forest are considerably higher than in older forests.

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1 See http://www.scribd.com/doc/176680253/Case-Studies-UNDP-SULEDO-FOREST-COMMUNITY-Tanzania for a description of the project and the participating communities.

2 MCDI is also developing a REDD+ project in their area aimed at reducing degradation from fire. During public presentations on the project, representatives of the project have repeatedly stressed that there are no opportunity costs in the forests in which they are working.

The forested part of the reference region is 6.4 times larger than the project area. The reference region size was limited due to the unique location of the project area with respect to forest types, forest tenure, and geography. Most of the coastal plateau forest areas to the north and south are now woody fallows or are in protected areas, while areas to the west are dominated by drier woodlands. The western boundary of the reference region corresponds to the Landsat scene used in the baseline analysis with the shortest western extent. The northern boundary is marked by the Mbwemburu river, which forms the boundary between Lindi Rural and Kilwa districts. The southern boundary corresponds to the southern most extent of PALSAR scenes used in the baseline analysis. Finally, the eastern boundary was drawn along the coast to avoid mangrove and coastal thicket that are not found in the project area. To ensure that the reference region only included forests under the same tenure regime as the project area, five national forest reserves were excluded from the reference region, as was Lindi municipality based on the ministry of lands 2007 survey map of the area.

After excluding the project area forests, the remaining forested part of the reference region (225,659 ha) is similar to the project area with respect to the three major criteria specified in the methodology as demonstrated below:

- **Agents and drivers of deforestation**
  - **Agent groups** – like the project area, the reference region consists of forest areas on rural village land where the deforestation agents are local residents and people from adjacent villages in border areas deforesting for small holder agriculture and in some areas charcoal production.
  - **Infrastructure drivers** – both the project area and the reference region include forests that are near and very distant to roads and settlements. The project area and reference region also include forests that are near and distant from the main highway running down the coast of Tanzania, which has been improved over the past 10 years. There was no new infrastructure added during the reference period or planned for in the next 10 years.
  - **Other spatial drivers expected to influence the project area –** there have been no other major spatial drivers within the reference region.
- **Landscape configuration and ecological conditions**
  - As required by the methodology, the landscape and ecological conditions within the non-project area parts of the reference region satisfy 3 of 4 possible similarity requirements with the project area. These are similarity of vegetation types, slope, and rainfall. The elevation range of the rest of the reference region forests only fell narrowly outside the range required to be considered similar to the project area. Elevation and slope data were derived from 3 arc second SRTM DEMs provided by CGIAR, while average annual rainfall data was derived from 30 arc second 1950 to 2000 monthly average precipitation data provided by www.worldclim.org. The vegetation map was derived from remote sensing as described in section 2 of this annex.
  - **Vegetation** – Both the project area and the rest of the reference region consist of coastal dry forest, coastal scrub, miombo woodland, and regeneration older than 10 years. There are no forest/vegetation types found in the project area that are not also present in the reference

region or vice versa. Thus the reference region meets the vegetation requirements of the methodology.

- **Elevation** – The non-project area parts of the reference region include areas that are lower and higher elevation than the project area [3]. Only 81% of the non-project area of the reference region is within the exact 1m elevation range of the project area (66 masl to 593 masl). However, 90% of the rest of reference region is within 50m of the elevation range of the project area (16 masl to 643 masl). Thus the reference region nearly meets the elevation similarity requirements.

- **Slope** – Rounding slope values to the nearest 1%, the average slope of the reference region excluding the project area (5%) is identical to the average slope value of the 99% least sloped parts of the project area. Thus, the reference region meets the slope requirements specified in the methodology.

- **Rainfall** – The average rainfall of the reference region excluding the project area (991mm) is within 10% of the average rainfall of 90% project area with the least amount of rainfall (991mm). Thus, the reference region meets the rainfall similarity requirements.

- **Socio-economic and cultural conditions**

  - **Legal status of land** – All of the land within the project area and the rest of the reference region is village land. There were no AFOLU related projects within the reference region or project area prior to the creation of this REDD project. Six national forest reserves were masked out of the reference region and project area.

  - **Land tenure** – All of the land within the project area and the rest of the reference region is under village ownership with customary rights assigned to community members who clear forests for agriculture. The Lindi municipality was masked out of the reference region.

  - **Land use –** The primary land use conversion within the reference region is conversion from forest to small scale agriculture to grow a mixture of cash and subsistence annual crops and is expected to be similar within the project area since such conversions have been observed within project villages. Deforestation agents in the reference region occasionally converted forests to tree crops (cashews, palm, or citrus) and this has also been observed within the project area villages, though the conversion of tree crops to non-forest is also occurring. Finally, charcoal production sometimes precedes the conversion to small-scale agriculture in communities nearest to Lindi town and this has been observed in the reference region including within the project area villages. All farming and most forest clearance activities are done using hand tools (axes, hoes, etc.) and this is expected to be similar within the reference region and project area. Farmers often fallow post deforestation for anywhere from 4 to 15 years, and this is reflected in the presence of regeneration following deforestation in the non-forest areas of the reference region and project area villages.

3 The higher elevation areas of the rest of reference region have lower population densities and are predominately woodland, which is not preferred for deforestation and thus including these areas actually reduces the observed deforestation rate for the reference region. They were included in order to balance areas of low road and population density between the project area and the rest of the reference region.

- **Enforcement policies –** prior to the REDD project, all of the reference region and project area were characterized by essentially no enforcement of land-use rules (such as clearing forests on steep slopes or clearing near or in streams) by either village or district officials. The forested areas of village land are treated as open access areas where any community member (and in some cases neighboring community members) are free to move in, clear, and establish a farm or make charcoal.

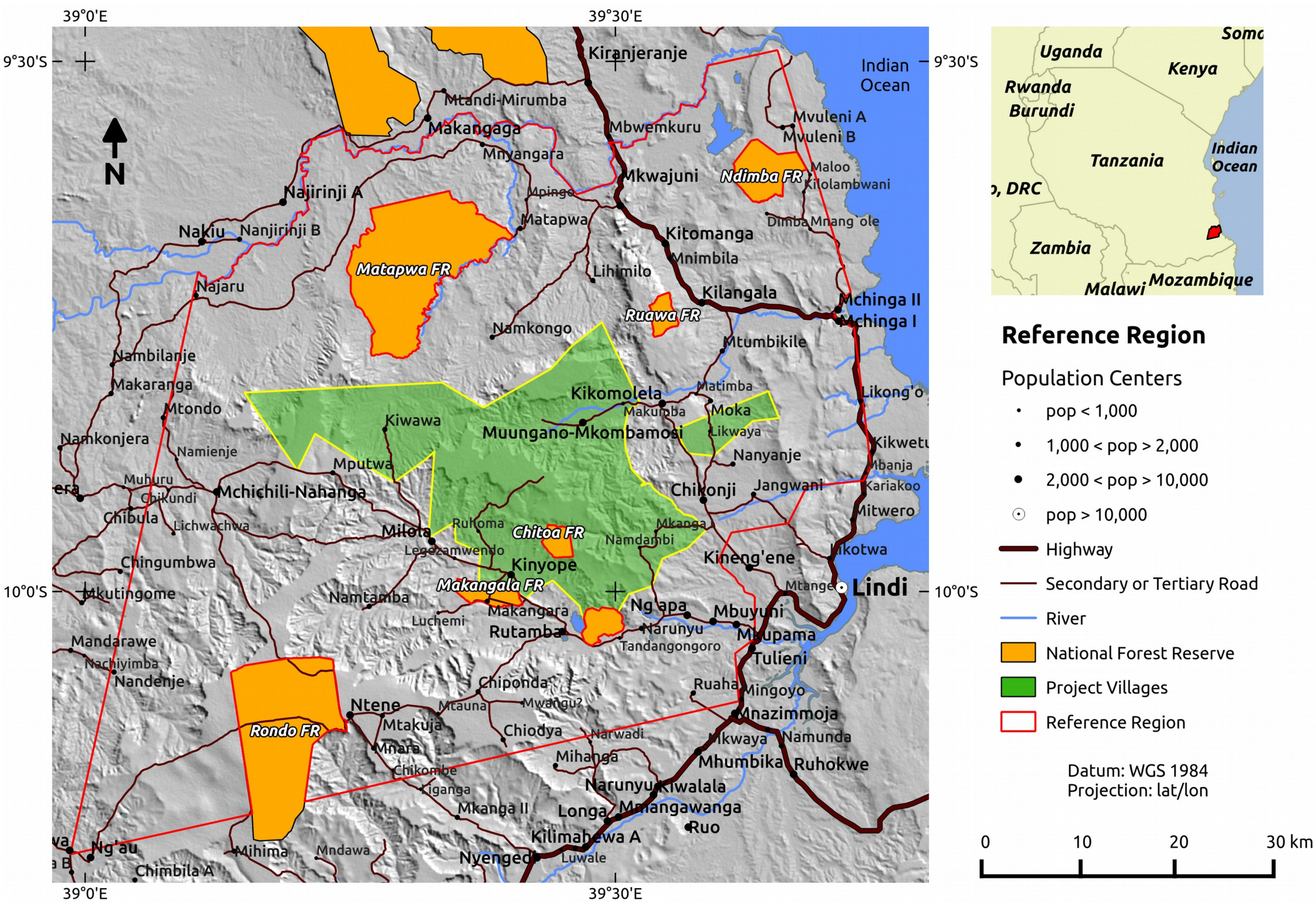

Figure 1: Map of reference region

1.1.2 Project Area

The project area (41,924 ha) (see Figure 2) includes all woody vegetation meeting the definition of forest in April 2012 within the village boundaries of the 10 participating villages with the exception of areas classified as non-forest in May 2001 or deforested between May 2001 and April. 2012.

Although all land within the village boundaries are under the authority of the village government, customary individual land tenure is recognized for farmland. Forest areas are seen as open access areas that can be converted to customary ownership if cleared for farmland. Under Tanzanian law, by establishing village forest reserves, village governments establish exclusive management rights to the forest and to revenue generated from the forest. Forests in village forest reserves can no longer be converted to customary tenure through clearance. Figure 3 shows the village forest reserves established as part of AUD activities. Overall, 67% of the project area forests were put into village forest reserves. When broken down by forest type (see Step 2.2 of this annex), 76% of high carbon forests were placed in village forest reserves and 49% of low carbon forests were placed into village forest reserves.

Forest areas within the project villages, but outside of the village forest reserves remain available for community members to convert to farmland and customary ownership, but are included in the project area because it is expected that the agricultural interventions, promoting of alternative livelihoods, and land-use planning undertaken by the project will reduce the deforestation rate in these areas as well (see section 1.8 of the VCS PDD for a full description of activities). Additionally, as participating villages have realized their potential earnings from REDD are lowered by the amount of forest they initially left out of their forest reserves, some have decided to expand their village forest reserves and this process is expected to continue. Finally, in other villages, the village assemblies have requested GIS support from the project to send the village natural resource committees to determine the responsible parties for all areas of deforestation in the village (both legal and illegal) so that only community members not engaged in deforestation will be eligible for REDD dividends. Thus, while forest areas outside the village forest reserves will not have the same level of protection as village forest reserves, the project activities will reduce emissions from these areas.

See section 1.4 of the VCS PDD for a full list of project proponents (villages) and their responsibilities.

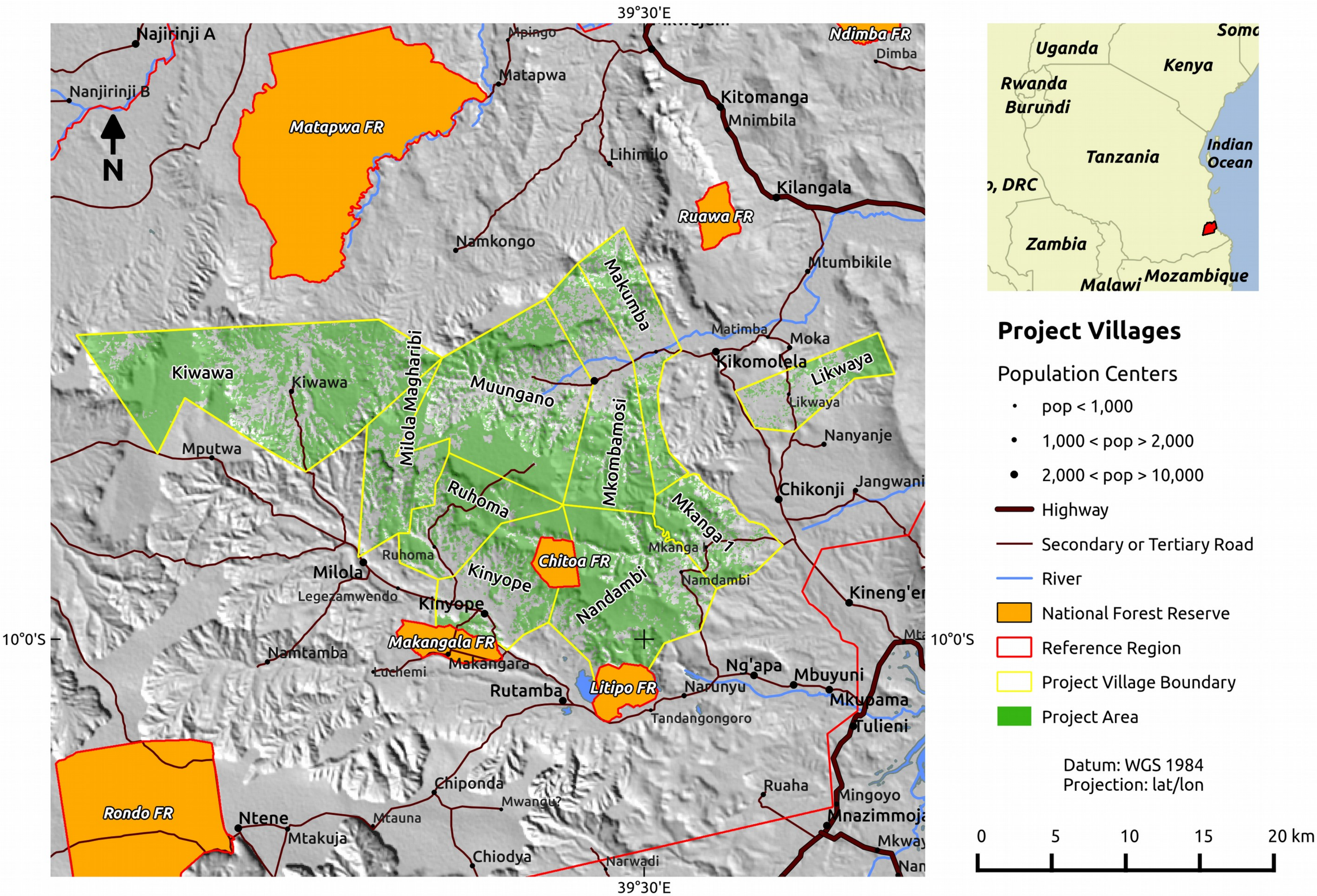

Figure 2: Map of project area (forest areas in project villages)

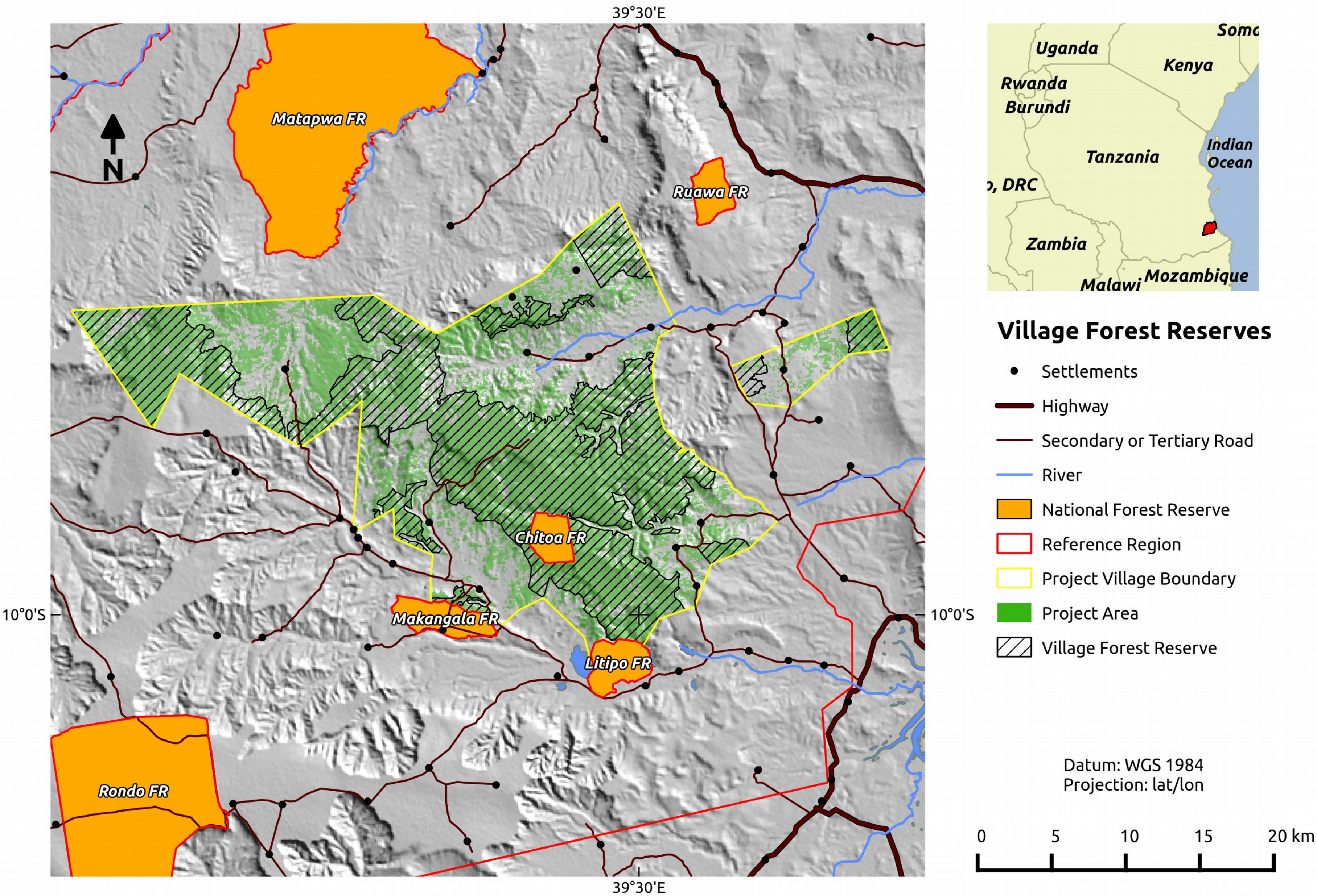

Figure 3: Map of village forest reserves

1.1.3 Leakage Belt

The project area is not part of a jurisdictional accounting program and therefore a leakage belt is required. There are no other AFOLU projects in the vicinity of the project area, so only leakage from the project area was considered. We chose the mobility approach to constructing the leakage belt because PFRA in the project area suggests that agriculture is the primary driver of deforestation in the area and that while almost all farmers earn some cash income from farming, a significant proportion (probably greater than 20%) of crop production is for household consumption. This assertion is supported by a ground survey by village natural resource committee (VNRC) members of deforestation detected by remote sensing between 2010 and 2012[4]. The VNRC members found that 92% of clearings were associated with maize cultivation, which is principally a food crop (though it can also be sold), and that sesame, which is exclusively a cash crop, was associated with only 27% of clearings.

We began the multi-criteria analysis for determining the leakage belt by examining possible constraints to the distance at which leakage was likely to occur. While deforestation in the reference region is more likely closer to human population centers and infrastructure, people are widely dispersed in the landscape and a significant portion of deforestation happens many kilometers from settlements and roads (also evidence that a significant portion of deforestation is not profit motivated). However, the mobility of deforestation actors does appear to be highly constrained by other factors.

The ground visits by village natural resource committee members to 52 areas deforested between 2010 and 2012 suggests that the mobility of deforestation agents within the reference region is limited. While only 58% of deforestation actors were from the village where the deforestation was located, due to the configuration of the forests in the project area, where most of the forest is bordered by villages participating in the project, only 33% of deforestation agents resided outside of a participating project village. All of the deforestation agents from outside the project area came from villages that directly border the project area and were no more than 2.7km from their home village boundary (and in most cases less than 1km). In all but two cases, the deforestation agents residing outside the project area were deforesting where boundaries were in dispute and, or where their home village center was actually closer than the center of the village to whom the forest belonged. Additionally, movement between villages is limited. In the same study, we found that only 5% of deforestation agents lived in their home village for less than 10 years, 10% from 10 to 29 years, and the remaining 85% of deforestation agents lived in their home village for over 30 years and, or were born there.

Thus, evidence from farmer interviews and the field suggests that the mobility of residents of the participating villages will be limited since they are unlikely to move to reside in a neighboring village and therefore are unlikely to deforest further than 2.7 km into neighboring villages. The mobility of the 33% of deforestation agents from outside the project area will be less constrained since they could deforest anywhere within their home village's land or even push up to 2.7 km into neighboring villages. However, we assume that mobility of all potential project area deforestation agents will have a linear relationship with distance to project area since that is where they are currently located or would come to be located in the baseline scenario.

As per the methodology, we used multi-criteria analysis to determine potential mobility and the extent of

4 VNRC members were provided with the location of deforestation between 2010 and 2012 entered into their GPS units and a paper questionnaire to record information about the clearing and the responsible parties. This exercise was part of the regular monitoring work undertaken by the VNRC and has not been written up as a separate study.

the leakage belt. However, rather than trying to determine the weights to apply to each criteria subjectively, we assumed the future deforestation probability map generated in step 4 of this annex already provided appropriate relative weights to all of the relevant criteria except for proximity to project area. Thus, the two criterion that facilitate mobility from the project area are proximity to the project area and the deforestation probability map generated in step 4 of this annex, which shows the areas most attractive for deforestation. However, since the weight applied to distance to project area could cause potential leakage to be projected into areas that had a very low probability of deforestation, we examined historical deforestation data to identify constraints to deforestation.

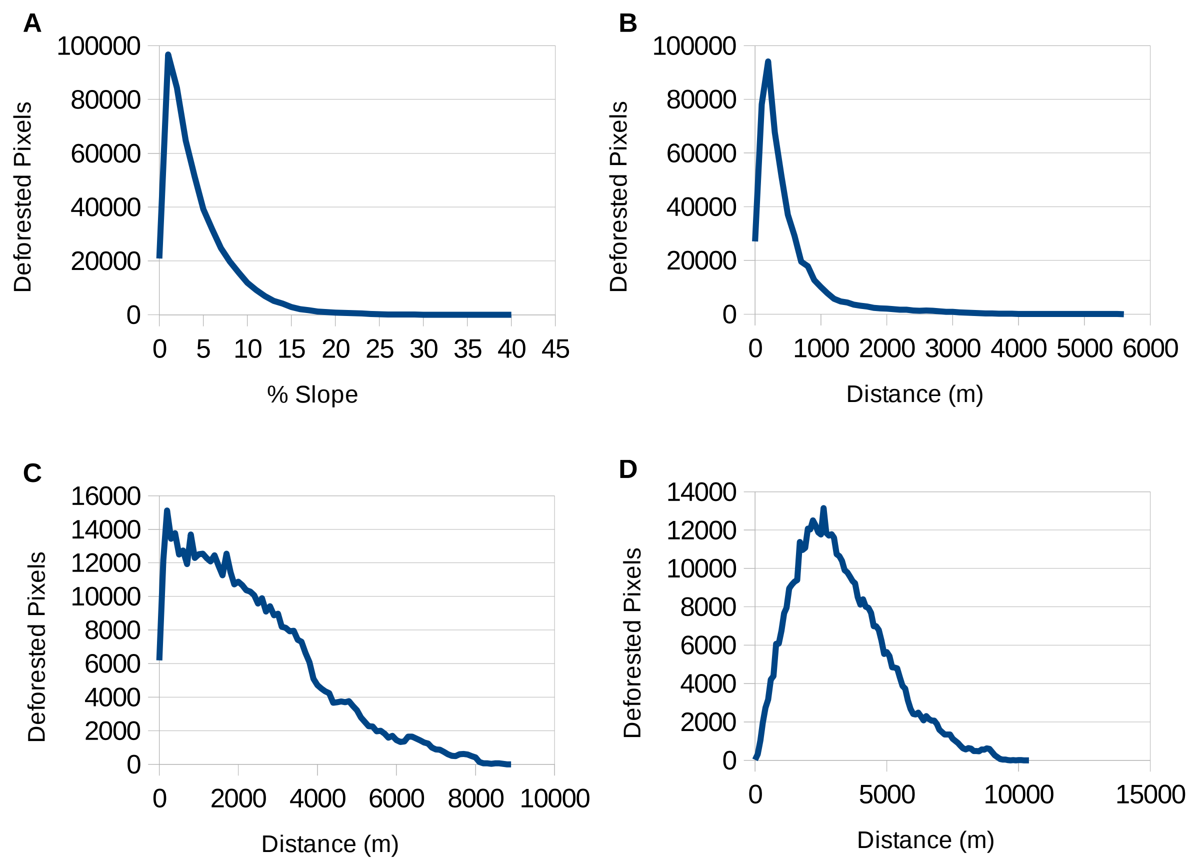

Figure 4: Count of deforested pixels from 2002 to 2012 by **(A)** % slope**, (B)** distance from 2001 to 2002 deforestation, **(C)** distance from roads**, (D)** distance from settlements.

Using the cross tab function the R raster package, we examined the relationship between deforestation from 2002 to 2012 and 4 variables likely to be associated with mobility, including percent slope, distance to deforestation between 2001 and 2002, distance to roads, and distance to settlements. To ease interpretation, we grouped the variable values into classes by rounding. Slope values were rounded to the nearest 1%, while distance values were rounded to the nearest 100 m. The cross tab results give the number of pixels deforested by the particular variable class. We present graphs of the cross tab results in Figure 4.

In some multi-criteria analysis for deforestation, relative frequency of past deforestation by class are interpreted as reflecting the relative preference of deforestation actors. However, this fails to account for the prior probabilities of encountering pixels and thus can lead to spurious interpretations. For instance, one might find that the number of pixels deforested at medium distances from settlements is greater than closer to settlements because there are fewer forest pixels remaining near settlements or simply because the perimeter at larger distances from a settlement will contain more pixels than at smaller distances. Thus, to get a better picture of deforestation preference, we divided the number of deforested pixels per variable class by the frequency of forested pixels in that class in 2002.

The probability graphs Figure 5 show some ups and downs for more extreme slope and distance values, but this appears to be largely noise caused by the low number of observations at these values. Overall, the probability graphs all show the same general trend, that deforestation becomes less probable at greater slopes and greater distances from recent deforestation, roads, and settlements.

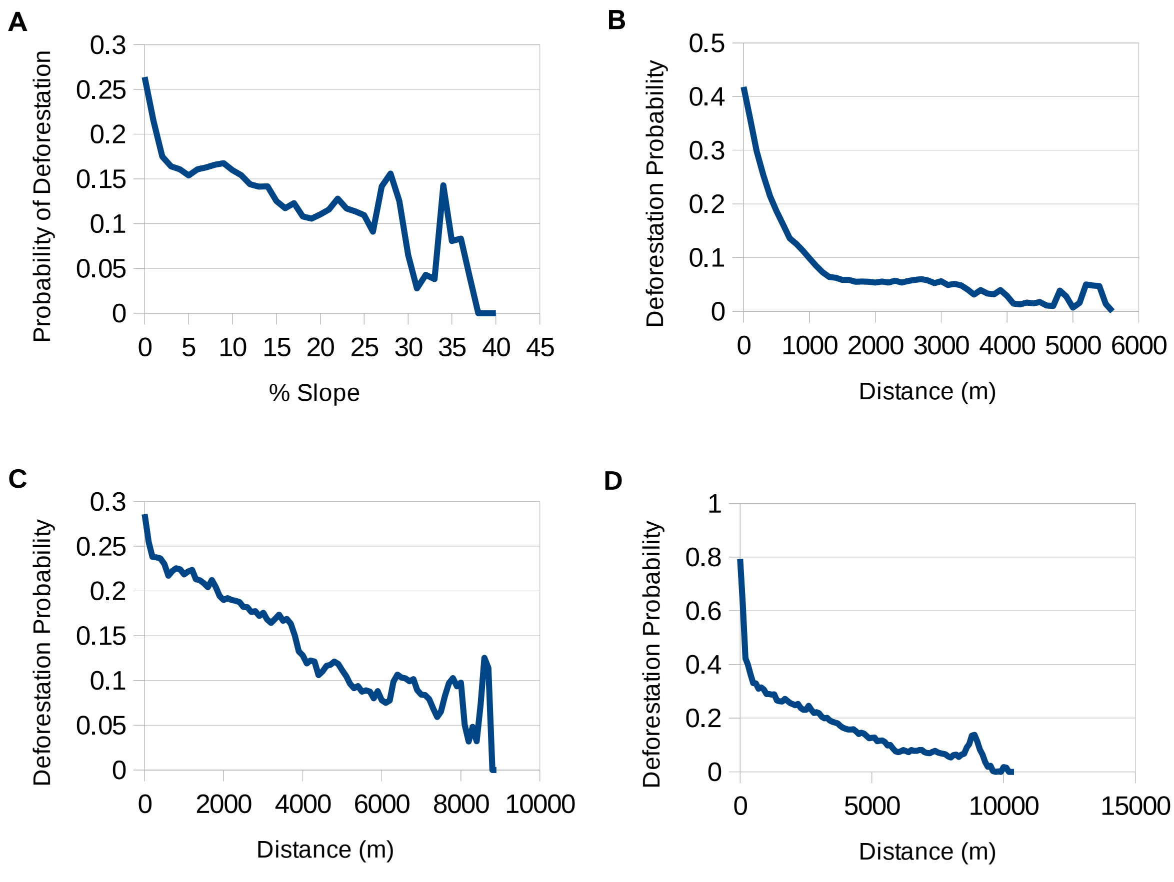

Figure 5: Probability of deforestation from 2002 to 2012 by **(A)** % slope**, (B)** distance from 2001 to 2002 deforestation, **(C)** distance from roads**, (D)** distance from settlements.

Therefore, it is appropriate to use a table of cumulative deforestation (presented as graphs in Figure 6) starting from 0% slope, or 0 meters distance from recent deforestation, roads, or settlements, to identify slope and distance values past which deforestation becomes relatively improbable. We chose 95% as the cut off point so that the largest slope, distance to recent deforestation, distance to roads, and distance to settlements values associated with less than 5% of historical deforestation would be considered improbable locations for projecting potential leakage. This is a conservative assumption because the probability graphs suggest that the actual probability of deforestation remains above 5% for even more extreme values. From the tables of cumulative deforestation, the 95% cut off points were 12%, 1650 m, 5700 m, and 6600 m for slope, distance to recent deforestation, distance to roads, and distance to

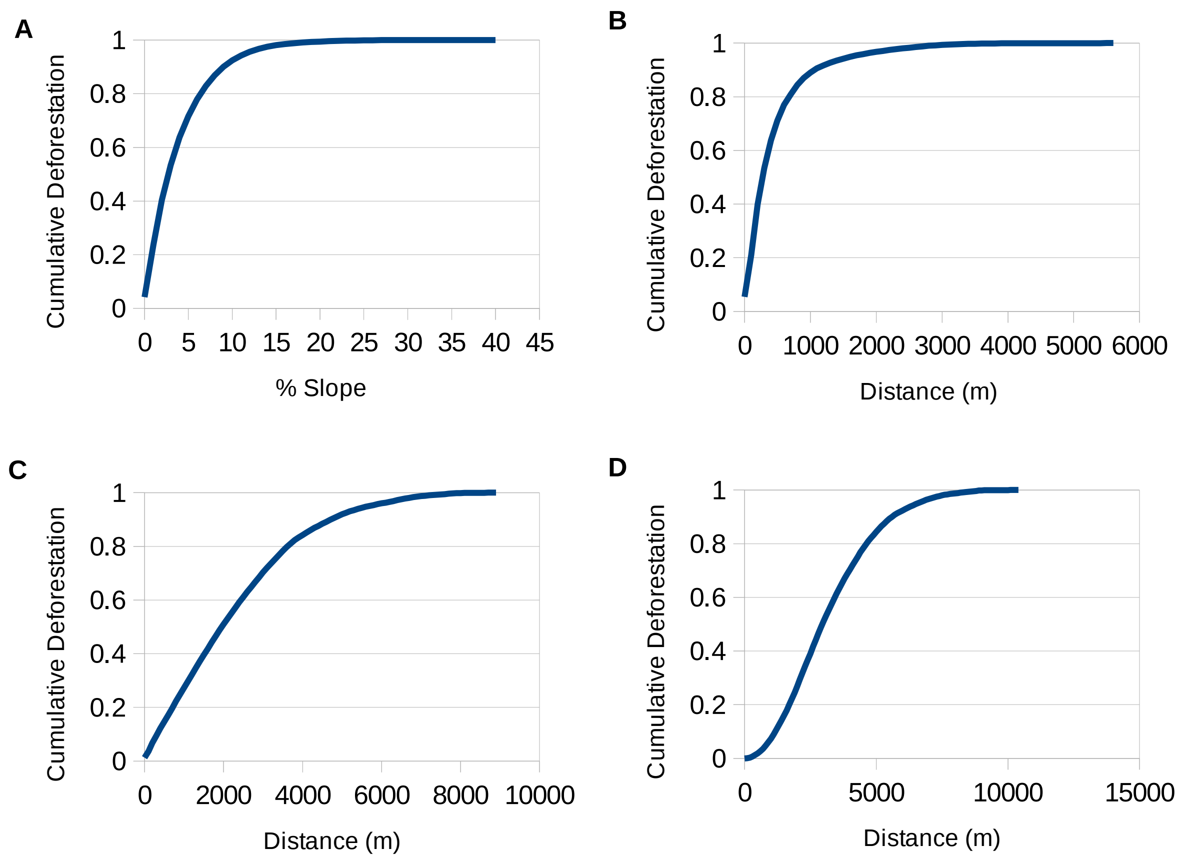

Figure 6: Cumulative deforestation from 2002 to 2012 by **(A)** % slope**, (B)** distance from 2001 to 2002 deforestation, **(C)** distance from roads**, (D)** distance from settlements.

settlements respectively.

We then applied the cut off points to 2012 data to develop constraints (masks) to prevent potential leakage from being projected into areas deemed to have a low probability of deforestation. Figure 7 shows slope, distance to 2010 to 2012 deforestation, distance to roads, and distance to settlements for forest areas in the reference region in 2012. Values above the cut off points identified in the cumulative deforestation tables are displayed in blue. Constraints (masks) were also applied to prevent leakage from being projected into the project area and into any non-forest areas within the reference region.

Finally, to determine mobility potential and the maximum extent of potential leakage, using a custom R script and the raster package, we performed the following tasks:

1. Rescaled the deforestation probability map from step 4 of this annex from 0 to 254 so that areas with the highest probability of deforestation had values of 254.
2. Rescaled a map of distance to project area from 0 to 254 so that areas closest to the project area had values of 254.

3. Combined the deforestation probability map and distance to project area map using the formula 0.33 * PM + 0.67 * D_PA, where PM is the probability map and D_PA is distance to project area (see next paragraph for explanation of choice of weights).
4. Masked out all non-forest areas in 2012, the project area, deforestation projected to occur in the baseline model between 2012 and 2022, and the areas (blue in Figure 7) deemed by the constraint analysis to be improbable locations of deforestation to create a final mobility probability map (Figure 8).
5. Created a frequency table of the masked mobility potential map from step 4.
6. Calculated the probability value from the frequency table where the number of pixels in probability classes greater than or equal to that probability was equivalent to the number of pixels projected to be deforested in the project area under the baseline model from step 4.
7. Created a raster with the potential leakage pixels (see Figure 9) selected from step 7.
8. Created a cross tab of the potential leakage pixels and the distance from project area map to determine the maximum extent of potential leakage.

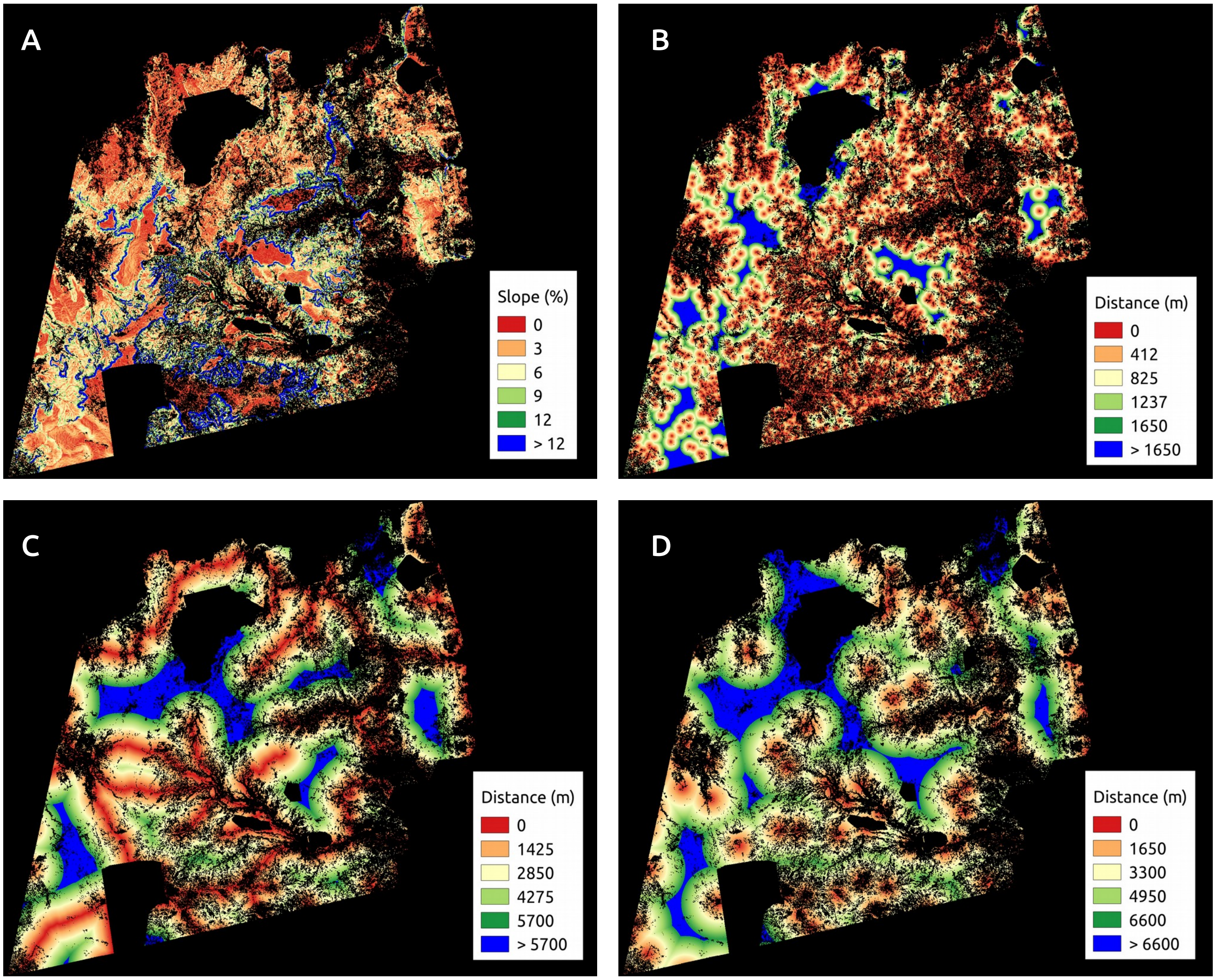

Figure 7: Reference region forest areas in 2012 displayed as (A) % slope, (B) distance from 2010 to 2012 deforestation, (C) distance from roads, (D) distance from settlements.

Selecting the appropriate weights to apply to the distance to project area and deforestation probability maps in step 3 was and iterative process. Since the exact preference for distance from the project area is unknown, we decided to choose weights that would force exactly 67% of the potential leakage to occur within 2.7 km of the project area. In other words, since no deforestation agents from outside the project villages were observed deforesting further than 2.7 km inside a project village, we assumed that the reverse would also be true and that deforestation agents from within the project villages that chose to shift their deforestation activities into neighboring villages would also not venture further than 2.7 km into the neighboring village. Since 67% of the deforestation agents reside within the project area, they would contribute to 67% of the potential leakage. By corollary we were also forcing 100% of leakage caused by the 33% of deforestation agents from outside the project area to occur at distances greater than 2.7 km (a conservative assumption), limited only by the interaction between distance to project area and the deforestation probability map.

We found that weights of 0.33 for the deforestation probability map and 0.67 for the distance to project area resulted in the expected pattern. The maximum distance that potential leakage was projected to occur was 6.1 km. Due to the inability to model the exact location of future deforestation in the baseline scenario with high spatial accuracy, we chose to define the leakage belt as all forests between 0 and 6.1 km from the project area, rather than just the potential leakage pixels identified in the analysis. Therefore, leakage will be defined as an increase in the deforestation related emissions from these forests compared to the baseline scenario projections.

The resulting leakage belt Figure 9 covers a forest area (59,453 ha) that is larger than the project forest area (42,194 ha), which is more than enough room to absorb up to 100% of projected baseline deforestation from the project area and the leakage belt over the next 10 years (the period for which the baseline is valid).

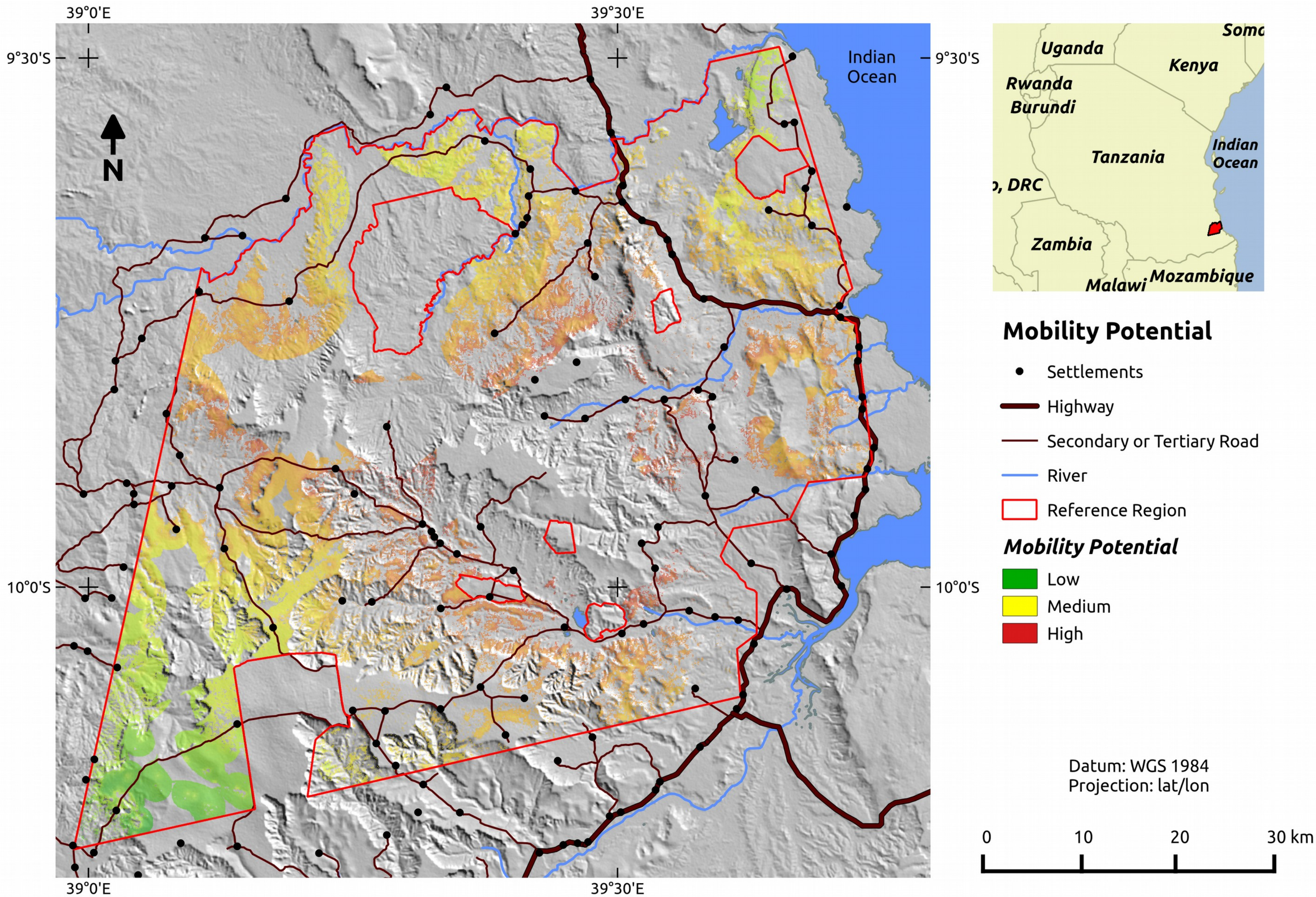

Figure 8: Map of potential mobility

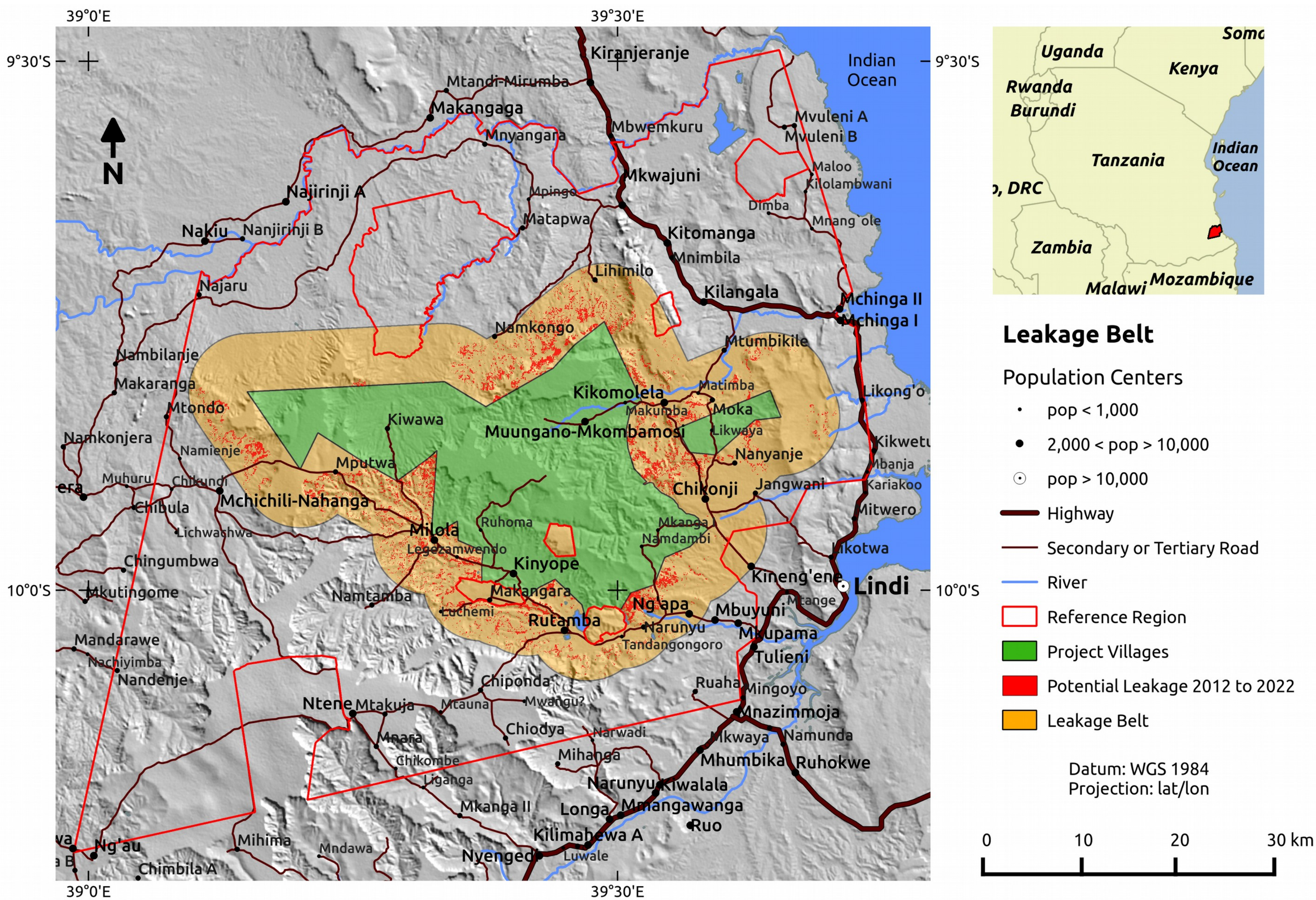

Figure 9: Map of leakage belt

1.1.4 Leakage Management Area

The project's leakage management areas consist of the non-forest areas in Figure 2 that are within the participating project villages boundaries. These are the areas where AUD activities related to improving agricultural yields and sustainability of yields are being carried out. For a detailed description of these AUD activities see section 1.8 of the project document.

1.1.5 Forest

The Tanzanian designated national authority selected the lowest possible threshold to define forest for CDM projects (at least 10% cover, 0.05 ha, 2 m height). Under this definition, in Lindi, some woody fallows as young as 4 years old meet the definition of forest. However, as the project area must only include forests older than 10 years, which are substantially different from young fallows, we used a two stage process to classify forests to ensure that the forest definition used in the reference region was consistent with the definition used for the project area. Due to the cloud cover, spectral similarity, and availability of corresponding high resolution imagery, we selected Landsat scenes from 2008 and 2001 as the two points in time to classify land cover. As per the Tanzanian definition, dense woody fallows at least 2m in height were classified as forest. Then, using change detection (see step 2 of this annex), we located areas classified as forest in 2001 and 2008 that were less than 10 years old and classified them as non-forest. Furthermore, areas of deforestation between 2008 and 2012, also detected with change detection, were classified as non-forest to arrive at an April 2012 map of forests older than 10 years. When mapping historical deforestation, a similar process was used to remove forests less than 10 years old from the start of the reference period using change detection from 1991 to 2001. Thus the minimum height of the areas classified as forest was closer to 5m (conservative relative to the Tanzanian definition) and consistent at both the start of the reference period and project period. Removing young regeneration from the reference region is conservative since the deforestation rate in young regeneration in Lindi is considerably higher than for older forests.

The minimum area required in the current Tanzanian definition is not mappable with Landsat data (and there are discussions at the national level about changing it). Therefore, as allowed by the methodology, we adopted a minimum forest area of 0.5 ha, which is the minimum mappable area with Landsat data.

For tree canopy cover, the project used the 10% cover as specified in the Tanzanian and FAO definitions. Adjustments were made when interpreting high resolution imagery, which tends to exaggerate canopy cover due to the angle of acquisition and by giving the appearance of solid tree cover where gaps in branches exist. Comparing higher resolution data with ground truthing suggested that 20% tree cover in high resolution imagery was closer to 10% cover on the ground. However, regenerating areas with less than 50% woody cover, were not distinguishable from grassland, and thus were classified as non-forest. Fortunately, open woody regeneration was rare.

Baobab trees were not treated as natural canopy cover because they are not detectable in May Landsat imagery (they don't have leaves in May) and are very rarely cut down. Baobab trees that fell within carbon measurement plots were not included in carbon estimates. We also hand digitized all areas of long term agroforestry in the project area and reference region using high resolution imagery and classified them as non-forest. Agroforestry was removed from analysis because it is difficult to accurately classify and a major source of false deforestation detection due to frequent clearing by farmers around trees that exposes bare soil and is spectrally indistinguishable from deforestation. Furthermore, crop trees are rarely converted to another land use and are under customary household ownership rather than communal village ownership like the rest of the project area.

1.2 Temporal Boundaries

1.2.1 Starting date and end date of the historical reference period

The historical reference period is from May 25th, 2001 to April 21st, 2012 and corresponds to the start and end dates of the imagery used in the historical land-use and land-cover change analysis in step 2 of this annex.

1.2.2 Starting date of the project crediting period

The project crediting period start date is April 21st, 2012. Although some project activities such as awareness raising and FPIC (free prior informed consent) began in 2010, the new land-use and village forest reserve bylaws passed by participating villages did not come into force until 2012. Furthermore, the first trial payment rewarding a community for having competed the REDD readiness activities was in November, 2011, while the rest were made in 2012. Therefore it was not expected that the project would have a significant effect on emissions prior to 2012.

1.2.3 Starting date and end date of the first fixed baseline period

The first fixed baseline period will be from April 21st, 2012 to April 20th , 2022.

1.2.4 Monitoring Period

Due to the nature of deforestation in the project area and the methods used to detect deforestation, deforestation must be monitored by remote sensing at least once every three years in order to ensure that all clearings are detected. The project intends to monitor deforestation annually and verify every one to two years.

1.3 Carbon pools

The methodology considers six carbon pools (Table 3). As per the methodology, the project plans to monitor all pools expected to undergo significant carbon stock changes.

VM Table 3. Carbon pools included or excluded within the boundary of the proposed AUD project activity

Carbon pools	Included / Excluded	Justification / Explanation of choice
Above-ground	Tree: Included	The carbon pool that will undergo the greatest change
	Non-tree: Excluded	No perennial non-tree crops are expected in the final land cover, thus this pool is conservatively excluded.
Below-ground	Included	Equal to approximately 30% of above ground biomass
Dead wood	Excluded	Optionally excluded as per the latest VCS AFOLU Requirements (v3.4).

Harvested wood products	Excluded	Not significant and thus excluded. See below.
Litter	Excluded	Not to be measured as per the latest VCS AFOLU Requirements (v3.4).
Soil organic carbon	Excluded	Optionally excluded as per the latest VCS AFOLU Requirements (v3.4).

Harvested wood products are excluded using the significance rule. Agriculture and, in a few villages, charcoal making, are the sole drivers of deforestation in the project area and agriculturalists seldom make timber from the areas they clear. Timber harvesting in the baseline scenario was highly selective targeting only a few commercially valuable species which are now largely depleted. Selective harvesting clearings associated with past timber harvesting outside of agricultural clearings would be too small to be detected as deforestation. Finally, a custom query of the carbon plot database revealed that less than 10% of carbon plots contained trees of the top 8 timber species (only 4 of which are preferred) large enough to make timber and the merchantable stem portion of these trees comprised only 5.8% of the above-ground biomass in these plots. Thus, even if every potential timber tree in a farm clearing and 100% of the merchantable stem were made into long lived wood products, these products would still comprise less than 1% (10% of plots * 5.8% of biomass) of just the above ground biomass.

Soil organic carbon, litter, grasses, and laying dead wood are conservatively excluded. Post deforestation land uses are variable in the region, but most clearings are only farmed for 1 to 2 years before being fallowed from 4 to 15 years. Thus, soil carbon losses in many instances may be minimal. Williams *et al.* 2007[5] conducted a study of the effect of conversion from miombo woodland to agriculture on soil organic carbon in Mozambique. They found that while intact woodland did have higher biomass on average, the result was not significant due to the large variability of soil carbon stocks in woodland.

1.4 Sources of GHG emissions

VM Table 4. Sources and GHG included or excluded within the boundary of the proposed AUD project activity

Sources	Gas	Included / Excluded	Justification / Explanation of choice
Biomass burning	CO_2	Excluded	Counted as carbon stock change
	CH_4	Included	Emissions from these gases will be reduced through a reduction in deforestation activities that involve biomass burning.
	N_2O	Excluded as per VCS	
Livestock emissions	CO_2	Excluded	Not a significant source as per the methodology.
	CH_4	Excluded	Emissions from livestock will not change in the with project scenario and are thus excluded. The project is not promoting livestock and it is not expected that there will be a significant increase in the number of livestock in the area in the project scenario compared to the baseline scenario.
	N_2O	Excluded	

5 Williams, M., Ryan, C. M., Rees, R. M., Sambane, E., Fernando, J., & Grace, J. (2008). Carbon sequestration and biodiversity of re-growing miombo woodlands in Mozambique. Forest Ecology and Management, 254(2), 145-155.

STEP 2: ANALYSIS OF HISTORICAL LAND-USE AND LAND-COVER CHANGE

2.1 Collection of appropriate data sources

VM Table 5 shows the Satellite imagery used to map historical land-use and land-cover change. Most imagery was acquired from USGS websites or viewed on Google Earth. We obtained Landsat 5 data from 2004 and 2006, which was missing in the USGS database, from CSIR, the authority in charge of the South African Landsat receiving station. We also received Spot satellite imagery at no cost from www.planet-action.org.

All Landsat imagery used for land-use land-cover mapping and change detection was from either the mid to late wet season (March to mid May) or immediately after the wet season (early June). Conversely, for radar imagery, we used dry season imagery, which is better suited for detecting deforestation.

VM Table 5. Data used for historical LU / LC change analysis

Vector	Sensor	Resolution		% Reference Region Cover	% Cloud Cover	Acquisition date	Scene identifier	
		Spatial (m)	Image Type			(DD/MM/YYYY)	Path	Row
Data used for classification and/or change detection								
Satellite	Landsat 5	30	multi-spec	100%	0%	07/06/1991	165	67
Satellite	Landsat 5	30	multi-spec	100%	<10%	12/06/1993	165	67
Satellite	Landsat 5	30	multi-spec	100%	0%	2/06/1995	165	67
Satellite	Landsat 7	30	multi-spec	100%	<10%	25/05/1998	165	67
Satellite	Landsat 7	30	multi-spec	100%	<1%	22/05/2000	165	67
Satellite	Landsat 7	30	multi-spec	100%	3%	25/05/2001	165	67
Satellite	Landsat 7	30	multi-spec	100%	<1%	12/05/2002	165	67
Satellite	Landsat 5	30	multi-spec	100%	<1%	25/05/2004	165	67
Satellite	Landsat 5	30	multi-spec	100%	<1%	31/05/2006	165	67
Satellite	Landsat 5	30	multi-spec	100%	<1%	20/05/2008	165	67
Satellite	Landsat 5	30	multi-spec	100%	>10%	10/05/2010	165	67
Satellite	Landsat 7	30	multi-spec	100%	>1%	03/06/2010	165	67
Satellite	Landsat 7	30	multi-spec	100%	>10%	20/03/2012	165	67
Satellite	Landsat 7	30	multi-spec	100%	>10%	5/04/2012	165	67
Satellite	Landsat 7	30	multi-spec	100%	<1%	21/04/2012	165	67
Satellite	ALOS PALSAR	25	radar	60%	N/A	19/08/2008	565	698.7
Satellite	ALOS PALSAR	25	radar	50%	N/A	17/09/2008	564	698.9
Satellite	ALOS PALSAR	25	radar	60%	N/A	23/09/2010	564	698.9

Satellite	ALOS PALSAR	25	radar	50%	N/A	10/10/2010	565	698.7
Data use for land-use / land-cover interpretation and/or accuracy assessment								
Satellite	Spot 5	2.5	false color	30%	<1%	12/06/2007	147	369
Satellite	Spot 5	2.5	false color	70%	<1%	14/08/2010	148	369
Satellite	IKONOS	< 1	visible light	3%	1%	07/08/2001	On Google Earth	
Satellite	IKONOS	< 1	visible light	4%	12%	14/05/2002	On Google Earth	
Satellite	IKONOS	< 1	visible light	11%	1%	27/06/2002	On Google Earth	
Satellite	IKONOS	< 1	visible light	12%	<1%	20/05/2004	On Google Earth	
Satellite	IKONOS	< 1	visible light	4%	0%	25/05/2004	On Google Earth	
Satellite	IKONOS	< 1	visible light	15%	15%	23/08/2004	On Google Earth	
Satellite	IKONOS	< 1	visible light	8%	<5%	28/05/2005	On Google Earth	
Satellite	IKONOS	< 1	visible light	6%	10%	03/07/2005	On Google Earth	
Satellite	IKONOS	< 1	visible light	4%	0%	12/03/2006	On Google Earth	
Satellite	IKONOS	< 1	visible light	6%	1%	26/05/2007	On Google Earth	
Satellite	Geoeye	< 1	visible light	15%	5%	28/05/2009	On Google Earth	
Satellite	Geoeye	< 1	visible light	11%	2%	19/06/2009	On Google Earth	
Satellite	Geoeye	< 1	visible light	16%	1%	12/09/2009	On Google Earth	
Satellite	Geoeye	< 1	visible light	7%	2%	01/09/2011	On Google Earth	

To aid in the interpretation of satellite imagery, field team members visited, photographed, and described 193 out of 200 randomly selected ground truthing points between 50 and 250 meters of roads within the reference region in Oct. 2010. Figure 10 shows the distribution of the ground truthing points within the reference region.

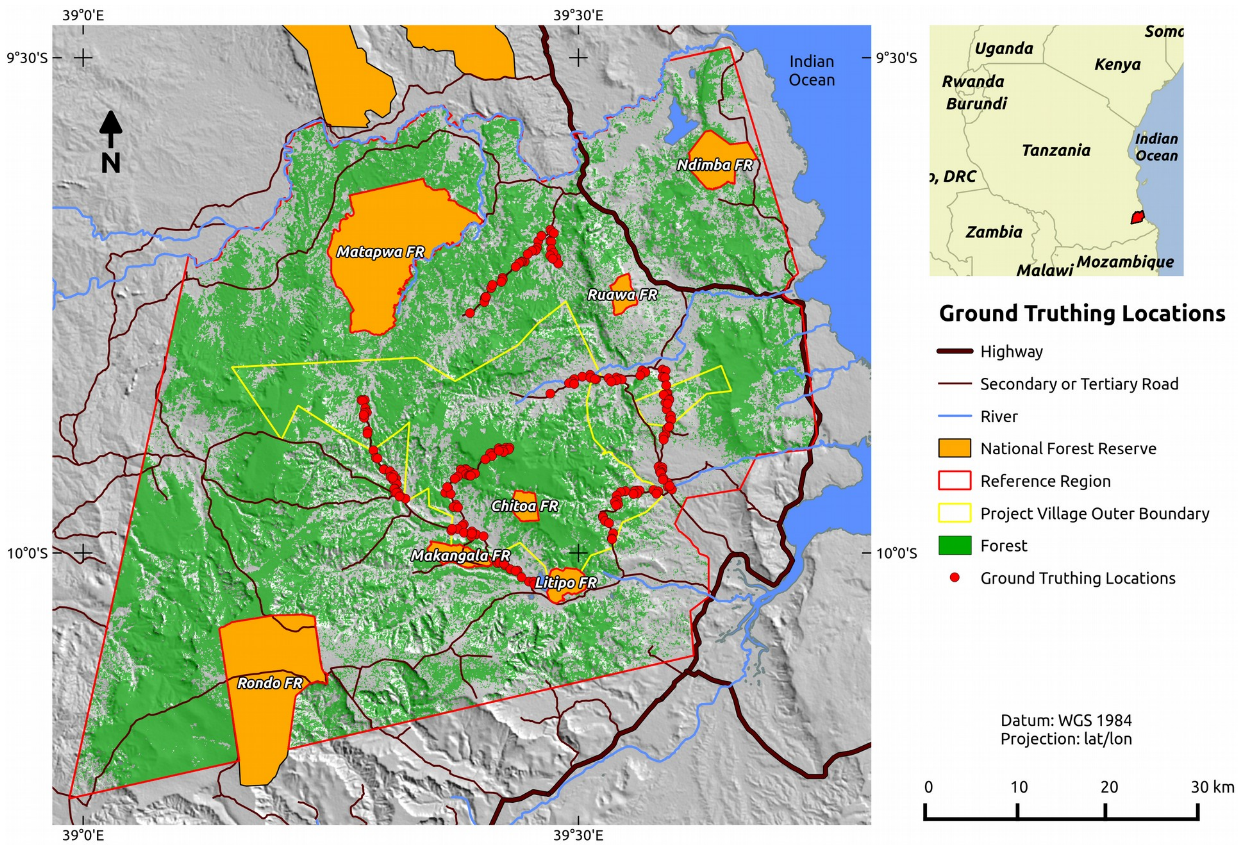

Figure 10: Map of ground truthing locations

2.3 Definition of classes of land-use and land-cover

The vegetative cover of Lindi district is highly variable. The natural forest types include coastal dry forest, scrub forest, Brachystegia forest, miombo woodland, maritime scrub forest, and other woodland[6]. The landscape has been strongly influenced by human activities. Most of the coastal dry forests have been selectively logged within the past 20 years, and are degraded as a result. Shifting cultivation within the past 30 years has left a patchwork of degraded and regenerating variations of all the natural forest types. Some cultivation is essentially permanent, with little regeneration occurring during short fallow periods, where other cultivation is short term with as little as 1 year of cultivation followed by up to 15 years of dense secondary woody regeneration before being cleared again. Other areas cleared for agriculture in the past have switched to grassy bushland despite having been abandoned for more than 15 years. Non-forest natural vegetation includes small areas of savanna and grassy seasonal flood plains.

Areas under human use include different types of agriculture and settlements. Agricultural land-covers include flooded rice cultivation in the valley floors, tree crops such as mango, citrus and cashew (especially in flat areas below 250 m), coconut palm plantations, and a wide variety of cash and subsistence annual crops grown on small farms ranging from less than 1 to several hectares. However, almost all deforestation in the project area is expected to be for shifting cultivation with annual crops and natural woody regrowth during fallow periods. A visit in 2012 by village natural resource community members to a sample of 52 clearings 1 acre and above made between 2010-2012 within the project area

6 Prins, E., & Clarke, G. P. (2007). Discovery and enumeration of Swahilian Coastal Forests in Lindi region, Tanzania, using Landsat TM data analysis. Biodiversity and Conservation, 16(5), 1551-1565.

villages revealed that 51 clearings were for annual crops or cassava and 1 was exclusively for charcoal. No clearings were associated with an intent to plant tree crops. Maize cultivation, was found in 92% of the clearings, usually combined with either hill rice, sesame, or cassava. Thus, although tree crops are found in 5% of non-forest found within the reference region polygon, they are not a likely outcome of future deforestation in the project area in the baseline scenario. Thus, post deforestation carbon stocks of individual plots will vary overtime depending on where the plot is in the cultivation / fallow cycle. Although, there is likely a trend towards shorter fallow periods given population growth in the region, we conservatively assume that long term post-deforestation carbon stocks in the baseline scenario will be constant and equal to the average of stocks found in historical clearings over the past 20 years.

As described in section 1.3 of this annex, the remaining valuable timber in the project area is not a significant fraction of the project area biomass. This, together with the fact that project activities (new village forest management bylaws) include restrictions on future timber harvesting and promote tree planting on farmland suggests that timber harvesting under the project scenario is unlikely to significantly affect carbon stocks. Harvesting wood fuel is also not expected to affect carbon stocks because community members generally take fuel wood from the more easily accessible and rapidly growing woody fallows rather than older forests. Charcoal harvesting is only a significant factor affecting forest cover in Likwaya village. However, according to high resolution imagery, almost all charcoal harvesting in the past 10 years in that village resulted in deforestation, rather than degradation. Finally, disturbance transects conducted in the project area in 2010 revealed that almost all significantly disturbed areas were cleared for farming shortly thereafter, suggesting that the disturbance was part of the preparation for deforestation rather than due to demand for wood products. Thus, project area carbon stocks should remain more or less constant in the project scenario, with the exception of increasing carbon stocks in some low carbon forests where deforestation is avoided. The project plans to monitor carbon stocks every 2 to 3 years, so that carbon stock increases can be claimed in future areas of avoided deforestation.

An initial classification was performed with 18 different land-covers (Table A), but the individual class accuracy of this classification did not meet the 80% requirement of the methodology. In the end, we settled on lumping all non-forest land-covers into one non-forest class and stratifying forest types into high carbon and low carbon stratum classes show in VM Table 6.

VM Table 6: List of all land use and land cover classes existing at the project start date within the reference region

Class Identifier		Trend in Carbon stock	Presence in[1]	Baseline activity[2]			Description
ID_{cl}	Name			LG	FW	CP	
1	High carbon	Constant	RR, LK, PA	X		X	In high resolution imagery, an area not cleared within the past 10 years corresponding to at least 6 Landsat pixels with more than 50% cover (assuming solid canopies) of distinguishable large tree canopies not counting baobab, cashew, citrus, or mango trees. Isolated patches of non-forest less than 6 pixels surrounded by a majority of high carbon forest are considered high carbon forest.

2	Low carbon	Increasing	RR, LK, PA		X	X	In high resolution imagery, an area not cleared within the past 10 years corresponding to at least 6 Landsat pixels with more than 50% cover of dense woody regeneration without distinguishable canopies or between 20% and 50% cover of large individual trees not counting Baobab, cashew, citrus, or mango trees. Isolated patches of non-forest less than 6 pixels surrounded by a majority of low carbon forest are considered low carbon forest.
3	Non-Forest	Constant	LM		X	X	In high resolution imagery, an area corresponding to at least 6 Landsat pixels with less than 20% cover of large trees not including baobab, cashew, citrus, or mango trees, or less than 50% cover of dense woody regeneration without distinguishable canopies. Any isolated patches of high or low carbon forest less than 6 pixels are also considered non-forest.

[1] RR = Reference region, LK = Leakage Belt, PA = Project Area, LM = Leakage Management Area

[2] LG = Logging, FW = Fuel-wood collection, CP = Charcoal Production

2.4 Definition of categories of land-use and land-cover change

The two possible land-use and land-cover change categories are shown in VM Table 7.a and detailed in VM Table 7.b.

VM Table 7.a: Potential land-use and land-cover change matrix

		Initial LU / LC class	
	ID_{cl}	High Carbon Forest	Low Carbon Forest
Final LU / LC class	Non-Forest	I1/F3	I2/F3

VM Table 7.b: List of land-use and land-cover change categories

ID_{ct}	Name	Trend in Carbon Stock	Presence in	Activity in the baseline case			Name	Trend in Carbon Stock	Presence in	Activity in the project case		
				LG	FW	CP				LG	FW	CP
I1, F3	High Carbon	constant	RR, LK, PA	X		X	Non-Forest	constant	RR, LK, PA		X	X
I2, F3	Low Carbon	increasing	RR, LK, PA		X	X	Non-Forest	constant	RR, LK, PA		X	X

2.5 Analysis of historical land-use and land-cover change

MUMJIMTA conducted all of the analysis required to map historical land-use / land-cover change in the reference region. The MJUMITA technical adviser settled on a hybrid approach combining classification and change detection in order to achieve the greatest accuracy in a highly seasonal and fragmented environment. This approach is similar to that used in a recent global analysis of deforestation, starting with a base year classification and then using change detection to map gross deforestation on a year to year basis up the present[7]. Here we present a description of the steps involved.

2.5.1 Pre-processing

Limited pre-processing was required for the analysis. All Landsat scenes were processed to the L1T level by USGS or CSIR. After downloading, image stacks were made for each scene using bands 1 through 5, and 7. To make the scenes compatible with local GIS data, it was necessary to transform the scenes from WGS 84 UTM north to UTM south as all Landsat scenes are processed in terms of WGS 84 UTM north even when covering the southern hemisphere. Geometric corrections were applied as needed. It was found that all but one of the Landsat scenes obtained directly from USGS had geometric errors of less than 1 pixel. The two scenes from CSIR and the Landsat scene from June, 1991, on the other hand, contained significant geometric errors, which were corrected using ground control points and cubic convolution in ENVI 4.2 to bring them within 1 pixel of the May 25, 2001 Landsat image.

Relative radiometric correction using pseudo invariant features detected by iteratively re-weighted multivariate change detection (IR-MAD)[8] was applied to the May, 2008, May, 2002 and May 2010 Landsat scenes, to bring them in line with the May, 2001 scene. This was necessary because the May, 2008 scene was the scene chosen as the scene to develop the initial land cover classification model, which would then be applied to the May, 2001 scene, while the May, 2002 and May, 2010 scenes were used to fill in clouds in the May, 2001 and May, 2008 scenes respectively. The radiometric correction operations were performed using Linux python scripts (iMad.py and radcal.py) provided by Dr. Mort Canty of the Juelich Research Center through email. The default options were used for both scripts.

Cloud masks were developed for each Landsat scene, using the following multi-step process:

a) IR-MAD performed to compare all bands of the target Landsat scene to the May, 2001 Landsat scene.

b) Training areas for clouds, cloud shadow, and non-cloud areas selected using visual interpretation

7 Hansen, M. C., *et al*. "High-resolution global maps of 21st-century forest cover change." science 342.6160 (2013): 850-853.

8 Canty, M. J., & Nielsen, A. A. (2008). Automatic radiometric normalization of multi-temporal satellite imagery with the iteratively re-weighted MAD transformation. Remote Sensing of Environment, 112(3), 1025-1036.

of the target Landsat scene and the relevant IR-MAD image.

c) Run a custom R script that selects random points from the training areas, acquires the Landsat and IR-MAD band data from those random points (pixels), and supplies them to the Randomforest[9] package as training data to develop a Randomforest model of clouds for the scene. Then the model is applied to the entire scene to create a map of clouds and output as a geotiff.

d) The cloud map from the Randomforest package is then loaded in QGIS, where a 3 pixel orthogonal sieve is applied using the Raster Tools to remove error caused by speckling.

e) Then a proximity analysis is performed using the Raster Tools in QGIS to create a final map of clouds including a 2 pixel buffer around the cloud areas remaining from step d.

In the 2001 and 2006 scenes, some small areas of haze were missed by the cloud masking procedure and the areas were added to the cloud masks for these areas using hand digitization. Alternative methods of cloud masking were explored before arriving at this technique, but using IR-MAD in the cloud masking process was found to be the best way to accurately identify cloud shadows, which are otherwise spectrally inseparable from forested shadows in areas with significant topography.

Cloud filling was performed for the May, 2001 scene using relative radiometric corrected data from May, 2002 and for May, 2008 using relatively radiometric corrected data from May, 2010. For all change detection operations, including cloud detection, all Landsat imagery from 1993 to 2001 was compared to the cloud free June, 1991 image, while Landsat imagery from 2002 to 2012 was compared to the May, 2001 image after filling in May, 2001 clouds.

In addition to cloud masks, for Landsat 7 imagery from after 2002, the project generated masks for the areas of image with missing data due to the scan line correction (SLC) failure that occurred in Landsat 7 in 2003. These masks were generated using band math to identify pixels with no-data for any of the Landsat bands 1-5, or 7.

Due to the lack of cloud free imagery from May 2010 and a recognition that cloud cover could be a problem in future years as well, we also incorporated ALOS PALSAR data into the process of deforestation detection. For PALSAR SLC data pre-processing, we used the SARscape 4.2 ENVI module. We extracted gamma nought values for the SLC HH and HV bands into 25m square pixels using a SRTM DEM and the optimal resolution approach with radiometric calibration and normalization. We used a local incident angle map generated by SARscape to mask out areas of radar shadow and overlay, which was less than 1% of the reference region. For visualizing the data as an RGB image, we also created a HH to HV band to use as the blue band and applied a gamma filter. Two PALSAR scenes were required to cover the reference region in each year, so the scenes (which were less than 1 month apart for each year) were combined into a single scene using the SARscape mosaic tool. Finally, the PALSAR mosaic was transformed to 30 meter square pixels and georeferenced to match Landsat data using ground control points and cubic convolution.

To improve the accuracy of the land-use land cover classification, non-spectral data was also used, including SRTM digital elevation data from CIGAR. Using the terrain tools in QGIS, aspect, slope, and shaded relief maps were also generated from the SRTM data. Two different shaded relief maps were generated for the May, 2001 and May, 2008 Landsat scenes using the sun elevation and azimuth data

9 Breiman, L. (2001). Random forests. Machine learning, 45(1), 5-32.

provided in the meta-data of each image.

2.5.2 Interpretation and classification

Classification

The reference region land-cover was classified using the same Randomforest R script used for classifying clouds in Step 2.4.1. The May, 2008 scene was selected as the base scene for which to develop the Randomforest land-cover model that could be applied to other scenes because it was almost cloud free (unlike the May, 2010 scene) and high resolution imagery was available from around the same period covering a large portion of the reference region. The Landsat 2001 scene was selected as the scene to use for the beginning of the reference period, because it was more similar to the May, 2008 scene in terms of the seasonal vegetation appearance than the May, 2000 or May, 2002 scenes and thus the classification model developed for the May, 2008 scene could be applied to the May, 2001 scene to arrive at an accurate classification.

We selected training data for the 2008 classification model from Geoeye and Spot imagery from 2007 to 2009, while also relying on ground truthing plots, PALSAR radar data, IR-MAD change images, and high resolution imagery from other time periods to aid interpretation. We identified 16 major land-use land-covers that could be differentiated including:

Table A: Land-use land-cover classes before combining to increase accuracy

CL #	Description
1	Bare surfaces (rock, roads, buildings, etc)
2	Grasslands (natural savanna with grass and occasional small trees or bushes)
3	Flood plains (wet grassy areas)
4	Annual cultivation (non-woody crops)
5	Flooded cultivation (paddy rice)
6	Coconut plantations (continuous or near continuous coconut palm cover)
7	Agroforestry (cashew nut, citrus, or mango tree cover)
8	Predominately grass fallows (abandoned agricultural land with less than 50% cover of short woody regeneration without differentiable tree crowns)
9	Predominately woody fallows (agricultural land abandoned within the past 10 years with greater than 50% cover of dense woody regeneration greater than 2 meters height without differentiable tree crowns)
10	Open Woodlands (20 to 50% cover of larger trees with differentiable tree crowns)
11	Regenerating forest / closed woodland (greater than 50% cover of dense woody regeneration older than 10 years surrounded by closed woodland or forest)

12	Regenerating coastal scrub (greater than 50% cover of dense woody regeneration older than 10 years surrounded by coastal scrub
13	Coastal scrub (Closed canopy woody vegetation greater than 5m in height with few differentiable tree crowns and no sign of recent clearance).
14	Miombo Woodland (50 to 70% cover of Miombo tree species with differentiable tree crowns)
15	Lower elevation coastal forest / mixed woodland (50 to 100% canopy cover of coastal forest tree species below 270 meters, occasionally with grass.
16	Coastal forest (50 to 100% canopy cover of coastal forest species above 270 meters).

Due to the fragmented nature of the Lindi landscape, training points had to be placed carefully. Since a majority of the best quality high resolution data was Geoeye data from Google Earth that could not be downloaded and could not be georeferenced to match the Landsat data, we adjusted the georeferencing of the Landsat data and other supporting data used to develop the 2008 classification model to match the Google Earth data using a simple image shift of 10 meters to the east and 14 meters to the north. The training points were made into 22m buffers and had been placed so that either 4, 2, and occasionally 1 pixel of the same class could be selected within the polygon by the classification R script. A total of 4458 training points were used in the final classification, resulting in approximately 12,000 unique potential training pixels that could be selected by the R script for training the Randomforest model.

Unlike other approaches to land-use land-cover classifications such as maximum likelihood Randomforest models can incorporate a wide range of non-spectral continuous and categorical data that have been shown to improve classification accuracy[10]. Thus, in the stack of data to be considered by the model, we included Landsat bands 1-5, and 7, a DEM, a slope map, an aspect map, a shaded relief map (specific to the scene being classified), an FAO soil type map, and a map of unusually dry areas for the specific Landsat scene. After being trained from the May, 2008 data, the model was then applied to the May, 2001 data to arrive at a map for the beginning of the reference region.

The accuracy of the 16 class classification did not meet the requirements of the methodology. Thus, as suggested by the methodology, to achieve the desired accuracy (see Step 2.5), we combined the classes listed in Table A to create the three classes listed in VM Table 6. This required that classes 1 through 8 in Table A be combined as non-forest, while classes 9 through 13 were combined as low carbon forest and classes 14 to 16 were combined as high carbon forest. Furthermore, as stated in section 1.1.5 of this annex, long term agro-foresty areas were hand-digitized from high resolution imagery and classified as non-forest. Also, deforestation detection (described later in this section) was used to identify areas of deforestation and regeneration from non-forest between 1991 and 2001, which were removed from areas classified as forest in 2001 to create the 2001 forest benchmark map (Figure 11). Similarly, for the 2012 forest benchmark map (Figure 12) and 2012 land-use land-cover map (Figure 13), we removed forest

10 Walker, Wayne S., *et al.* "Large-area classification and mapping of forest and land cover in the Brazilian Amazon: a comparative analysis of ALOS/PALSAR and Landsat data sources." Selected Topics in Applied Earth Observations and Remote Sensing, IEEE Journal of 3.4 (2010): 594-604.

areas detected as deforested between 2001 and 2012, or classified as non-forest in the 2001 land-cover map (before removing change from 1991 to 2001) from the 2008 land cover map. Therefore, the 2012 forest benchmark map, does include a few forest areas not included as forest in the 2001 benchmark map, but no forest areas that did not meet the Tanzanian definition of forest continuously starting in 2001. While somewhat unorthodox, we believe this approach is more appropriate for regions with shifting cultivation as it means the reference region used to determine deforestation rates and model the future location of deforestation will more accurately represent the forests found in the project area. Furthermore, in our case, this approach is conservative because excluding these young forest fallows from the reference region significantly reduces the baseline deforestation rate.

To ensure that forest patches were at least 0.5 ha or larger and to reduce noise in the classifications, we applied two passes of a 3x3 majority filter and one pass of a 5 pixel orthogonal sieve with replacement to the benchmark maps using the Sextant toolbox in QGIS.

Change detection

To map land-use / land-cover change during the reference period (May 2001 to April 2012), we used the python script (iMad.py) described in Step 2.4.1 to perform IR-MAD change detection to compare Landsat imagery from 2002, 2004, 2006, 2008, 2010, and 2012 to the May, 2001 Landsat scene. This approach to change detection has the advantage of being invariant to most differences in the data that are constant across a scene such as atmospheric scattering, sensor calibration, and to a certain extent differences in vegetation greenness due to seasonality[11]. For each year of comparison, the IR-MAD script produces a final output image which consists of 6 bands (in order of increasing coherence) and a chi-square layer representative of the degree of change relative to other pixels. By comparing the IR-MAD bands with actual examples of deforestation and persistence identified in high resolution imagery in different years, we determined that for the imagery used in the analysis, values less than -1 in the 6th IR-MAD band corresponded to deforestation while avoiding most change associated with seasonality and degradation, especially if the chi-square values were higher than 50. However, in June imagery, occasionally seasonality related changes in vegetation (especially in woodland) had the same characteristics as deforestation. Therefore, June imagery was only used to map change in areas where no other imagery was available due to Landsat 7 SLC errors or cloud cover.

Due to excessive cloud cover during the 2008 to 2010 time period, PALSAR data was used to supplement Landsat based change detection during this period. Previous research has suggested that the HV band is the most sensitive to changes in changes in woody biomass (particularly for dry season data)[12]. Therefore, we used band math to subtract the 2008 HV values from the 2010 HV values to generate a change map. By overlaying the change map on high resolution imagery, we could see that deforestation generally corresponded to a decrease in the HV band of more than 0.010 when the 2010 HV value was less than 0.017. Areas of deforestation detected with PALSAR data were compared to the areas detected for a similar time period using the cloud free portions of the Landsat data. The two systems of change detection showed very good agreement. Also the rate of deforestation for the period mapped by PALSAR (Sept, 2008 to Oct, 2010) is consistent with the trends seen in the Landsat data and thus does not appear to exaggerate or underestimate deforestation.

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11 Nielsen, A. A. (2007). The regularized iteratively re-weighted MAD method for change detection in multi-and hyperspectral data. *Image Processing, IEEE Transactions on*, *16*(2), 463-478.

12 Mitchard, E. T. A., *et al*. "Using satellite radar backscatter to predict above-ground woody biomass: A consistent relationship across four different African landscapes." Geophysical Research Letters 36.23 (2009).

To create a map of historical gross deforestation, we wrote an R script (shared with the validation entity) that uses the principles of a decision trees to select pixels corresponding to the criteria found to be associated with deforestation in the IR-MAD and PALSAR data, while avoiding pixels identified as clouds in the cloud masks. Since an area can only be deforested once, the script selects the deforestation in order so that the deforestation is coded to the time period in which is occurred. The output map of change events ordered by year is then subjected to the same 2 passes of a 3x3 majority filter and a 5 pixel orthogonal sieve applied to the benchmark maps. Finally, this filtered map is compared in another R script with the 2001 benchmark map so that only change corresponding to an area classified as forest in the 2001 benchmark map is kept in the map of gross deforestation and persistence for the reference period (Figure 14). The same process, without the step of limiting the change map to areas mapped as forest in a benchmark map was applied to Landsat imagery from 1991, 1993, 1995, 1998, 2000, and 2001 to identify areas of forest fallow in the May 2001 image to be reclassified as non-forest in the 2001 forest benchmark map before it was fed into the deforestation tree for 2001 to 2012. As requested by the methodology, we produced a map of land-use land-cover change by combining the 2012 land-use land-cover map with the deforestation map for the period 2008-2012 (Figure 15). A matrix of land-use land-cover change is presented in Table C.

Finally, as per the methodology, to calculate annual deforestation rates for each of the observed periods in the reference period from the baseline map of deforestation (Figure 14), we used the formula[13]:

$$r = \frac{1}{t_2 - t_1} \ln\left(\frac{A_2}{A_1}\right) \quad \text{(A)}$$

Where:

r	Annual deforestation rate; %
t	1, 2, 3 … *T*, a year in the reference period; expressed in terms of factions of a year in the event that the time period covered is not exactly 1 or 2 years.
A	Forest area at time *t*; ha

Because we started with cloud filled data in 2001 and in 2008 and compared all later images to these images using change detection, we assumed that deforestation hidden under clouds in all the other years (which was typically less than 1%), would likely be detected as deforestation in following years since there was little cloud overlap. Therefore, for most time periods, for calculating deforestation rates, we did not limit the starting forest cover to only what was observable for the purpose of calculating rates. The only exceptions were for the period from 2001 to 2002 to account for the 2001 cloud areas filled with 2002 data and the period from 2010 to 2012, when almost 7% of forest was unobserved due to cloud cover and gaps in Landsat 7 scenes. Since the time periods covered by the analysis varied in length, to calculate an average rate for the whole period, deforestation rate observations for sub-periods were weighted by the proportion of the total reference period falling in each sub-period calculated in terms of months. The results of the analysis are presented in Table B.

13 Puyravaud, J. P. (2003). Standardizing the calculation of the annual rate of deforestation. Forest Ecology and Management, 177(1), 593-596.

Table B: Gross forest cover loss in the reference region from 2001 to 2012

Time Period	Deforestation detected (ha)	Starting Forest Area	% Non-Observable	Months in period	Annual % Change	Observation weight
May, 2001 to May, 2002	6,598	267,583	2.76%	12	-2.50%	0.09
May, 2002 to May, 2004	10,140	260,985	0.00%	24	-1.98%	0.18
May, 2004 to May, 2006	7,128	250,845	0.00%	24	-1.44%	0.18
May, 2006 to May, 2008	8,033	243,717	0.00%	24	-1.68%	0.18
May, 2008 to Sept, 2008	1,128	235,684	0.00%	4	-1.44%	0.03
Sept, 2008 to Oct, 2010	9,783	234,556	0.00%	24	-2.13%	0.18
Oct, 2010 to April, 2012	8,737	224,773	6.88%	19	-2.68%	0.15
Weighted[1] Average Annual Change					-1.99%	

[1] Due to the timing of available of cloud free Landsat data and substitute radar imagery, the time periods covered vary in duration. Therefore, the annual deforestation rates for each period were weighted by the period duration in months to arrive at one average annual deforestation rate for the entire 2001 to 2012 period.

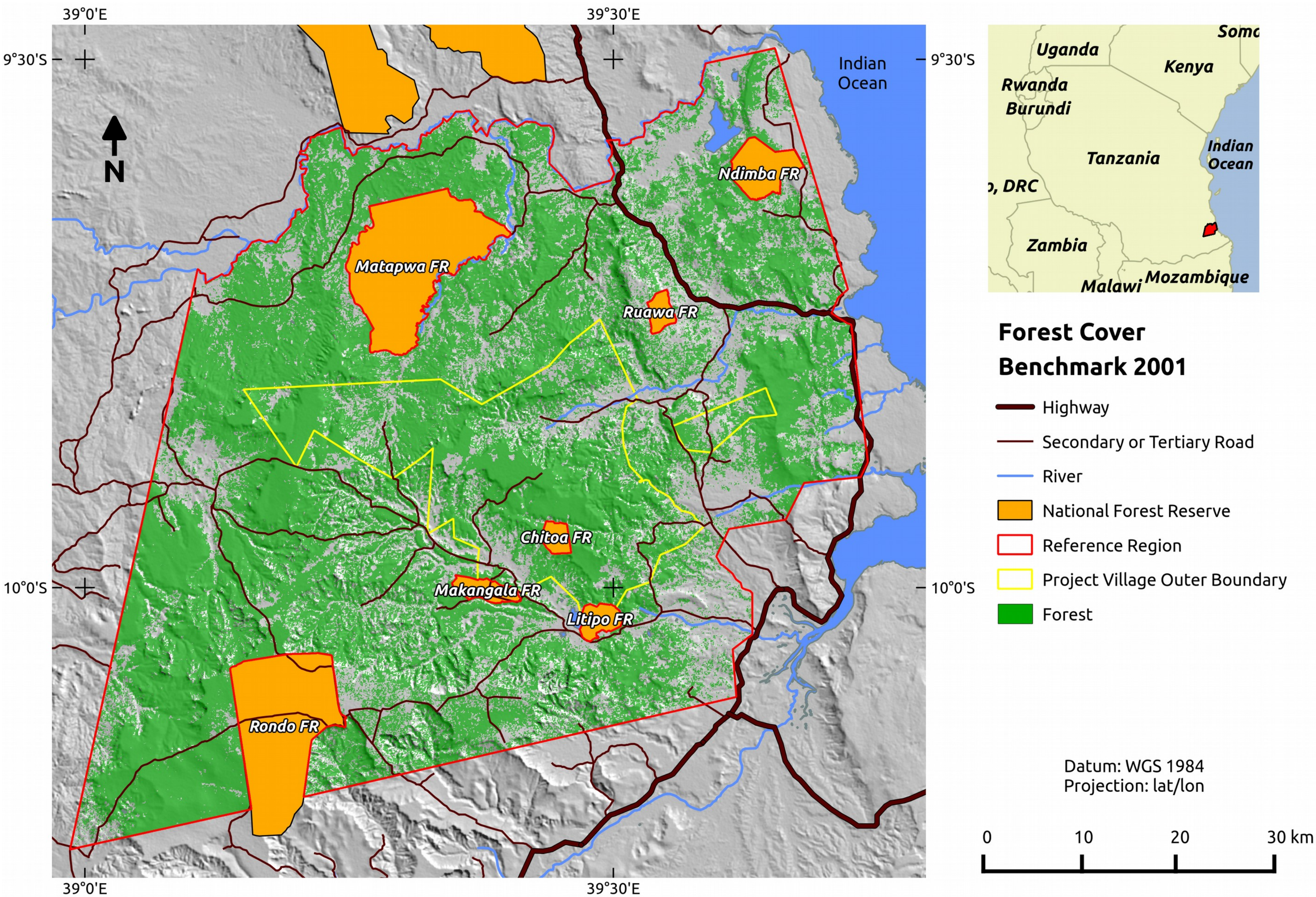

Figure 11: Forest cover benchmark map 2001

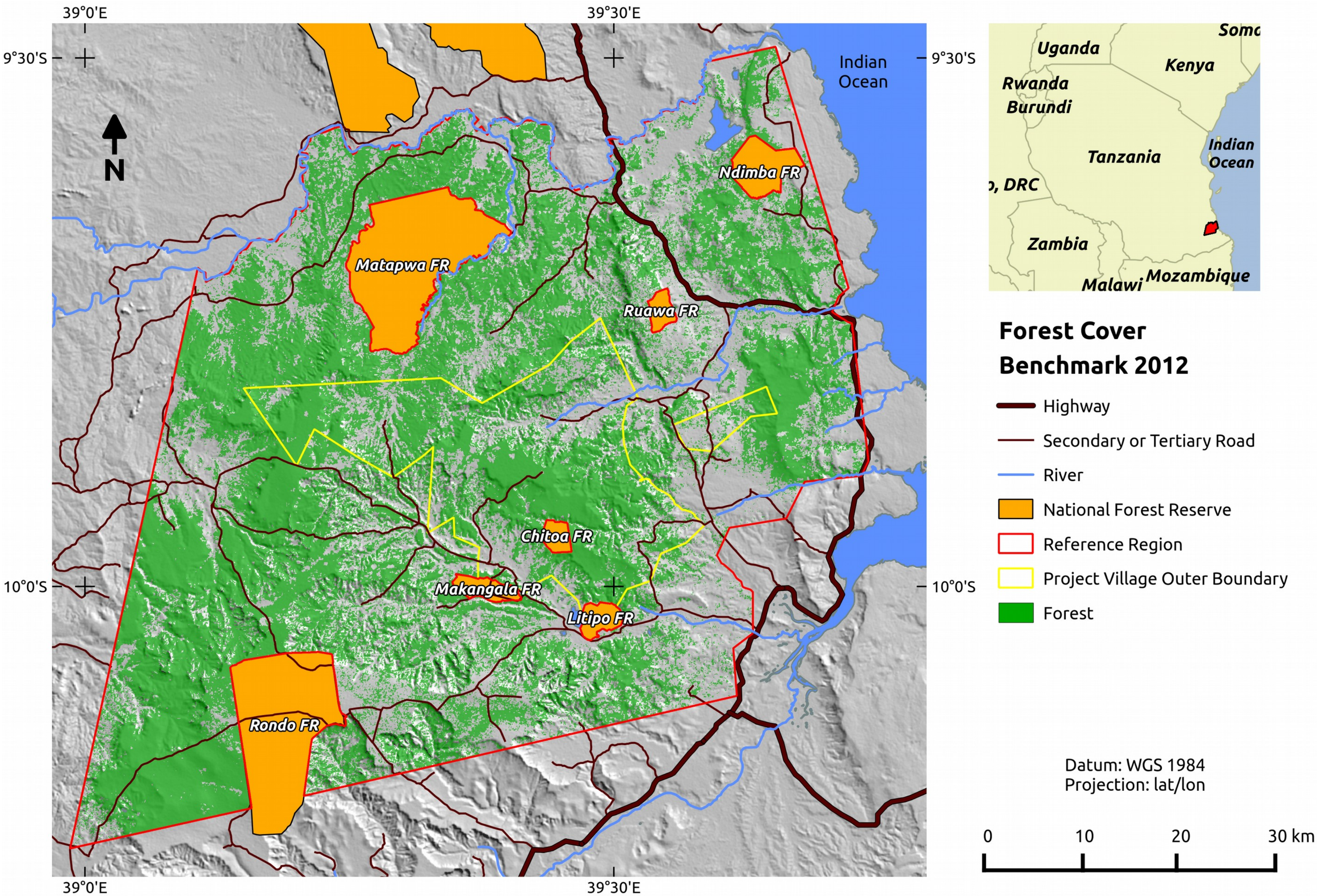

Figure 12: Forest cover benchmark map 2012

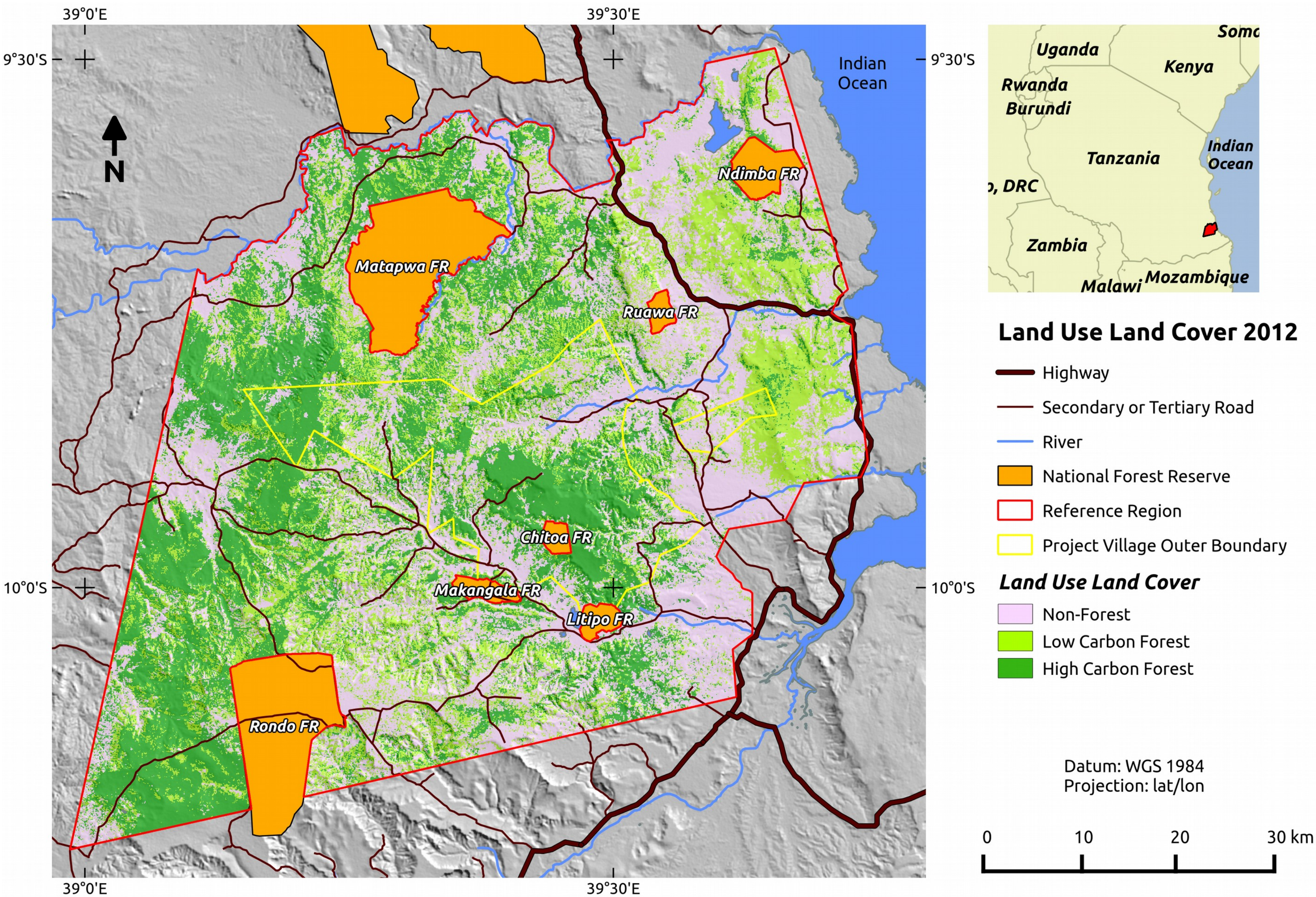

Figure 13: Land use, land cover map 2012

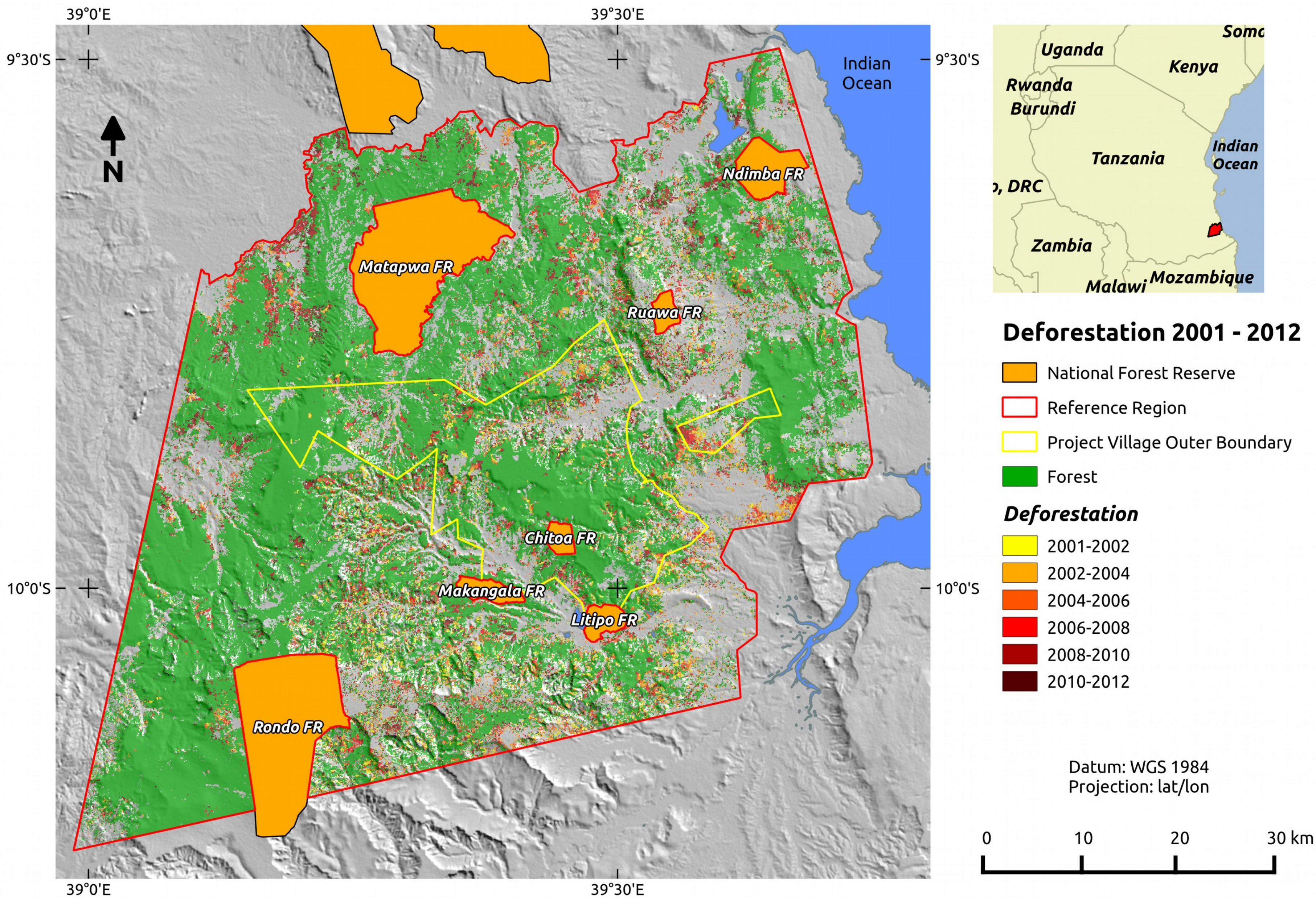

Figure 14: Map of 2001 to 2012 deforestation

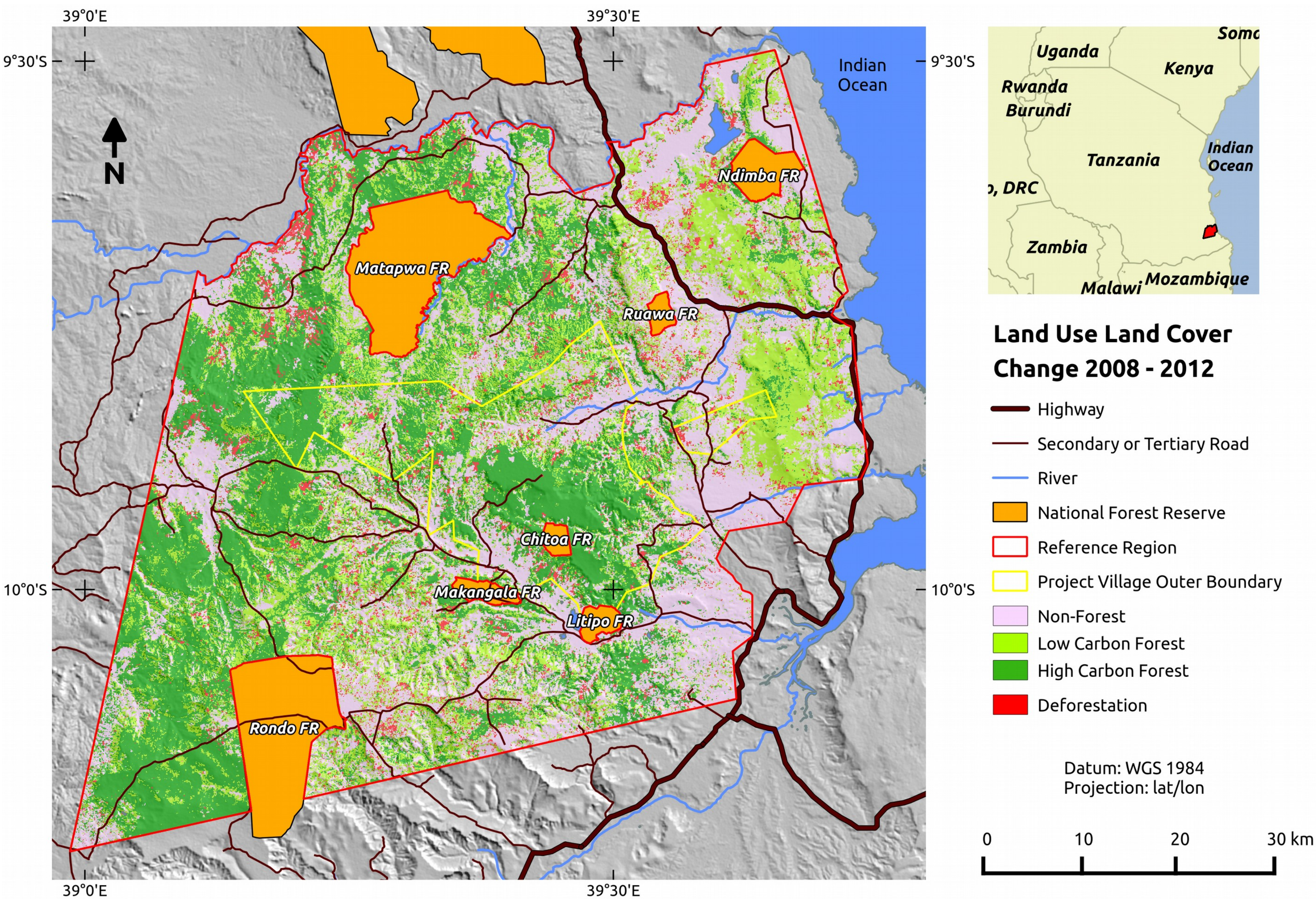

Figure 15: Land use land cover change map 2008 - 2012

Table C: Land use land cover change matrix 2008-2012 in ha.

Initial / Final	Low Carbon Forest	High Carbon Forest	Final Area
Low Carbon Forest	88,015		88,015
High Carbon Forest		128,021	128,021
Non-Forest	9,968	8,976	18,944
Initial Area	97,983	136,997	234,980
Net Change	-9,968	-8,976	

2.6 Map accuracy assessments

We assessed the accuracy of the May 2008 land use land cover classification using 500 random points stratified by land cover in areas covered by high resolution satellite imagery from June 2007 – August 2009. A grid corresponding to the Landsat scene pixels was overlaid on the high resolution imagery in QGIS and classes were determined using the same rules used for land-use land-cover training data. As required by the methodology, each land-use land-cover class had an overall accuracy greater than 80% (Table D) and the overall accuracy was 88.4%. The overall forest non-forest accuracy (after combining the two forest classes) was 95%.

Table D: Confusion matrix for May 2008 land use land cover classification.

Ground Truth / Classified	Non-Forest	Low Carbon Forest	High Carbon Forest	User's Accuracy
Non-Forest	144	16	0	90.0%
Low Carbon Forest	10	158	11	88.3%
High Carbon Forest	1	20	140	87.0%
Producer's Accuracy	92.9%	81.4%	92.7%	

The accuracy of the May 2001 land use land cover classification could not be assessed due to insufficient historical data. However, it was assumed to have greater than 90% forest non-forest accuracy since the 2001 image was from nearly the same day of the year as the 2008 image, relative radiometric correction was performed to match the 2008 and 2001 images, and the same classification model and post classification steps were applied.

Following the guidance in Stehman and Czaplewski, 1998[14], we designed an appropriate system for assessing the accuracy of the land-use land-cover change map. Since the areas of greatest interest were deforested patches, we stratified the sampling equally between detected deforestation and persistence, rather than relying on simple random sampling. This means that areas of non-forest, where change could

14 Stehman, S. V., & Czaplewski, R. L. (1998). Design and analysis for thematic map accuracy assessment: fundamental principles. Remote Sensing of Environment, 64(3), 331-344.

not occur, were not included in the sampling frame and areas of deforestation were over sampled in terms of their relative presence in the landscape. These choices lead to a conservative estimation of the accuracy of the map since an increased amount of sampling is focused on areas where error is most likely to occur.

Land use land cover change accuracy was assessed using 100 clearing and 100 persistence detection points drawn at random from the baseline deforestation map and compared to historical high resolution satellite imagery from 2002, 2004, 2006, and 2009. The number of deforestation and persistence points to draw for each year was determined by the proportion of total deforestation or persistence within the historical deforestation map found within the area covered by the high resolution image for a particular year. For instance, the deforestation detected in the deforestation map for the year 2002 falling within the area covered by high resolution imagery from June, 2002, made up 2.91% of total deforestation for the years 2002 to 2008 and 24.77% of all deforestation from 2002 to 2008 was covered by high resolution imagery from any year. Therefore, 11.74% (2.91 / 24.77) or 12 points of the deforestation sample should be drawn at random from the map of deforestation in 2002 within the area covered by June, 2002 high resolution imagery.

Since the minimum mapping unit was larger than one pixel, deforestation accuracy was assessed on a multi-pixel basis and an area was deemed to be accurately detected as deforested if the pixel where the random sampling point fell was orthogonally connected to an area of at least 0.5 hectares (5 other orthogonally connected pixels) that had fallen below the threshold of forest even if the point landed in a pixel that was still forested. This helped to control for edge effects and slight errors in georeferencing between the high resolution and Landsat data, which are otherwise problematic since individual clearings in Lindi are relatively small and a large proportion of clearing pixels are therefore edge pixels. It was also found that deforestation in some cases was a multi-year process and in these cases change detection would often class an area as deforested before the process was complete. However, as very few areas of degradation that did not ultimately result in deforestation were discovered, these areas were classified as correctly detected deforestation if the area was eventually fully deforested. The overall accuracy of persistence and deforestation detection was 93.5% (Table E).

Table E: Confusion matrix for deforestation and persistence from 2002 to 2008.

Ground Truth / Classified	Persistence	Deforestation	User's Accuracy
Persistence	96	4	96%
Deforestation	9	91	91%
Producer's Accuracy	91.4%	95.8%	93.5%

STEP 3: ANALYSIS OF AGENTS, DRIVERS AND UNDERLYING CAUSES OF DEFORESTATION AND THEIR LIKELY FUTURE DEVELOPMENT

The project gathered information on the agents, drivers, and underlying causes of deforestation from a wide variety of sources including, both formal and informal meetings with community members, discussions with local government authorities, discussions with regional experts, household questionnaires and in depth farmer interviews, surveys of recent deforestation, and published crop production statistics for Lindi region. For more details see "TFCG Technical Report 26: Analysis of the drivers of deforestation and stakeholders in the Lindi project site" and "Improving agricultural practices in the context of REDD readiness in Lindi Rural District, Tanzania: a review of current agricultural practices and recommendations for project interventions" available at http://www.tfcg.org/makingReddWork.html.

3.1 Identification of agents of deforestation

All of the forest land in the project area and reference region is on village land under communal tenure[15]. Village residents, and in some cases residents from neighboring villages are the primary deforestation agents. Non-villagers may occasionally be involved in timber harvesting and charcoal making, but have not made a measurable contribution to deforestation in the area.

As presented elsewhere in the methodology, MJUMITA conducted a study of recent deforestation in the project villages in 2012. Using remote sensing, MJUMITA located 52 forest clearings made between Oct. 2010 and April. 2012. In November of 2012, village natural resource committee (VNRC) members used GPS units to locate these clearings, where they conducted a survey of the deforestation agents they encountered. They found that 100% of the deforestation agents were local village residents or residents from villages directly bordering the village that owned the land. Sixty-seven percent of deforestation agents were from a participating project village, while the remaining 33% were from neighboring villages outside the project area. Farmers interviewed in Lihimilo village, which is in the leakage belt, also claim that almost all the deforestation agents in their village are local with the exception of a few farmers from the nearest neighboring village.

Historical movement of people into the area and between villages in the area appears to be very limited. The VNRC members found that 85% of deforestation agents were either born in their home village or had lived there for more than 30 years. Ten percent of deforestation agents had lived in the area between 10 and 29 years and only 5% had lived in the area for less than 10 years. Farmers interviewed in Lihimilo village report only 1 farmer that they know of who had moved to the village from another village.

According to 2002 and 2012 census data, the population growth rate within the reference region villages averaged 0.59% per annum compared to 0.9% for all of Lindi Region. Overall, population growth within the region has been much slower than predicted by the 2002 census, in part because villages appear to export men to urban areas and in particular Dar es Salaam. This is mentioned in stakeholder discussions and can be observed by comparing the female and male population statistics by age group. However, with the new improved highway to Dar es Salaam and corresponding enhanced cash farming opportunities, this demographic trend could change.

3.2 Identification of deforestation drivers

3.2.1 Quantity Drivers

Agriculture

There is universal agreement amongst all stakeholders that the main driver of deforestation in the reference region is expansion of shifting and permanent cultivation for small-holder subsistence and cash

15 It should be noted that large scale (5000 + ha) commercial biofuel ventures have acquired land from villages elsewhere in Lindi Region and large scale commercial agricultural ventures pose an increasing threat to forests in the region. However, this has not occurred anywhere within reference region or project villages and is conservatively not included in the baseline for this project.

crop farming. Annual gross deforestation rates in the reference region between 2001 and 2012 started at 2.57%, gradually declined to 1.44% in the middle of the period and then gradually increased to 2.68% at the end of the period. The same down up pattern of deforestation rates in the reference region was observed in the project area villages.

Overall, the impression amongst community members was that sesame, which is the main annual cash crop, played a significant role in deforestation and recent increasing sesame prices had resulted in an increase in deforestation. Indeed, some farmers surveyed reported very large earnings from sesame in 2012. However, in the same survey, VNRC members found that sesame cultivation was only found in 27% of clearings (which made up 32% of deforestation by area), and only 2 clearings were exclusively for sesame. Maize cultivation, on the other hand was associated with 92% of clearings (making up 93% of deforestation by area) and was usually planted over the greatest area within a clearing. An expert familiar with the area, pointed out that sesame farmers tend to make small clearings separated from other farms to avoid pest and that the analysis, which only included clearings larger than 0.5 hectares might have missed these clearings. An analysis of the deforestation data suggested that 60% of discreet clearings are smaller than 0.5 hectares. However, these small clearings (many of which are simply error) make up less than 10% of the total area deforested. Thus, given that sesame is only found in clearings that make up 32% of the deforested area and usually grown with other crops that dominate the clearing, even counting unobserved micro-deforestation, sesame's overall contribution to the total area deforested each year is most likely less than 20%. The discrepancy between the community member impressions regarding sesame cultivation and the field observations may be explained by community members counting the total number of clearings for sesame (which is admittedly greatly underestimated by our approach), rather than its total contribution to deforestation by area.

Thus, from the ground data, it appears that demand for food crops for sale and subsistence is actually the primary driver of deforestation in the region. This observation is supported by a comparison of Lindi Region[16] crop harvest statistics obtained from the Tanzanian Ministry of Agriculture's website and deforestation from the baseline analysis (Figure 16). Changes in the average annual maize harvest from 2001 to 2010[17] for Lindi Region correspond very closely to changes in the average annual gross deforestation in the reference region. A simple linear model of average maize production per period vs deforestation per period was significant at 95% confidence and explained 83% of the variance. This finding is also supported by the fact that maize is particularly demanding in terms of soil fertility, fertilizer use in the area is almost nonexistent, and farmers say the preferred location for maize cultivation is in recently cleared mature forest. At the same time, Figure 16 suggests that there is no positive association between sesame cultivation and deforestation (though perhaps a weak negative association) as postulated by community members.

Explaining trends in maize production is complicated. Rainfall is clearly one of the most important factors. A simple linear model relating January to April rainfall[18] to maize production on a year to year basis was significant at 99% confidence and explained 62% of the variation. However, it doesn't directly follow that lower rainfall would result in less deforestation since most of the clearing happens in the dry season at the end of the previous year and farmers don't have access to accurate long term weather forecasts that might lead them to not clear before a drought year. Therefore, changes in maize production associated

16 The reference region contains sizable parts of both Lindi Rural and Ruangwa districts, which are both part of Lindi Region. Thus, we assume that the trends in crop production for the entire region are reflective of the trends in the reference region.

17 At the time of writing this document, crop production data from 2010-2012 was not yet available.

18 We used rainfall data from the Mtwara weather station, which is the nearest station to Lindi.

with changes in rainfall should come mostly from lower productivity rather than a change in the area cultivated. However, farmers state that drought can be discouraging and thus they may not devote as much effort to clearing more land the following year. Furthermore, the decision whether or not to expand a farm is based in large part on the condition of the current farm. In drought years, if the crop fails or does poorly, more soil nutrients would still be in the ground, while pest and weed levels would likely be lower than during a high rainfall year. Thus, even apart from discouraging farmers, drought conditions may also reduce the need for farm expansion in subsequent years. Since the deforestation analysis is grouped in two year periods, lower maize production in one year could be captured in terms of lower deforestation the next year. For instance, the most severe drought in the reference period was during the long rains (Jan - May) in 2003 and was followed by normal rainfall in 2004. The 2003 drought may also help to explain why maize production shows the lowest correlation with deforestation during the 2002 to 2004 period.

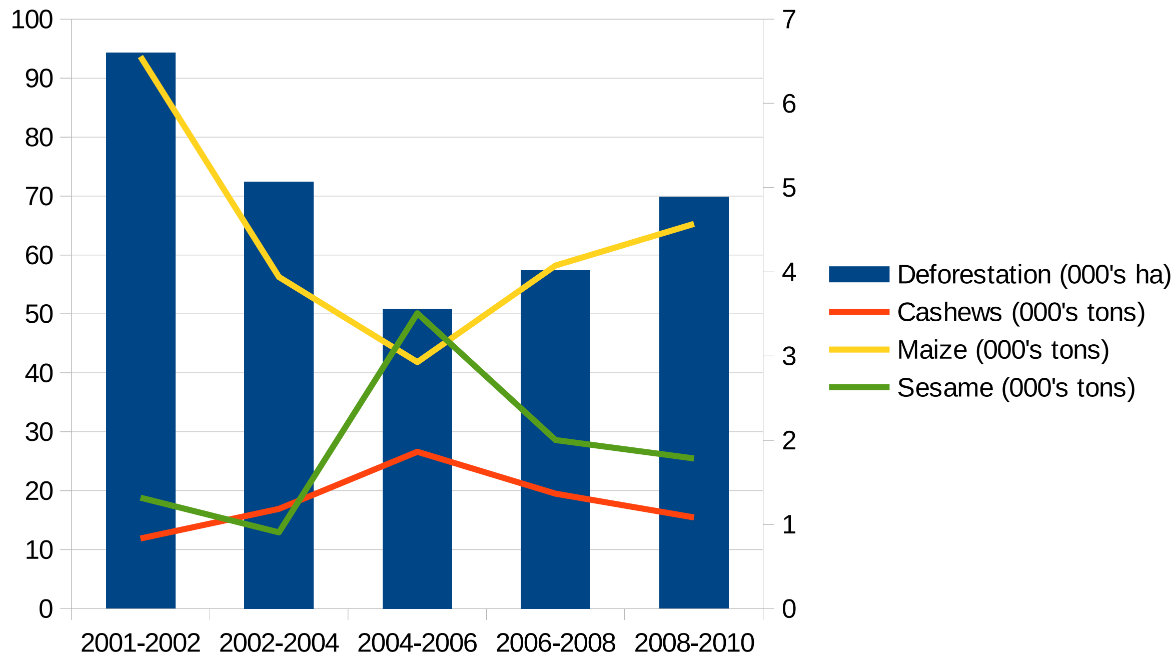

Figure 16: Average annual Lindi Region crop production in 000's tons (left y axis) and average annual deforestation in the reference region in 000's ha (right y axis) from 2001 to 2010.

However, rainfall is not the only determinant of maize production. Figure 16 suggests a negative relationship between cashew nut production, maize production, and deforestation. It is likely that the relationship is not coincidental. Typically, short term changes in cashew nut production in Tanzania do not represent changes in the area under cashew nut cultivation. As one women in Likwaya village put it, “even the trees our grandfathers planted keep producing <u>if you tend them</u>". However, tending to cashew trees requires a great deal of labor. In years when cashew farming is less attractive, farmers may decide to spend their labor on other activities. While not all farmers have cashew trees, farmers with many trees often hire other farmers to help tend the trees. Thus, changes in cashew nut production are related to changes in the labor distribution between different farm activities across the whole region. Simple linear models relating cashew nut production to deforestation and maize production were both significant at the 95% confidence interval, explaining 73% and 82% of variance respectively. However, when production data for maize and cashews are compared on a year to year basis rather than averages of two year intervals, the relationship disappears. This is likely because the role of rainfall has a greater effect on year to year yields for maize and cashews than labor competition. For two year periods, the role of rainfall is reduced by averaging high and low rainfall years. To test this idea, we modeled annual rainfall as a function of both cashew nut and maize production. The results (Table F) show that indeed maize and cashew nut production have significant positive correlation with rainfall, but have a significant negative interaction with each other. Thus, part of the decline in deforestation in the middle of the reference period appears to be explained by switching labor from maize to cashew nut production.

Table F: Rainfall model as a function of Maize and Cashew Production with interaction.

Coefficients:	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-1137.13	366.07	-3.11	0.027
Maize	28.30	5.03	5.62	0.002
Cashew	76.88	18.26	4.21	0.008
Maize:Cashew	-1.21	0.27	-4.41	0.007
Adjusted R^2 = 0.89 F= 22.7, df1 = 3, df2 = 5 p = 0.002				

Sesame production was not significantly correlated with deforestation or maize cultivation. However, it could have a weak moderating effect on deforestation. So long as the attraction of sesame cultivation does not pull new immigrants into the region, as with cashews, increases in sesame production reflect shifts in the existing labor distribution between crops. Farmers indicate that sesame is not as demanding as maize in terms of soil fertility, and thus it can be grown successfully in more accessible fallow clearings, which don't contribute to gross deforestation. However, even when farmers clear forest to grow sesame, swapping labor from maize production to sesame could still result in less overall deforestation because sesame farming is more labor demanding on a per area basis than maize.

Wood Products

Charcoal production, which is exclusively for sale to urban consumers, is also a factor behind deforestation in some villages, particularly those near Lindi town. Within the project area, Likwaya village is the only village where charcoal plays a significant role in deforestation, though community members in Mkanga I and Mkombamosi also report making charcoal. In the 2012 survey of deforestation, only 1 of 52 clearings was associated exclusively with charcoal production. Fuel wood is the primary source of energy for cooking throughout the reference region, but does not contribute to deforestation as most cooking fuel is either gathered as down wood or cut from fallows. Timber harvesting, which is highly selective, is also not a contributing factor to deforestation, though historically caused significant degradation of the coastal forests in the region. Data from carbon plots in the project area suggest that current timber stocks are very low and make up less than 1% of the biomass.

For a list of project activities and an explanation for how they address some of the key drivers of deforestation, see Section 1.8 of the Project Description.

3.2.2 Spatial Drivers

This section lists the spatial drivers associated with the main drivers of deforestation in the reference region.

Soil and topography

At the small scale, soil conditions are probably the most important factor affecting where farmers choose to deforest. Farmers report that certain tree species indicate good soils for cultivation. Unfortunately, soil and vegetation maps available for the area are general and not able to pick up on the fine scale variations observed by farmers on the ground. However, some larger scale geological phenomenon do appear to be associated with deforestation. In particular, farmers prefer lower slope areas, such as valleys or plateau tops. However, they also deforest on sloped land where streams have created a concave landscape configuration, since the soils will often remain moist. Elevation is negatively associated with deforestation, but this probably reflects distance to population and infrastructure drivers rather than an actual preference for lower elevation forests since all deforestation for agriculture today is associated with rain fed agriculture and higher elevations receive more rainfall. In the distant past, when valley bottoms still contained forest, farmers would have had a preference for lower elevation areas due to superior soil, but almost all these forests were cleared before the reference period.

Distance to deforestation

Distance to other farmers is also an important factor associated with deforestation. Farmers often move in small groups into previously uncultivated areas so that they can better defend their farms against elephants, baboons and other crop-raiding animals. Also, since a large portion of the cultivation in frontier parts of the reference region is shifting cultivation, distance to recent deforestation is a good predictor of future deforestation because it shows where people are currently active in the landscape and they aren't likely to suddenly shift their activities to another part of the forest, but will rather expand out from their current location.

Distance to infrastructure and services

As a significant portion of deforestation is associated with crops that will be sold, distance to roads and markets (settlements) are also important predictors of where people are more likely to deforest. Also, access to services like schools and health clinics encourages people to deforest closer to settlements. Many farmer's have houses in settlement centers and must walk to their farms daily or camp out at their farm as the harvest season approaches in order to defend it against wild animals.

Population density

Population is not evenly distributed throughout the landscape. Some villages (such as Ruhoma village) have relatively low population densities, while other villages (like Milola) are densely populated. Villages with higher population densities put more pressure on the forest surrounding them than less densely populated villages.

Proximity to urban areas

Charcoal production is currently confined to villages that are near Lindi town or the highway. Larger trees are best for charcoal production, but charcoal makers will also make charcoal out of regenerating forest if large trees are inaccessible. Therefore, proximity to Lindi town and the Dar es Salaam – Lindi – Mtwara highway are the best predictors of charcoal related deforestation.

3.3 Identification of underlying causes of deforestation

The 5 main underlying causes of deforestation in the reference region are as follows:

Local population growth

According to census data, population in the reference region has grown 0.59% per annum between 2002 and 2012. This population growth has translated into increased local demand for agricultural products and increased labor to facilitate forest clearing. The population of Lindi town, which is only 20km from the project area and a major market for crops and charcoal produced in the project area, nearly doubled between 2002 and 2012 from 41,000 to 79,000 people. Local population growth will likely continue at the historical rate and may even increase with improved road infrastructure in the region. The project can have little effect on this underlying driver. However, communities will likely spend some of their REDD earnings on improving local health and education services (as they did with test REDD payments) which may in the long run contribute to reduced local population growth through improved access to family planning and improved economic opportunities for young women.

National urban population growth

National urban population growth translates into increased demand for charcoal and food crops across the nation. According to census data, Dar es Salaam, the countries largest city grew by 5.6% per annum between 2002 and 2012. Maize constitutes 33% of the caloric intake Tanzania[19], so increasing urban populations translates into increased demand for maize production, which is linked very strongly in Lindi to deforestation. As a whole, the country is still only about 30% urban, so the rural to urban migration will still continue to result in increasing urban populations during the next 30 years. The project can not address this underlying driver.

Open-access land use regime

Prior to the project, 100% of the project area forests were under an open-access land use regime whereby people from the participating villages and to some extent surrounding villages, were free to clear forest for farming. Under the customary land tenure system employed in these villages, clearing forest allowed households to convert forest land from open access communally owned land to individual household tenure. The only constraints on clearing forests were labor supply and demand for crops like maize. While the national government has plans for all villages to undergo land-use planning, progress is very slow. Furthermore, the national land-use planning guidelines suggest that communities set aside large areas for future agricultural use, which in forested communities results in large forest areas being set aside for clearing. The project has directly addressed this underlying driver of deforestation by facilitating land-use and forest management planning in all project villages. In an effort to make their plans compatible with REDD, rather than following the national guidelines, the villages choose to prevent future farming in the majority of their remaining forest areas.

Farming conditions

Poor soils, weeds, grass and pests cause many farmers to shift their cultivation frequently. Historically, when populations within the reference region villages were lower, shifting cultivation was probably

19 Minot, N., 2010. Staple food prices in Tanzania, in: Contributed Paper Prepared for the COMESA Policy Seminar Maputo, Mozambique. Citeseer, pp. 25–26.

sustainable and forests had sufficient time to regenerate between clearings. Today, however, fallow periods have declined substantially, rarely exceeding 15 years and usually not exceeding 10 years. Other clearings have been converted to permanent farms and due to changes in soil and fire frequency some clearings failed to regenerate at all despite being abandoned for more than 10 years after cultivation. In the absence of the project, the soil,weed and pests conditions would likely only worsen in the future as population growth would put even greater limitations on fallow lengths. The project has partially addressed this underlying driver through promoting conservation agriculture interventions that help to maintain soil fertility, prevent the buildup of weeds, and increase yields through a combination of improved seeds and labor intensive soil moisture management techniques.

Lack of alternatives to farming

The social impact assessment conducted by the project revealed that the region is one of the poorest in the country, the workforce is almost entirely unskilled, and there are very few non-farm related economic alternatives in the region. Most of the timber in the region has already been exploited, consumptive use of wildlife is illegal, and most residents don't have the skills required to participate in very limited wildlife tourism industry in the region. In the absence of the project, education and economic alternatives to farming would likely continue to slowly improve in the region. However, the project will accelerate this process. REDD earnings paid as dividends to members of participating communities will provide some communities members with the capital they need to start small businesses or improve education opportunities for their children. A survey of community members after the REDD test payments found that 35% of households reported spending REDD dividends on entrepreneurial activities and 20% reported spending dividends on education. Additionally, all villages decided to spend some of their earnings on improving education services, which will help their children access a broader ranger of economic opportunities in the long run.

For more details regarding project activities and an explanation for how they address some of the underlying causes of deforestation, see Section 1.8 of the Project Description.

3.4 Analysis of chain of events leading to deforestation

In summary, rural population growth in Lindi provides both the means (increased labor supply) and the necessity (increased need for subsistence and cash crops) for the expansion of permanent and shifting cultivation associated with deforestation, while urban population growth increases demand for charcoal and food crops. Due to the lack of alternative economic opportunities and low skilled population, farming is the only economic activity available to the vast majority of the regions inhabitants. Furthermore, due to the complete absence of land-use restrictions, intensification-related financial and technical hurdles, expanding the area of cultivation through deforestation is preferred to expanding yields through agricultural intensification.

Crop choice affects rates of deforestation in the region. When economic conditions favor maize cultivation, deforestation is higher because maize requires higher soil fertility, which can be obtained by clearing mature forest. Cash crops are a substitute for food crops. Therefore, farmers likely decide to grow one crop or another based on the prices of both cash and food crops. The region is the second biggest producer of cashews and when market conditions favor cashew cultivation over maize, deforestation declines because farmers devote more of their labor to tending to their existing cashew trees.

3.5 Conclusion

Future Trends of Underlying Causes

In the absence of REDD, most of these conditions would continue to persist and drive deforestation. Education is slowly improving in the region, which will make it easier for young people from the area to move to urban areas in search of economic opportunities. However, it seems unlikely that population growth in the region will actually decline over the next decade. Furthermore, Lindi is less isolated today. Some areas of Lindi region are experiencing migration from outside the region, and this could eventually effect the leakage belt and project villages as well. Another possible phenomenon, is that men born in the region may return to the region if new economic opportunities present themselves. Over the past decade, the Tanzanian government has constructed a bridge over the Rufiji River that previously separated Lindi Region from the northern Tanzania Coast and Dar es Salaam, and has also slowly improved the highway linking Lindi town to Dar es Salaam and Mtwara. Furthermore, these infrastructure improvements are on going, with about 60 km of the highway from Dar es Salaam still unpaved in Kilwa district. Unfortunately, there is no appropriate location in Tanzania that could be used as a proxy to estimate the effects of this improved infrastructure on future deforestation in Lindi. Therefore, as the future pattern and timing of these events is uncertain, migrants and returning residents are not included as deforestation agents for this baseline period.

Agriculture - Future Trends

Given the complicated interactions between weather, cash crops, food crops, and deforestation, predicting the future of deforestation in the region with any certainty is difficult. However, evidence suggests that the historical baseline is conservative and deforestation is likely to increase in the near future. Lindi Region is the least densely populated region in the country and the theory of labor swapping between cash and food crops resulting in changes in deforestation only holds true so long as the farm labor supply in Lindi is constrained. As described in section 3.1, census data from 2002 to 2012 does suggest that the labor supply in Lindi was historically constrained. However, this beneficial relationship between increased cash crop farming and reduced deforestation could very easily evaporate if the region becomes attractive to migrants from elsewhere in the country, which is a real possibility given the increased returns to agriculture that improvements to the transportation infrastructure in the region over the past decade might bring.

However, regardless of changes in migration patterns, it should be noted that in response to the 2002/2003 cropping season drought, the government of Tanzania imposed a ban on maize exports and this ban remained in place until the end of 2010, with the exception of 1 month in 2006[20]. A new ban was then put in place again for a few months in 2011, and then lifted. Thus, the only observation periods in the baseline where a maize export ban was not in place were from 2001 to 2002 and parts of 2010 to 2012, which were the two periods with the highest deforestation rates. In 2012, in response to studies conducted by USAID and the World Bank that showed export bans did not improve food security and increased rural poverty, the Tanzanian government made a commitment not to impose crop export bans in the future[21]. At the same time, export taxes on cashew nuts have been increased, and the new

20 Ahmed, S. A., Diffenbaugh, N. S., Hertel, T. W., & Martin, W. J. (2012). Agriculture and trade opportunities for Tanzania: past volatility and future climate change. Review of Development Economics, 16(3), 429-447.

21 Saiboko, A. 2013. Food export ban move a failure, reports Chiza. Daily News, Dar es Salaam. Available at: http://www.dailynews.co.tz/index.php/local-news/22936-food-export-ban-move-a-failure-reports-chiza

warehouse receipt system introduced in 2008, which was designed to provide cashew farmers with a guaranteed price at the beginning of the cropping season has proved highly dysfunctional[22] - even leading to riots by disgruntle cashew farmers in Lindi region[23]. Thus, the future policy environment will most likely favor maize production, and therefore deforestation, much more than the historical policy environment.

Wood Products – Future Trends

While rural population growth in the reference region over the past decade was relatively slow (0.59%), urban population growth was rapid. The population of Lindi Urban District (Lindi Town) grew from 41,075 to 78,841 from 2002 to 2012. Urban population growth is likely to continue to be strong and thus demand for charcoal will likely increase and reach further into the project area and reference region in the future.

Conclusion

The preponderance of evidence suggests that deforestation rates in the region will increase in the near future. However, given that the historical baseline does not show a clear upward trend and that there is no appropriate proxy area that could be used to quantify the exact effects of the new policy environment and improved infrastructure on the future rates of deforestation in the region, we have conservatively decided to use the historical average deforestation rate.

STEP 4: PROJECTION OF FUTURE DEFORESTATION

In this step, the future amounts and locations of deforestation within the reference region are predicted.

4.1 Projection of the quantity of future deforestation

The methodology suggests stratifying the reference region according to the results of the analysis of section 3 in the event that different drivers affect different parts of the reference region. While charcoal production only affects communities closest to the highway and Lindi municipality, it appears to be only a minor driver of deforestation at the moment and is difficult to disentangle from agriculture. Only 2 of the 52 clearings surveyed in the project villages in 2012 were charcoal making sites and only one of these clearings was not subsequently used for agriculture. Agriculture, on the other hand, affects all parts of the reference region.

However, an analysis of historical deforestation rates by initial forest class (Table G and Table H) shows that historically there has been far greater deforestation in low carbon forests than in high carbon forests and that this has been a consistent trend over the past decade. Higher rates of deforestation in low carbon forests is due to the fact that low carbon forests are more accessible lowland forests, but also because low carbon forests are often areas of regeneration from very old agricultural clearings. Thus, low carbon forests are areas that farmers already identified as favorable for agriculure in the past. Therefore, we chose to stratify the reference region by intial forest class for the purpose of projecting quantities of future deforestation (as reflected in VM Table 8).

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22 Domasa, S. 2013. Cashew farmers petition against warehouse receipts system. The Guardian, Dar es Salaam. Available at: http://www.ippmedia.com/frontend/?l=53929

23 Daily News. 2013. Police team formed to arrest Lindi chaos. Daily News, Dar es Salaam. Available at: http://www.dailynews.co.tz/index.php/local-news/16758-police-team-formed-to-arrest-lindi-chaos

Table G: Gross high carbon forest cover loss in the reference region from 2001 to 2012

Time Period	Deforestation detected (ha)	Starting Forest Area	% Non-Observable	Months in period	Annual % Change	Observation weight
May, 2001 to May, 2002	2,625	151,418	0.00%	12	-1.75%	0.09
May, 2002 to May, 2004	4,354	148,793	0.00%	24	-1.48%	0.18
May, 2004 to May, 2006	3,209	144,439	0.00%	24	-1.12%	0.18
May, 2006 to May, 2008	3,793	141,231	0.00%	24	-1.36%	0.18
May, 2008 to Sept, 2008	272	137,437	0.00%	4	-0.60%	0.03
Sept, 2008 to Oct, 2010	4,910	137,165	0.00%	24	-1.82%	0.18
Oct, 2010 to April, 2012	4,234	132,255	7.33%	19	-2.21%	0.15
Weighted[1] Average Annual Change					-1.56%	

[1] Due to the timing of available of cloud free Landsat data and substitute radar imagery, the time periods covered vary in duration. Therefore, the annual deforestation rates for each period were weighted by the period duration in months to arrive at one average annual deforestation rate for the entire 2001 to 2012 period.

Table H: Gross low carbon forest cover loss in the reference region from 2001 to 2012

Time Period	Deforestation detected (ha)	Starting Forest Area	% Non-Observable	Months in period	Annual % Change	Observation weight
May, 2001 to May, 2002	3,973	116,165	0.00%	12	-3.48%	0.09
May, 2002 to May, 2004	5,786	112,191	0.00%	24	-2.65%	0.18
May, 2004 to May, 2006	3,919	106,405	0.00%	24	-1.88%	0.18
May, 2006 to May, 2008	4,240	102,486	0.00%	24	-2.11%	0.18
May, 2008 to Sept, 2008	855	98,246	0.00%	4	-2.62%	0.03
Sept, 2008 to Oct, 2010	4,873	97,391	0.00%	24	-2.57%	0.18
Oct, 2010 to April, 2012	4,503	92,518	6.24%	19	-3.36%	0.15
Weighted[1] Average Annual Change					-2.57%	

[1] Due to the timing of available of cloud free Landsat data and substitute radar imagery, the time periods covered vary in duration. Therefore, the annual deforestation rates for each period were weighted by the period duration in months to arrive at one average annual deforestation rate for the entire 2001 to 2012 period.

VM Table 8. Stratification of the reference region

Stratum ID		Description	Area
ID	Name		
1	HC Reference Regione	All high carbon forests in the 2012 forest bench mark map within the reference region polygon excluding national forest reserves.	131,030 ha

2	LC Reference Region	All low carbon forests in the 2012 forest bench mark map within the reference regoin polygon excluding national forest reserves.	100,608 ha

4.1.1 Selection of the baseline approach

The analysis in section 3 shows conclusive evidence that changes in the deforestation during the baseline period in Lindi were due to a combination of factors including weather, the relative economic attractiveness of cashews vs maize, and population growth. In the near future, the economic environment will favor maize cultivation, which historically is associated with greater levels of deforestation. However, this situation could change if cashew sector policies are reformed. Population in the region will continue to grow, but it is uncertain whether population growth rates will accelerate or remain the same. Doubtlessly, the weather will continue to fluctuate from year to year. While it is possible to model deforestation as simply a factor of the current maize farming policy environment, we view this as inappropriate because there are not enough data points from the historical analysis to accurately control for other factors. Thus, we have conservatively chosen the historical average approach.

4.1.2 Quantitative projection of future deforestation

4.1.2.1 Projection of the annual areas of baseline deforestation in the reference region

As per the methodology, since we chose the historical average approach, the annual baseline deforestation area that applies at year t to stratum i within the reference region was calculated as follows (results presented in VM Table 9.a):

$$ABSLRR_{i,t} = ARR_{i,t-1} * RBSLRR_{i,t} \quad \text{(VM 3)}$$

Where:

$ABSLRR_{i,t}$ = Annual area of baseline deforestation in stratum i within the reference region at year t; ha yr^{-1}

$ARR_{i,t-1}$ = Area with forest cover in stratum i within the reference region at year t-1: ha

$RBSLRR_{i,t}$ = Deforestation rate[24] applicable to stratum i within the reference region at year t; %

t = 1, 2, 3 ... T, a year of the proposed project crediting period; dimensionless

i = 1, 2, 3 … $I_{,RR}$, a stratum within the reference region; dimensionless

4.1.2.2 Projection of the annual areas of baseline deforestation in the project area and leakage belt

The annual areas of baseline deforestation in the project area and leakage belt were calculated using GIS from the results of deforestation risk location modeling conducted in step 4.2.

4.1.2.3 Summary of step 4.1.2

The results of steps 4.1.2.1 and 4.1.2.2 are presented in the following tables.

24 These rates are taken from the bottom of Table G and Table H, which are the time weighted average deforestation rates for the high and low carbon forest strata for all the observation periods from 2001 to 2012.

VM Table 9.a: Annual area of baseline deforestation in the reference region

Project year t	Stratum i in the reference region		Total	
	1	2	Annual	Cumulative
	$ABSLRR_{1,t}$	$ABSLRR_{2,t}$	$ABSLRR_t$	$ABSLRR$
	ha	ha	ha	ha
1	2,044	2,586	4,630	4,630
2	2,012	2,519	4,531	9,161
3	1,981	2,454	4,435	13,596
4	1,950	2,391	4,341	17,938
5	1,919	2,330	4,249	22,187
6	1,890	2,270	4,160	26,346
7	1,860	2,212	4,072	30,418
8	1,831	2,155	3,986	34,404
9	1,802	2,099	3,902	38,306
10	1,774	2,046	3,820	42,126

VM Table 9.b: Annual areas of baseline deforestation in the project area

Project year t	Stratum i of the reference region in the project area		Total	
	1	2	Annual	Cumulative
	$ABSLPA_{1,t}$	$ABSLPA_{2,t}$	$ABSLPA_t$	$ABSLPA$
	ha	ha	ha	ha
1	452	503	955	955
2	398	460	858	1,813
3	406	430	836	2,649
4	418	410	828	3,477
5	387	402	789	4,266
6	377	377	754	5,020
7	359	351	711	5,730
8	375	335	710	6,440
9	362	320	682	7,122
10	351	313	664	7,786

VM Table 9.c: Annual areas of baseline deforestation in the leakage belt

	Stratum i of the reference region in the leakage belt		Total	
	1	2	Annual	Cumulative

Project year t	$ABSLLK_{1,t}$	$ABSLLK_{2,t}$	$ABSLLK_t$	$ABSLLK$
	ha	ha	ha	ha
1	755	696	1,451	1,451
2	589	628	1,217	2,668
3	567	620	1,187	3,855
4	578	586	1,164	5,019
5	572	540	1,112	6,132
6	570	531	1,101	7,232
7	556	494	1,051	8,283
8	574	495	1,069	9,352
9	552	478	1,030	10,382
10	537	443	980	11,363

4.2 Projection of the location of future deforestation

This section describes the steps taken to model the future location of deforestation in the reference region, project, and leakage belt, from 2012 to 2022.

4.2.1 Preparation of factor maps

Using the knowledge of drivers of deforestation in the reference region gained from the sources listed at the beginning of Step 3, we identified factors that influence the location of deforestation and created the factor maps listed in VM Table 10 to be used for modeling the future location of deforestation. The process for creating most of the factor maps is self-explanatory following relatively simple GIS procedures such as creating Euclidean distance maps or using basic terrain modeling tools to generate terrain data from digital elevation maps. It should be noted that distance maps were generated from data maps with data well beyond the reference region boundaries in order to prevent edge effects at the boundaries of the reference region. All factor maps and the data used to create them were shared with the validator. Justifications for including each factor map in the model are provided in Table I.

Population pressure mapping

Here we describe the process for creating population pressure maps, which is more complicated than the other factors maps. A recent study found that population pressure was a significant predictor of forest disturbance in Tanzania[25]. The premise behind a population pressure map is that larger populations exert more pressure than smaller populations and that closer populations exert more pressure than distant populations. The authors of the study, graciously provided MJUMITA with a copy of the R script, which implements the following equation:

$$pp_i = \sum_{j=1}^{n} p_j \times \exp\left(-\left(\frac{d_{ij}}{\sigma}\right)^2\right) \quad \text{(B)}$$

25 Green, Jonathan MH, et al. "Estimating management costs of protected areas: A novel approach from the Eastern Arc Mountains, Tanzania." Biological Conservation 150.1 (2012): 5-14.

Where: pp_i = population pressure in cell *i*; dimensionless

p_j = population at remote cell *j*; dimensionless

d_{ij} = Euclidean distance between focal cell *i* and remote cell *j*; meters

n = number of cells in the population density map[26]; dimensionless

σ = distance decay function constant; dimensionless

The first step in creating density maps to feed into the population pressure model was to identify the location of all the population centers in the reference region and immediately outside the reference region. This was done with the use of high resolution imagery, 1:50,0000 topographic maps, and an enumeration areas map obtained from the Tanzanian Bureau of Statistics. A point was placed in the main population centers (greatest concentration of houses) for each village. Then, the 2002 and 2012 census total population data for each village was added to the attribute table for the points. Populations for the year 2006 were calculated using a simple linear extrapolation of the change in population between 2002 and 2012.

Next, village boundaries were established for each village so that population densities could be calculated on a village by village basis. Unfortunately, there are no reliable sources of village boundaries for the entire reference region. The boundaries of the enumeration areas can be consolidated by village to come up with approximate village boundaries. However, we found that the approximate village boundaries constructed from the enumeration areas had very little correlation with the boundaries of the villages in the project areas which had been established as part of the project's land-use planning activity. Instead, we discovered that a weighted Voronoi diagram[27] resulted in village boundaries much closer to those that had been mapped in the project area and therefore presumably the actual boundaries of villages in the rest of the reference region. In fact, four major areas of disagreement between the official village boundaries and the voronoi approximate boundaries were known to be areas with boundary conflicts, where villagers from larger villages were found farming in the lands belonging to smaller villages. The weighted Voronoi diagrams were generated using an ArcGIS Extension[28] written by Pinliang Dong, using the natural log of village populations as weights.

Then, to generate more accurate population density figures for the inhabited parts of villages, the forest areas and uninhabited non-forest land covers such as savanna, were subtracted from the village polygons so that only inhabited parts of the village land remained. Then, population density of each village was calculated by dividing the village population by the inhabited village area in terms of 30 square meters. These operations were performed separately for the years 2002, 2006, and 2012 so that changes in population and changes in the size of the inhabited area of villages were factored into the population density calculations for each year.

Since the land-use land-cover data used to determine the inhabited parts of each village was in 30 meter resolution and the population density figures were expressed in terms of population per 30x30 meters, the

26 The population density map was larger than the reference region so that the nearest population centers to the edge of the reference region could exert population pressure on the reference region. Otherwise, population pressure projections at the edge of the reference region would be biased.

27 Dong, P. (2008). Generating and updating multiplicatively weighted Voronoi diagrams for point, line and polygon features in GIS. Computers & Geosciences, 34(4), 411-421.

28 The extension is available at http://arcscripts.esri.com/details.asp?dbid=15481.

population density information was first burned into a 30 meter raster. Then, to reduce calculation time and better reflect the true resolution of the data, the 30 meter raster was re-sampled to a 990 meter square pixel raster using aggregation so that the population figures for each 990x990 meter pixel was equal to the sum of the population in the 30x30 meter pixels used to create it. Therefore, in the final map of population density, forests that were far from inhabited parts of villages had population densities of zero, while edge pixels would have population densities that were a sum of zero density forest pixels and whatever density was calculated for the inhabited parts of the village, and pixels in areas without any forest would have a population density equal to the average population density for the village per 990x990 meters. An example of the population density map for 2002 is provided in Figure 17.

Next, the 990x990 grid of population density was converted to a .txt file with the center of the pixel in lat/long and the population density as attributes. The .txt file was supplied to the R script to calculate the population pressure map, which is also output as a .txt file. The output population pressure map .txt file was then converted back to a 990 x 990 meter raster. Finally, the 990x990 population pressure map was re-sampled to 30 meters and cropped to the reference region so it could be used in conjunction with the other factor maps. Different maps were generated for each distance decay function constant. The population pressure map for 2002 using a distance decay function constant of 5 is provided in Figure 18.

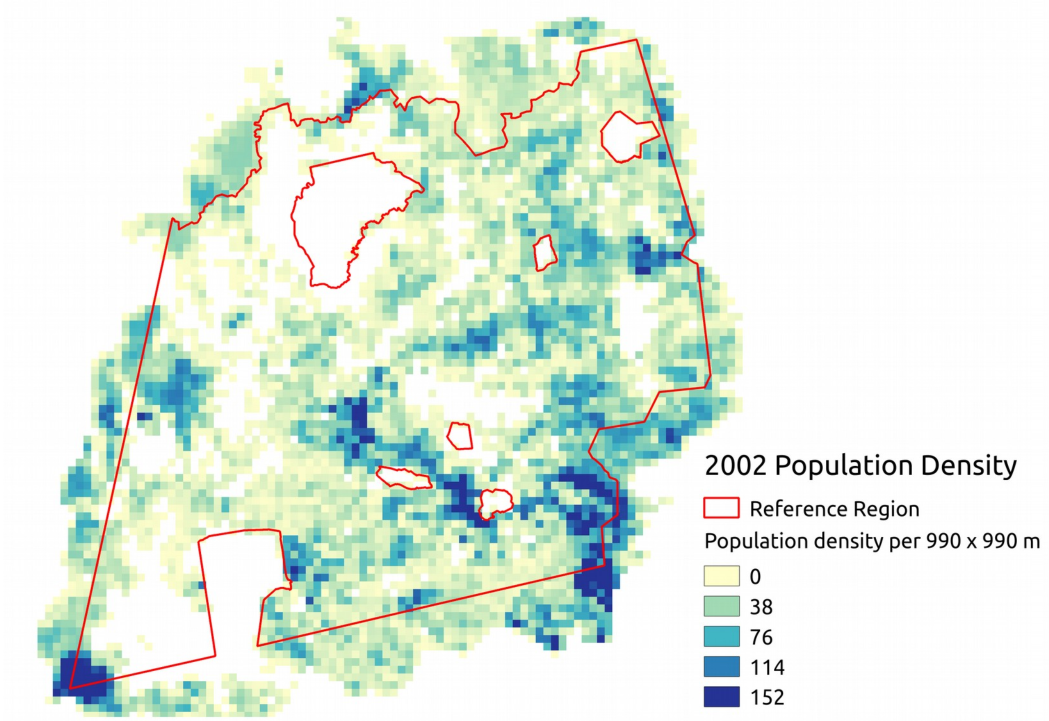

Figure 17: Extended reference region population density in 2002

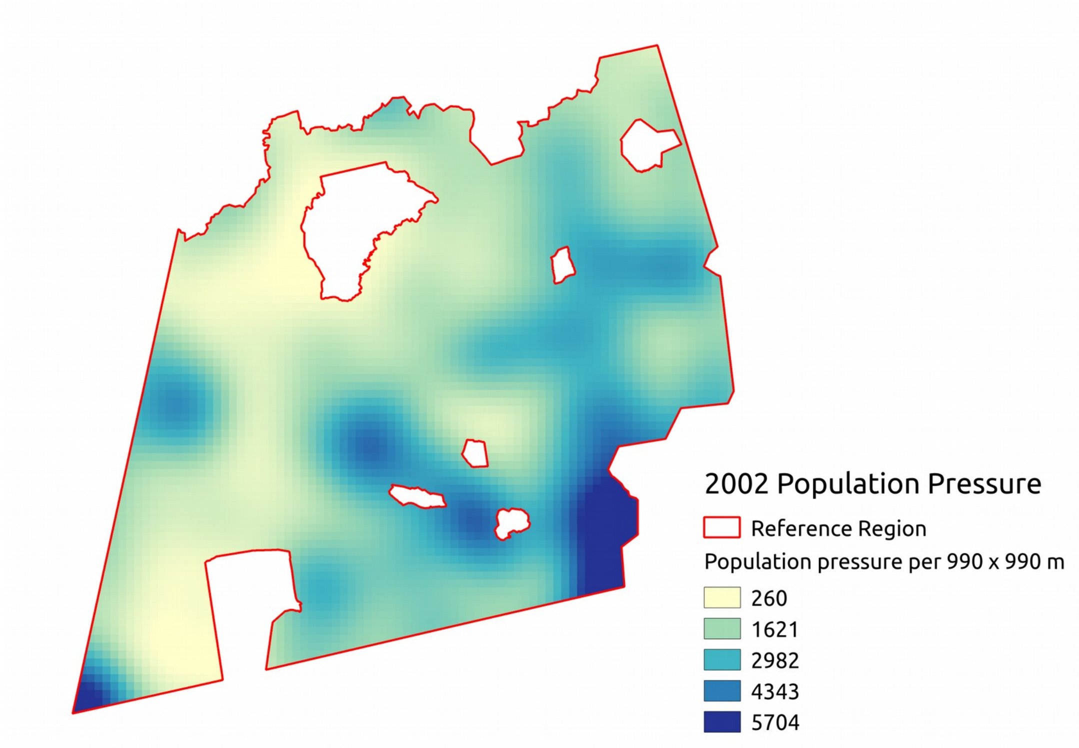

Figure 18: Population pressure in 2002

VM Table 10: List of variables, maps, and factor maps

Factor Map		Source	Variable represented		Meaning of the categories or pixel value		Other Maps and Variables used to create the Factor Map		Algorithm or Equation used	Comments
ID	File Name[1]		Unit	Description	Range[2]	Meaning	ID	File Name		
1	d_rec_x	self	m	Euclidean distance to deforestation that occurred in the year or two years prior to the period to be modeled.	2002: 0 – 8996 2006: 0 – 6374 2012: 0 - 3794	Distance to recent deforestation in meters	13	Def_2001-2012	Proximity in QGIS Raster Tools	See Step 2.4.2 for details on deforestation mapping
2	d_past_x	self	m	Euclidean distance to deforestation that occurred in the past 9 to 10 years prior to the period to be modeled.	2002: 0 – 3494 2006: 0 – 3494 2012: 0 - 3517	Distance to past deforestation in meters	14 & 15	Def_2001-2012 & Def_1991-2001	Proximity in QGIS Raster Tools	See Step 2.4.2 for details on deforestation mapping
3	d_road	self	m	Euclidean distance to drivable roads in the reference region digitized from high resolution imagery and 1:50,000 topographic maps. No roads added over time.	0 – 8853	Distance in meters from the nearest road	16	Roads.shp	Proximity in QGIS Raster Tools	
4	d_set	self	m	Euclidean distance to all settlements in the reference region digitized from high resolution imagery with guidance from 2002 census enumeration areas GIS data. No settlements added over time.	0 – 10362	Distance in meters from the nearest settlement (cluster of 10 or more houses)	17	Settlements.shp	Proximity in QGIS Raster Tools	
5	dem	CIGAR	m	3 arc second SRTM DEM	7 – 917	Meters above				

				from CIGAR re-sampled to 30m		sea level				
6	slope	self	%	Percent slope created from SRTM DEM and re-sampled from 30m	0 – 40	Percent slope	5	dem	Terrain Models in QGIS Raster Tools	
7	tpi	self		Topographic Position Index created from SRTM DEM and re-sampled to 30m	-16 to 17	Concave < 0 Flat = 0 Convex > 0	5	dem	Terrain Models in QGIS Raster Tools	
8	soil	IIASA		Soil type from the Harmonized World Soil Database from the International Institute for Applied Systems Analysis		See Harmonized World Soil Database for Codes				
9	d_srtm	self	m	Euclidean distance to streams digitized from 1:50,000 topographic maps.	0 – 5941	Distance in meters from nearest stream	18	Streams.shp	Proximity in QGIS	
10	ftype_x	self		Detailed map of 16 land-use land-cover classes from Table A of step 2.4.2.		See Table A for forest type codes			Randomforest classification of land-cover	See Step 2.4.2 for more details
11	pop_s5_x	self		1km grid population pressure map re-sampled to 30m. 2002 and 2012 census data used to create population density maps from which population pressure is calculated with R script.	2002: 86 – 7988 2006: 102 – 7564 2012: 145 – 7456	The amount of population pressure exerted on a forested grid cell from surrounding populated cells	19 20 21	Density_2002 Density_2006 Density_2012	R Script by Philip Platts and Jonathan Green (decay constant set to 5)	See Step 2.4.2 for more details
12	pop_s10_x	self		1km grid population pressure map re-sampled to 30m. 2002 and 2012	2002: 1828 – 18492 2006: 1910 –	The amount of population pressure	22 23 24	Density_2002 Density_2006 Density_2012	R Script by Philip Platts and Jonathan	See paragraph after this table

				census data used to create population density maps from which population pressure is calculated with R script.	18447 2012: 2122 – 18391	exerted on a forested grid cell from surrounding populated cells			Green (decay constant set to 10)	for more details

[1] The x in the file name represents the year. In the files provided to the validater, there are different versions of these files for the start of the training period (2002), the start of the validation period (2006), and the start of the project period (2012, because they are all masked for the forest areas at the start of these periods.

[2] Ranges are only shown for continuous data and only reflect the values found in forested areas within the reference region. If only one range is listed then the range was constant for all years. Otherwise, ranges for each year are displayed.

Table I: Justifications for factor map inclusion

Factor Map ID	Relationship to deforestation
1	Distance to recent deforestation gives the greatest spatial discrimination for predicting the location of future deforestation. Ninety-five percent of deforestation between 2002 and 2012 fell within 1.6 km of deforestation between 2001 and 2002.
2	Distance to past deforestation is also strongly associated with the location of future deforestation and gives more information than distance to non-forest would since some non-forest land-covers are uninhabited savanna or flood plains.
3	Distance to road is an important factor as farmers growing cash crops are less likely to do so at great distance from roads and therefore access to markets.
4	Distance to settlements is an important factor as farmers are less likely to grow crops at great distances from settlements which provide access to markets and social services.
5	Lower elevations experience greater rates of deforestation due to their proximity to river valleys, which have the most fertile soil. Additionally, including the elevation allows the model detect non-linear patterns in deforestation also associated with elevation.
6	Slope is included because farmers prefer to cultivate lower slop areas, which are easier to work, less likely to suffer from erosion, and more likely to have fertile soils.
7	Topographic position index is included because farmers prefer flat or concave land formations since they will capture and retain more soil moisture than convex land formations.
8	The Harmonized World Soil Database soil map is very generalized, but it is likely that some general soil types found within the region are more preferred for farming than others.
9	Distance to streams is included because farmers prefer to cultivate in stream valleys and they are also the main source of drinking water for

	farmers.
10	The land-use land-cover map is included because forest types can be an indicator of soil type and rainfall and therefore the relative preference of a farmer for an area.
11 - 12	Population pressure is a predictor of deforestation since farmers living in areas of high population density are more likely to experience a shortage of land and thus more likely to expand into forest than farmers living in areas with lower population density. Although a range of different decay constants were tested, only population pressure maps with a decay constant of 5 and 10 improved the model's FOM (see Step 4.2.3). The decay constant of 5 gives greater weight to closer populations, while the decay constant of 10 gives greater weight to large populations.

4.2.2 Preparation of deforestation risk maps

To arrive at the most accurate deforestation risk map, we experimented with several different modeling packages and models, including a weights of evidence model in Dinamica Ego, a machine learning model in Idrisi's Land Change Modeler, and a Randomforest[29] class probability model implemented in R. We also experimented with different combinations of risk factor maps.

In order to calibrate and validate the models, using option 'a' from the methodology, we broke the historical deforestation data (Figure 14) into calibration (2002-2006) and validation (2006-2010) time periods. The models were trained using only data from the calibration period and then used to predict the validation period. These two periods were chosen because they both represented approximately 4 years of deforestation and had similar average deforestation rates. A hard prediction map for the validation period was created using an R script that selects pixels from the risk map starting with the highest probability of deforestation and working backwards until the number of pixels selected is equal to the amount of deforestation for the period. The deforestation rate for the validation period was set equal to the observed rate of deforestation during the period, so that only the model's accuracy at predicting the location of deforestation was evaluated.

4.2.3 Selection of the most accurate deforestation risk map

As per the methodology, the relative accuracy of each model was evaluated by comparing the hard prediction maps for the validation period to the actual observed deforestation maps for the period on a pixel by pixel basis to calculate the figure of merit:

$$FOM = B / (A+B+C) \qquad \text{(VM 9)}$$

Where:

FOM = “Figure of Merit”; dimensionless

A = Area of error due to observed change predicted as persistence; ha

B = Area correct due to observed change predicted as change; ha

C = Area of error due to observed persistence predicted as change; ha

After several model runs, it was found that the Randomforest model consistently produced higher figure of merits than the other models. Here are the parameters for the most accurate Randomforest model (a copy of the R script was provided to the validator):

Training Data Location: Equal stratified (deforestation and persistence) random sample of 150,000 pixels.

Variables Used: All (all of the factor maps listed in step 4.2.1)

29 Randomforest is a well established model in the international science community used for a variety of purposes. Its implementation in R is open source. In the GIS world, it is most often used for land use land cover classification. However, in addition to outputting hard classifications, it can also output class probabilities. In the case of a two class map of deforestation and persistence, these probabilities represent relative deforestation risk.

Non-Default Arguments Used for Randomforest: nodesize[30] = 7, ntree[31] = 3999

At the single 30 x 30 m pixel resolution, the model had an *FOM* for the 2006 to 2010 validation period of 15.3%, which is almost twice the amount of change being modeled for the period (7.7%). Thus, as per the methodology, the model is deemed to have an acceptable level of accuracy. The accuracy of the model was also evaluated at larger scales, where it was found to be much more accurate. For instance, the amount of deforestation predicted to occur in all of the project villages during the validation period was 96% of what actually occurred. At the scale of individual project villages, the model had an *FOM* of 62%.

To prepare the final deforestation risk map (Figure 19) for predicting the locations of deforestation from 2012 to 2022, a new Randomforest model was created with the same parameters as the most accurate model above, but including training data from all of 2002 to 2012.

30 Setting the nodesize higher reduces memory consumption, but increases computing time.

31 Although as few as 500 trees would create nearly identical results, a large number of trees was required in order to generate the precision (number of digits in the probability values) necessary to separate small numbers of pixels for predicting individual years

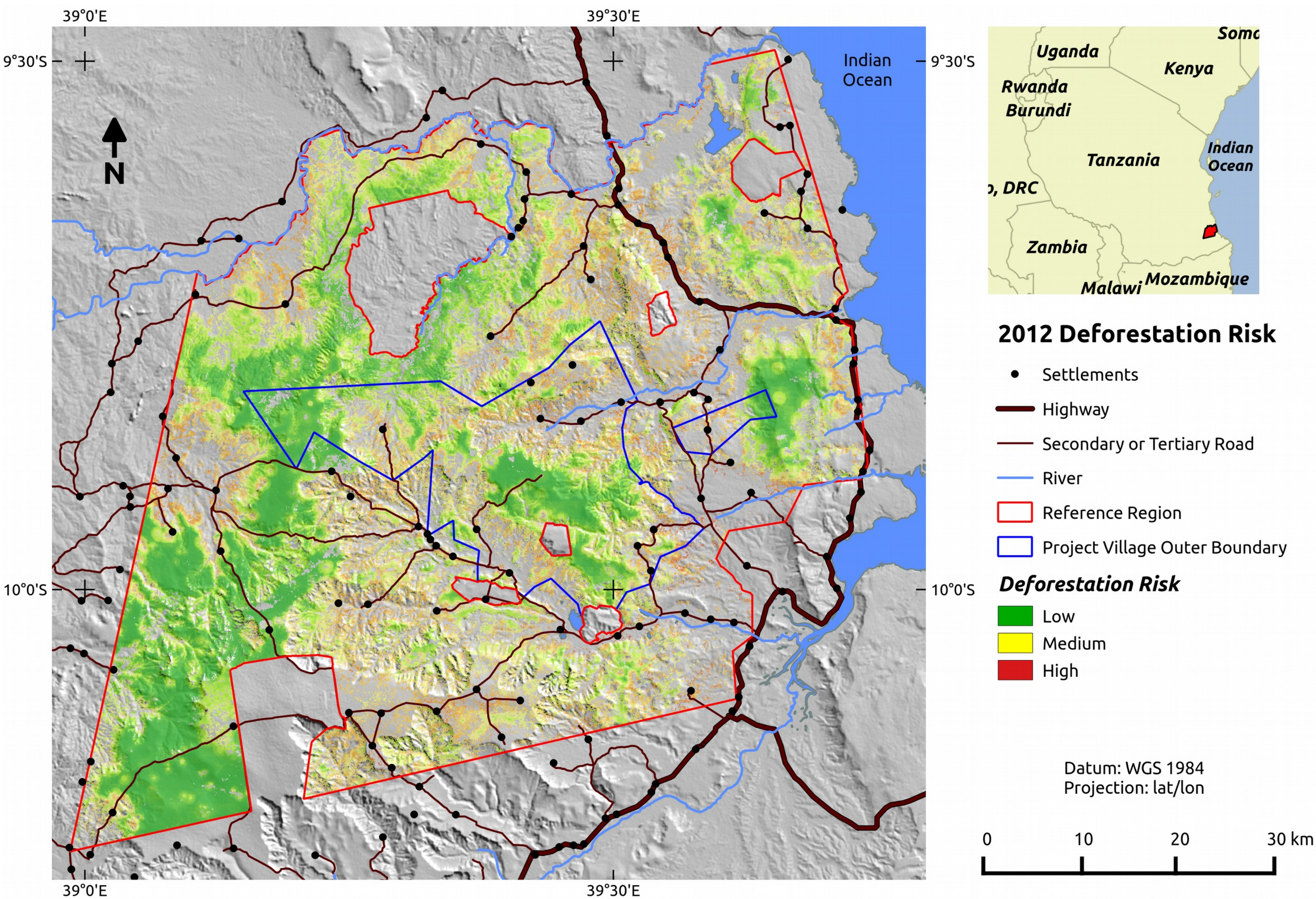

Figure 19: Deforestation risk map for 2012

4.2.4 Mapping the locations of future deforestation

As part of the process of evaluating the Randomforest model accuracy, we wrote an R script that creates a hard deforestation prediction map by selecting pixels in the reference region with the highest probability of deforestation until the number of pixels selected is equal to the deforestation rate for the period. To arrive at the map of annual baseline deforestation for the entire fixed baseline period (Figure 20), this script was applied to the 2012 deforestation risk map (Figure 19) to select deforestation on a year by year and stratum by stratum basis using the historical average annual deforestation rates for each stratum (Table G and Table H). The area of predicted deforestation for each stratum declines over time because the deforestation rate is applied to an increasingly smaller forest area in the baseline scenario.

The annual baseline deforestation map for the fixed baseline period was used in combination with masks for the project area and leakage belt to calculate the figures presented in VM Table 9.b and VM Table 9.c.

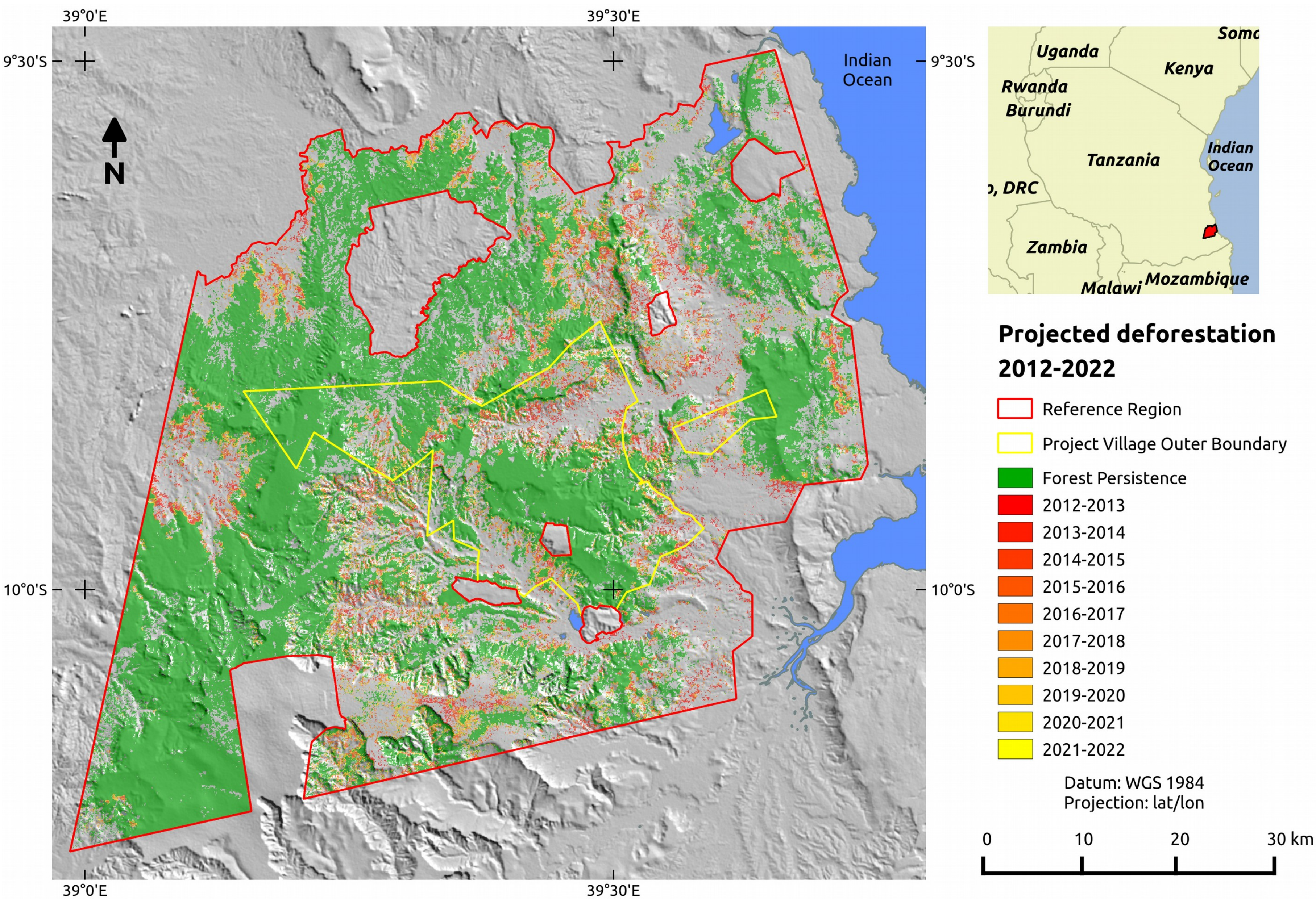

Figure 20: Map of projected baseline deforestation 2012-2022

STEP 5: DEFINITION OF THE LAND USE AND LAND COVER CHANGE COMPONENT OF THE BASELINE

In this step, we calculate activity data of the initial forest classes that will be deforested and activity data of the post-deforestation classes that will replace them in the baseline case.

5.1 Calculation of baseline activity data per forest class

Using the crosstab command in the R raster package and masks, we produced tables of projected baseline deforestation (Figure 20) by forest class (Figure 13) for the reference region (VM Table 11.a), project area (VM Table 11.b), and leakage belt (VM Table 11.c). Since the reference region was stratified by forest class for the purpose of projecting baseline deforestation, these tables have identical values to VM Table 9.a – 9.c.

VM Table 11.a: Annual areas deforested per forest class icl within the reference region in the baseline case (baseline activity data per forest class)

Area deforested per forest class icl within the reference region			Total baseline deforestation in the reference region.	
ID_{icl}>	1	2		
Name >	High Carbon	Low Carbon	$ABSLRR_t$	$ABSLRR$
			annual	cumulative
Project year *t*	ha	ha	ha	ha
1	2,044	2,586	4,630	4,630
2	2,012	2,519	4,531	9,161
3	1,981	2,454	4,435	13,596
4	1,950	2,391	4,341	17,938
5	1,919	2,330	4,249	22,187
6	1,890	2,270	4,160	26,346
7	1,860	2,212	4,072	30,418
8	1,831	2,155	3,986	34,404
9	1,802	2,099	3,902	38,306
10	1,774	2,046	3,820	42,126

VM Table 11.b: Annual areas deforested per forest class icl within the project area in the baseline case (baseline activity data per forest class)

Area deforested per forest class icl within the project area			Total baseline deforestation in the project area	
ID_{icl}>	1	2		
Name >	High Carbon	Low Carbon	$ABSLPA_t$	$ABSLPA$
			annual	cumulative
Project year *t*	ha	ha	ha	ha

1	452	503	955	955
2	398	460	858	1,813
3	406	430	836	2,649
4	418	410	828	3,477
5	387	402	789	4,266
6	377	377	754	5,020
7	359	351	711	5,730
8	375	335	710	6,440
9	362	320	682	7,122
10	351	313	664	7,786

VM Table 11.c: Annual areas deforested per forest class icl within the leakage belt in the baseline case (baseline activity data per forest class)

Area deforested per forest class icl within the leakage belt			Total baseline deforestation in the leakage belt	
ID_{icl}>	1	2		
Name >	High Carbon	Low Carbon	$ABSLLK_t$	*ABSLLK*
			annual	cumulative
Project year *t*	ha	ha	ha	ha
1	755	696	1,451	1,451
2	589	628	1,217	2,668
3	567	620	1,187	3,855
4	578	586	1,164	5,019
5	572	540	1,112	6,132
6	570	531	1,101	7,232
7	556	494	1,051	8,283
8	574	495	1,069	9,352
9	552	478	1,030	10,382
10	537	443	980	11,363

5.2 Calculation of baseline activity data per post-deforestation forest class

The methodology allows for either the historical proportions or modeling to be used to determine the quantities of post deforestation land-uses expected in the baseline scenario. We chose the historical proportions approach.

The methodology calls for the reference region to be divided into zones if different post-deforestation land-uses are more likely in some part of the reference region than others. We considered using elevation as a means of creating zones since agroforestry is confined to areas below 270 m and higher elevation areas might experience faster woody regeneration in fallows due to increased rainfall. However, the initial set of carbon plots in post-deforestation land-uses revealed no significant trends by elevation. This is because the majority of the variation in post-deforestation carbon stocks is related to fallow length, which varies from plot to plot in an unpredictable manner, and whether or not farmers left any of the plots original trees standing, which is also unpredictable. Therefore, we choose only one zone for the entire reference region.

A wide range of post deforestation land-uses are possible in the baseline scenario including shifting agriculture with varying woody fallow length, permanent agriculture, degraded wooded grassland, and ago-forestry, with shifting agriculture being the most likely post deforestation land-use for the majority of the reference region. However, due to the fragmented nature of land use in Lindi, we were not able to separate these classes with a high degree of accuracy in the land-cover classification. Furthermore, the carbon stocks of these land-uses, and in particular shifting agriculture with varying fallow lengths, vary over time in an unpredictable manner. Thus, we combined all post-deforestation land-uses into one non-forest class and took the average carbon stock of this one class to represent the average post deforestation carbon stocks in the baseline scenario.

5.3 Calculation of baseline activity data per LU/LC change category

This step would only apply if the project had chosen the modeling approach in step 5.2.

STEP 6: ESTIMATION OF BASELINE CARBON STOCK CHANGES AND NON-CO2

In this step, we present the calculations of baseline carbon stock changes (section 6.1) and Non-CO2 emissions from biomass burning (section 6.2).

6.1 Estimation of baseline carbon stock changes

6.1.1 Estimation of the average carbon stocks of each LU/LC classification

Biomass plots

To measure the carbon pools selected for consideration by the project in section 1.3, the project established permanent biomass assessment plots in the two initial forest classes (low and high carbon) and single post-deforestation land use in the project villages. Due to the sensitivity of neighboring communities about land tenure and historical boundary conflicts, it was not possible to establish biomass plots elsewhere in the reference region. However, there is no reason to suspect that the leakage belt would have higher biomass than the project area for the same strata, since it is on average lower elevation than project area and equally accessible. The project used the same plot structure as the National Forestry Resources Monitoring and Assessment of Tanzania (NAFORMA), which will eventually be used to estimate forest biomass at the national level. The project's carbon monitoring officer spent 1 week in the field with the NAFORMA team to learn how to establish plots and perform measurements. The monitoring officer then worked with village natural resource committee members from each village to establish biomass assessment plots in each villages land.

The biomass plots are round with 15 meter radius. All standing trees falling within the boundary of a plot with a dbh greater than or equal to 20 cm were measured, while smaller trees were only measured within concentric subplots to save time (Figure 21). To save effort, the project did not measure stems with less than 5 cm dbh, while NAFORMA measured stems down to 1 cm dbh.

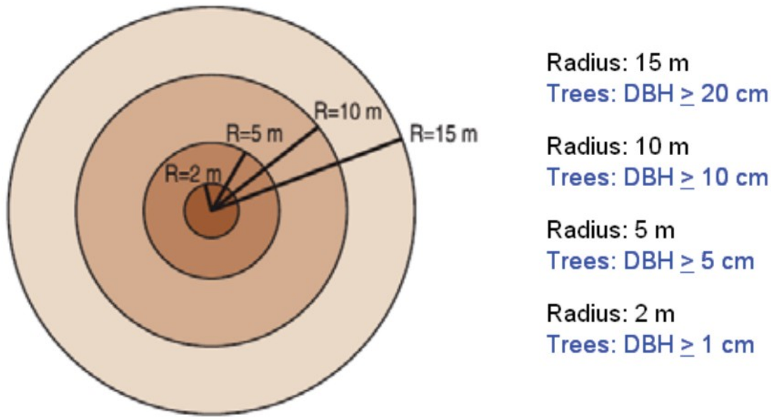

Figure 21: Biomass sample plot design from NAFORMA with concentric circles used by the project. The project did not measure trees less than 5 cm.

Sampling Framework for Forest Classes

The locations of an initial set of 34 plots (black dots in Figure 22) were generated using the random point tool in QGIS. The plots were constrained to the forest area polygon for the project area villages. These plots were assessed in April, 2011, by a team including the project carbon monitoring officer, trained members of the village natural resource committee of the village where the plot was located, and a botanist. Four plots were too remote or too steep to be assessed. In these initial plots, for all trees to be measured per the concentric circles rules, dbh, species, local name, and health status data were recorded. Tree height data was measured for every 5th tree in the plots starting from the middle working out, and for all trees in the plot greater than 20 cm dbh. The data from these initial plots was used to inform the stratification of the forest into high and low carbon forest classes achieved by combining other forest classes. For instance, the data from these plots suggested that there was no significant difference in the biomass of coastal forest and miombo woodlands in the area, which allowed these classes to be combined in order to improve the accuracy of the land-cover classification. Additionally, the data was used to establish the local names for different species.

Then, we generated the locations for approximately 500 plots stratified per village[32] using the same random point tool in QGIS and constraining the locations to fall within the forest area polygons of project area villages. These plots were assessed between Jan. 2012 and Aug. 2013 (unexpected village boundary changes delayed the work in some villages). Due to the difficulty in assessing some of the more remote plots, location error, village boundary conflicts, recent deforestation, and later changes in the forest classification (removal of ago-forestry from forest classes) only 456 of these plots (blue dots in Figure 22) were able to be established in an area classified as forest in the final classification. Due to changes in village boundaries after the completion of some biomass plots, a few fall outside of a project village in the leakage belt. Most of these plots were conducted by trained VNRC members without assistance. Given the difficulty associated with accurately measuring tree heights, only dbh data was recorded, along with local tree names. Additionally, no slope corrections were made when establishing the

32 Optimal sampling was applied to achieve <15% error at the village level so that future changes in carbon stocks can be estimated at the village level and factored into the distribution of carbon credit earnings between villages.

boundaries of the plot on the ground as the project staff believed that accurately estimating slope and then calculating the slope correction factor would be difficult for VNRC members to do on their own. This introduces some conservativeness into the biomass estimates, though most of the area is relatively low slope and many of the steepest slope plots were not measured due to the difficulty of accessing and working on those plots.

To ensure that the VNRC members in charge of carbon assessments did quality work, the project carbon officer remeasured a random selection of 10% of the plots within each village. For 4 villages, the checks were performed in the field and involved simply comparing tree measurements from the forms completed by the VNRC with measurements obtained by the carbon monitoring officer. For 6 villages, the carbon monitoring officer redid the entire plots and calculated the biomass for the plots using a simple DBH to biomass equation for miombo woodland. His comparison of the biomass estimates for these plots revealed that on average the VNRC estimates were 5% less than his own estimates (data shared with the validator). There were substantial disagreements in some plots, but with the exception of one plot, all plot estimates had similar magnitudes indicating that they had been done in the same general vicinity. The disagreements were probably due to the fact that the plots had not been properly monumented and thus the original and recheck plots did not have exactly the same plot centers. Thus, when there were substantial disagreements, the most frequent cause was disagreements on whether or not a tree on the edge of the plot should have been included, with VNRC members seeming to be more likely to leave these trees out. VNRC members had been told that their work would be checked by the carbon monitoring officer and by third parties and therefore may have been more comfortable to error on the side of lower estimates. Since, the VNRC carbon plot estimates were used to calculate project area carbon stocks, this contributes to the conservativeness of the carbon stock estimates.

Sampling Framework for Post-Deforestation Classes

To assess average post-deforestation carbon stocks, we established biomass assessment plots in areas that were deforested roughly 10 and 20 years prior to being measured. We used the deforestation analysis from 1991 to 2001 (see supplement X) to identify plots that had been deforested between May, 1993 and May, 1995 and the reference period deforestation analysis to identify plots that had been deforested between May, 2002 and May, 2004. Since most farm clearing happens in the dry season between June and November each year, most of the deforestation detected between May, 1993 and May, 1995, would have happened in 1994 and 1993, or 19 to 20 years before being measured in May to Dec., 2013. Likewise, the majority of areas detected as deforested between May, 2002 and May, 2004 would have been deforested in 2002 and 2003, or 10 and 11 years before years before being measured. Therefore, the results of the biomass assessment of these historically deforested areas were assumed to represent average post deforestation carbon stocks at 10 and 19 years after deforestation.

A total of 15 plot locations (only 12 were measured) were chosen using the random point tool from areas deforested between 1993 and 1995 (light blue dots in Figure 23). The same procedure was used to select 35 plot locations (only 31 were measured) in areas deforested between 2002 and 2004 (dark blue dots in Figure 23). For all post deforestation carbon stocks, as with the majority of the forest carbon plots, only *dbh* and local tree names were recorded.

Equations for Biomass Estimation

Four different allometric equations were used to convert tree measurements to above ground standing tree biomass. For estimating above ground standing live woody biomass in the miombo woodland plots, we selected the Lindi *dbh* only equation from a recent biomass study in Tanzania[33]. The equation was developed from 47 trees destructively harvested from miombo woodland in Lindi Region. The formula is:

$$AGB = 0.0981 \times dbh^{2.4897} \quad \text{(C)}$$

Where: *AGB* = tree above-ground biomass in kg

dbh = tree diameter at breast height in cm

To estimate biomass in coastal forest plots, we applied a new lowland forest allometric equation[34] developed from destructive harvesting of 60 trees in two different coastal forests in Tanzania. Due to the high variability of trees in these forests, in contrast to the miombo equations, where *dbh* only equations performed similarly to equations with *dbh* and height, the lowland forest *dbh* only equation showed significant bias when applied to different sites. Thus, we chose to use the more complex general Tanzanian lowland forest equation from that included *dbh*, height, and woody density as follows:

$$AGB = 0.1196 \times (WD \times dbh^2 \times h)^{0.9227} \quad \text{(D)}$$

Where: *AGB* tree above ground biomass in kg

WD tree woody density in g/cm

dbh tree diameter at breast height in cm

h tree height in m

Since height was only measured for a few trees in the initial biomass plots, we developed a site specific *dbh* to height equation for lowland forest (coastal forest) to fill in the missing height data for other stems. To have a sufficient number of stems covering all size classes to develop the model of height, we obtained dbh and tree height data from National Forest and Resources Monitoring and Assessment Project (NAFORMA)[35] biomass plots located in lowland forest in the reference region and combined it with data from the initial biomass plots conducted by the project. This gave us a total of 232 stems with *dbh* and height data with dbh ranging from 1 to 80 cm. Using the nls function in the R nlstools package, we tested several different model forms from a recent publication[36] to relate *dbh* and height. In the end, we found the strongest model (lowest AIC score and good visual fit of data) to be a log-linear formula of the form:

$$h = \exp(1.276 + 0.415 \ln(dbh)) \quad \text{(E)}$$

Where: *h* tree height in m

dbh tree diameter at breast height in cm

33 Mugasha, W. A., Eid, T., Bollandsås, O. M., Malimbwi, R. E., Chamshama, S. A. O., Zahabu, E., & Katani, J. Z. (2013). Allometric models for prediction of above-and below-ground biomass of trees in the miombo woodlands of Tanzania. Forest Ecology and Management, 310, 87-101.

34 Mugasha *et al.* 2014. The authors of the study on allometric equations for Miombo in Tanzania also developed lowland forest equations at the end of 2013, but they will not be published until sometime in 2014. Wilson Mugasha kindly shared these equations in advance of publication.

35 Data was obtained directly from the NAFORMA database with permission. See http://www.fao.org/forestry/17847/en/tza/

36 Mugasha, W. A., Bollandsås, O. M., & Eid, T. (2013). Relationships between diameter and height of trees in natural tropical forest in Tanzania. Southern Forests: a Journal of Forest Science, 75(4), 221-237.

Density data was obtained from the Global Wood Density Database[37]. If wood density was not available for a species, then the tropical Africa genus average was used. When only one genus values was available for tropical Africa, the average for the genus for all tropical parts of the world was used. For a few species, even genus level data was unavailable. In these cases, the average basal area weighted density for all stems with density data in coastal forest plots was used (0.5g/cm^3).

Since the land-cover classification was not able to separate coastal forest and woodland at greater than 80% accuracy and the regeneration classes could also not be divided by woodland and coastal forest, for the purpose of choosing which allometric equation to apply, biomass plots were identified on a plot by plot basis as either woodland or forest based on species compositions. In reality, there is a smooth transition between woodland and forests in the region, with many areas consisting of mix of species common in both. Additionally, due to historical human disturbance other kinds of ecological features (like presence / absence of grass and % canopy cover) are not always indicative of forest type. Furthermore, some areas dominated by miombo tree species have closed canopies with no grass. Thus, we compiled a complete list of identified species in the project area and classified them as either being common in woodland, forest, or both. We relied primarily on Burgess *et al*. 2000[38], which provides species lists and descriptions of different coastal forest types for East Africa. Finally, plots were classified as forest or woodland based on the relative basal area of woodland and forest species in the plot. The plot classification results (Figure 24) show relatively good agreement with the original land cover classification, with woodland plots falling mostly in areas classified as woodland.

The health of trees was recorded for each stem. However, due to the technical challenges in accurately measuring heights, the project did not include height measurements for the majority of plots conducted by community members. The absence of bole height data made it impossible to account for standing dead wood biomass as per the methodology. However, the miombo equations developed by Mugasha *et al.* 2013 and lowland forest equations developed by Mugasha *et al*. 2014 also included equations to predict merchantable stem biomass from *dbh*, which is similar to (though likely slightly less than) bole biomass. Thus, we applied the merchantable stem allometric equations to all standing dead trees. Adopting this approach is conservative because the equation was applied to all dead trees regardless of decomposition stage, instead of following the methodology, which allows dead trees in decomposition stage 1 to be counted as a live tree less 2 to 3% of biomass for twigs and leaves.

The merchantable stem allometric equation for woodland trees is:

$$AGB_{stm} = 0.0535 \times dbh^{2.3099} \quad \text{(F)}$$

Where: AGB_{stm} merchantable stem above-ground biomass in kg

dbh tree diameter at breast height in cm

The merchantable stem allometric equation for coastal forest trees is:

$$AGB_{stm} = 0.0722 \times (WD \times dbh^2 \times h)^{0.8915} \quad \text{(G)}$$

37 Zanne, A. E., Lopez-Gonzalez, G., Coomes, D. A., Ilic, J., Jansen, S., Lewis, S. L., ... & Chave, J. (2009). Global wood density database. Dryad. Identifier: http://hdl. handle. net/10255/dryad, 235.

38 Burgess, N. D., & Clarke, G. P. (Eds.). (2000). Coastal forests of eastern Africa. IUCN.

Where: AGB_{stm} merchantable stem above ground biomass in kg

WD tree woody density in g/cm^3

dbh tree diameter at breast height in cm

h tree height in m

To calculate below ground (root) tree biomass of trees in plots classified as miombo woodland, we used the general below ground biomass equation from Mugasha *et al.* 2013. The equation was developed from destructive harvesting of tree roots from 80 miombo woodland trees from 4 different sites in Tanzania. The equation is as follows:

$$BGB = 0.2113 \times dbh^{1.9838} \quad \text{(H)}$$

Where: BGB tree below ground (root) biomass in kg

dbh tree diameter at breast height in cm

To calculate the root biomass of trees in plots classified as lowland forest, we used the IPCC default root to shoot ratio for tropical dry forests (0.28) as shown on page 140 of VM0015. Thus lowland forest below ground root biomass was calculated as:

$$BGB = AGB \times 0.28 \quad \text{(I)}$$

Where: BGB tree below ground (root) biomass in kg

AGB tree above ground biomass in kg

To organize biomass data and perform allometric calculations, we created a mysql database. The main tables were plot level data, stem level data, and species level data (which included species density and forest type information). We created a front end for the database in Open Office Base to enter and query data. Data cleaning routines were performed, including double checking the dbh values of all the stems with greater than 70 cm dbh, double checking plot locations recorded on data sheets that showed significant shifts from the original locations (6 plots were thrown out due to bad location data), and removing any baobab stems mistakenly recorded. Then, a query was created to categorize plots as forest or woodland based on a comparison of woodland and forest species basal areas in a plot. Another query was created to calculate the basal area weighted average wood density of all forest plots. Then, finally, we created queries to calculate above and below ground biomass estimates for each plot in terms of tons per ha using the appropriate allometric equation for each plot (forest or woodland) and tree stem (living or dead). The database and query script were shared with the validating organization.

The plot location and above-ground biomass data were imported into QGIS and saved as a shapefile. Then, using the Raster Interpolation Plug-in, we extracted the final 2012 land-cover classification (Figure 13) for each plot. In a spreadsheet, above ground and below ground forest biomass averages were calculated for each village for high carbon and low carbon forest types. Then, to calculate the mean above and below ground biomass stock for each forest type for the entire project area, we took the sum of the village means for each forest type weighted by the proportion of that forest type in the project area that fell within each village using the following formula.

$$\bar{y} = \sum_{h=1}^{L} \frac{N_h}{N} \bar{y}_h \qquad (J)$$

Where: $\bar{y}$ = the mean biomass for the forest type for the project area

N = the total area of the forest type in the project area

N_h = the total area of the forest type in village h

$\bar{y}_h$ = the mean biomass of the forest type in village h

Then, we estimated the total variance for each forest type using the formula:

$$\hat{var}(\bar{y}) = \sum_{h=1}^{L} \left(\frac{N_h}{N}\right)^2 \left(\frac{N_h - n_h}{N_h}\right) \frac{s_h^2}{n_h} \qquad (K)$$

Where: $\hat{var}(\bar{y})$ = total variance of forest type in project area

N = the total area of the forest type in the project area

N_h = the total area of the forest type in village h

n_h = the number of samples (plots) in the forest type in village h

s_h = the standard deviation of the forest type in village h

Finally, we took the square root of the variances to calculate the standard error for each forest type and then multiplied by 1.645 to calculate the 90% confidence interval. The average above and below ground biomass estimates for initial forest classes are presented in VM Table 15.a for the project area and leakage belt. The biomass values to be used after discounts for uncertainty are presented in VM Table 15.b for the project area and leakage belt. They are identical to the average values since the error in total carbon stocks ($Ctot_{icl}$) was less than 10% for both forest types and thus as per page 67 of the methodology, no discounting was necessary.

Given that the post-deforestation plots were not stratified, to estimate post-deforestation carbon stocks, we simply calculated means and 90% confidence intervals for the two different post-deforestation age classes. Due to the complicated nature of post deforestation land use, it was not possible to separate post deforestation land-uses into categories. Areas with no biomass at the time of assessment could have been cleared the year of assessment after having regrown for all years prior to assessment, or might have been used continuously since the first deforestation event. Likewise, plots with woody regeneration at the time of assessment might have been cleared several times since the first date of deforestation. Thus, we assumed the biomass estimates all represented different states of the same post-deforestation land-use and accepted the large uncertainty penalty associated with the 90% confidence interval of the means.

Fewer plots were located in areas deforested 19 years prior to deforestation because we assumed that the 10 year stocks could be interpreted as equal to the average stocks over a 20 year period. We assumed older class plots would simply serve as verification that the average of 10 year plots was a reasonable estimate of the long term average stocks. However, we found that the 19 year old plots had significantly less biomass on average than a linear projection of the rate of change for the first 10 years would produce. This is not surprising given that while some plots may be fallowed continuously for up to

10 years, it is exceptionally rare for plots to be fallowed continuously for 19 years. Additionally, the plots with the highest post deforestation biomass estimates were plots where farmers had left one or two large trees standing and this was just as likely to occur in 10 year old plots as in 19 year old plots.

Therefore, we calculated the average carbon stock change in post deforestation plots during the first 10 years as follows. We assumed that in the first year, carbon stocks in the pools that we were measuring would essentially be zero[39] because farmers would have cultivated the area for at least one year. Therefore, the plots would accumulate the average biomass seen in year 10 during the next 9 years and the average stock increase after year 1 is equivalent to the average year 10 biomass (after adding the 90% CI due to uncertainty) divided by 9. For years 11 to 20, we first calculated the average growth rate from year 11 to 19 by subtracting the average 10 year post deforestation stocks (after adding the 90% CI) from the average 19 year post-deforestation stocks (after adding the 90% CI) and dividing by 9. Then we assumed that the growth rate from year 19 to 20 would be the same as the previous year. The same calculations were preformed for both above and below ground biomass estimates. The results are presented in VM Table 16.a. For average post deforestation stocks in the leakage belt (VM Table 16.b), the same calculations were preformed except that the 90% CI was subtracted rather than added to the averages.

VM Table 15.a: Estimated carbon stocks per hectare of initial forest classes icl existing in the project area and leakage belt

Project year t	Initial forest class *icl*					
	Name:	High Carbon				
	Id_{icl}:	1				
	Average carbon stock per hectare ±90 % CI					
	Cab_{icl}		Cbb_{icl}		$Ctot_{icl}$	
	C stock	±90 % CI	*C stock*	±90 % CI	*C stock*	±90 % CI
	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}
0	159.23	7.66	49.81	2.40	209.04	10.06
1	159.23	7.66	49.81	2.40	209.04	10.06
2	159.23	7.66	49.81	2.40	209.04	10.06
3	159.23	7.66	49.81	2.40	209.04	10.06
4	159.23	7.66	49.81	2.40	209.04	10.06
5	159.23	7.66	49.81	2.40	209.04	10.06
6	159.23	7.66	49.81	2.40	209.04	10.06
7	159.23	7.66	49.81	2.40	209.04	10.06
8	159.23	7.66	49.81	2.40	209.04	10.06
9	159.23	7.66	49.81	2.40	209.04	10.06
10	159.23	7.66	49.81	2.40	209.04	10.06
Pr	Initial forest class *icl*					

39 In reality, many of the roots from the initial forest class still remain, but this is accounted for later in the methodology when calculating emissions factors for roots.

oject year t	Name:	Low Carbon				
	$Id_{icl:}$	2				
	Average carbon stock per hectare ±90 % CI					
	Cab_{icl}		Cbb_{icl}		$Ctot_{icl}$	
	C stock	±90 % CI	C stock	±90 % CI	C stock	±90 % CI
	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}
0	107.03	10.42	37.44	3.96	144.47	14.38
1	107.03	10.42	37.44	3.96	144.47	14.38
2	107.03	10.42	37.44	3.96	144.47	14.38
3	107.03	10.42	37.44	3.96	144.47	14.38
4	107.03	10.42	37.44	3.96	144.47	14.38
5	107.03	10.42	37.44	3.96	144.47	14.38
6	107.03	10.42	37.44	3.96	144.47	14.38
7	107.03	10.42	37.44	3.96	144.47	14.38
8	107.03	10.42	37.44	3.96	144.47	14.38
9	107.03	10.42	37.44	3.96	144.47	14.38
10	107.03	10.42	37.44	3.96	144.47	14.38

VM Table 15.b: Carbon stock values to be used after discounts for uncertainties in project area and leakage belt

Project year t	Initial forest class *icl*					
	Name:	High Carbon				
	$Id_{icl:}$	1				
	Average carbon stock per hectare ±90 % CI					
	Cab_{icl}		Cbb_{icl}		$Ctot_{icl}$	
	C stock	C stock change	C stock	C stock change	C stock	C stock change
	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}
0	159.23	0	49.81	0	209.04	0
1	159.23	0	49.81	0	209.04	0
2	159.23	0	49.81	0	209.04	0
3	159.23	0	49.81	0	209.04	0
4	159.23	0	49.81	0	209.04	0
5	159.23	0	49.81	0	209.04	0
6	159.23	0	49.81	0	209.04	0
7	159.23	0	49.81	0	209.04	0
8	159.23	0	49.81	0	209.04	0
9	159.23	0	49.81	0	209.04	0

Project year t	Initial forest class *icl*					
	Name: Low Carbon					
	Id_{icl}: 2					
	Average carbon stock per hectare ±90 % CI					
	Cab_{icl}		Cbb_{icl}		$Ctot_{icl}$	
	C stock	*C stock change*	*C stock*	*C stock change*	*C stock*	*C stock change*
	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}
10	159.23	0	49.81	0	209.04	0
0	107.03	0	37.44	0	144.47	0
1	107.03	0	37.44	0	144.47	0
2	107.03	0	37.44	0	144.47	0
3	107.03	0	37.44	0	144.47	0
4	107.03	0	37.44	0	144.47	0
5	107.03	0	37.44	0	144.47	0
6	107.03	0	37.44	0	144.47	0
7	107.03	0	37.44	0	144.47	0
8	107.03	0	37.44	0	144.47	0
9	107.03	0	37.44	0	144.47	0
10	107.03	0	37.44	0	144.47	0

VM Table 16.a: Long term (20-years) average carbon stocks per hectare of post-deforestation LU/LC classes present in the Reference Region (to be used for project area calculations)

Project year t	Post deforestation class *fcl*					
	Name: Non-Forest					
	ID_{fcl}: 3					
	Average carbon stock per hectare +90 % CI [1]					
	Cab_{fcl}		Cbb_{fcl}		$Ctot_{fcl}$	
	C stock	*C stock change*	*C stock*	*C stock change*	*C stock*	*C stock change*
	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}
t*	0	0	0	0	0	0
t*+1	3.47	3.47	1.12	1.12	2.47	4.59
t*+2	6.93	3.47	2.23	1.12	4.95	2.47
t*+3	10.4	3.47	3.35	1.12	7.42	2.47
t*+4	13.87	3.47	4.46	1.12	9.89	2.47
t*+5	17.34	3.47	5.58	1.12	12.36	2.47
t*+6	20.8	3.47	6.69	1.12	14.84	2.47

t*+7	24.27	3.47	7.81	1.12	17.31	2.47
t*+8	27.74	3.47	8.92	1.12	19.79	2.47
t*+9	31.21	3.47	10.04	1.12	22.26	2.47
t*+10	32.58	1.37	10.28	0.24	23.14	1.61
t*+11	33.95	1.37	10.52	0.24	24.02	0.88
t*+12	35.32	1.37	10.76	0.24	24.9	0.88
t*+13	36.69	1.37	10.99	0.24	25.78	0.88
t*+14	38.06	1.37	11.23	0.24	26.66	0.88
t*+15	39.43	1.37	11.47	0.24	27.54	0.88
t*+16	40.8	1.37	11.71	0.24	28.42	0.88
t*+17	42.17	1.37	11.95	0.24	29.3	0.88
t*+18	43.54	1.37	12.19	0.24	30.18	0.88
t*+19	44.91	1.37	12.43	0.24	31.06	0.88
Average	27.17		8.19		35.36	

1 The C stock values presented in this table have been increased by the 90% confidence interval since measurement error in post deforestation plots exceeded 10%.

VM Table 16.b: Long term (20-years) average carbon stocks per hectare of post-deforestation LU/LC classes present in the Reference Region (to be used for leakage belt calculations)

Project year t	Post deforestation class *fcl*					
	Name:	Non-Forest				
	ID_{fcl}:	3				
	Average carbon stock per hectare −90 % CI [1]					
	Cab_{fcl}		Cbb_{fcl}		$Ctot_{fcl}$	
	C stock	*C stock change*	*C stock*	*C stock change*	*C stock*	*C stock change*
	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}
t*	0	0	0	0	0	0
t*+1	1.69	1.69	0.5	0.5	2.47	2.19
t*+2	3.39	1.69	1	0.5	4.95	2.47
t*+3	5.08	1.69	1.5	0.5	7.42	2.47
t*+4	6.77	1.69	2.01	0.5	9.89	2.47
t*+5	8.47	1.69	2.51	0.5	12.36	2.47
t*+6	10.16	1.69	3.01	0.5	14.84	2.47
t*+7	11.85	1.69	3.51	0.5	17.31	2.47
t*+8	13.54	1.69	4.01	0.5	19.79	2.47
t*+9	15.24	1.69	4.51	0.5	22.26	2.47
t*+10	14.62	-0.62	4.31	-0.20	23.14	-0.82
t*+11	13.99	-0.62	4.11	-0.20	24.02	0.88

t*+12	13.37	-0.62	3.91	-0.20	24.9	0.88
t*+13	12.75	-0.62	3.71	-0.20	25.78	0.88
t*+14	12.13	-0.62	3.51	-0.20	26.66	0.88
t*+15	11.51	-0.62	3.3	-0.20	27.54	0.88
t*+16	10.88	-0.62	3.1	-0.20	28.42	0.88
t*+17	10.26	-0.62	2.9	-0.20	29.3	0.88
t*+18	9.64	-0.62	2.7	-0.20	30.18	0.88
t*+19	9.02	-0.62	2.5	-0.20	31.06	0.88
Average	9.72		2.83		12.55	

1 The average C stock values presented in this table have been decreased by the 90% confidence interval since measurement error in post deforestation plots exceeded 10%.

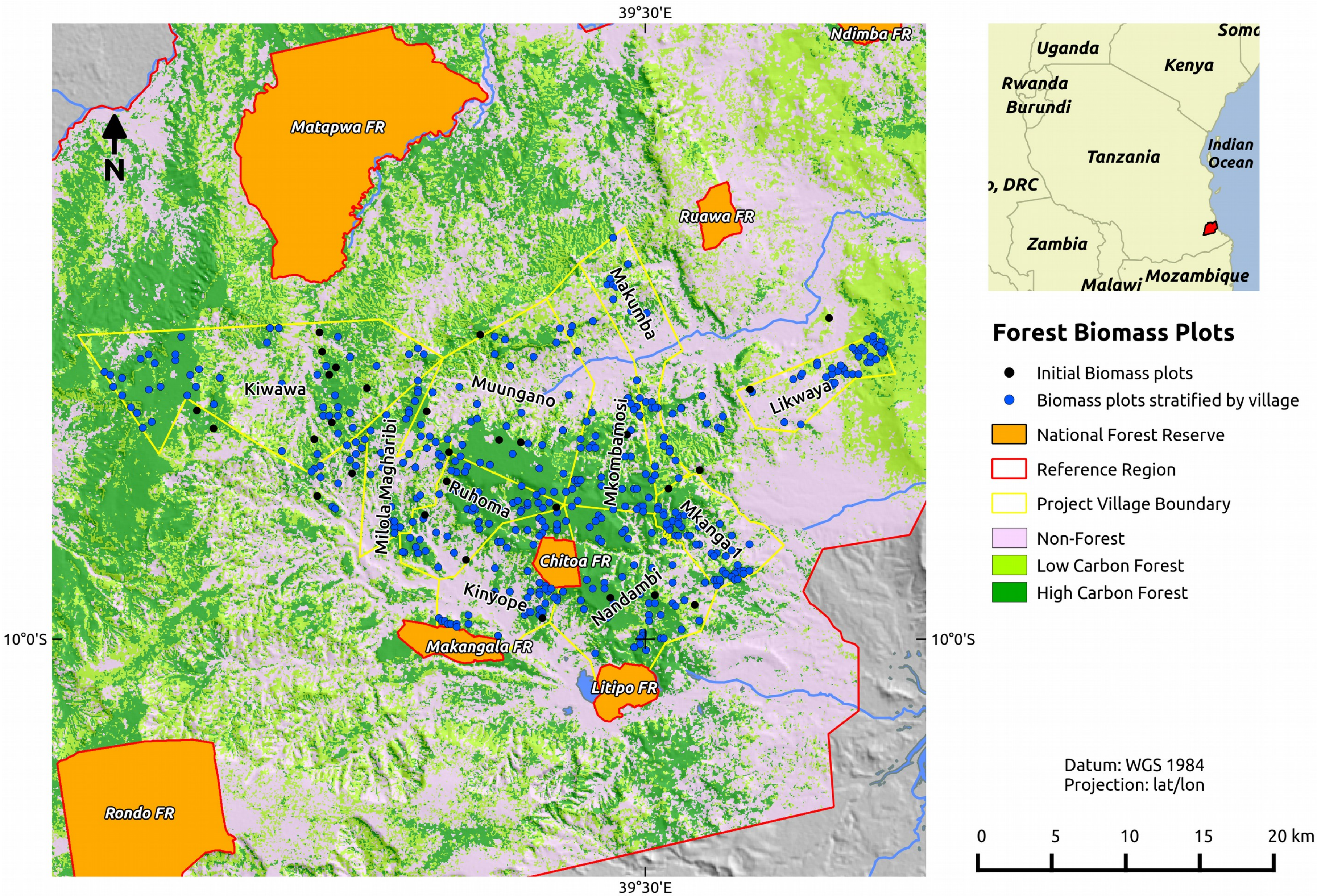

Figure 22: Forest biomass plot locations map

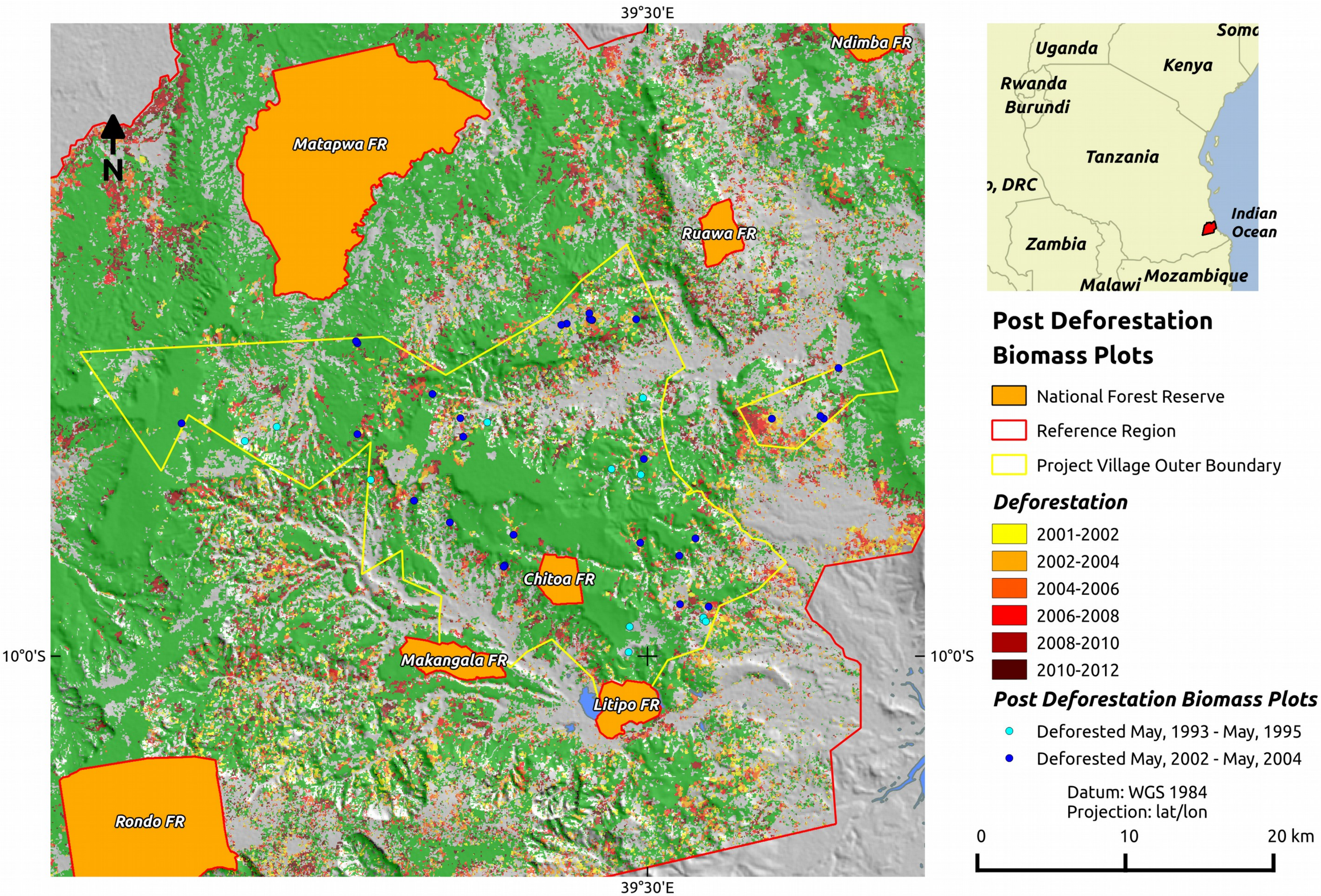

Figure 23: Post deforestation biomass plot locations map

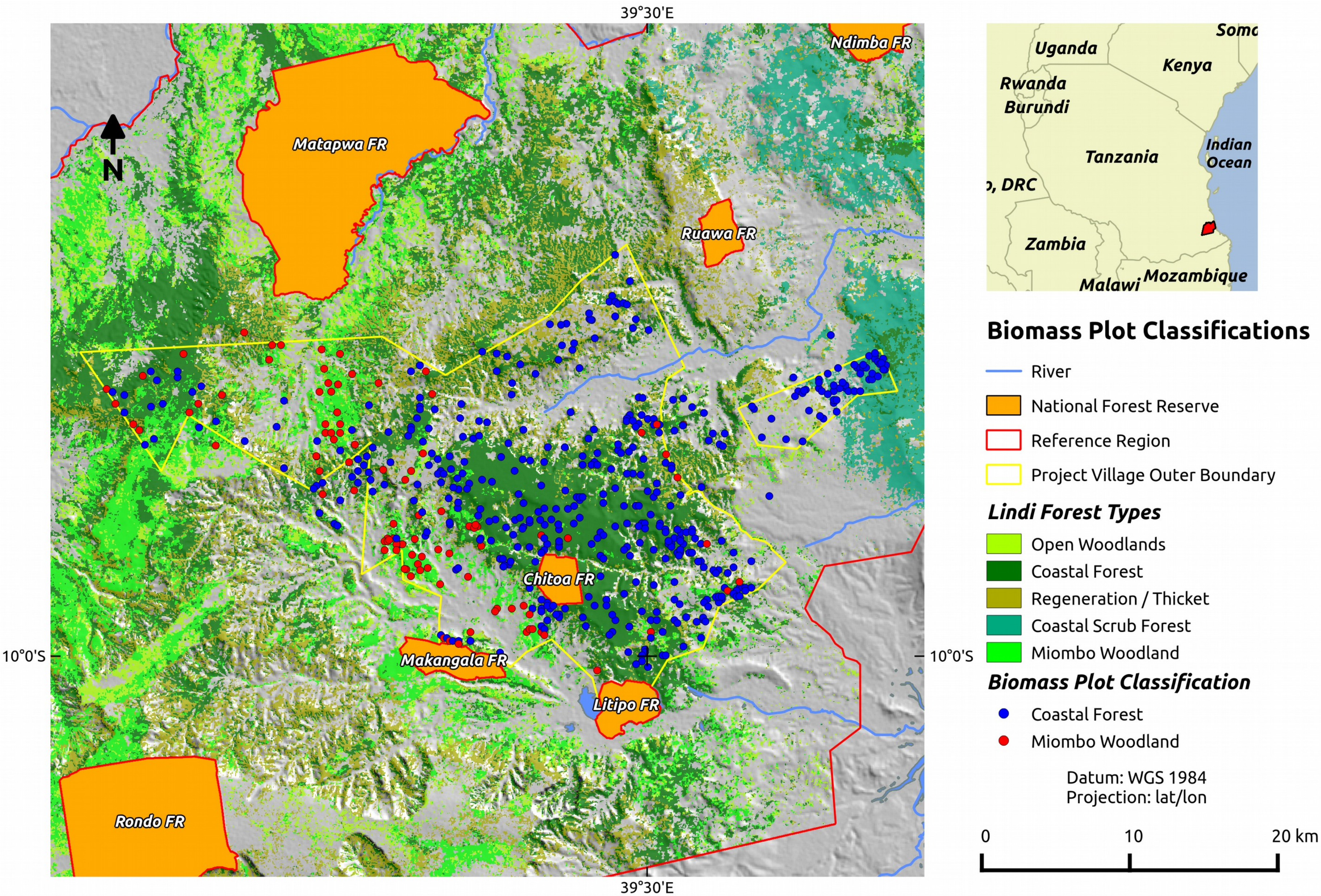

Figure 24: Biomass plot classification map

6.1.2 Calculation of carbon stock change factors

In this section, the methodology calls for activity data for each category of land-use land-cover change to be broken down by zone. However, as only one zone was identified in section 5.2, this step is unnecessary in the case of this project. The only possible change categories are those presented VM Table 7.a and the areas of these possible change categories in baseline scenario for the project area and leakage belt are equal to the areas of baseline deforestation for each initial forest class presented in VM Table 11.b and VM Table 11.c respectively. Thus, in this step we present only the carbon stock change factors for each initial forest class (VM Table 20.a) and for the final post-deforestation class (VM Table 20.b).

VM Table 20.a.1: Carbon stock change factors for initial forest classes icl in the project area (Method 1)

		Initial forest class *icl*			
	Name:	High Carbon Forest		Low Carbon Forest	
	$Id_{icl:}$	1		2	
Years after deforestation		$\Delta Cab_{icl,t}$	$\Delta Cbb_{icl,t}$	$\Delta Cab_{icl,t}$	$\Delta Cbb_{icl,t}$
1	*t**	-159.23	-4.98	-107.03	-3.74
2	*t**+1		-4.98		-3.74
3	*t**+2		-4.98		-3.74
4	*t**+3		-4.98		-3.74
5	*t**+4		-4.98		-3.74
6	*t**+5		-4.98		-3.74
7	*t**+6		-4.98		-3.74
8	*t**+7		-4.98		-3.74
9	*t**+8		-4.98		-3.74
10	*t**+9		-4.98		-3.74
11	*t**+10				
12	*t**+11				
13	*t**+12				
14	*t**+13				
15	*t**+14				
16	*t**+15				
17	*t**+16				
18	*t**+17				
19	*t**+18				
20	*t**+19				

VM Table 20.a.2: Carbon stock change factors for initial forest classes icl in the leakage belt Method 1)

		Initial forest class *icl*			
	Name:	High Carbon Forest		Low Carbon Forest	
	Id_{icl}:	1		2	
Years after deforestation		$\Delta Cab_{icl,t}$	$\Delta Cbb_{icl,t}$	$\Delta Cab_{icl,t}$	$\Delta Cbb_{icl,t}$
1	*t**	-159.23	-4.98	-107.03	-3.74
2	*t**+1		-4.98		-3.74
3	*t**+2		-4.98		-3.74
4	*t**+3		-4.98		-3.74
5	*t**+4		-4.98		-3.74
6	*t**+5		-4.98		-3.74
7	*t**+6		-4.98		-3.74
8	*t**+7		-4.98		-3.74
9	*t**+8		-4.98		-3.74
10	*t**+9		-4.98		-3.74
11	*t**+10				
12	*t**+11				
13	*t**+12				
14	*t**+13				
15	*t**+14				
16	*t**+15				
17	*t**+16				
18	*t**+17				
19	*t**+18				
20	*t**+19				

VM Table 20.b.1: Carbon stock change factors for final classes fcl in the project area (Method 1)

Post deforestation class *fcl*			
	Name:	Non-Forest	
	Id_{fcl}:	3	
Years after deforestation		$\Delta Cab_{fcl,t}$	$\Delta Cbb_{fcl,t}$
1	*t**	2.72	0.82
2	*t**+1	2.72	0.82
3	*t**+2	2.72	0.82
4	*t**+3	2.72	0.82

5	*t**+4	2.72	0.82
6	*t**+5	2.72	0.82
7	*t**+6	2.72	0.82
8	*t**+7	2.72	0.82
9	*t**+8	2.72	0.82
10	*t**+9	2.72	0.82
11	*t**+10		
12	*t**+11		
13	*t**+12		
14	*t**+13		
15	*t**+14		
16	*t**+15		
17	*t**+16		
18	*t**+17		
19	*t**+18		
20	*t**+19		

VM Table 20.b.2: Carbon stock change factors for final classes fcl in leakage belt (Method 1)

Post deforestation class f*cl*			
Name:		Non-Forest	
$Id_{fcl:}$		3	
Years after deforestation		$\Delta Cab_{icl,t}$	$\Delta Cbb_{icl,t}$
1	*t**	0.97	0.28
2	*t**+1	0.97	0.28
3	*t**+2	0.97	0.28
4	*t**+3	0.97	0.28
5	*t**+4	0.97	0.28
6	*t**+5	0.97	0.28
7	*t**+6	0.97	0.28
8	*t**+7	0.97	0.28
9	*t**+8	0.97	0.28
10	*t**+9	0.97	0.28
11	*t**+10		
12	*t**+11		
13	*t**+12		
14	*t**+13		
15	*t**+14		
16	*t**+15		

17	t^*+16		
18	t^*+17		
19	t^*+18		
20	t^*+19		

6.1.3 Calculation of baseline carbon stock changes

As the reference region has only one post-deforestation class and no zones, we chose method 1 for calculating the baseline carbon stock changes in the project area, and leakage belt. The spreadsheets used to perform the calculations were shared with the validation organization. The results for the project area are presented in VM Table 21.b.1 and VM Table 21.b.2. Results for the leakage belt can be found in VM Table 21.c.1 and VM Table 21.c.2. For example, as per VM0015, under method 1, total baseline carbon stock changes at year *t* in the project area are calculated as follows:

$$\begin{aligned}\Delta CBSLPA_t = \sum_{p=1}^{p} \Big(& \sum_{icl=1}^{icl} ABSLPA_{icl,t} * \Delta Cp_{icl,t=t^*} - \sum_{z=1}^{z} ABSLPA_{z,t} * \Delta CP_{z,t=t^*} \\ & + \sum_{icl=1}^{icl} ABSLPA_{icl,t-1} * \Delta Cp_{icl,t=t^*+1} - \sum_{z=1}^{z} ABSLPA_{z,t-1} * \Delta CP_{z,t=t^*+1} \\ & + \sum_{icl=1}^{icl} ABSLPA_{icl,t-2} * \Delta Cp_{icl,t=t^*+2} - \sum_{z=1}^{z} ABSLPA_{z,t-2} * \Delta CP_{z,t=t^*+2} \quad + \ldots \\ & + \sum_{icl=1}^{icl} ABSLPA_{icl,t-19} * \Delta Cp_{icl,t=t^*+19} - \sum_{z=1}^{z} ABSLPA_{z,t-19} * \Delta CP_{z,t=t^*+19} \Big)\end{aligned} \quad \text{(VM 10)}$$

Where:

$\Delta CBSLPA_t$	Total baseline carbon stock change within the project area at year *t*; tCO_2-e
$ABSLPA_{icl,t}$	Area of initial forest class *icl* deforested at time *t* within the project area in the baseline case (as per VM Table 11.b); ha
$ABSLPA_{icl,t-1}$	Area of initial forest class *icl* deforested at time *t*-1 within the project area in the baseline case (as per VM Table 11.b); ha

…

$ABSLPA_{icl,t-19}$	Area of initial forest class *icl* deforested at time *t*-19 within the project area in the baseline case (as per VM Table 11.b); ha
$\Delta Cp_{icl,t=t^*}$	Average carbon stock change factor for carbon pool p in the initial forest class *icl* applicable at time *t* (as per VM Table 20.a); tCO_2-e ha^{-1}
$\Delta Cp_{icl,t=t^*+1}$	Average carbon stock change factor for carbon pool p in the initial forest class *icl* applicable at time $t=t^*+1$ (2nd year after deforestation, as per VM Table 20.a); tCO_2-e ha^{-1}

…

$\Delta Cp_{icl,t=t^*+19}$	Average carbon stock change factor for carbon pool p in the initial forest class *icl* applicable at time $t=t^*+1$ (20th year after deforestation, as per VM Table 20.a); tCO_2-e ha^{-1}

$ABSLPA_{z,t}$	Area of the zone z "deforested" at time *t* within the project area in the baseline case (in this project is equal to $ABSLPA_{icl,t}$); ha
$ABSLPA_{z,t-1}$	Area of the zone z "deforested" at time *t-1* within the project area in the baseline case (in this project is equal to $ABSLPA_{icl,t-1}$); ha
…	
$ABSLPA_{z,t-19}$	Area of the zone z "deforested" at time *t-19* within the project area in the baseline case (in this project is equal to $ABSLPA_{icl,t-19}$); ha
$\Delta Cp_{z,t=t^*}$	Average carbon stock change factor for carbon pool p in zone z applicable at time $t = t^*$ (as per VM Table 20.b); tCO_2-e ha^{-1}
$\Delta Cp_{z,t=t^*+1}$	Average carbon stock change factor for carbon pool p in zone z applicable at time $t = t^*+1$ (2^{nd} year after deforestation, as per VM Table 20.b); tCO_2-e ha^{-1}
…	
$\Delta Cp_{z,t=t^*+19}$	Average carbon stock change factor for carbon pool p in zone z applicable at time $t = t^*+1$ (20^{th} year after deforestation, as per VM Table 20.b); tCO_2-e ha^{-1}
icl	1, 2, 3 ... *Icl* initial (pre-deforestation) forest classes; dimensionless
z	1, 2, 3 … *Z* zone (only 1 zone was identified in step 5.2); dimensionless
p	1, 2, 3 … *P* carbon pools included in the baseline; dimensionless
t	1, 2, 3 … *T,* a year of the proposed project crediting period; dimensionless
*t**	the year at which the area $ABSLPA_{icl,t}$ *is deforested in the baseline case.*

VM Table 21.b.1: Baseline carbon stock change in above-ground biomass in the project area

Carbon stock changes in the above ground biomass per initial forest class *icl*			Total carbon stock change in above-ground biomass of the initial forest classes in the project area		Carbon stock changes in above ground biomass per post-deforestation zone *z*		Total carbon stock change in above-ground biomass of post-deforestation zones in the project area		Total net carbon stock change in the above-ground biomass of the project area	
ID_{icl}	1	2	$\Delta Cab\ BSLPA_{icl,t}$	$\Delta Cab\ BSLPA_{icl}$	*IDz*	1	$\Delta Cab\ BSLPA_{z,t}$	$\Delta Cab\ BSLPA_{z}$	$\Delta Cab\ BSLPA_{t}$	$\Delta Cab\ BSLPA$
Name	High Carbon	Low Carbon	annual	cumulative	Name	All	annual	cumulative	annual	cumulative
Project year *t*	t CO_2e	t CO_2e	t CO_2e	t CO_2e	Project year *t*	t CO_2e	t CO_2e	t CO_2e	t CO_2e	t CO_2e
1	-71,972	-53,836	-125,808	-125,808	1	2,598	2,598	2,598	-123,210	-123,210
2	-63,374	-49,234	-112,607	-238,415	2	4,931	4,931	7,529	-107,676	-230,886
3	-64,647	-46,023	-110,670	-349,086	3	7,205	7,205	14,734	-103,465	-334,351
4	-66,558	-43,882	-110,440	-459,526	4	9,457	9,457	24,192	-100,983	-435,334
5	-61,622	-43,026	-104,648	-564,174	5	11,604	11,604	35,795	-93,045	-528,379
6	-60,030	-40,350	-100,380	-664,554	6	13,654	13,654	49,450	-86,726	-615,105
7	-57,164	-37,568	-94,731	-759,285	7	15,586	15,586	65,035	-79,146	-694,250
8	-59,711	-35,855	-95,566	-854,852	8	17,517	17,517	82,552	-78,050	-772,300
9	-57,641	-34,250	-91,891	-946,742	9	19,372	19,372	101,924	-72,519	-844,819
10	-55,890	-33,500	-89,390	-1,036,133	10	21,178	21,178	123,102	-68,212	-913,031

VM Table 21.b.2: Baseline carbon stock change in below-ground biomass in the project area

Carbon stock changes in the below-ground biomass per initial forest class *icl*			Total carbon stock change in below-ground biomass of the initial forest classes in the project area		Carbon stock changes in below-ground biomass per post-deforestation zone *z*		Total carbon stock change in below-ground biomass of post-deforestation zones in the project area		Total net carbon stock change in the below-ground biomass of the project area	
ID_{icl}	1	2	$\Delta Cbb\ BSLPA_{icl,t}$	$\Delta Cbb\ BSLPA_{icl}$	*IDz*	1	$\Delta Cbb\ BSLPA_{z,t}$	$\Delta Cbb\ BSLPA_{z}$	$\Delta Cbb\ BSLPA_{t}$	$\Delta Cbb\ BSLPA$

Name	High Carbon	Low Carbon	annual	cumulative	Name	All	annual	cumulative	annual	cumulative
Project year *t*	t CO_2e	t CO_2e	t CO_2e	t CO_2e	Project year *t*	t CO_2e	t CO_2e	t CO_2e	t CO_2e	t CO_2e
1	-2,251	-1,881	-4,132	-4,132	1	783	783	783	-3,349	-3,349
2	-4,233	-3,602	-7,835	-11,967	2	1,487	1,487	2,270	-6,348	-9,697
3	-6,255	-5,210	-11,465	-23,432	3	2,172	2,172	4,442	-9,293	-18,990
4	-8,337	-6,743	-15,080	-38,511	4	2,851	2,851	7,293	-12,229	-31,218
5	-10,264	-8,247	-18,510	-57,022	5	3,498	3,498	10,791	-15,012	-46,231
6	-12,141	-9,657	-21,798	-78,820	6	4,116	4,116	14,908	-17,682	-63,912
7	-13,929	-10,969	-24,898	-103,718	7	4,699	4,699	19,606	-20,200	-84,112
8	-15,797	-12,222	-28,019	-131,737	8	5,281	5,281	24,887	-22,738	-106,850
9	-17,599	-13,419	-31,018	-162,755	9	5,840	5,840	30,727	-25,178	-132,028
10	-19,347	-14,590	-33,937	-196,692	10	6,385	6,385	37,112	-27,553	-159,581

VM Table 21.c.1: Baseline carbon stock change in above-ground biomass in the leakage belt

Carbon stock changes in the above-ground biomass per initial forest class *icl*			Total carbon stock change in above-ground biomass of the initial forest classes in the leakage belt		Carbon stock changes in above ground biomass per post-deforestation zone *z*		Total carbon stock change in above-ground biomass of post-deforestation zones in the leakage belt		Total net carbon stock change in the above-ground biomass of the leakage belt	
ID_{icl}	1	2	$\Delta Cab\ BSLLK_{icl,t}$	$\Delta Cab\ BSLLK_{icl}$	*IDz*	1	$\Delta Cab\ BSLLK_{z,t}$	$\Delta Cab\ BSLLK_{z}$	$\Delta Cab\ BSLLK_{t}$	$\Delta Cab\ BSLLK$
Name	High Carbon	Low Carbon	annual	cumulative	Name	All	annual	cumulative	annual	cumulative
Project year *t*	t CO_2e	t CO_2e	t CO_2e	t CO_2e	Project year *t*	t CO_2e	t CO_2e	t CO_2e	t CO_2e	t CO_2e
1	-120,219	-74,493	-194,712	-194,712	1	1,407	1,407	1,407	-193,304	-193,304
2	-93,786	-67,215	-161,001	-355,713	2	2,588	2,588	3,995	-158,413	-351,717

3	-90,283	-66,359	-156,642	-512,355	3	3,739	3,739	7,735	-152,903	-504,620
4	-92,035	-62,720	-154,755	-667,109	4	4,868	4,868	12,603	-149,886	-654,506
5	-91,080	-57,796	-148,876	-815,985	5	5,947	5,947	18,550	-142,929	-797,435
6	-90,761	-56,833	-147,594	-963,579	6	7,015	7,015	25,565	-140,579	-938,014
7	-88,532	-52,873	-141,405	-1,104,984	7	8,034	8,034	33,599	-133,371	-1,071,385
8	-91,398	-52,980	-144,378	-1,249,362	8	9,070	9,070	42,669	-135,307	-1,206,692
9	-87,895	-51,160	-139,055	-1,388,417	9	10,070	10,070	52,739	-128,986	-1,335,678
10	-85,507	-47,414	-132,921	-1,521,338	10	11,020	11,020	63,759	-121,901	-1,457,579

VM Table 21.c.2: Baseline carbon stock change in below-ground biomass in the leakage belt

Carbon stock changes in the below-ground biomass per initial forest class *icl*			Total carbon stock change in below-ground biomass of the initial forest classes in the leakage belt		Carbon stock changes in below ground biomass per post-deforestation zone *z*		Total carbon stock change in below-ground biomass of post-deforestation zones in the leakage belt		Total net carbon stock change in the below-ground biomass of the leakage belt	
ID_{icl}	1	2	$\Delta Cbb\ BSLLK_{icl,t}$	$\Delta Cbb\ BSLLK_{icl}$	*IDz*	1	$\Delta Cbb\ BSLLK_{z,t}$	$\Delta Cbb\ BSLLK_{z}$	$\Delta Cbb\ BSLLK_{t}$	$\Delta Cbb\ BSLLK$
Name	High Carbon	Low Carbon	annual	cumulative	Name	All	annual	cumulative	annual	cumulative
Project year *t*	t CO_2e	t CO_2e	t CO_2e	t CO_2e	Project year *t*	t CO_2e	t CO_2e	t CO_2e	t CO_2e	t CO_2e
1	-3,760	-2,603	-6,363	-6,363	1	406	406	406	-5,957	-5,957
2	-6,693	-4,952	-11,645	-18,008	2	747	747	1,153	-10,898	-16,855
3	-9,517	-7,271	-16,787	-34,795	3	1,079	1,079	2,233	-15,708	-32,562
4	-12,395	-9,462	-21,857	-56,653	4	1,405	1,405	3,638	-20,452	-53,015
5	-15,244	-11,482	-26,726	-83,378	5	1,717	1,717	5,355	-25,009	-78,023
6	-18,082	-13,468	-31,550	-114,928	6	2,025	2,025	7,380	-29,525	-107,549
7	-20,851	-15,315	-36,167	-151,095	7	2,319	2,319	9,699	-33,848	-141,396
8	-23,710	-17,167	-40,876	-191,971	8	2,618	2,618	12,317	-38,258	-179,654

9	-26,459	-18,954	-45,413	-237,384	9	2,907	2,907	15,224	-42,506	-222,161
10	-29,133	-20,611	-49,744	-287,128	10	3,181	3,181	18,405	-46,563	-268,724

6.2 Baseline non-CO_2 emissions from forest fires

With the exception of cases involving charcoal production (which was found in less than 4% of clearings between 2010 and 2012 and also involves biomass burning) slash and burn is the primary means of clearing land for farms. Slash is often piled before burning to increase burning efficiency and control over the fire, though in some cases slash is burned where it falls. In general, almost all of the above-ground woody biomass is burned before cultivation. Thus, as per the methodology, we calculated baseline non-CO_2 emissions from forest fires (VM Table 24) using the following equations:

$$EBBtot_{icl,t} = EBBCH4_{icl,t} \quad \text{(VM 11)}$$

Where:

$EBBtot_{icl,t}$	Total GHG emission from biomass burning in forest class *icl* at year *t*; tCO_2-e ha^{-1}
$EBBCH4_{icl,t}$	CH_4 emission from biomass burning in forest class *icl* at year *t*; tCO_2-e ha^{-}

$$EBBCH4_{icl,t} = EBBCO2_{icl,t} * 12/44 * ER_{CH4} * 16/12 * GWP_{CH4} \quad \text{(VM 13)}$$

Where:

$EBBCO2_{icl,t}$	Per hectare CO_2 emission from biomass burning in slash and burn in forest class icl at year *t*; tCO_2-e ha^{-1}
$EBBCH4_{icl,t}$	Per hectare CH_4 emission from biomass burning in slash and burn in forest class icl at year *t*; tCO_2-e ha^{-1}
ER_{CH4}	Emission ratio for CH_4 (used IPCC default value of 0.012)
GWP_{CH4}	Global Warming Potential for CH_4 (used IPCC default value of 21)

$$EBBCO2_{icl,t} = Fburnt_{icl} * \sum_{p=1}^{p} \left(C_{p,icl,t} * Pburnt_{p,icl} * CE_{p,icl} \right) \quad \text{(VM 14)}$$

Where:

$EBBCO2_{icl,t}$	Per hectare CO_2 emission from biomass burning in the forest class *icl* at year *t*; tCO_2-e ha^{-1}
$Fburnt_{icl}$	Proportion of forest area burned during the historical reference period in the forest class *icl*; %
$C_{p,icl,t}$	Average carbon stock per hectare in the carbon pool *p* burnt in the forest class *icl* at year *t*; tCO_2-e ha^{-1}
$Pburnt_{p,icl}$	Average proportion of mass burnt in the carbon pool *p* in the forest class *icl*; %
$CE_{p,icl}$	Average combustion efficiency of the carbon pool *p* in the forest class *icl* (used 0.78[40])

40 This is the lowest combustion efficiency value from the range of values for slash and burn in tropical dry forest found in Table

p	Carbon pool that could burn (only above-ground standing tree biomass was considered)
icl	1, 2, 3, …*Icl* (pre-deforestation forest classes
t	1, 2, 3, … *T*, a year of the proposed project crediting period; dimensionless

VM Table 23: Parameters used to calculate non-CO_2 emissions from forest fires

Initial Forest Class		Parameters							
		Fburnt$_{icl}$	*Cab*	*Pburnt*$_{ab,icl}$	*CE*$_{ab,icl}$	*ECO2-ab*	*EBBCO2-tot*	*EBBCH4*$_{icl}$	*EBBtot*$_{icl}$
IDcl	Name	%	tCO_2-e ha^{-1}	%	%	tCO_2-e ha^{-1}	tCO_2-e ha^{-1}	tCO_2-e ha^{-1}	tCO_2-e ha^{-1}
1	High Carbon	100	159.23	100	78	124.2	124.2	11.38	11.38
2	Low Carbon	100	107.03	100	78	83.48	83.48	7.65	7.65

VM Table 24.a: Baseline non-CO2 emissions from forest fires in the project area

Project year *t*	Baseline emissions of non-CO_2 gases from forest fires				Total baseline non-CO_2 emissions from forest fires in the project area	
	ID$_{icl}$ = 1		*ID*$_{icl}$ = 2		annual	cumulative
	ABSLPA$_{icl,t}$	*EBBBSLtot*$_{icl}$	*ABSLPA*$_{icl,t}$	*EBBBSLtot*$_{icl}$	*EBBBSLPA*$_t$	*EBBSLPA*
	ha	tCO_2-e	ha	tCO_2-e	tCO_2-e	tCO_2-e
1	452	5,144	503	3,848	8,992	8,992
2	398	4,530	460	3,519	8,049	17,041
3	406	4,621	430	3,290	7,910	24,951
4	418	4,757	410	3,137	7,894	32,845
5	387	4,405	402	3,075	7,480	40,325
6	377	4,291	377	2,884	7,175	47,500
7	359	4,086	351	2,685	6,771	54,271
8	375	4,268	335	2,563	6,831	61,102
9	362	4,120	320	2,448	6,568	67,670
10	351	3,995	313	2,394	6,389	74,059

VM Table 24.b Baseline non-CO2 emissions from forest fires in the leakage belt

Project	Emissions of non-CO_2 gases from baseline forest fires	Total baseline non-CO_2

3A.1.12 of IPCC GPG for LULUCF.

year *t*					emissions from forest fires in the leakage belt	
	ID_{icl} = 1		ID_{icl} = 2		annual	cumulative
	$ABSLLK_{icl,t}$	$EBBBSLtot_{icl}$	$ABSLLK_{icl,t}$	$EBBBSLtot_{icl}$	$EBBBSLLK_t$	$EBBSLLK$
	ha	tCO_2-e	ha	tCO_2-e	tCO_2-e	tCO_2-e
1	755	8,593	696	5,324	13,917	13,917
2	589	6,704	628	4,804	11,508	25,425
3	567	6,453	620	4,743	11,196	36,621
4	578	6,578	586	4,483	11,061	47,683
5	572	6,510	540	4,131	10,641	58,324
6	570	6,487	531	4,062	10,549	68,873
7	556	6,328	494	3,779	10,107	78,980
8	574	6,533	495	3,787	10,320	89,300
9	552	6,282	478	3,657	9,939	99,239
10	537	6,112	443	3,389	9,501	108,740

STEP 7: *EX ANTE* ESTIMATION OF ACTUAL CARBON STOCK CHANGES AND NON-CO_2 EMISSIONS IN THE PROJECT AREA

As per the methodology, this step provides *ex ante* estimates of future carbon stock changes and non-CO_2 emissions from forest fire under the project scenario.

7.1 *Ex ante* estimation of actual carbon stock changes

7.1.1 *Ex ante* estimation of actual carbon stock changes due to planned activities

There are no planned deforestation or degradation activities associated with project implementation. Although villages will still allow some harvesting of fuel wood and timber in the project area, due to the reasons presented in sections 1.3 and 2.2 of this methodology annex, these activities are not expected to have a significant effect on carbon stocks.

However, since a significant portion of the project area was deforested in the past 100 years and has not reached maturity, it is likely that with the new protection afforded by project activities, carbon stocks will increase in the project area, especially in the more rapidly growing low carbon forests, most of which are less than 30 years old. The project plans to account for the increase in carbon stocks in areas of avoided deforestation using ex post monitoring. However, for the purposes of *ex ante* carbon stock change estimation, these carbon stock increases are conservatively excluded.

7.1.2 *Ex ante* estimation of carbon stock changes due to unavoidable unplanned deforestation within the project area.

The project includes activities that will both prevent deforestation in some parts of the project area, e.g. establishing new village forest reserves and land-use restrictions, and activities, e.g. promoting conservation agriculture and alternative livelihoods, that will slow the rate of deforestation in other parts of the project area where deforestation for agriculture will still be permitted. Both types of activities will contribute to reduced deforestation across the entire project area and reduced emissions.

However, since a portion of the project area will still remain available for deforestation, and enforcement of the new village forest reserve bylaws and land-use restrictions will not be 100% effective, a significant amount of deforestation will occur in the project area in the with-project scenario. As per the methodology, the *ex ante* estimated emissions from unplanned deforestation in the project case were calculated as follows:

$$\Delta CUDdPA_t = \Delta CBSL_t * (1 - EI) \qquad \text{(VM 16)}$$

Where:

$\Delta CUDdPA_t$	Total *ex ante* actual carbon stock change due to unavoided unplanned deforestation at year t in the project area; tCO_2-e
$\Delta CBSL_t$	Total baseline carbon stock change at year t in the project area; tCO_2-e
EI	*Ex ante* estimate Effectiveness Index; %
t	1, 2, 3, … *T*, a year of the proposed project crediting period; dimensionless

The effectiveness index will improve overtime as the village authorities become more effective at enforcing the new land-use and forest reserve bylaws, the few community members who did not participate in the project planning process become aware of the new bylaws, and more community members adopt the conservation agriculture techniques and alternative livelihoods promoted by the project. Additionally, some villages have indicated that they would like to increase the size of their village forest reserves so that a smaller percentage of the project area falls outside of village forest reserves. Finally, since it is expected that more deforestation will happen in the parts of the project area that are outside of village forest reserves, over time, a greater proportion of the remaining project area will fall in village forest reserves.

We present conservative *ex ante* estimates of effectiveness and total carbon stock decreases due to unavoided unplanned deforestation in VM Table 27.

VM Table 27: *Ex ante* estimated carbon stock change due to unavoided unplanned deforestation at year t in the project area.

Project year *t*	Baseline Carbon Stock Emissions	Effectiveness Index	Total carbon stock decrease due to unavoided unplanned deforestation	
	Annual	Annual	Annual	Cumulative
	$\Delta CBSL_t$	EI	$\Delta CUDdPA_t$	$\Delta CUDdPA$
	tCO_2-e	%	tCO_2-e	tCO_2-e
1	-126,560	30	-88,592	-88,592
2	-114,024	35	-74,116	-162,707
3	-112,758	40	-67,655	-230,362
4	-113,212	45	-62,266	-292,628
5	-108,057	50	-54,028	-346,657

6	-104,407	55	-46,983	-393,640
7	-99,345	60	-39,738	-433,378
8	-100,788	60	-40,315	-473,693
9	-97,697	60	-39,079	-512,772
10	-95,765	60	-38,306	-551,078

7.1.3 *Ex ante* estimated net carbon stock change in the project area under the project scenario

Since there are no planned activities that are expected to significantly reduce carbon stocks in the with project scenario and we have conservatively excluded expected carbon stock increases from *ex ante* estimations, the *ex ante* estimate net carbon stock change in the project area under the project scenario is equal to the total carbon stock decrease due to unavoided unplanned deforestation presented in VM Table 27.

7.2 *Ex ante* estimation of actual non-CO_2 emissions from forest fires

As with the baseline scenario, the majority of the deforestation events in the project scenario will be associated with clearing forest for farming. In the baseline scenario, nearly 100% of farm clearing involves burning the cleared biomass. Due to project activities educating farmers about the harm that fire does to their farmland and providing farmers with alternatives to burning, it is expected that less than 100% of farm clearings in the project scenario will involve burning the cleared biomass. However, as these emission saving cannot be claimed under this methodology, we conservatively estimate non-CO_2 emissions from forest fires (VM Table 28) as per the methodology:

$$EBBPSPA_t = EBBBSPA_t * (1 - EI) \qquad \text{(VM 17)}$$

Where:

$EBBPSPA_t$ Total *ex ante* non-CO_2 emissions from forest fire due to unavoided unplanned deforestation at year t in the project areal; tCO_2-e

$EBBBSPA_t$ Total non-CO_2 emissions from forest fire due at year t in the project areal; tCO_2-e

EI *Ex ante* estimated Effectiveness Index; %

t 1, 2, 3, … *T*, a year of the proposed project crediting period; dimensionless

VM Table 28: Total e*x ante* estimated actual emissions from non-CO_2 gases due to forest fires in the project area

Project year *t*	Baseline non-CO_2 Emissions	Effectiveness Index	Total *ex ante* estimated actual non-CO_2 emissions from forest fires in the project area	
	Annual	Annual	Annual	Cumulative
	$EBBBSPA_t$	EI	$EBBPSPA_t$	$EBBPSPA$
	tCO_2-e	%	tCO_2-e	tCO_2-e
1	8,992	30	6,295	6,295
2	8,049	35	5,232	11,526

3	7,910	40	4,746	16,272
4	7,894	45	4,342	20,614
5	7,480	50	3,740	24,354
6	7,175	55	3,229	27,583
7	6,771	60	2,708	30,291
8	6,831	60	2,732	33,023
9	6,568	60	2,627	35,651
10	6,389	60	2,556	38,206

7.3 Total *ex ante* estimations for the project area

VM Table 29 presents the total *ex ante* estimations for the project area by combining the results from VM Table 27 and VM Table 28.

VM Table 29: Total *ex ante* estimated actual net carbon stock changes and emissions of non-CO_2 gases in the project area

Project year *t*	Total *ex ante* net carbon stock change[1]		Total *ex ante* estimated actual non-CO_2 emissions from forest fires in the project area	
	Annual	Cumulative	Annual	cumulative
	$\Delta CPSPA_t$	$\Delta CPSPA$	$EBBPSPA_t$	$EBBPSPA$
	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e
1	-88,592	-88,592	6,295	6,295
2	-74,116	-162,707	5,232	11,526
3	-67,655	-230,362	4,746	16,272
4	-62,266	-292,628	4,342	20,614
5	-54,028	-346,657	3,740	24,354
6	-46,983	-393,640	3,229	27,583
7	-39,738	-433,378	2,708	30,291
8	-40,315	-473,693	2,732	33,023
9	-39,079	-512,772	2,627	35,651
10	-38,306	-551,078	2,556	38,206

1 This is the same as total carbon stock decrease due to unavoided unplanned deforestation from VM Table 27 because there are no other expected changes in carbon stocks in the project scenario.

STEP 8: *EX ANTE* ESTIMATION OF LEAKAGE

In this step, possible decreases in carbon stock and increases in GHG emissions (other than carbon stock change) due to leakage are estimated *ex ante*.

8.1 *Ex ante* estimation of the decrease in carbon stocks and increase in GHG emissions due to leakage prevention measures

As per the methodology, emissions from nitrogen fertilizers and fossil fuel use associated with the project were not considered. Only changes in carbon stocks in leakage management areas due to leakage management activities and non-CO_2 emissions from livestock intensification were considered as potential leakage caused by leakage prevention measures.

8.1.1 Carbon stock changes due to activities implemented in leakage management areas

Project activities are listed in section 1.8 of the project description. The primary leakage prevention activity includes promoting labor intensive conservation agriculture techniques to improve agricultural productivity and sustainability. These techniques include soil conservation measures and promoting alternatives to the use of burning to clear land. The techniques promoted by the project will slow the loss of carbon stocks in leakage management areas compared to the baseline scenario. The other major leakage prevention activity includes promoting alternative livelihoods through saving and credits schemes and REDD revenue sharing. These activities are not expected to affect carbon stocks in leakage management areas. Thus, in summary, leakage prevention activities can conservatively be assumed to have no effect on carbon stocks in the leakage management areas.

8.1.2 *Ex ante* estimation of CH_4 and N_2O emissions from grazing animals

There are no plans to promote grazing animals as part of project interventions. Some community members could conceivably use their shares of REDD revenue to purchase livestock and thus there could be more grazing animals in the project scenario than in the baseline, but this is expected to be rare. In the first round of trial REDD revenue sharing, no households invested their earnings in livestock. Thus, increases in emissions from grazing animals are considered insignificant.

8.1.3 Total *ex ante* estimated carbon stock changes and increases in GHG emissions due to leakage prevention measures

The results of section 8.1.2 and 8.1.3 show that there are no anticipated GHG emission increases associated with leakage prevention.

8.2 *Ex ante* estimation of the decrease in carbon stocks and increase in GHG emissions due to activity displacement leakage

Ex ante baseline carbon stock changes and GHG emissions for the leakage belt were calculated in sections 6.1 of this methodology annex. Estimates for baseline changes in above-ground and below-ground carbon stock in the leakage belt are presented in VM Table 21.c.1 and VM Table 21.c.2 respectively.

The methodology states that *ex ante* activity displacement leakage should be calculated, “by multiplying the estimated baseline carbon stock changes for the project area by a displacement leakage factor (DLF)” and then suggests in the footnotes that the DLF should be set to the proportion of the project area deforestation agents who do not participate in leakage prevention or other project activities. However, this would result in double counting unavoided baseline deforestation since the project does not anticipate 100% effectiveness of avoided deforestation activities. By definition, deforestation activities that continue in the project area, cannot leak to outside the project area. Thus, rather than multiplying the DLF by the baseline carbon stock changes, we multiplied the DLF by the difference between the baseline and the *ex ante* estimates of project scenario carbon stock changes (which changes over time as anticipated effectiveness changes). Therefore, as the participating project villages become more effective at preventing deforestation, leakage would also rise since a greater number of deforestation agents will be displaced.

There is limited data available to estimate the percentage of deforestation agents who will not be participating the project activities. We assume that 100% of deforestation agents living within the participating project villages who do not continue to deforest under the project scenario will be participating in project activities. The project also plans to conduct agricultural related activities with people from villages neighboring the project villages who historically were involved in deforestation within the project area villages. Additionally, the project will create some positive leakage since it will involve people from the project villages who in the baseline scenario would have gone to deforest in the leakage belt. Therefore, the project estimates that about half of the leakage that would have been caused by the 33% of deforestation agents who are not residents of project villages will be mitigated either by their participation in project activities or reduced baseline leakage caused by project area residents (see section 1.1.3 of this annex). Thus, a DLF of 17% was chosen instead of 33%.

As per the methodology, the same *DLF* was also applied to estimated non-CO_2 green house gas emissions from biomass burning. The ex ante estimates of activity displacement leakage are shown in VM Table 34.a for displaced deforestation and VM Table 34.b for displaced forest fires.

VM Table 34.a: *Ex ante* estimated leakage due to activity displacement

Project year t	Difference between baseline and *ex ante* project area carbon stock changes	Displacement Leakage Factor	Total *ex ante* estimated decrease in carbon stocks due to displaced deforestation	
	Annual	Annual	annual	cumulative
	$\Delta CBSL_t$ - $\Delta CPSPA_t$	*DLF*	$\Delta CADLK_t$	$\Delta CADLK$
	tCO_2-e	%	tCO_2-e	tCO_2-e
1	-37,968	17	-6,455	-6,455
2	-39,908	17	-6,784	-13,239
3	-45,103	17	-7,668	-20,906
4	-50,945	17	-8,661	-29,567
5	-54,028	17	-9,185	-38,752
6	-57,424	17	-9,762	-48,514
7	-59,607	17	-10,133	-58,647
8	-60,473	17	-10,280	-68,928
9	-58,618	17	-9,965	-78,893
10	-57,459	17	-9,768	-88,661

VM Table 34.b: *Ex ante* estimated leakage due to displaced forest fires

Project year t	Difference between *ex ante* and baseline project area non-CO_2 emissions from fire	Displacement Leakage Factor	Total *ex ante* increase in GHG emissions due to displaced forest fires	
	Annual	Annual	annual	cumulative
	$EBBBSPA_t$ - $EBBPSPA_t$	*DLF*	$EADLK_t$	*EADLK*
	tCO_2-e	%	tCO_2-e	tCO_2-e
1	2,698	17	459	459
2	2,817	17	479	938
3	3,164	17	538	1,475
4	3,552	17	604	2,079
5	3,740	17	636	2,715
6	3,946	17	671	3,386
7	4,063	17	691	4,077
8	4,098	17	697	4,773
9	3,941	17	670	5,443
10	3,834	17	652	6,095

8.3 *Ex ante* estimation of total leakage

All of the *ex ante* estimates of leakage from step 8 are summarized in VM Table 35.

VM Table 35: *Ex ante* estimated total leakage

Project year t	Total GHG emissions from increased grazing activities		Total *ex ante* increase in GHG emissions due to displaced forest fires		Total *ex ante* decrease in carbon stocks due to displaced deforestation		Carbon stock decrease due to leakage prevention measures		Total net carbon stock change due to leakage		Total net increase in emissions due to leakage	
	annual	cumulative	annual	cumulative	annual	cumulative	annual	cumulative	annual	cumulative	annual	cumulative
	$EgLK_t$	$EgLK$	$EADLK_t$	$EADLK$	$\Delta CADLK_t$	$\Delta CADLK$	$\Delta CLPMLK_t$	$\Delta CLPMLK$	ΔCLK_t	ΔCLK	ELK_t	ELK
	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e
1	0	0	459	459	-6,455	-6,455	0	0	-6,455	-6,455	459	459
2	0	0	479	938	-6,784	-13,239	0	0	-6,784	-13,239	479	938
3	0	0	538	1,475	-7,668	-20,906	0	0	-7,668	-20,906	538	1,475
4	0	0	604	2,079	-8,661	-29,567	0	0	-8,661	-29,567	604	2,079
5	0	0	636	2,715	-9,185	-38,752	0	0	-9,185	-38,752	636	2,715
6	0	0	671	3,386	-9,762	-48,514	0	0	-9,762	-48,514	671	3,386
7	0	0	691	4,077	-10,133	-58,647	0	0	-10,133	-58,647	691	4,077
8	0	0	697	4,773	-10,280	-68,928	0	0	-10,280	-68,928	697	4,773
9	0	0	670	5,443	-9,965	-78,893	0	0	-9,965	-78,893	670	5,443
10	0	0	652	6,095	-9,768	-88,661	0	0	-9,768	-88,661	652	6,095

STEP 9: *EX ANTE* TOTAL NET ANTHROPOGENIC GHG EMISSION REDUCTIONS

9.1 Significance assessments

As per the methodology, the latest EB-CDM approved "Tool for testing significance of GHG emissions in A/R CDM project activities" was used to determine the significance of each of the *ex ante* calculated carbon stock changes and GHG emissions. All *ex ante* estimated changes in carbon stocks are significant and must be accounted for, while emissions from forest fires are not significant and are optionally included.

9.2 Calculation of *ex ante* estimation of total net GHG emissions reductions

As per the methodology, the net anthropogenic GHG emission reduction of the proposed AUD project activities (VM_Table 36) was calculated as follows:

$$\Delta REDD_t = (\Delta CBSLPA_t + EBBBSLPA_t) - (\Delta CPSPA_t + EBBPSPA_t) - (\Delta CLK_t + ELK_t) \qquad \text{(VM 19)}$$

Where:

$\Delta REDD_t$	*Ex ante* estimated net anthropogenic greenhouse gas emission reduction attributable to the AUD project activity at year *t*; tCO_2e
$\Delta CBSLPA_t$	Sum of baseline carbon stock changes in the project area at year *t*; tCO_2e
	Note: The absolute value of $\Delta CBSLPA_t$ is used in equation 19.
$EBBBSLPA_t$	Sum of baseline emissions from biomass burning in the project area at year *t*; tCO_2e
$\Delta CPSPA_t$	Sum of *ex ante* estimated actual carbon stock changes in project area at year *t*; tCO_2e
	Note: If $\Delta CPSPA_t$ represents a net increase in carbon stocks, a negative sign before the absolute value of $\Delta CPSPA_t$ is used. If $\Delta CPSPA_t$ represents a net decrease, a positive sign is used.
$EBBPSPA_t$	*Sum of (ex ante estimated)* actual emissions from biomass burning in the project area at year *t*; tCO_2e
ΔCLK_t	Sum of *ex ante* estimated leakage net carbon stock changes at year *t*; tCO_2e
	Note: If the cumulative sum of ΔCLK_t within the fixed baseline period is > 0, ΔCLK_t *shall be set to zero.*
ELK_t	Sum of *ex ante* estimated leakage emissions at year *t*; tCO_2e
t	1, 2, 3 … *T,* a year of the proposed project crediting period; dimensionless

9.3 Calculation of *ex ante* Verified Carbon Units (VCUs)

As per the methodology, the number of Verified Carbon Units (VCUs) to be generated through the proposed AUD project activities (VM_Table 36) at year t was calculated at follows:

$$VCU_t = \Delta REDD_t - VBC_t \qquad \text{(VM 20)}$$

$VBC_t = (\Delta CBSLPA_t - \Delta CPSPA_t) * Rf_t$ (VM 21)

Where:

VCU_t	Number of Verified Carbon Units that can be traded at time *t*; tCO_2e
	Note: If $VCU_t < 0$ no credits (VCUs) will be awarded and VCUs can only be granted if:

$$\sum_{t=0}^{t} \Delta REDD_t > 0$$

$\Delta REDD_t$	*Ex ante* estimated net anthropogenic greenhouse gas emission reduction attributable to the AUD project activities at year *t*; tCO_2e
VBC_t	Number of Buffer Credits deposited in the VCS Buffer at time *t*; tCO_2e
$\Delta CBSLPA_t$	Sum of baseline carbon stock changes in the project area at year *t*; tCO_2e
$\Delta CPSPA_t$	Sum of *ex ante* estimated actual carbon stock changes in the project area at year *t*; tCO_2e
RF_t	Risk factor used to calculate VCS buffer credits; %
	Note: RF_t was determined to be 10% using the latest version (v3.2) of the VCS-approved AFOLU Non-Permanence Risk Tool available at the time of writing this annex.
t	1, 2, 3 … *T*, a year of the proposed project crediting period; dimensionless

VM Table 36. *Ex ante* estimated net anthropogenic GHG emission reductions *($\Delta REDD_t$)* and Verified Carbon Units *(VCU_t)*

Project year t	Baseline carbon stock changes		Baseline GHG emissions		*Ex ante* project carbon stock changes		*Ex ante* project GHG emissions		*Ex ante* leakage carbon stock changes		*Ex ante* GHG leakage emissions		*Ex ante* net anthropogenic GHG emission reductions		*Ex ante* VCUs tradable		*Ex ante* buffer credits	
	annual	cumulative	annual	cumulative	annual	cumulative	annual	cumulative	annual	cumulative	annual	cumulative	annual	cumulative	annual	cumulative	annual	cumulative
	$\Delta CBSLPA_t$	$\Delta CBSLPA$	$EBBBSLPA_t$	$EBBBSLPA$	$\Delta CPSPA_t$	$\Delta CPSPA$	$EBBPSPA_t$	$EBBBSLPA$	ΔCLK_t	ΔCLK	ELK_t	ELK	$\Delta REDD_t$	$\Delta REDD$	VCU_t	VCU	VBC_t	VBC
	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e
1	-126,560	-126,560	8,992	8,992	-88,592	-88,592	6,295	6,295	-6,455	-6,455	459	459	33,752	33,752	29,956	29,956	3,797	3,797
2	-114,024	-240,583	8,049	17,041	-74,116	-162,707	5,232	11,526	-6,784	-13,239	479	938	35,462	69,215	31,471	61,427	3,991	7,788
3	-112,758	-353,341	7,910	24,951	-67,655	-230,362	4,746	16,272	-7,668	-20,906	538	1,475	40,062	109,276	35,551	96,978	4,510	12,298
4	-113,212	-466,553	7,894	32,845	-62,266	-292,628	4,342	20,614	-8,661	-29,567	604	2,079	45,233	154,509	40,138	137,117	5,095	17,392
5	-108,057	-574,610	7,480	40,325	-54,028	-346,657	3,740	24,354	-9,185	-38,752	636	2,715	47,948	202,457	42,545	179,662	5,403	22,795
6	-104,407	-679,017	7,175	47,500	-46,983	-393,640	3,229	27,583	-9,762	-48,514	671	3,386	50,937	253,394	45,195	224,856	5,742	28,538
7	-99,345	-778,362	6,771	54,271	-39,738	-433,378	2,708	30,291	-10,133	-58,647	691	4,077	52,846	306,240	46,885	271,742	5,961	34,498
8	-100,788	-879,150	6,831	61,102	-40,315	-473,693	2,732	33,023	-10,280	-68,928	697	4,773	53,594	359,834	47,547	319,288	6,047	40,546
9	-97,697	-976,847	6,568	67,670	-39,079	-512,772	2,627	35,651	-9,965	-78,893	670	5,443	51,924	411,758	46,062	365,351	5,862	46,408
10	-95,765	-1,072,612	6,389	74,059	-38,306	-551,078	2,556	38,206	-9,768	-88,661	652	6,095	50,873	462,631	45,127	410,477	5,746	52,153

PART 3 – METHODOLOGY FOR MONITORING AND RE-VALIDATION OF THE BASELINE

TASK 1: MONITORING OF CARBON STOCK CHANGES AND GHG EMISSIONS FOR PERIODIC VERIFICATIONS

1.1 Monitoring of actual carbon stock changes and GHG emissions within the project area

1.1.1 Monitoring of project implementation

All of the core project startup activities have been completed. Documentation of these activities is available at http://www.tfcg.org/makingReddWork.html, or provided as addendum to the project design document in the form of completed and approved land-use plans, forest management plans, forest bylaws, and village forest reserve maps. The project will monitor ongoing project implementation on an annual basis regardless of whether the project plans to verify each year, so that communities can be compensated based on their yearly performance. Data regarding the ongoing project activities will be gathered annually by MJUMITA from village natural resource committees, village councils, and from independent monitors paid to collect data on the project's social and biodiversity impacts. Table J provides the details for monitoring the core AUD activities that will continue throughout the project life span.

Table J: Annual ongoing project implementation monitoring plan

Activity	Indicators	Indicator Data Sources
Enforcement of Land Use and Village Forest Reserve bylaws	• Increased awareness of the village forest reserve bylaws and boundaries • Evictions and, or fines for people found violating bylaws • Reduction of deforestation compared to the baseline • Number of Village Land Use Management committees with work plans that are being implemented • Frequency of patrols of Village Forest Reserves	• Village Natural Resource Committee Forest Patrol Reports • *Ex post* version of VM Table 36 in verification reports
Promoting sustainable agricultural practices to improve yields	• Increase in the number of farmers who adopt sustainable agricultural practices	• Reports from community based trainers. • VM Table 21.d in verification reports

	• Reduction or elimination of leakage	
REDD revenue benefit sharing	• Amount of revenue dispersed according to agreed bylaws. • Number of village development projects completed with funding from REDD revenue	• Village REDD dividend payment books • Village assembly meeting minutes • Photographic evidence of village development projects

1.1.2 Monitoring of land-use and land-cover change

The project site is not part of a jurisdictional REDD program and there is no third party monitoring of the project site at this time. Therefore, the project will be responsible for monitoring land-use land-cover change in the project area and leakage belt. Land-use land-cover change will be monitored using the same change detection techniques employed for the historical deforestation analysis (see Part 2, Step 2.4 and Step 2.5).

Change detection will either be carried out using either Landsat, PALSAR, or PALSAR equivalent L-band radar. The launch of Landsat 8 and anticipated launch of PALSAR II in 2014 should provide adequate data to carry out land-use land cover change monitoring on an annual basis. Due to the nature of IR-MAD change detection, which is invariable to scene wide differences between images, it is anticipated that no adjustments will need to be made to the change detection process when comparing Landsat 8 imagery to other Landsat imagery. However, this will be confirmed by checking the deforestation results against high resolution imagery (< 5m) during the first verification.

PALSAR II data will be used as PALSAR data was during the historical deforestation analysis, to map deforestation in the event that cloud cover and Landsat 7 SLC error can not be lowered to less than 10% through combining cloud-free Landsat data from multiple scenes. Likewise, to prevent false deforestation detection associated with seasonality, the project will give preference to Landsat imagery from March to May for deforestation detection and will only use imagery from June for monitoring change in areas covered by clouds or SLC error in March to May imagery.

Annual land-use land-cover change monitoring will involve the following steps:

1. Acquire March to May Landsat 7 and Landsat 8 imagery necessary to conduct IR-MAD change detection covering the project area and leakage belt. Excessively cloudy and or hazy imagery will be avoided. In the event that cloud cover and SLC error cannot be lowered to below 10% through combining imagery, acquire Landsat 7 or 8 data from June or acquire PALSAR II data from the dry season (June to Nov).
2. If PALSAR II data is acquired, it will be processed to the same specifications as the PALSAR data used in the historical deforestation analysis (see Part 2, Step 2.4).
3. Check and correct, if necessary, the georeferencing of the acquired imagery against the base image that will be used for change detection. In the case of Landsat data, this will be the Landsat 5 scene from May 20th, 2008 which has been cloud filled with data from May 10th, 2010 (unless a more recent cloud free scene becomes available). In the case of PALSAR II imagery, this will be the PALSAR mosaic from Oct-Nov 2010 which has already been georeferenced to match the

May, 2008 scene.

4. Perform IR-MAD change detection by comparing the acquired Landsat imagery to the May, 2008 cloud filled base image using the python script provided by Mort Canty. If PALSAR imagery is included in the analysis, generate a change image using band math to subtract the HV band of the base year from the HV band of the target year.
5. Create cloud masks and SLC error masks following the procedures described in Part 2, Step 2.4.
6. Using the cloud and SLC masks, calculate the percent of the project area and leakage belt for which no data is available. If this is greater than 10%, then acquire Landsat data from June or PALSAR II data necessary to cover the missing areas.
7. Use a decision tree in R to select the pixels from the IR-MAD change or PALSAR HV band difference images that are associated with deforestation as per Part 2, step 2.4 and output the identified areas of deforestation as a geotif file. This process will include data from each year since the start of the project period, so that all deforestation to date is captured.
8. Perform two passes of a 3x3 majority filter followed by a 5 pixel orthogonal sieve on the deforestation image.
9. Overlay the filtered deforestation image with the 2012 forest benchmark map and remove areas of change in areas that were not forest in 2012.
10. Compared the deforestation map to high resolution imagery covering the time period on Google Earth. If there is no Google Earth imagery for the period, then order Spot imagery via Planet Action. If significant discrepancies are seen between the deforestation map and high resolution imagery, then adjust the values used to identify deforestation in step 7.
11. Perform an accuracy assessment of the deforestation map using available high resolution imagery or ground truthing data collected by village natural resource committee members following the procedure described in Part 2, Step 2.5. If the deforestation map accuracy is less than 80%, adjust values or imagery used in step 7, until 80% is obtained.
12. Calculate the annual and cumulative areas of gross forest loss per forest type required for *ex post* tables of activity data per stratum.

The results from the deforestation analysis will be used to fill in *ex post* versions of VM Tables 11.b (project area deforestation per forest type), and 11.c (leakage belt area deforestation per forest type). VM tables 13.b and 13.c will not be filled as per the methodology because they are identical to VM tables 11.b and 11.c since there is only one deforestation zone for the entire reference region.

1.1.3 Monitoring of carbon stocks and non-CO2 emissions from forest fires

Monitoring of carbon stock changes

Currently, there are no significant planned harvesting activities within the participating villages or leakage belt as there are very few remaining valuable timber trees and there is limited demand for charcoal. This is likely to remain the case throughout the first fixed baseline period of 10 years. Therefore, the project does not currently plan to monitor any areas for planned significant carbon stock decreases.

Fire is common in the landscape, but rarely destructive as the forests that burn regularly are fire adapted (remote sensing analysis conducted as part of the historical deforestation analysis showed no evidence of a destructive fire occurring from 1991 to 2012). Fire in the region can cause degradation through the death of individual trees and inhibiting regeneration, but only over long periods of time. The project has promoted fire awareness and alternatives to the use of fire in clearing land for agriculture. Additionally, since farmers will no longer be active in the core forest areas of the project, the risk of escaped fires moving into the core forest area will be greatly reduced. Thus, it is not anticipated that monitoring carbon stock changes associated with fire will be necessary and there are no other kinds of catastrophic events that can affect carbon stocks in the area. In the unlikely event that a catastrophic fire does occur, the area of the burn will be determined using remote sensing and the change in carbon stocks will be calculated using the permanent carbon plots already established in the area described in Part 2, 6.1.

Although the project included constant carbon stocks in the *ex ante* calculations for conservativeness, the project does anticipate that carbon stocks will increase in the project area given that a substantial portion of the project area is not old-growth forest and will receive greater levels of protection than in the past. Therefore, the project will periodically monitor for significant carbon stock changes using the permanent carbon plots and techniques described in Part 2, Step 6.1. These periodic measurements will take place every 2 to 5 years in order to give enough time for the magnitude of any changes to be statistically significant. Due to difficulties of monitoring initial forest class carbon stocks outside of the project are, it will be conservatively assumed that any carbon stock changes seen in the project area have also occurred in the leakage belt. Data from revisited carbon plots will be stored and analyzed using the same database described in Part 2, Step 6.1.

The results of periodic carbon stock monitoring will be used to update VM Table 15 (*ex post* carbon stock per hectare of initial forest classes in the project area and leakage belt). As per the methodology, any changes in VM Table 15 (subject to validation), and the results of the deforestation analysis in section 1.1.2 will be used to create *ex post* versions of VM Tables 25.a – g (*ex post* decreases in carbon stocks), VM Tables 26.a – g (*ex post* increases in carbon stocks), and VM Table 27 (ex post total net carbon stock change in the project area).

Monitoring of non-CO2 emissions from forest fires

Ex post Non-CO2 emissions from forest burning will be calculated as they were in the *ex ante* baseline scenario using *ex post* versions of VM Tables 23 and 24.

1.1.4 Monitoring of impacts of natural disturbances and other catastrophic events

As described in the previous section, the likelihood of a catastrophic event leading to a significant change in carbon stocks is very low. However, the project will continue to monitor for such events based on the remote sensing planned in section 1.1.2 and village natural resource committee monitoring reports. In the event that a catastrophic event occurs, its effect on carbon stocks will be assessed in terms of both reduction of stocks in areas remaining forest and from deforestation.

In the event of a catastrophic loss of carbon stocks, the net change in carbon stocks and GHG emissions in the area(s) that generated VCUs prior to the event will be estimated and an equivalent amount of VCUs will be canceled from the VCS buffer and no further VCUs will be generated until the project all carbon stock losses and increases in GHG emissions have been offset.

1.1.5 Total *ex post* estimated actual net carbon stock changes and GHG emissions in the project area

An ex post version of VM Table 29 will be used to summarize the results of all the *ex post* estimations in the project area and calculate the actual net carbon stock changes and GHG emissions in the project area.

1.2 Monitoring of leakage

This project is not within a jurisdictional VCS or UNFCCC registered program and thus leakage monitoring is required.

1.2.1 Monitoring of carbon stock changes and GHG emissions associated to leakage prevention activities

As described in Part 2, Step 8.1, there are no significant carbon stock changes or GHG emissions anticipated from the leakage prevention activities and thus they will not be monitored.

1.2.2 Monitoring of carbon stock decrease and increase in GHG emissions due to activity displacement leakage

Monitoring of carbon stock changes

Emissions from carbon stock changes greater than those predicted by the baseline assessment of leakage, will be considered leakage.

Using the deforestation data for the leakage belt generated in step 1.1.2, an ex post version of VM Table 21.c will be generated. As per the methodology, the difference between the *ex ante* and ex post versions of VM Table 21.c will be reported in VM Table 21.d.

As per the methodology, where the project can provide strong evidence that the deforestation in the leakage belt is attributable to deforestation agents not linked to the project area, the deforestation may not be considered leakage.

Monitoring of increases in GHG emissions

The project will monitor and report GHG leakage in the leakage belt area by comparing an *ex post* version of VM Table 24 (calculated using the parameters from VM Table 23) to an *ex ante* version of VM Table 24 for the leakage belt.

1.2.3 Total *ex post* estimated leakage

A summary of *ex post* estimations of leakage will be presented in an *ex post* version of VM Table 35.

1.3 *Ex post* net anthropogenic GHG emission reductions

Finally, *ex post* net anthropogenic GHG emission reductions and Verified Carbon Units (VCUs) will be calculated using a version of VM Table 36 where the *ex ante* estimates of carbon stock changes and GHG emissions are replaced with ex post estimates.

Additionally, a map showing cumulative areas credited within the project area shall be updated and presented to the VCS verifying organization at each verification event.

TASK 2: REVISITING THE BASELINE PROJECTIONS FOR FUTURE FIXED BASELINE PERIOD

As per the methodology, the project will revisit and update the baseline once every 10 years. If an applicable sub-national or national jurisdictional baseline becomes available, it will be used.

2.1 Update information on agents, drivers and underlying causes of deforestation

The data used to understand agents, drivers, and underlying causes of deforestation in Part 2, Step 3, will be updated and Step 3 will be redone at the end of the 10 year fixed baseline period.

The factor maps used to model the location of future deforestation (VM Table 10) will be updated to reflect changes that occurred during the 10 year fixed baseline period.

2.2 Adjustment of the land-use and land-cover change component of the baseline

If a sub-national or national baseline meeting the criteria specified in VM Table 2 or relevant updated VCS requirements, it will be used. If not, the project will update the baseline as follows:

2.2.1 Adjustment of the annual areas of baseline deforestation

Deforestation data from the reference region during the previous fixed baseline period will be used to update the projected annual areas of baseline deforestation following the methods in Part, 2 Steps 2 – 3.

2.2.2 Adjustment of the location of the projected baseline deforestation

The location of the projected baseline deforestation will be updated by redoing Part, 2 Step 4, using the updated projected annual areas of baseline deforestation. All areas of credited avoided deforestation will be excluded from the revisited baseline projections.

2.3 Adjustment of the carbon component of the baseline

The periodic monitoring of carbon stocks in initial forest classes using permanent plots will be used to update the carbon component of the baseline. The procedures described in Part, 2 Step 6.1 will be used. Due to the fact that the original carbon plots were not properly monumented (plot centers were not marked), the project will not be able to use the first round of carbon stock monitoring scheduled for 2015 to update the carbon stocks. Instead, changes between the second and future rounds of carbon stock monitoring will be used to update carbon stock estimates.