Mpingo Conservation & Development Initiative

Combining REDD, PFM and FSC certification in South-Eastern Tanzania

Final Report 2015

Executive Summary

Project title
Combining REDD, PFM and FSC certification in South-Eastern Tanzania

Primary proponent
Mpingo Conservation & Development Initiative

Total budget
$1,948,123

Timeframe
5 years: 2010 – 2014

Summary description of project

Integrating Reduced Emissions from Deforestation and Forest Degradation (REDD) with Participatory Forest Management (PFM) is key to ensuring benefits from REDD reach forest-adjacent communities, and that local incentives are aligned with national and global interests in conserving forests to reduce carbon emissions. The Mpingo Conservation & Development Initiative (MCDI) has extensive experience with PFM through the operational model and brand it has developed in SE Tanzania whereby communities earn revenue from selling sustainably harvested timber. The organisation also holds the first Forestry Stewardship Council (FSC) certificate for community-managed natural forest in Africa. Between 2010 and 2014, MCDI proposed to combine REDD with its PFM+FSC model in south-eastern Tanzania as an additional means to bring benefits to poor and natural resource-dependent rural communities managing local forests.

The foremost driver of forest degradation in MCDI's project area in Kilwa District is annual burning of miombo woodlands, which suppresses tree growth and biomass. The project therefore invested in developing a new methodology for carbon accounting in miombo woodlands affected by fire, a method which can be applied widely within the miombo biome that covers much of southern Africa.

An important component of the project involved working in collaboration with international partners to develop improved methods of measuring carbon stored in miombo woodlands, and from this developing efficient participatory assessment and monitoring procedures (drawing on MCDI's experience with participatory timber inventory), as well as protocols for monitoring and verification through remote sensing. Another major component of the project was the development of best practice for delivering and monitoring benefits to communities.

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Contents

Glossary of Terms

CBFM	–	Community-Based Forest Management
CBFiM	–	Community-Based Fire Management
CCB	–	Carbon, Community & Biodiversity standard / association
CCIAM	–	Centre for Climate Change Impacts, Adaptation and Modelling
CIFOR	–	Centre for International Forestry Research
CO2e	–	Carbon Dioxide or equivalent (tCO2e, tonnes of CO2e, is the standard unit for trading carbon credits and offsets)
CoP	–	Conference of Parties (usually used in reference to UNFCCC)
CSO	–	Civil Society Organisation
CT	–	Carbon Tanzania (project partner)
DNV	–	Det Norske Veritas (a VVB accredited by VCS)
EACF	–	East African Coastal Forest
FCPF	–	Forest Carbon Partnership Fund
FFI	–	Fauna & Flora International (project partner)
FRI	–	Fire Return Interval (number of years, on average, between successive fires)
FSC	–	Forest Stewardship Council (a forest certification authority)
GapFire	–	A computer model developed by UoE to predict tree mortality and biomass losses from different fire regimes
GEMI	–	Global Environmental Monitoring Index
GHG	–	Greenhouse Gas
IPCC	–	Intergovernmental Panel on Climate Change
JFM	–	Joint Forest Management
KDC	–	Kilwa District Council
LEAT	–	Lawyers' Environmental Action Team
MCDI	–	Mpingo Conservation & Development Initiative
MIRBI	–	Mid Infrared Burn Index
MJUMITA	–	Community Forest Conservation Network of Tanzania (*Mtandao wa Jamii wa Usimamizi wa Misitu Tanzania*)
MNRT	–	Ministry of Natural Resources and Tourism
MODIS	–	Moderate Resolution Imaging Spectroradiometer (satellite)
MRV	–	Monitoring, Reporting and Verification
NAFORMA	–	National Forest Resources Monitoring & Assessment (national forest surveying

effort by Tanzanian government with support from FAO and Finnish government)

NDVI	–	Normalised Difference Vegetation Index
NICFI	–	Norwegian International Climate and Forest Initiative
PDD	–	Project Design Document
PFM	–	Participatory Forest Management
PLUP	–	Participatory Land-Use Planning
PSP	–	Permanent Sample Plot (used in forest surveys)
REDD	–	Reduced Emissions from Deforestation and Forest Degradation
RNE	–	Royal Norwegian Embassy in Tanzania (funders of this project)
SBSTA	–	Subsidiary Body for Scientific and Technological Advice
SCS	–	Scientific Certification Systems (a VVB accredited by VCS)
TNRF	–	Tanzania Natural Resources Forum (MCDI is a full member)
TFCG	–	Tanzania Forest Conservation Group
UCL	–	University College London (project partner)
UEA	–	University of East Anglia (project partner)
UoE	–	University of Edinburgh (project partner)
UNFCCC	–	United Nations Framework Convention on Climate Change
VCS	–	Verified Carbon Standard
VCM	–	Voluntary Carbon Market
VCU	–	Verified Carbon Unit, measure of carbon offsets issued by VCS (in tCO2e)
VER	–	Verified Emissions Reduction, carbon offsets verified by VCS
VfN	–	Value for Nature (project partner)
VGA	–	Village General Assembly
VLFR	–	Village Land Forest Reserve
VNRC	–	Village Natural Resources Committee
VVB	–	Validation and Verification Body
WWF	–	World Wildlife Fund

Background

Global REDD Landscape

The state of REDD

Reduced Deforestation and Forest Degradation (REDD) is a framework that was first launched at the Bali UNFCCC COP in 2007[1]. The vision was that REDD would be a mechanism through which developing countries would be rewarded financially through a performance-based system for any emissions reductions achieved through a decrease in the degradation of their natural forests and/or a reduction of their loss. Having identified current and/or projected rates of deforestation and forest degradation, a country taking remedial action to effectively reduce those rates would be financially rewarded relative to the extent of their achieved emissions reductions. When REDD was launched at the Bali COP in 2007, it involved several innovations aimed at overcoming decades of failure in attempts to reduce tropical deforestation. It was envisaged that REDD would raise billions of US dollars to pay the opportunity costs of forest conservation, and that it would create a performance-based, conditional system for delivering rewards to those stakeholders who avoid elimination or degradation of forests. Remote sensing technology would be applied toward verifying avoided deforestation against a pre-established reference level. Policies and measures would be implemented at the national and sub-national levels to lay the institutional groundwork for REDD and exert leverage toward assuring its success. Internationally it was agreed that REDD become REDD-plus (+) in the Cancun Agreements of 2010 at the UNFCCC conference (COP-16) to include: (a) Reducing emissions from deforestation; (b) Reducing emissions from forest degradation; (c) Conservation of forest carbon stocks; (d) Sustainable management of forests; and (e) Enhancement of forest carbon stocks. The full REDD+ mechanism was finally agreed at the UNFCCC conference (COP-19) in 2013 in Warsaw, Poland, but still lacks the requisite finance and financing mechanisms required to enable it to go to scale.

Seven years after the Bali COP, the idea of REDD+ has taken hold and grown, reflected in the large number of countries and initiatives participating in the REDD+ experiment, the many publications written about it and the large commitment of donor funds. There has been explosive growth in the number of REDD+ sub-national initiatives and there are now more than 300[2]. REDD+ has been given prominent attention year by year in UN technical Subsidiary Body for Scientific and Technological Advice (SBSTA) meetings and COP negotiations because it has been viewed as a leading option for addressing climate change early and affordably.

However, the implementation of REDD+ has fallen far short of what was hoped despite all the investment in REDD+-readiness in the last seven years. Following the Bali COP in 2007 international funding for REDD+ quickly ramped up, with large pledges from governments and the development of voluntary markets. Since 2010, however, the flow of funds has been smaller and, by 2014, the large

[1] A significant part of this section is drawn from REDD+ on the ground: Sunderlin, W. D., Pratama, C. D., Bos, A. B., Avitabile, V., Sills, E. O., de Sassi, C., Joseph, S., Agustavia, M., Pribadi, U. A. and Anandadas, A. 2014a. *The need for scientific evidence.* In: Sills, E. O., Atmadja, S. S., de Sassi, C., Duchelle, A. E., Kweka, D. L., Resosudarmo, I. A. P. and Sunderlin, W. D., eds. 2014. *REDD+ on the ground: A case book of sub-national initiatives across the globe.* Bogor, Indonesia: Center for International Forestry Research.

[2] Simonet, G., Karsenty, A., de Perthuis, C., Newton, P. and Schaap, B. 2014. *REDD+ projects in 2014: An overview based on a new database and typology.* Information and Debate Series No. 32. Paris, France: Paris-Dauphine University, Climate Economics Chair.

amount of funding meant to drive REDD+ had not yet materialized. As of early 2014, some USD 8.7 billion from the public and private sectors had been pledged or invested[3] in developing REDD+ readiness, and in bridging and stimulating demand for REDD+. However it is estimated that USD 5.0–12.5 billion is needed annually[4] and that there will be a USD 15–48 billion funding gap in the coming years[5]. Even for the currently existing and active forest carbon projects a substantial financing gap exists - estimated at between $249 million and $450 million per year in 2014; the $192 million market value in 2014 falls short of this need by between $57 million and $258 million per year. To date the nature of the required financial arrangement (either a compliance market and/or a fund-based system) to help address these major financing shortfalls remains unclear.

Public sector funding of REDD+ was meant to be temporary, but it continues to partially fill the gap because of failure of the market for forest carbon credits (both voluntary and compliance) to develop. Many REDD+ sub-national initiatives are ‘treading water,’ waiting for conditions to be more propitious, and some are drifting away from the concept of REDD+. Formulation of REDD+ policy at the national level has in some cases met stiff resistance by forces aligned against it. Systems for measurement, reporting and verification (MRV) meant to assure the efficient functioning of REDD+ are substandard in some countries. Perhaps most importantly, although a binding global climate change agreement would likely propel the regulatory environment necessary for funding REDD+ forward, the prospect of an agreement at the Paris COP in 2015 is certainly not to be taken for granted. It is unclear where REDD+ is going, and there are equal measures of hope and discouragement about prospects for fulfilling its desirable goals.

The state of REDD+ finance

A number of issues will be important in determining the future success of REDD+. For example, forest and land tenure are important for REDD+ as sufficiently secure and permanent rights for the land and forest holders (frequently local communities) affected by and/or managing REDD+ initiatives need to be in place; they need to be recognized as: (i) the rightful beneficiaries of conditional and performance based benefit streams; (ii) having legally enforceable exclusive rights to their lands and forests guarding against land loss and encroachment, and; (iii) as the lawful owners of forested lands, thereby dis-incentivizing what has often been the normative and widespread alienation, exploitation and conversion of forests by elites.

The scale of REDD+ also has important implications. REDD+ is an inherently multilevel process, and involves harmonizing the efforts of sub-national REDD+ projects and programs into national frameworks, with different options possible for achieving this. There is an increasing move towards developing jurisdictional approaches at the sub-national level at scale, as means for integrating low emissions rural development with REDD+ via sustainable supply chains, domestic policies and finance through a shared performance metric. Interest in sub-national jurisdictional programs has also been motivated by the lack of progress in international climate negotiations toward binding agreements.

The efficacy of monitoring, reporting and verification (MRV) will be central to the success of REDD+. Two challenges exist in particular: the first is integrating sub-national GHG emissions reporting into a

[3] Norman M and Nakhooda S. 2014. *The state of REDD+ finance.* Working Paper 378. CGD Climate and Forest Paper Series, No. 5. Washington, DC: Center for Global Development.

[4] Stern N. 2006. *The Stern Review: The Economics of Climate Change.* Cambridge, UK: Cambridge University Press, 217

[5] Interim Forest Finance Project. 2014. *Stimulating interim demand for REDD+ emission reductions: The need for a strategic intervention from 2015 to 2020.* Oxford, UK: Interim Forest Finance Project, 8.

national monitoring framework when the former may often be carried out according to different guidelines / standards which can lead to very different results; the second pertains to the varying levels of capacity at national and sub-national level across countries in being able to carry out MRV to the requisite standards.

Countries with National REDD+ programs are required to comply with the seven social safeguards, and the implementation of these will therefore also be important in regards to REDD+ success. The safeguards require REDD+ projects to: (i) complement national forest programs and international conventions and agreements; (ii) maintain transparent governance; (iii) respect the knowledge and rights of indigenous peoples and local communities; (iv) obtain effective participation in REDD+ design and implementation; (v) promote forest conservation and other environmental and social co-benefits; (vi) address risks of reversals; and (vii) reduce leakage. Furthermore, jurisdictions and initiatives already engaged with multi- and bilateral donors and third-party certifiers must consider additional standards for demonstrating high social and environmental performance, such as those of the FCPF, the UN-REDD Programme, the CCBA and the REDD+ Social and Environmental Standards Initiative.

Finally – and arguably the most critical issue at present – is financing. The success of REDD+ globally will depend heavily on the availability of sufficient finance to incentivize countries, landholders and others to take actions to reduce their forest-based emissions – i.e. the success of REDD+ will depend on, "*… the scale and reliability of its financing, the mechanism's ability to financially compete with alternate land uses, and the fair and wide distribution of financial benefits*"[6]. Of the USD 8.7 billion secured by early 2014 for REDD+ 61% had been allocated for readiness activities not conditioned on performance, and 88% had been pledged by the public sector through multilateral and bilateral channels (nearly all as grants) of which 41% was pledged by Norway. Norway has played a particularly important role in REDD+ finance as the largest donor, with a strategy focused primarily on climate mitigation, multiyear investments that have raised the domestic profile of REDD+ in key countries and a willingness to test performance-based funding mechanisms[7]. Norway has provided 60% of the funding for REDD+ in Tanzania.

Donor funding was initially intended to support the start-up of REDD+ and to be quickly supplanted by carbon markets. REDD+ did represent the largest volume (22.6 million tCO2e) and value (USD 94 million) in voluntary carbon offset markets in 2013[8] but this was partly because of bilateral funding intended to bolster a flagging market.

There is currently no source of demand to pay for medium to long-term emission reductions from REDD+ at the scale needed to meet emission reduction targets in tropical forest countries[9]. Between 2015 and 2020 – by which time a global climate agreement expected to be concluded in Paris in December 2015 is expected to come into effect, with clear financing mechanisms for REDD+ finalised

[6] Pascual U, Garmendia E, Phelps J and Ojea E. 2013. WP/2013/054 *Leveraging global climate finance for sustainable forests: Opportunities and conditions for successful foreign aid to the forestry sector.* WIDER Working Paper. Vol 2013/054. United Nations University (UNU-WIDER), 13.

[7] Other significant donors globally include the United States, Germany and the United Kingdom, with Japan also making substantial contributions to MRV capacity, Australia to REDD+ in Indonesia and France to Francophone Africa.

[8] Peters-Stanley M and Gonzalez G. 2014. *Sharing the stage: State of the Voluntary Carbon Markets 2014.* New York: Forest Trends' Ecosystem Marketplace.

[9] GCP, IPAM, FFI and UNEP FI. 2014. *Stimulating Interim Demand for REDD+ Emission Reductions: The Need for a Strategic Intervention from 2015 to 2020.* Global Canopy Programme, Oxford, UK; the Amazon Environmental Research Institute, Brasília, Brazil; Fauna & Flora International, Cambridge, UK; and UNEP Finance Initiative, Geneva, Switzerland.

and put in place – the projected supply of emission reductions from REDD+ and/or other forest and land-based activities is estimated to be between 13 and 39 times larger9 than potential total demand. In the meantime, the global production and cumulative value of forest carbon offsets has grown over the last five years but this growth is not currently sustainable because of the increasing difference between supply and demand, brought about by the large financing gap and uncertain signals to the private sector as to when compliance market(s) for forest- and land-use based offsets may be expected to begin.

The sources of potential demand for the interim (2015–2020) are detailed below. This finance is separate to the USD 3.29 billion pledged by multilateral and bilateral agencies to developing countries for developing REDD+ preparedness and REDD actions.

> **Compliance markets:** These are still in the early stages of development, and thus have comprised only 25% of the value of the global forest carbon market to date. The California Emissions Trading Scheme may allow internationally sourced jurisdictional REDD+ credits to be used, although these are likely to be sourced from countries that are members of the Governors' Task Force initiative (no African countries), and possibly Acre State in Brazil. In addition, the European Union and Japanese Emissions Trading Schemes are also considering REDD+-based credits.

> **Funds-based purchasers:** These currently comprise the BioCarbon Fund, the KfW (German Development Bank; *Kreditanstalt für Wiederaufbau*) REDD+ Early Movers Programme, and the Forest Carbon Partnership Facility (FCPF) Carbon Fund (although Tanzania has not progressed far with its FCPF programme). The BioCarbon Fund has a size of USD 280 million, the KfW Early Movers Programme has USD 43 million, and FCPF Carbon Fund USD 219 million, with carbon prices assumed at USD 5/tCO2e for the first two funds, and USD 3.15/tCO2e for the latter.

> **Voluntary carbon market:** The overall value of the VCM is currently estimated cumulatively to be 70 – 82 million tCO2e for the period until 2020, worth (at current prices) about USD 392 – 459 million. There is confidence among market participants about the growth of the market which has dropped little since 2012. This market is largely driven by the private sector being motivated by corporate social responsibility to offset their emissions (27%), to demonstrate industry leadership (13%), or just to 'take action on climate change' (12%)[10].

Because of the current financing gap and weak policy signals, it is likely that forest carbon prices will remain low in the medium term as supply rises more strongly than demand – a record 29.4 MtCO2e of forestry offsets were issued in 2013, more than tripling issuance volumes from 2012, and over the next five years more than 200 million tonnes of forest carbon are in the pipeline to come on to the market – and sales remain heavily driven by the growing but less predictable voluntary (pre-compliance) market. African projects transacted 5.6 MtCO2e in 2013, more than an 80% increase in volume when compared to that transacted in 2012, as REDD+ projects in Zimbabwe, the Democratic Republic of Congo, Kenya, Uganda, and other countries attracted voluntary demand. Offsets from Africa-based projects were typically priced at an average of $5.8/tCO2e. However, the overall value and average price for all African forest-offset projects declined 14% and 53%, respectively from 2012. REDD+ offsets represented the vast majority of the offsets transacted in the region.

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[10] Much of the information in this section is based on: Goldstein, A. Gonzalez, G. Peters-Stanley, M. Ed. 2014. *Turning over a new leaf: State of the Forest Carbon Markets 2014*. A Report by Forest Trends' Ecosystem Marketplace.

While it is very clear that actions to mitigate forest- and land-use based GHG emissions must be part of an effective global climate solution, the challenging uncertainty lies in when sufficiently clear financing policy signals will materialize in regards to REDD+, and what these policies will be. Observers have long recognized that policy-driven compliance-based market offset demand remains key to bringing the forest carbon market to scale with healthy prices to help bridge the very considerable financing gap.

Voluntary Markets for REDD+ Offsets

The Voluntary Carbon Market (VCM) is comprised of direct private purchasers, channel providers, resellers / aggregators, and brokers. Direct purchasers buy offsets directly from the source – i.e. individual projects generating (forest) offsets – such as BioCarbon Partners' Lower Zambezi REDD+ Project. Channel providers provide a web-based platform which enables individual purchasers to select the type of carbon offset most appealing to them and to purchase it directly from a project. Resellers / aggregators act as sales agents, buying from multiple selected offset producers to develop an offset product offering, and then selling this on at a margin to a portfolio of customers. Brokers provide purchasers with offsets in bulk and at the lowest price – the provenance or nature of the offset is often depreciated, and these offsets fetch the lowest prices. The private sector is the largest source of demand for carbon credits (19.7 $MtCO_2e$ or 70% of market activity in 2013), with two out of every three offsets being sold to multi-national companies. These companies were motivated by 'offset-inclusive' corporate social responsibly (CSR) programmes, allowing them to show climate leadership within their sectors and to meet GHG emissions targets.

Buyers from 20 different countries purchased forest offsets in 2012, 99% of these from developed nations. Buyers within the European Union, predominantly the UK, France and Germany made up over half of these purchases, and accounted for all purchases of offsets derived from African projects, reflecting an interest in land based offsets that support social development and environmental outcomes (see **Error! Reference source not found.** below).

The VCM has grown consistently since 2006 to a level of 134 $MtCO_2e$ in 2012-13, valued at US $897 million based on an average of US $7.8 / tCO_2e (see **Error! Reference source not found.** below). In 012-13, the global VCM for offsets generated through land-use based projects – including REDD+, but also afforestation, reforestation, and improved agriculture – transacted 28 $MtCO_2e$, a 9% increase since 2011[11].

Despite this promising initial trend, there was a drop in the overall value and volume of credits in the VCM in 2014.[11] Specific data on forest based credits has not yet been released; however, preliminary analysis by Reuters indicates an average price of USD $4 - $5 / tCO_2e. It is worth noting that this is merely an indicative mean, and the market is characterized by a wide variety of offset types, vintages and certification pedigrees, leading to a wide range of recorded prices.

The highest bids for issued REDD+-derived credits reached US $9/t in 2013, but the volumes purchased at this price were modest, ranging from a few hundred to thousands of tonnes. Bids on negotiated or closed contracts ranged from US $4 - 9/t, while offers on issued REDD+ VERs ranged between US $4 and 10/t. The highest prices were obtained by small-scale project owners, generating a maximum annual volume of up to 100,000 tonnes. Bids and offers on non-issued REDD+ credits averaged US $4 – 5/t. The lowest forward bid was near US $2.5/t for credits from some large-scale projects, although most

[11] Peters-Stanley, M. and Yin, D. 2013. *Maneuvering the Mosaic: State of the Voluntary Carbon Market 2013.* A report by Forest Trends Ecosystem Marketplace, Washington D.C. and Bloomberg New Energy Finance, New York. Figures **Error! eference source not found.** and **Error! Reference source not found.** below are also taken from this report.

low-end offers for both spot and forward deals reached close to US $4 - 5/t. This represents the unofficial price floor, because offers below this level are unlikely to cover project costs, and thus it is not worth selling below US $4/t.

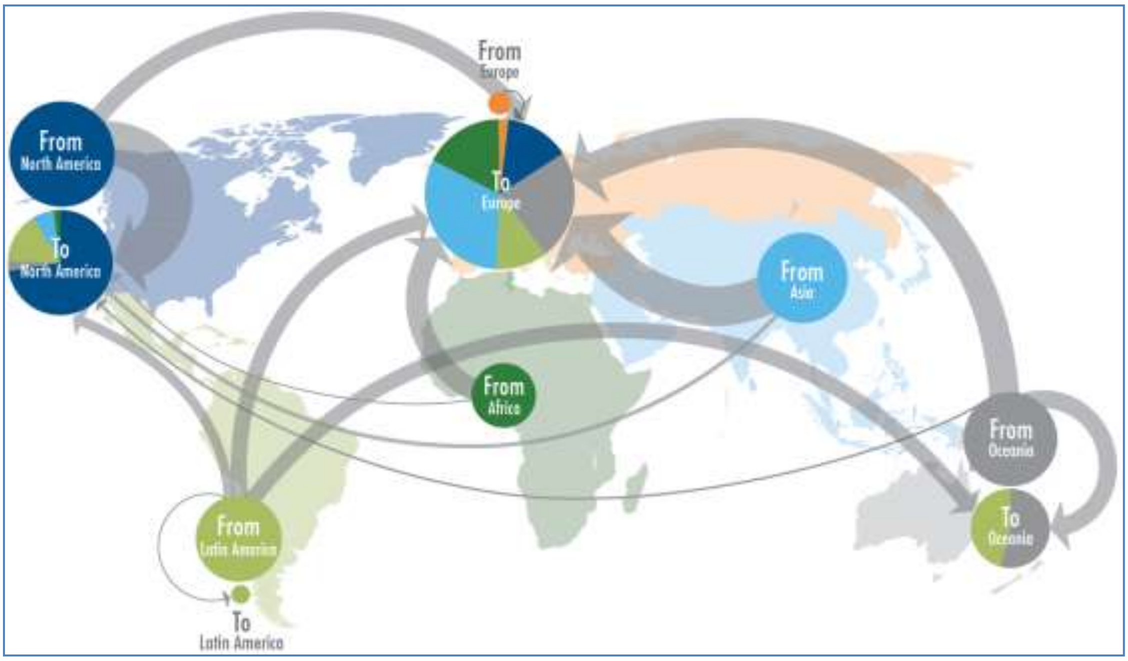

Figure 1. Voluntary Carbon Market revenue flows.

Figure 2: Forestry based carbon offset transactions.

In the final quarter of 2013, the sale prices of credits generated through REDD+ projects also dropped in comparison to the previous quarter, as many sellers acknowledged the realities of the REDD+ market: an absence of market demand and an oversupply of credits. During the last months of 2013 the market was illiquid, characterized by a large variation in USD / t, in some cases up to US $5/t for offers of issued REDD+ VERs. The average value of bids (the price that a dealer or buyer is willing to pay) and offers (the price asked for by the seller) for issued credits during this time was USD $5.5 – 6.5/t, about 50 cents down compared to the third quarter of 2013. The forward contract, which is generally based on forward selling of ex-ante credits, bid and offer averaged US $4 – 5/t, representing a 50 cent decrease on the bid and US $1/t drop on the offer. The lowest bid on issued credits was slightly above US $4/t for large volume contracts amounting up to a few hundred thousand tonnes.

Subsequent trading through 2014 has seen a relative stabilization of the price for REDD+ credits, although the market has been characterized by a very large spread of prices across project types and offset certifications. For example, in the second quarter of 2014, ten transactions were closed through the Carbon Trade Exchange (CTX) with an average price of USD $5. While this represents a small proportion of the total VCM in this period, the fact that exchange-traded credits were recorded after a period where confidence in these has been so low, can be taken as a positive sign. The average value of the credits sold is also encouragingly hints at a secondary market for Verified Carbon Standard (VCS) REDD+ credits that would at least meet the minimum opportunity and management costs of current forestry based projects.

Price continues to be a factor in buyer preferences, although REDD+ project location and co-benefits, as well as the volume contracted, also play roles in motivating buyers. Forestry and land-use offsets were the most popular offset category in 2013 and comprised 49% of VCM value. Buyers have always sought out forest carbon offsets because of their "charisma" – projects that save endangered ecosystems are easy to convey to consumers – and until recently, forestry offsets were priced significantly higher than renewable energy and have therefore sold in smaller volumes. Bids also tend to be higher on projects with maximum generating capacity below 100,000 tonnes per year. This reflects buyers' interest in smaller projects, and unwillingness to be associated with large projects as they are often seen as more risky (in terms of monitoring impacts). Most of these buyers are end-users who more often than not purchase small volumes and consider small projects to have stronger environmental and social benefits than larger ones. Conversely, large-scale REDD+ projects are more attractive to project aggregators, which plan to resell purchased volumes in the future in a regulated market when, and if, REDD+ credits become compliance units.

Tanzanian Context

A promising foundation for REDD+

In Tanzania, the annual per capita value of subsistence use of forest products in rural areas has been estimated as USD 25–50, with forests providing 90% of energy supplies, 75% of building materials and 100% of traditional medicines.[12] There is a major need for forest-adjacent rural communities across the country to be able to sustainably manage and economically benefit from their natural forests. This is because nearly half of the country's forests occur on village lands, but currently only about 20% of the forests on village lands are legally managed by local communities.

A firmly rooted government programme of participatory forest management (PFM) established on the basis of a well formulated forest law (1998) allows communities to secure management control and user rights over their forests by establishing Village Land Forest Reserves (VLFRs). PFM comprises Community-Based Forest Management (CBFM), where communities can secure the right to manage and benefit from the forest(s) on village lands, and Joint Forest Management (JFM), where communities co-manage and benefit from state forest reserves (JFM has been long-stymied by the slow development of a benefit sharing formula); it has resulted in some 4.1 million hectares of natural forest in Tanzania coming under the direct legal management of some 1,400 villages (of about 12,000 villages, many of which are not forest adjacent) or under co-management between communities and the government, making

[12] United Republic of Tanzania. 2013b. *The national strategy for reducing emissions from deforestation and forest degradation.* Dar es Salaam: Vice President's Office, Department of Environment.

Tanzania one of Africa's leaders in community forest management. An estimated 16 million ha of forest and woodland that occurs on village lands has not yet come under formal community management, while the remaining 13 million ha of forest and woodland in Tanzania lie in central and local government forest reserves, set aside for either protection or production.

This PFM programme has resulted in improved forest conservation at the local level, but only marginal direct economic gains for the communities conserving their forests. Less than an estimated 5% of the area of these community forests, and not more than 2% of these communities, has developed locally significant[13] revenues from sustainably managing the natural forest inside their VLFRs. As a result, the local economic and development value of these forests has remained untapped, and with it any direct economic incentive for poor rural communities to continue conserving their existing VLFRs, or further expanding them. Furthermore, PFM involves formal, complex processes that generally require input from an external facilitator – either local government and/or NGOs. This has slowed the uptake of PFM and as a result large tracts of forest on village lands are essentially managed traditionally, if at all, and are often de facto open access.

While the country's PFM programme without doubt forms a strong foundation for Tanzania to sustainably manage its forests, the country still has a long way to go towards addressing the complex and challenging drivers of deforestation and degradation detailed in the *Table* 1 below. This is because PFM only covers about 11% of the forest estate, with state protected areas covering a further 45% (with varying levels of efficacy), leaving some 44% of forests in Tanzania largely under open access exploitation. As a result Tanzania has a substantial deforestation rate of 1.1% – one of the 10 highest rates of net national forest area loss in the world[14].

Ecosystem /forest type	**Extent/location**	**Main DD drivers and threats**	**Other considerations**
Miombo Woodlands	~220,000 sq km, about 2/3rds total forest, esp. west & south: Tabora, Morogoro, Iringa, Manyara, Tanga regions	Medium level pressure from agriculture (e.g. tobacco in Tabora area) and charcoal	Mostly outside forest reserves or other protected areas; valuable timber spp.
Coastal Forests (excluding mangroves)	~8,000 sq km in 50-200 km coastal belt - Dar es Salaam, Tanga, Lindi, Pwani & Mtwara Areas	High pressure from illegal logging, charcoal, biofuel plantations and agriculture.	High levels of biodiversity and endemism (except thicket forest); tends to be small isolated patches, especially hilltops, islands
Eastern Arc and other Montane Catchment Forests	Eastern Arc ≈ 3,500 sq km; mainly found in national forest reserves (NFRs) and Nature Reserves at top of mountain blocks in Iringa, Morogoro, Tanga & Kilimanjaro regions	High pressure from fire, encroachment, illegal logging for valuable timber spp, slash & burn farming	Very high levels of endemism and biodiversity; high tourism potential
Mangrove Forests	~1,150 sq km located in NFRs along coastal strip.	High pressure for poles, timber, boat building (especially near towns), shrimps & salt pans	High carbon levels and critical role for climate change adaptation

[13] An arbitrary of more than USD 5,000 per village would constitute locally significant revenue for most communities. In reality although most villages do not generate even this minimal amount from community forestry, many villages (100s) potentially could earn tens of thousands of dollars a year in revenue, and a smaller but still considerable number hundreds of thousands of dollars a year.

[14] Food and Agriculture Organization of the United Nations. 2010. *Global forest resources assessment 2010.* Rome: FAO.

Ecosystem /forest type	Extent/location	Main DD drivers and threats	Other considerations
Wetlands (non-marine)	~2,000 sq km, mainly found mainly in Morogoro, Iringa and Tabora regions	High pressure from irrigated rice, livestock Grazing	Important water catchment functions; high carbon levels
Acacia Savannah woodlands	~175,000 sq km in north & central Tanzania, mainly in protected areas (including game reserves)	Medium-low pressure from woodfuel, poles, subsistence farming, grazing	Game parks – tourism; livestock a key component of ecosystem
Guinea – Congolean lowland forests	~6,700 sq km in Kagera & Mwanza regions in NW Tanzania (Lake Victoria Basin); mainly National Forest Reserves	Medium-high pressures from agriculture, esp. livestock, charcoal, near urban areas	High biodiversity values; includes Podocarpus swamp forests

Table 1. Forest Ecosystems in Tanzania: Location, Threats and Characteristics.[15]

Tanzania's context of a well formulated forest policy and law, together with a strong legacy of participatory forestry but a continuing high rate of forest loss, has attracted substantial investment in developing REDD+ preparedness in the country. Tanzania has the most sub-national REDD+ initiatives of any country in Africa outside of the Congo Basin, mainly financed by Norway's International Climate and Forest Initiative (NICFI). The substantial level of investment (estimated at some USD 84 million) theoretically should have been well placed to demonstrate how CBFM and REDD+ could be integrated to enhance PFM by giving local communities another income stream from their forests.

REDD+ readiness

National REDD+ readiness efforts and the policy process started in 2008 with NICFI. The Department of Environment (DoE) under the Vice President's Office oversees all climate change issues. It formed a national climate change steering committee (to report on deforestation and degradation indicators) and established a climate change focal point in each ministry to oversee sectoral coordination. The Ministry of Natural Resources and Tourism (MNRT) leads MRV components and the National Carbon Monitoring Center (NCMC) will provide technical services on measuring, reporting and verification of REDD+ activities across the country. It serves as a depository of all data and information concerning REDD, including the National Carbon Accounting System for Tanzania, and is intended to coordinate national carbon activities. A national REDD+ task force drafted the national REDD+ framework, a national REDD+ strategy and subsequent REDD+ action plans to guide the implementation of REDD+.

Funds from the Governments of Norway (USD 58 million) and Finland (USD 5.9 million) for the first phase of REDD+ were focused on MRV capacity, national governance and institutional legal frameworks, benefit-sharing mechanisms, national standards for safeguards, strengthened stakeholder support, and implementation of demonstration projects. However, despite initial enthusiasm and fanfare, readiness efforts slowed by 2013 due to delays and political challenges in developing the national framework, the on-going stalemate in international climate agreements, and the drawn-out technical nature of the REDD+ process that was not anticipated at the beginning. Further, the goals of REDD+ are being overshadowed by other well-funded donor initiatives that aim to develop both small- and large-scale commercial agriculture and may encourage expansion of agriculture into forests[16].

[15] Richards, M. *et al.* 2009. *Getting Started on REDD in Tanzania: A Scoping Study for the Katoomba Ecosystem Services Incubator.* Forest Trends and the East and Southern Africa Katoomba Group.

[16] Hertel TW, Ramankutty N and Baldos UL. 2014. *Global market integration increases likelihood that a future African Green Revolution could increase crop land use and CO2 emissions.* Proceedings of the National Academy of Sciences 111(38): 13799–804.

REDD+ sub-national pilot initiatives

Concerns[17] over the implementation capacity and fiduciary risk of the Tanzanian Government led Norway to channel most REDD+ funds to academic and civil society organizations (CSOs). Coupled with pressure to produce rapid results, this left the government reluctant to develop the institutional arrangements necessary to see REDD+ beyond the pilot phase, in particular for finance and benefit-sharing mechanisms. This has created challenges for the nine sub-national initiatives funded by Norway through a REDD+ fund managed by the Royal Norwegian Embassy (RNE) in Dar es Salaam. While some of these pilots have had important successes, their implementation has uncovered substantial challenges including: (i) uncertainties about land tenure[18]; (ii) carbon rights and benefit-sharing rules; (iii) insufficient technical skills for MRV; and, (iv) the difficulty of effectively addressing the underlying deforestation drivers.

The current land, forest and carbon tenure arrangements simultaneously represent some of the most promising and most concerning issues for REDD+ in Tanzania. REDD+ aims to benefit the communities and individuals that bear the costs and do the work of reducing deforestation. In practice, communities with secure, recognized tenure over their land are likely to realize substantial benefits if that tenure extends to carbon. However, the Tanzania National REDD+ Strategy does not explicitly tie carbon ownership to land or forest tenure, "*leaving communities and other forest owners vulnerable to losing out on rightful benefits, or possibly even compromising their current legal right to use and manage recognized forest land*".[19]

At the same time, communities and individuals who rely upon forests to which access is variably restricted for REDD+ will bear costs, regardless of their tenure status. Given the technical and financial barriers to registering land and forests, such as the cost of land surveying, most villages remain unregistered. As a result, this creates substantial concern that REDD+ is unlikely to benefit and is instead likely to burden local forest communities that do not – or are not able to – obtain legal recognition of their land and forest tenure. Indeed, the issue of land tenure has often had to be addressed by the REDD+ pilots, both in terms of working to resolve land tenure and boundary disputes as well as facilitating the acquisition of village title, effectively absorbing the cost and responsibility of what ostensibly should have been the responsibility of local government.

Ensuring equitable and transparent distribution of benefits to communities whose livelihoods are intimately bound to forest resources is crucial. Within the context of REDD+, various distribution systems have been proposed by civil society and government agencies, including national, project and nested/hybrid approaches. In Tanzania, a national approach could entail linking international markets/exchanges to a national fund that could, in turn, either link directly to local communities or to district governments who would then disburse funds to villages; a framework for a National Carbon Trust Fund has been drafted but had not yet been implemented by 2014. Many CSOs advocate for a nested approach whereby a national payment and carbon monitoring system coexists with projects implemented by intermediary organizations that facilitate direct linkages between carbon markets and

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[17] This section is substantially adapted from Kweka, D.L., Quail, S. and Campese, S. 2014. *REDD+ in Tanzania: The national context.* In: Sills EO, Atmadja SS, de Sassi C, Duchelle AE, Kweka DL, Resosudarmo IAP and Sunderlin WD, eds. 2014. *REDD+ on the ground: A case book of subnational initiatives across the globe.* Bogor, Indonesia: CIFOR.

[18] Although national laws support community forest tenure, its implementation on the ground faces barriers including poorly done land-use plans and unregistered village lands.

[19] Tanzania Forest Conservation Group and MJUMITA. 2012. *Recommendations from civil society organizations for Tanzania's 2nd draft national REDD+ strategy and draft action plan.* Dar es Salaam: Tanzania Natural Resource Forum, 2.

forest communities. Past experience shows that government initiatives often fail to deliver on benefit sharing with local communities, e.g. under joint forest management, hunting blocks and tourism[20]. This has led to questions about the efficacy of a strictly national fund approach, although a strictly project-based approach suffers from a lack of economies of scale as well as possible higher implementation and transaction costs. Under a nested approach, those costs could be reduced if the national government assumed technical responsibilities for MRV, baselines and other activities. Subnational initiatives can give communities the autonomy to choose arrangements for distributing funds within villages that work best for them.

The Pilot REDD+ sub-national initiatives have sought to move beyond readiness to actually reduce forest carbon emissions. They are thus critical empirical reference points on the successes and failures of REDD+ at delivering both reduced emissions and co-benefits for local livelihoods and environmental services. Ultimately, implementation of REDD+ will depend on decisions made at the sub-national and local levels, as with all climate mitigation strategies.

The sub-national pilot initiatives funded by RNE have come to an end, and none have sold carbon in any market. The largest of these initiatives (led by the Community Forest Conservation Network of Tanzania [MJUMITA] and the Tanzania Forest Conservation Group), representing almost half of the forests in Tanzania's REDD+ intervention areas, has achieved emissions reductions of 30% and identified interested buyers. Some initiatives exhausted funds before accomplishing their objectives (e.g. in Kigoma and Shinyanga), while others are struggling with the long process of meeting the requirements for selling carbon (e.g. in Zanzibar) and/or are suffering a shortage of technical capacity to push the process forward.

The future of REDD+ in Tanzania

Compared to other countries funded by NICFI, Tanzania's progress has been slow. Nonetheless, a reference emissions baseline is expected to be completed by 2015, and the newly built National Carbon Monitoring Centre at Sokoine University of Agriculture will continue research on the emissions baseline and MRV system, which are key remaining uncertainties in Tanzania. This is necessary groundwork for any REDD+ finance and benefit-sharing system.

Mpingo Conservation & Development Initiative

The Mpingo Conservation & Development Initiative (MCDI) is a Tanzanian Registered NGO based in Kilwa District in the south-eastern part of the country. MCDI have been working to achieve forest conservation and community development in Kilwa through the facilitation of PFM in south-eastern Tanzania since 2004. MCDI are principally concerned with developing CBFM initiatives, under which communities can receive the lion's share of profits from forest product sales, without being burdened by additional negotiations with forest reserve authorities. In just 10 years, MCDI supported 16 forest-adjacent communities to set aside more than 180,000 hectares of forest as VLFRs.

MCDI has extensive experience implementing PFM through the operational model and brand it has developed whereby communities earn revenue from selling sustainably harvested timber. MCDI's mode of operation has been to engage villages in PFM and to get their forest management activities certified under the Forest Stewardship Council (FSC). MCDI was awarded the first certificate from FSC for community-managed indigenous forests in Africa in 2009, when MCDI also facilitated the first

[20] Milledge SA, Gelvas IK and Ahrends A. 2007. *Forestry, governance and national development: Lessons learned from a logging boom in southern Tanzania*. Dar es Salaam: TRAFFIC East and Southern Africa; Tanzania Development Partners Group; Ministry of Natural Resources and Tourism; URT. 2009b. *Ibid.*

commercial timber harvest from a community managed natural forest in all of Tanzania. In just five years, the Organization has helped five communities to earn more than USD $200,000 (340 million Tanzanian Shillings) from certified timber sales. This makes MCDI initiative one of the leading examples in Tanzania which has actually enabled communities to sustainably harvest and benefit from their VLFRs.

In 2009, MCDI received a grant from the Royal Norwegian Embassy (RNE) in Tanzania to develop a project to capitalise on the financial value of carbon offsets from community-based and FSC certified PFM, and to use this capital to cover the transaction costs of expanding this PFM model to additional villages. The project will provide additional revenue to rural communities from managing their forests, helping to alleviate poverty and ensuring that ongoing support costs can be covered. In preparation for this, and over the last 5 years (2010–2014), MCDI has been working in selected villages across the miombo woodlands of Kilwa District. These dry land forests are widespread in Africa and therefore an important focus for REDD+ pilot projects.

Project Overview

Rationale

MCDI's timber and forest certification programme offers considerable incentives for rural communities in Tanzania to protect their forest. However, for it to become truly sustainable, revenues need to be sufficient to cover the full costs of implementation and ongoing support whilst providing substantial profits for communities engaged in PFM. Another challenge is that in 2009, at the start of the project, the area of certified forest was relatively small; major timber buyers require the capacity to supply in large volumes before they will engage, so a greater area of forest was needed to attract such key customers. Thus the rationale for MCDI's REDD project was to provide complementary revenue flows from PFM to ensure the viability of PFM as a sustainable enterprise, and, where sufficient surpluses could be generated, additionally to support expansion of the area of forest under sustainable community management.

Over the period of project implementation, certain limitations to both the timber and REDD strategies, especially the decline in the international carbon price, pushed the project design inexorably towards focusing on the simpler first ambition (complementary revenue flows), with other funding becoming available to support the geographical expansion originally envisaged. See *Appendix I: History of Project Development* for more on this evolution in approach.

Concept

Theory of Change

An assessment of the drivers of deforestation and forest degradation in Kilwa district was carried out early on in the project (see section on Drivers of Deforestation in Kilwa below). This showed that fire was a major driver of forest degradation with an estimated 0.5tC/ha lost annually as a result of uncontrolled bush fires that afflict large swathes of the forests in Kilwa.

Analysis of satellite imagery shows that ~65% of the forest in Kilwa burns each year[21]. Around 75% of these fires take place in the mid-to-late part of the dry season (July – November). By this time of year the forest has dried out considerably creating a bigger fuel load for fires that pass through. Two of the peak months (July and August) are characterised by stronger east-to-west winds that fan the flames and spread fires faster. Hence these mid-to-late season fires are both hotter (and hence more damaging to the forest), and spread further, damaging large areas of forest.

Late season fires reduces the forest biomass stock in three principle ways:

1. Regeneration is repressed as the above-ground growth of most seedlings and saplings are killed by hot fires.
2. Full grown trees in Miombo are typically able to survive bush fires, but hotter fires increase tree mortality both in the moment (if trees are unlucky enough to catch fire) and in damaging bark, making the trees more vulnerable to diseases and later fires.

[21] The exact area fluctuates from one year to the next, and it is not always the same areas of forest affected from one year to the next.

3. East African Coastal Forest is often impervious to fires due to lack of grassy undergrowth, but repeated hot fires may nibble away at forest edges, gradually shrinking patches of EACF.

These effects are summarised in the theory of change behind the project, depicted in *Figure 3* below.

Other biodiversity components are also likely to be affected by regular hot fires, especially herbaceous plants and ground-dwelling animals. A hypothesised consequence of all these factors is that hot fires can be expected, eventually, to lead to habitat conversion as forest in some places is degraded into woodland, and pre-existing woodland in other places degrades to wooded savannah, until a new equilibrium is reached. It is not clear whether the forests in Kilwa are in equilibrium with their fire regime, although the long time period over which it has been prevalent (>50 years) suggests that if not yet at equilibrium, then the ecosystem may be close to it. In turn that implies that any successful strategy to reduce late season fires should eventually lead to these habitat changes to be reversed, with savannah returning to woodland, and woodland to forest.

Figure 3. MCDI REDD Project Theory of Change.

Fire Management

Nearly all forest fires in Kilwa are anthropogenic in origin. Fires are lit for a variety of reasons[22]. The three main reasons are:

- Visibility – so that people can see easily in the forest and thus avoid any difficult encounters with dangerous animals (elephants, buffalos and snakes) when walking through the forest.
- Shifting Agriculture – fires are often lit to clear the undergrowth from new fields.
- Hunting – fires may be lit to encourage a fresh flush of grass to attract game to an area, to increase visibility so hunters can see their targets, and to chase wildlife into an ambush area.

Other fires are lit to act as firebreaks, to chase away snakes and other animals spotted, by beekeepers to force bees to evacuate their hives whilst the beekeeper collects the honey, and as a result of superstition or for entertainment (to see whose fire can burn the farthest).

[22] See Hauf, H. 2012. *Mitigating forest fires in Kilwa District, Tanzania: an investigation of anthropogenic drivers.* University of Oxford, Oxford.

There are essentially two basic approaches available to reduce the impact of late dry season fires on the forest, either:

- Reduce the causes of fires, or
- Reduce the damage such fires can cause.

The former requires behaviour change on behalf of local people *before* practical benefits are exhibited. This is generally difficult to achieve; simply preaching good behaviour often has remarkably little effect if not support by strong social pressure to conform. If only a few people forget and behave how they are used to doing the capacity of fires to spread widely will eliminate most of the gains. Then those who made the effort to moderate and control better their use of fire may rapidly lose faith due to lack of returns. In short the returns on investment for partial success are small.

Three further factors count against trying to reduce the causes of fires: firstly, many fires are lit when people are on their own or in small groups when peer pressure is much lower (instigators are less likely to be identified and blamed), and social research shows that such fires are more likely to burn out of control[23]. Secondly, reducing fires itself requires people to practice restraint at all times, a much harder proposition. Finally reducing fires not only requires behaviour changes in the community that owns the forest, but also amongst neighbouring communities, requiring benefits to be spread amongst a greater number of people, decreasing the per person benefit which may therefore be insufficient to justify behavioural change.

In contrast a damage mitigation approach has a higher chance of delivering proportional benefits for partial success; smaller areas of forest can be protected for smaller cost, and if deemed to be profitable the efforts can be scaled up. Moreover it is a team activity, thus benefitting from positive peer pressure to contribute, that happens in a short, well-defined period of time, after which people can behave how they like with relatively little impact, and only the forest owners need to be co-opted into the scheme.

Hence the project focused almost exclusively on fire management through prescribed **Early Burning** (i.e. burning in the early part of the dry season before the forest has fully dried out and thus fuel loads are lower). The practice is also known as **Pre-emptive Burning**, because it seeks to pre-empt damaging late season fires with much less damaging early season fires which also fragment the landscape thus impeding the spread of later fires. Even should there be a fresh flush of grass that eventually burns, the fuel load will already have be much reduced making the later fire much cooler.

The aim is thus for early burning to reduce both fire intensity and fire frequency in the VLFRs. Note that the expectation is not to eliminate entirely late season fires; a few will always happen, and there will be diminishing returns from the increased effort required to pre-emptively burn the entire forest. Instead MCDI targeted a reduction in late season fire frequency from about 40% of the landscape affected each year to around 10% of the forest subject to damaging hot fires. Expert advice suggested this could be achieved by burning around 35-40% of the forest each year in the early dry season.

A significant advantage of focusing the project on fire management is that leakage should be negligible: fires are generally not lit elsewhere in compensation for those which would otherwise have burned through a protected VLFR. Most fires are lit in order to burn off grasses from a particular area, and are not intended to burn such large areas, but some spread uncontrollably from where they were originally lit. The only time such compensatory action could happen is if fires were being used for hunting (forbidden inside VLFRs); in such a case a fire lit elsewhere would most burn areas that in all likelihood

[23] Hauf, H. 2012. *Ibid.*

would be burned eventually anyway. Thus such displaced fire activity will in fact bring forward the average burn date in the year; earlier burn dates should – in general – result in cooler fires and thus less damage to the forest. Hence any leakage may actually be positive.

Anticipated Changes in Carbon Stocks

Even without active fire management, not all of the forests and woodlands are burned every year. Higher elevation forest burn occasionally, but greener vegetation combined with lower oxygen availability (due to thicker vegetation, especially in the understory) often serve to prevent entry of wild fires into such forest areas, and stark boundaries between woodland, which burns annually, and forest are not uncommon within the project area. MCDI estimate that such forest covers roughly 20% of the project area, leaving a remainder that is woodland and wooded savannah.

Following the logic set out in the Theory of Change above, with proper fire management MCDI expect to see a gradual transition in these habitat types to denser vegetation, such that in time some woodland will become forest and some savannahs thickly wooded enough to be termed woodland. Such ecotonal changes will be moderated by elephants, relatively abundant in Kilwa, who, from time to time, clear trees in localised areas, pushing forest back to woodland and woodland back to savannah. This is the natural rhythm of miombo mosaic habitats which are shaped principally by the confluence of fire and elephants.

Prior to the start of this project the Global Change Ecology research group at the University of Edinburgh had developed a model of fire impacts in miombo called **GapFire** based on fire experiments conducted in Zimbabwe and Mozambique[24]. It was this model that was the source of the above-mentioned initial estimate of 0.5tC/ha annual losses due to fire. The model was subsequently refined substantially to fit the requirements of this project see section on *Modelling Averted Carbon Emissions* below.

The GapFire model also predicted that forests subjected to annual burning over a period of multiple decades will be degraded and lose their woody biomass. Such outcomes had been observed in Zimbabwe, but not in Kilwa where fire management practices are not believed to have changed significantly over the last few decades. It is hypothesised that Kilwa's forests may be more productive than Zimbabwean miombo (perhaps driven by proximity to the coast and higher rainfall), and hence may degrade at slower rates. Since it is unknown whether or not the forests of Kilwa are yet in equilibrium with their fire regime, it cannot be said what proportion of the GHG emissions averted by the project will stem from a mix of improved forest management (stocks recovery) and what proportion from avoided degradation (further erosion of stocks).

Selling Carbon Offsets

The global community has spent years trying to iron out the details of a REDD+ mechanism under the UN Framework Convention on Climate Change (UNFCCC), but negotiations have yet to result in a fully operational mechanism in place (and some believe an agreement will not be reached until 2020). Therefore, the only REDD credits being sold and traded today are being done through the voluntary carbon market, which has a number of different voluntary offset standards to choose from.

MCDI pursued project validation from the Verified Carbon Standard (VCS) and the Climate, Community and Biodiversity Standard (CCBS). These two leading standards are commonly used in concert to verify combined carbon offsets and co-benefits (social and environmental). They are also the most robust standards, and therefore bring the greatest credibility to the project.

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[24] Ryan, C. M. & Williams, M. 2011. *How does fire intensity and frequency affect miombo woodland tree populations and biomass?* Ecological Applications, 21: 48 – 60.

Within the voluntary markets, the best known and toughest standards are maintained by VCS Association; VCS is the most widely used standard on the voluntary market today, as illustrated in Figure 4 below. VCS certifies the greenhouse gas reduction of a carbon project. Upon third-party verification, VCS issues Voluntary Carbon Units (VCUs), which represents emission reductions of one tonne of carbon dioxide equivalent (CO_2e). VCS has a carbon registry where carbon credits can be bought, sold and retired.

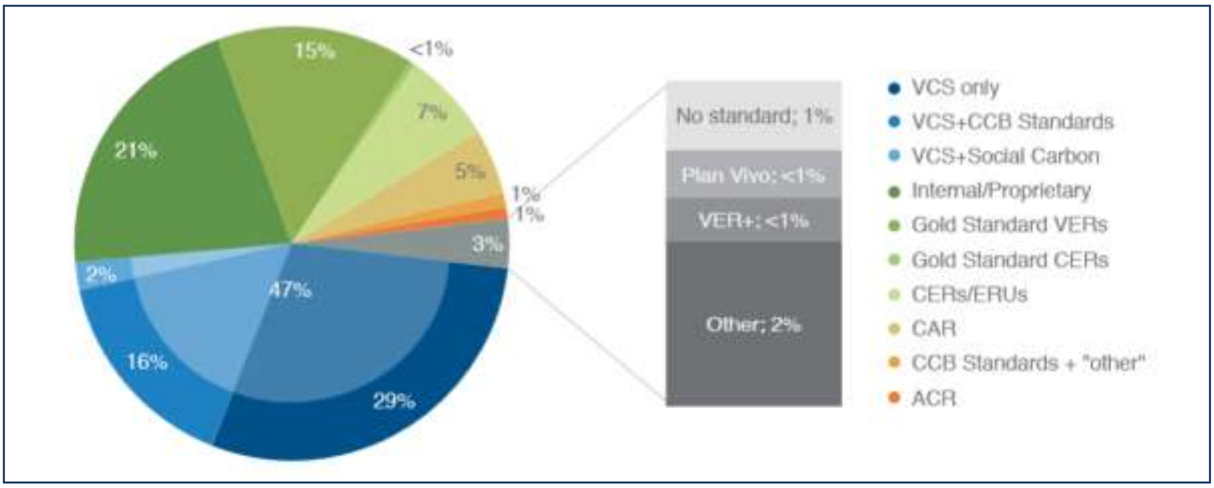

Figure 4. Market Share by Project Standard.[25]

MCDI prepared its REDD project to meet the highest of certification standards for both a potential regulated carbon market (adopted under the UNFCCC process) and for the existing voluntary carbon market. VCS model their requirements on the rules put forward by the UNFCCC, and they are closely aligned with the IPCC guidelines, meaning that projects and organisations that meet VCS criteria should be able to transition relatively easily to the compliance market, as and when it should emerge in Tanzania.

CCBS does not issue or register carbon credits, but instead validates a project's socio-economic and environmental co-benefits. As these co-benefits are central to MCDI's overall project goals, MCDI intends to seek project validation to prove the quality of the offsets produced. This should be relatively easy for MCDI because many of the CCBS requirements are similar to the criteria for FSC certification, which MCDI has already achieved. CCBS has a gold standard to recognise projects which deliver either:

1. Additional climate change adaptation benefits, or
2. Exceptional community benefits, or
3. Exceptional biodiversity benefits.

MCDI expects to qualify for the gold standard based on the second criterion.

Geographical Focus

The project was piloted in Kilwa District, Lindi Region, where MCDI is based, with a potential for it to be later expanded to other districts as resources become available. Kilwa is one of the poorest parts of Tanzania with one of the lowest rates of literacy and education achievement of any district in the country. South-eastern Tanzania is a priority area for economic development in the country; a successful REDD

[25] Peters-Stanley, M. and Yin, D. 2013. *ibid.*

project may yet contribute significantly to regional advancement in the Mtwara Development Corridor and related initiatives.

Kilwa District is also one of the most highly forested districts in the country, with forests and woodlands covering around 70% of the district, making it an obvious place to pilot REDD initiatives. The forests in south and central Kilwa, where MCDI's work focused, are a mix of miombo woodlands and patches of East African Coastal Forests (EACF), which together make up a complex mosaic including many ecotones and species overlaps. Miombo woodlands are the most widespread forest biome in Tanzania, comprising some 90% of the country's forests and woodlands, hence methods developed for measuring carbon and managing it under PFM could make a major contribution to the country's overall REDD readiness. EACF, in contrast, is a biodiversity hotspot of truly global significance harbouring large numbers of endemic species, and some of the largest remaining intact patches of coastal forests in Tanzania are to be found in Kilwa District. Effective PFM supported by a combination of timber sales, FSC certification and REDD will thus deliver outstanding co-benefits in terms of biodiversity conservation.

The project was piloted in five villages[26] in central Kilwa District, see Figure 5 below. The key characteristics of these five villages are given in Table 2 below.

[26] Work was also commenced in Nambondo village, but had to be abandoned due to a serious boundary dispute with a neighbouring village that threatened to turn violent.

Figure 5. Map of MCDI-supported villages in Kilwa District.

Village	Population	Village area (ha)	VLFR area (ha)	Date VLFR established	Date FSC certified
Likawage	5,994	119,784	19,196	Mar 2013	Nov 2013
Ngea	423	9,521	2,406	Jan 2013	Dec 2014
Mitole	3,842	23,544	1,515	Jan 2013	n/a
Mchakama	1,435	6,648	1,526	Feb 2013	Dec 2014
Mandawa	1,859	10,568	2,553	Mar 2013	Dec 2014
Total	**13,553**	**170,065**	**27,196**		

Table 2. Characteristics of REDD pilot villages.

Target Beneficiaries

The primary beneficiaries of this project were rural communities in south-eastern Tanzania. They are some of the poorest communities in the country; median household income is below $1 per day. Average household size is 4-5 so the majority of people in these villages are living substantially below the internationally accepted line of absolute poverty ($1 per day). Typical villages in Kilwa District are 1,000 to 1,500 people.

Project Design

Overall Goal

Institutions and selected local communities in South Eastern Tanzania are REDD ready by 1st January 2014.[27]

Project Purpose

Pilot the integration of new financial flows from carbon offsetting activities under REDD with PFM and forest certification, leveraging these revenues to support sustainable forest management and use in SE Tanzania, bringing a further seven rural communities (~10,000 people, ~25,000ha of forest) into MCDI's FSC group certificate by end of project.[28]

Outputs

1. Combined group certificate, validation and verification scheme covering timber and carbon-based products open to widest possible variety of community-managed forests in Tanzania.
2. Mechanisms to sell carbon offsets and credits for expansion of group certificate and/or forest recovery, and compatible with developing national REDD standards.
3. Efficient, scientifically robust and cost-effective methods for participatory assessment and monitoring of carbon stored in forests including soil carbon.
4. Drivers of deforestation controlled and reduced.
5. Best practice established for equitable management and sharing of economic benefits from forest conservation across the entire community.
6. Achievements disseminated with policy recommendations for national and international audiences.

Activities

The following lists all activities planned over the course of the project. A number of these were modified as part of the project re-design undertaken in 2011/12 (see *Appendix I: History of Project Development*). An overview of the actual outputs compared to planned outputs is presented in *Appendix II: Logical Framework.* The final version of the planned activities is given below.

1. Combined group certificate scheme covering timber and carbon for community-managed forests in Tanzania

1.1. Preliminary policy analysis and detailed scheme outline.

1.2. Revise and sign new carbon agreements with communities.

1.3. Develop REDD Project Design Document.

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[27] The project was originally intended to last four years, before being granted a one year extension.

[28] This is a slight amendment to the purpose as set out in the original project proposal (2009) and subsequent revision proposal (2012). See *Appendix I: History of Project Development* for more information on this.

1.4. Achieve carbon validation to industry-leading standards (VCS and CCBS).

1.5. Confidence-building preliminary steps to PFM including land-use planning.

1.6. Complete PFM expansion to all pilot villages including FSC certification.

1.7. Monitor participatorily avifauna biodiversity and threats to biodiversity in community forests.

1.8. Design new VCS methodology and support it through the double-approval process.

2. Mechanisms to sell carbon offsets for expansion of group certificate and/or forest recovery

2.1. Participate in development of national standards and systems for sales, monitoring, assessment, reporting and verification of carbon credits.

2.2 Establish all necessary systems to comply with national REDD standards as they evolve.

2.3. Develop market linkages through Carbon Tanzania and international carbon exchanges.

3. Methods for participatory assessment and monitoring of carbon stored in forests

3.1. Assess stem and root biomass carbon in miombo woodlands in SE Tanzania.

3.2. Assess soil carbon in miombo woodlands in SE Tanzania.

3.3. Develop participatory method for assessing biomass.

3.4. Monitoring effects of fire on forest biomass and carbon balance.

3.5. Spatial analysis of regional biomass by fusing remote-sensing data with ground surveys.

3.6. Develop simple and efficient protocol to allow for remote verification of participatory carbon monitoring.

4. Drivers of deforestation controlled and reduced

4.1. Analysis of local drivers of deforestation.

4.2. Design programme for community-based fire management in community forests.

4.3. Implement community-based fire management in community forests.

5. Best practice established for equitable management and sharing of economic benefits

5.1. Identify and test best methods for participatory poverty assessment.

5.2. Pilot protocol for best financial management at village level with mechanisms to deliver democratic benefit sharing, with benefits felt across the community.

5.3. Develop methods for and establish baseline for participatory assessment of village governance.

5.4. Monitor changes in village governance.

5.5. Monitor households' socio-economic status over length of project.

5.6. Monitor communities' perceptions of project progress and impact on their lives.

6. Achievements disseminated with policy recommendations for national and international audiences

6.1. Publish annual policy analyses throughout life of project.

6.2. Document achievements and methods developed, and disseminate to national and international audiences.

6.3. Knowledge on carbon assessment transferred to Tanzanian partners.

6.4. Final report compiling all policy recommendations together with methods, experiences and lessons learned from pilot project.

Implementing Partners

MCDI (www.mpingoconservation.org) led the consortium, coordinating all activities within Tanzania, managing logistics for all the fieldwork, and was the primary point of contact for communities and local government in Kilwa District. MCDI had primary responsibility for implementing the PFM, certification, participatory assessment and benefit sharing components.

The Global Change Ecology research group at the University of Edinburgh (www.met.ed.ac.uk) led on all technical issues related to carbon measurement, both above- and below-ground components, and development of the remote sensing methods and up-scaling methodologies. UoE already had significant existing experience from their work on the N'Hambita project in miombo woodlands in Mozambique (see www.miombo.org.uk). UoE subsequently brought in colleagues from University College London Department of Geography (www.geog.ucl.ac.uk) to help with the analysis of remote sensing, and in particular on the burn scar maps which underpinned the analysis of historical fire prevalence in Kilwa over the last ten years.

UEA's School of International Development (www.uea.ac.uk/dev) is a world renowned centre on rural development and poverty alleviation, with specific expertise on the socio-cultural elements of community-based natural resources management. They led on design of socio-economic monitoring systems to track and report actual benefits realised within participating communities.

Carbon Tanzania (www.carbontanzania.com) is the first Tanzanian not-for-profit company dedicated to REDD. They led marketing the carbon credits in the voluntary market, developing market linkages to international exchanges, and also provided technical support on biodiversity monitoring.

Value for Nature (www.valuefornature.com) is a specialist consultancy company with in-depth experience of carbon forestry projects in the framework of the Kyoto Protocol's Clean Development Mechanism (CDM) and voluntary markets carbon standards. They led on designing the new VCS methodology.

321 Fire (www.321fire.co.mz), another consultancy, provided specialist advice and training on the use of controlled burning to manage fire risks over large areas of forest.

In addition there were two advisory partners: Maliasili Initiatives (www.maliasili.org) and Fauna & Flora International (www.fauna-flora.org) They provided general advice and support where needed with an international perspective, and Maliasili Initiatives led on policy analysis elements of the project.

Combined Group Certificate

This output area was expected to comprise of eight activities. These are listed under *Activities* on 26 of the *Project Overview*, and explained in detail here. In the event, activities 1.3 (Develop REDD Project Design Document) and 1.4 (Achieve carbon validation to industry-leading standards) were not completed due to 1.8 (Design new VCS methodology and support it through the double-approval process) over-running. See *Appendix I: History of Project Development* for details on the initial scheme outline (activity 1.1) that was produced in the first year of the project.

VCS Methodology

MCDI sought methodological and operational validation from the VCS, the most widely used standard on the voluntary carbon market. The VCS system is made up of three inter-locking elements as illustrated below. These are:

- Methodologies which specify how GHG emissions averted through specific actions can be quantified.
- Rules governing the independent assessment and auditing of methodologies and implementing projects.
- A carbon registry that tracks each and every Verified Carbon Unit (VCU) from generation, through each different buyer and seller, to retirement, when the final buyer offsets it against GHG emissions they have caused, thereby reducing their net GHG emissions.

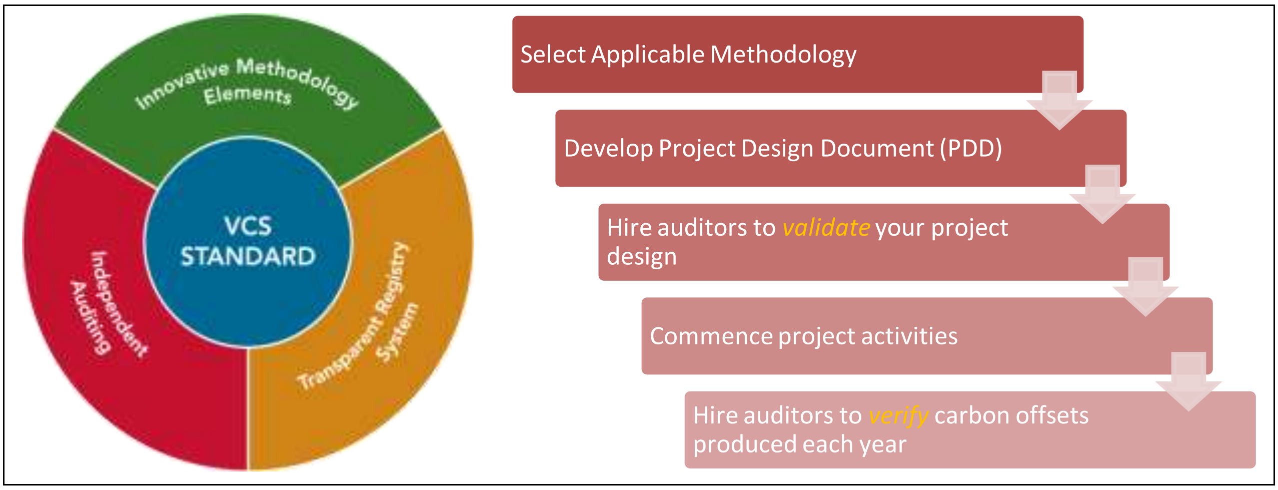

Figure 6. The VCS model and standard project work-flow.

Methodology Development

As shown in the above standard work flow, to be certified by VCS, projects must follow approved methodologies to prove that GHG emission reductions or removals are real, measurable, additional, permanent, independently verified, conservatively estimated, uniquely numbered and transparently listed. The VCS accepts any methodology that has been approved under the United Nation's Clean Development Mechanism. It also has a host of already approved VCS methodologies that project developers can use to quantify their project's emissions reductions. However, for some projects there is no appropriate methodology that currently exists, and VCS allows project developers to develop their own methodology, which then needs to be assessed and validated by VCS through their double approval process. This was the case for this project, as there is no existing methodology covering carbon fluxes in dryland forests as a result of fire management, meaning that MCDI and its partners had to develop an innovative methodology and management practices to proceed with the approach.

Since once a new methodology has been approved it is available for general use by all projects that fit the criteria, VCS is extremely demanding with regards to new methodologies. Key requirements[29] are that:

- Methodologies must be demonstrably conservative at each step.
- Every variable that is used in the calculation must be exactly specified in respect to how it is measured or derived.
- Every element must have minimum accuracy criteria.
- No loopholes should be left through which careless or unscrupulous project developers could claim to GHG savings not actually achieved.

Writing a methodology is much harder than designing a project. Each element of what you intend to do needs to be translated into the abstract: what is it that you are trying to do, and what minimum standards should be expected of that element? E.g. it is not sufficient to say that *'we surveyed X number of forest plots'*, but instead you must answer the questions: what is the minimum number of plots that are required? What size should each plot be? What degree of variance in the allometric data collected should be allowed for it to be accepted as a reasonable reflection of the forest? Then, having determined each of these thresholds, methodology developers must justify them as either clearly conservative and/or adhering to best practice.

There is, however, one advantage of developing one's own methodology: you can ensure that it is applicable to your project. This is not insignificant because some project proponents have encountered real difficulties with apparently appropriate methodologies which turn out to have some small criterion that, although not self-obvious at the start, is insurmountable to the project concerned – e.g., requiring a baseline reference region that is 5 times the size of the project area, when a project can only identify similar sites that amount to 4.5 times the size of the project area. VCS is now loosening up a little on such requirements, but that does not entirely eliminate the advantage from writing one's own methodology.

MCDI tried to design its VCS methodology so that it can be used as widely as possible by anyone wishing to fund fire management in dryland forest ecosystems via the carbon market, but limited project resources and lack of appropriate data on other regions meant that the methodology's applicability had to be restricted to the Eastern Miombo Ecoregion. Those wishing to use the methodology in other dryland forest ecosystems (or just other parts of the Miombo region) will need to amend the methodology and recalibrate the GapFire model for their location. Several other compromises to general usability had to be implemented in order to finish within the budget and deadline for completion.

Methodology Design

A brief summary of the main points of the methodology follows.

The VCS methodology developed is applicable only in the situations listed below:

- Forests (>5tC/ha) in Eastern Miombo Ecoregion only
- No changes in land-use over past 10 years

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[29] A full list of VCS requirements for new methodologies is provided in: *VCS Standard Requirements Document, 2013.* Version 3.4. Available from www.v-c-s.org.

- Fire is the predominant driver of forest degradation over past 10 years
- Must implement early burning, but no other carbon enhancement activities
- No prohibition of baseline fire-driving activities, except where required by law
- May allow selective logging, but charcoal production must be minimal
- Cannot have lost more than 10% of basal area over last 10 years

These and other secondary criteria are set out in the full methodology document.

The methodology covers three sorts of GHG emission sources:

- CO_2 from forest fires that would otherwise be sequestered as biomass
- CH_4 & NO_2 emitted from burning biomass
- CO_2 lost during selective logging

CH_4 & NO_2 are also greenhouse gases. They are not the primary focus of the methodology, but there are standardised equations available to estimate, conservatively, the quantities emitted when woody biomass is burned due to incomplete combustion. Including these gases could add around 10% to the total VERs that are accounted for, and thus can be sold, improving financial returns for project implementers.

The carbon pools considered under the methodology are as follows:

Carbon Pool	Notes
Included:	
Above-ground tree biomass	Major carbon pool affected by project activities
Wood products	Wood removed during selective logging
Excluded:	
Above-ground non-tree biomass & Leaf litter	Grasses and bushes will always eventually burn, so there is no long lasting carbon storage
Below-ground biomass	Only marginal impacts from burning (many root systems will survive after the above-ground plant is killed, although eventually they will die, and carbon gradually returned to the soil), and not practical to measure.
Dead wood	Will decay more slowly under early burning so it is conservative to exclude it
Soil carbon	Not enough known about it to quantify, although impact is expected to be positive

Table 3. Carbon pools considered under the VCS methodology.

The methodology uses the GapFire model and other technical results derived from MCDI work under the 3rd output of this project; these are detailed under the section *Methods for Assessing Forest Carbon* below. In particular, the methodology requires development of a carbon density map that satisfies the following criteria:

- Must be <10 years old (and <5 years old at start)
- Spatial resolution not coarser than 200 x 200 m pixel size
- The 95 percent confidence interval of the map mean biomass must be no wider than 30 percent of the mean estimate
- Must be stratified into 5tC/ha classes

Also required is a detailed fire history which must be determined by following these steps:

- Determine key parameter dates (start and end of dry season, cut-off date for early burning)
- Collate all available satellite data from chosen source (e.g. LandSat)
- Apply burn scar detection algorithm, classification accuracy must be > 95%
- Only recognise as burn scars when at least 60% sure
- Attribute burn scars probabilistically to early / late dry season periods
- Check there is enough data (discard pixels with insufficient observations)
- Need at least 50% ‘countable’ pixels in each biomass stratum
- For each stratum compute burn probabilities:

$$BLPROB_{Earlyburn,i} = \sum CountEarlyburn_{i,y} / \sum CountPix_{i,y}$$

- Show project area and baseline reference region have similar fire histories (Chi-squared test at 90% confidence level)

The impact of the early burning is assessed using ground-based monitoring (again, see the section *Methods for Assessing Forest Carbon* below for more detail), and fire frequencies provided as input parameters to the GapFire model. Verified Emissions Reductions are then calculated using the following equation:

Net Emissions Reduction =

(Expected Carbon Losses in Baseline Scenario (*GapFire model*)

+ Expected CH_4 and NO_2 losses from biomass burning in baseline scenario

− Carbon Losses in Project Scenario (*GapFire model*)

− CH_4 and NO_2 losses from biomass burning in project scenario

− Carbon Losses from selective logging)

× (1 – Leakage %)

× (1 – Risk Buffer %)

The Risk Buffer is a standard requirement of VCS projects, and its calculation is separately defined through a process common to all REDD+ methodologies.

Managing Leakage

Leakage is a critical issue in most REDD+ projects. It cannot be ignored in any VCS methodology, but where the leakage is *de minimis* (i.e. less than 5%) it can be assumed to be zero. In general it is to be expected that projects applying MCDI’s VCS methodology do not cause activity-shifting leakage (when activities that damage the forest are simply displaced elsewhere with no overall reduction in greenhouse gas emissions) from early burning. This is partly based on the applicability condition that projects may not prohibit or actively discourage baseline fire-driving activities, unless required to do so by law, in which case displacement of such activities is not attributable to the project but to the law, and partly on the fact that most fires are lit to burn a specific targeted area, not for the fire itself.

Project implementers may, however, seek to reduce the fire incidence related to fire-driving activities by engaging with fire agents and raising awareness regarding the benefits of reducing fire pressure on the miombo woodlands. Thus, hunting, for example, may not be prohibited, but the project could work with hunters to reduce the use of fire during this activity; in practice MCDI is not following this approach[30]. That all said, project implementers must support this general argument by construction of a matrix to

[30] The full argument for why mitigating damages caused by fires is expected to be more effective than reducing the causes of fires is given in the *Project Overview* above (*Concept* section).

compute leakage of fire driving activities. The case for MCDI is set out below.

Month	May	June	July	Aug	Sept	Oct	Nov	Overall
Baseline Burn Rate	**0.6%**	**5.2%**	**9.4%**	**22.6%**	**13.2%**	**6.5%**	**7.6%**	**65.0%**
Monthly Burn Prop[n]	0.9%	8.0%	14.4%	34.8%	20.4%	9.9%	11.6%	**100.0%**
Fire Causes in VLFRs	*weighted by area affected*							
Visibility	95%	85%	60%	55%	40%	20%	15%	**47%**
Agriculture			5%	10%	20%	35%	30%	**15%**
Sub Hunting		10%	10%	10%	10%	15%	20%	**12%**
Comm Hunting			20%	20%	20%	20%	25%	**19%**
Other	5%	5%	5%	5%	10%	10%	10%	**7%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Max Displaceability	*weighted by area affected*							
Visibility	0%	0%	0%	0%	0%	0%	0%	**0%**
Agriculture			0%	0%	0%	0%	0%	**0%**
Sub Hunting		33%	33%	33%	33%	33%	33%	**33%**
Comm Hunting			0%	0%	0%	0%	0%	**0%**
Other	25%	25%	25%	25%	25%	25%	25%	**25%**
Total								**5.6%**
Fires Displaced	*weighted by area affected*							
Visibility	0%	0%	0%	0%	0%	0%	0%	**0%**
Agriculture			0%	0%	0%	0%	0%	**0%**
Sub Hunting		3%	3%	3%	3%	5%	7%	**4%**
Comm Hunting			0%	0%	0%	0%	0%	**0%**
Other	1%	1%	1%	1%	3%	3%	3%	**2%**
Total	**1.3%**	**4.6%**	**4.6%**	**4.6%**	**5.8%**	**7.5%**	**9.1%**	**5.3%**
Burned Area Displaced	*proportion of forest area whose burning will be displaced*							
Visibility	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Agriculture			0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Sub Hunting		0.2%	0.3%	0.7%	0.4%	0.3%	0.5%	**2.5%**
Comm Hunting			0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Other	0.0%	0.1%	0.1%	0.3%	0.3%	0.2%	0.2%	**1.2%**
Total	**0.0%**	**0.2%**	**0.4%**	**1.0%**	**0.8%**	**0.5%**	**0.7%**	**3.6%**
Additional Burning	*proportion after allowing for some displacement merely bringing forward date of burn*							
Visibility	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Agriculture			0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Sub Hunting		0.1%	0.2%	0.5%	0.4%	0.3%	0.5%	**1.9%**
Comm Hunting			0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Other	0.0%	0.0%	0.1%	0.2%	0.3%	0.1%	0.2%	**0.9%**
Total	**0.0%**	**0.1%**	**0.2%**	**0.7%**	**0.7%**	**0.4%**	**0.7%**	**2.9%**

Table 4. Matrix to compute leakage of project fire driving activities.

Market leakage is not applicable to projects applying the methodology and selective harvesting of trees is allowed in both baseline and project scenarios.

Methodology Approval

MCDI's methodology was submitted on 27 February 2014. It then had to pass through a thorough and exacting review process, see steps listed below, before it could be adjudged robust and fit for use within the VCS scheme. Two of these reviews are by independent accredited Validation and Verification Bodies (VVBs) approved by VCS for this purpose.

VCS Methodology Review Process

1. Presented publically (webinar held on 08 March 2014) and opened for public comment
2. First External Review by VVB (SCS in MCDI case)
3. Internal Review by VCS
4. Second External Review by VVB (DNV in MCDI case)
5. Reconciliation of changes made since first external review.

The first review is normally the hardest hurdle since it is the first time that the methodology is subjected to serious, in-depth scrutiny. SCS's experts listed a total of 42 findings for MCDI's method which had to be fixed over two iterations before they were satisfied. The significance of these findings varied enormously, with some relating to minor formatting errors, and others that presented serious technical (and even philosophical) challenges. The full list of findings and their resolutions is available in the report from SCS.

The internal review by VCS does not assess technical issues; it is designed to ensure methodologies comply exactly with VCS framing requirements, e.g. so that the right text appears in the right places, terms are properly defined, etc; it is not expected to take long. In fact this was a new step introduced by VCS with a view to reducing the time taken and issued to be solved in the second external review. However, internal resource constraints within VCS instead delivered the opposite outcome: SCS completed their review in August 2014, six months after the methodology was submitted, but it was not until mid December 2014 that VCS completed this internal review. This meant that DNV had very little time to complete their second assessment before the end of the project. Thankfully, the original SCS assessment was sufficiently robust that DNV only found 8 further issues to be resolved, all of which were very minor, and appropriate amendments could quickly written into the text. This was done and DNV issued their formal report passing the methodology in late January 2015.

The final few steps – to reconcile changes made since the first approval with SCS and for VCS to apply final refinements – were underway at the time this report was being completed. The final methodology should thus be ready and available for download from the VCS website imminently. This new method will have the potential to open up a whole new frontier in REDD+ opportunities given that miombo woodlands stretch across some 2.8 million km^2 of southern Africa, one of the largest expanses of fire-affected dryland forests in the world.

Land Use Planning & PFM Expansion

Like REDD, PFM involves a series of technical processes that generally require assistance from an external facilitator, usually a government agency or an NGO. The steps to PFM are summarised in the diagram below. MCDI thus provided technical and financial support to the Village Council and VNRC in each of the five project villages to establish VLFRs under the PFM framework.

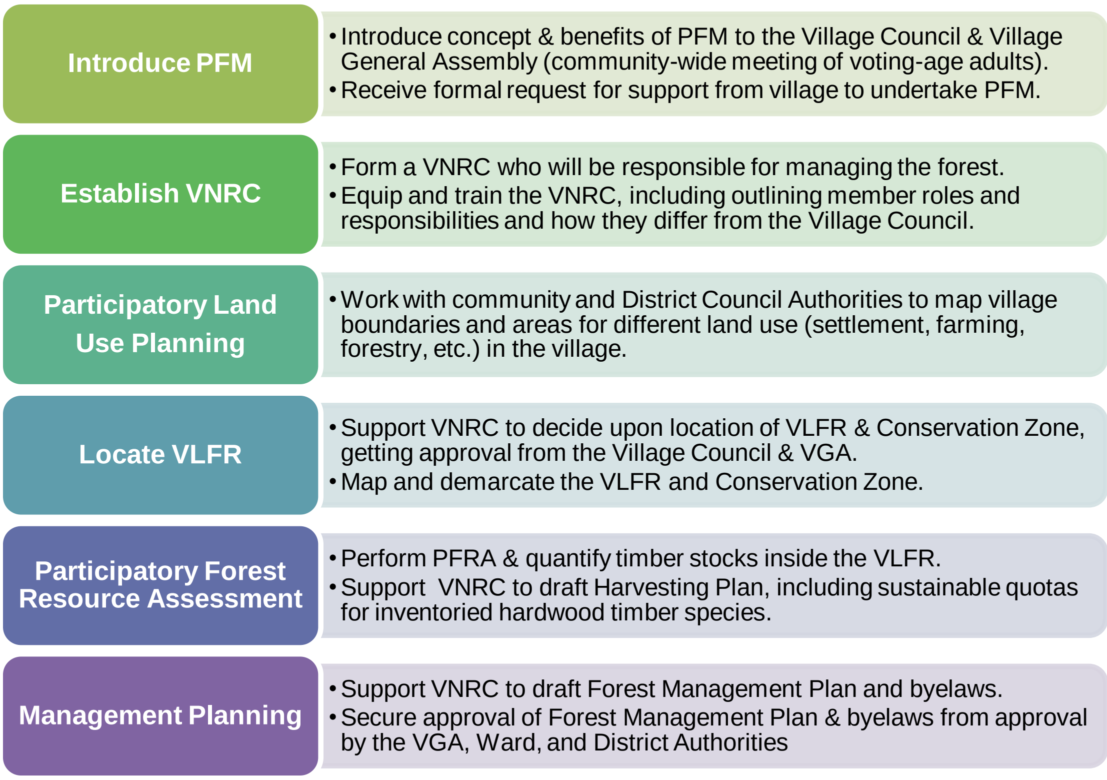


Figure 7. Stages of Participatory Forest Management

Under the PFM framework, following a recommended (but not compulsory) participatory land-use planning exercise, communities are invited to choose an area of forest for which they have no other significant plans and set it aside as a VLFR. Central and southern Kilwa District is still sparsely populated and highly forested, which makes this proposition easier than other locations in Tanzania in which villages are challenged to make the hard choices between forest conservation (funded by REDD) and agricultural extensification. The short-term opportunity costs for villages entering MCDI's scheme are very low. Hence MCDI's approach carries relatively low risk for its partner communities, as they are not being asked to surrender short-term agricultural production options or activities.

Through participatory land-use planning, communities formally designate specific areas of village lands for different activities (e.g. livestock grazing, farming, settlement, forestry, etc.). This reduces conflict over land within villages. Initially, MCDI assumed that it would not need to engage in participatory land-use planning prior to starting PFM work; proper land-use planning is not a legal prerequisite of PFM implementation, merely recommended. This is not because MCDI is opposed to such land-use planning – it is a logical first step that embeds forestry in the wider set of issues faced by communities – but because the officially recommended framework is rather heavy-weight and expensive, requiring large multi-disciplinary teams and GPS points to be collected, which drives up the cost of the PFM process. In addition, once the plan has been produced it is not amenable to easy editing by communities.

Previously this omission from MCDI's standard operating procedures had not excited any attention, but the higher profile accorded to REDD pilot projects nationally meant that MCDI faced significant pressure to conform to a key national strategy for effective land management. Upon being informed of this Kilwa District Council (KDC) asked MCDI to begin the PFM process in future with participatory land use planning. MCDI therefore explored light-weight solutions to land-use planning that meet all the requirements of the law, and worked with KDC to design a mutually acceptable, cost-effective solution.

Beyond the financial implications (MCDI was able to re-budget work to support this), land use planning introduced a new step for which MCDI is only partly responsible, since the process should be led by District officials, and it is the District Land Office who produce the land use maps. Inconsistent boundaries as displayed on government maps were also a source of confusion, and various inter-village boundary disputes posed challenges, but appropriate diplomatic representations ensured progress was made, with both the Regional and District Commissioners playing constructive roles.

Finalisation of the VLFRs was also held up by lack of time at KDC Full Council Meetings to consider and approve the byelaws that give legal underpinning to the forest management plans. MCDI worked around this, and the byelaws were approved in the second half of 2014. After this, MCDI swiftly admitted three of the villages concerned to its FSC group certificate. One village – Mitole – has yet to be accepted due to a soon-to-be-resolved issue in respect to the VLFR boundaries, and funding permitting should be certified in 2015.

Carbon Contracts

MCDI initially saw developing contractual agreements as a sensible way to start engaging with local communities. This is because MCDI initial understanding was that, once the communities committed to protecting the forests, they could start claiming carbon offsets. To demonstrate its commitment, MCDI developed a contract with the communities outlining what project activities they would do. This turned out to be a difficult challenge that MCDI approached the wrong way.

MCDI began designing its initial flawed project design (based on mitigating charcoal production) in 2010. As an NGO, MCDI goal was not to maximise profits, so drafted contracts that put all the risk and upfront investment on MCDI, and stated that communities could leave with only 90 days' notice. The contracts made it clear that:

- The land and forests still belonged to the communities;
- MCDI would sell carbon offsets on their behalf and pass the profits back to communities; and,
- MCDI would assist communities to manage their forests and to become FSC-certified.

MCDI started trying to sign the contracts with communities in late 2010, with legal representation provided for villages through Lawyers Environmental Action Team (LEAT). However, at this stage MCDI did not know how much revenue could be gained from carbon offset sales, so the benefits were unclear. The communities also had addition concerns: recently large land deals in the area with a biofuel company had not worked in their favour, and although MCDI's contracts explicitly confirmed that communities retained land ownership, they contained maps and therefore looked like a land deal. The 30-year time frame, which is the standard way to meet the permanence requirement in REDD+, was also problematic for many communities, representing a higher level of commitment than the minimum five-year period of FSC group certificate membership.

Explaining the technicalities of the contracts was also made difficult because REDD+ is a hard and complex concept to grasp, especially for communities who struggle to even understand the basic concepts of carbon release and storage. Future financial returns are also uncertain; you can approach communities and explain how they can make money from selling sustainably logged timber, because they know timber has value, but trying to explain what carbon dioxide is or how they can make money by not doing something (i.e. not cutting down the forest for charcoal) is much harder. These uncertainties and complexities create confusion and misunderstanding, and local politicians can seize on this in a bid to promote themselves.

MCDI's business-like approach also attracted significant opposition from some government leaders. The organisation believes that tropical forest conservation needs to move on from a simplistic aid dependency relationship, to a more equal partnership based on trade, so it viewed asking communities to sign contracts as a sensible approach. However, some government officials maintained a more traditional view: NGOs give, communities receive, and therefore MCDI's approach made them uncomfortable; they wanted to know why the NGO was designing contracts to make money out of their forests. With the benefits as yet un-quantified, MCDI found its contracts stirring up significant opposition, and they were soon dropped in favour of basic agreements of project cooperation. Once the new project design focusing on fire management rather than charcoal production was developed, however, it was relatively easy to go back to the communities and say: *"What do you think about fire management as a project? Is it feasible? What recommendations for activities would you have?"*. MCDI were able to have useful, meaningful discussions with communities on how to implement such a project.

The agreements of project cooperation, or *'project joining forms'*, with communities do not entitle MCDI to sell carbon offsets on their behalf. Therefore, some kind of formal contract will still be required when such sales are started. By the end of this project, MCDI have a better idea of exactly what benefits there will be to communities in terms of likely revenue, and the first sales should follow swiftly after, helping to build community confidence in REDD+ and its ability to generate revenues from the forests. As ever, the ability to effect change depends on having a strong trust relationship with the communities being supported, which is in turn extremely vulnerable to perceptions of unfairness, thus emphasising the importance of getting these contracts right. Exactly what then happens to the money earned by communities is another matter. Good village leadership and equitable benefit sharing are critical, and MCDI have already worked on getting these right with communities receiving money from timber sales (see section *Improving Village Governance*).

Biodiversity Monitoring

Monitoring biodiversity in areas designated for sustainable management is a requirement of most third party certification standards, including FSC and CCB. These standards require projects to have an understanding of both short and long-term impacts of project activities on biodiversity, implemented by establishing the baseline conditions and conducting monitoring, both professional and community based.

Since 2009, MCDI has conducted a number of detailed studies aimed at better understanding the ecological baseline of fauna within the project area. These have focused primarily on the potential impacts of timber harvesting on avifauna[31], and when combined with data from the Tanzanian Bird Atlas[32] together with ad-hoc visits by ornithologists, have allowed MCDI to build a comprehensive inventory of the resident and migratory birds in VLFRs. These specific studies on avifauna formed the basis for MCDI's community-based biodiversity monitoring method, which focuses on the encounter frequency of three selected indicator bird species: Crested Guineafowl *(Guttera pucherani)*, African Broadbill *(Smithornis capensis)*, and the Dark-backed Weaver *(Ploceus bicolor)*, as well as opportunistic recording of large mammals. Community patrol teams perform avifauna monitoring on a monthly basis in the no-take Conservation Zone, an area of at least 10% of the VLFR that they are required to set aside under MCDI's FSC group certificate scheme.

MCDI's existing monitoring strategies have been designed to assess the impact of logging on forest biodiversity over time. However, changes in the timing and hence intensity of forest fires will be brought about by community-based fire management under this project, which is likely to alter parts of the understory, enhance canopy cover, and increase the abundance of invertebrates. In turn, these changes

[31] Maclean *et al*. 2008. *Impacts of harvesting on Tanzania Forest Avifauna.* Report for MCDI.

[32] *Tanzania Bird Atlas*, Iringa, Tanzania.

are expected to have a direct impact on some of the bird and small mammal species currently not monitored under existing community methodologies, but also known to occur within the area. Hence, the donor, RNE, and MCDI were keen to explore how such changes might be tracked.

Carbon Tanzania (also known as Ecological Initiatives) have considerable experience in such issues and helped MCDI to develop a new biodiversity monitoring strategy that is designed, so far as it is possible, to track biodiversity responses to early burning. This strategy combines a roll-out of MCDI’s existing community-based biodiversity monitoring, with a dedicated expert-led monitoring effort looking at relative species abundance in birds. As well as looking at broad scale shifts in the commonest birds, the new method looks for changes in ground-nesting birds which, MCDI hypothesise, will be the most likely to be impacted by changes to the fire regime amongst those taxonomic groups which are relatively easy to monitor.

At the heart of this additional effort are timed species count data that look at species frequency which can be used to analyze more specific differences between the sites, and thereby detect changes that may occur at a species level due to the fire management regime. Repeat monitoring will determine whether these change significantly, with deductions on broader ecological changes in the forest deduced from the known characteristics of these birds. The absence of any of these species or significant changes in abundance within the surveyed area would require more detailed investigation, although it should be noted that species variation can be attributed to other factors such as weather conditions.[33]

The baseline data for this was collected in 2013, working in two VLFRs: Likawage and Ngea, in which early burning would later be performed under this project, as well as two control sites: Rungo and Mitaurure Forest Reserves (see Figure 8).

[33] See the separate project report *Ecological baseline for monitoring changes to biodiversity following early burning* for full details.

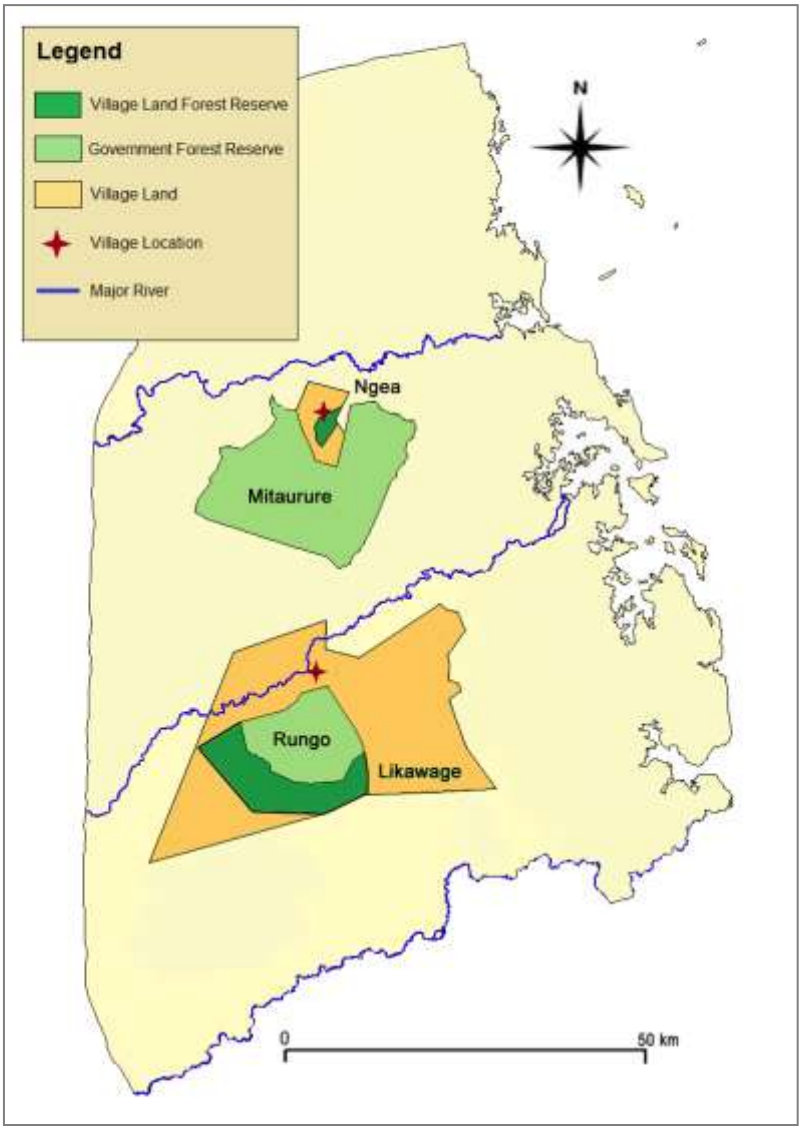


Figure 8. Sites used during biodiversity monitoring baseline data collection.

Seventeen mammal species were recorded in total, several of which had not previously confirmed as living in the VLFRs, including the Blotched Genet, Miombo Genet, Honey Badger, Southern African Porcupine, Civet and Four-toed Elephant Shrew. Between 36 and 58 bird species were identified at each site, with diversity ranging from 5.7 species per kilometre to 8.7 per km. The top five common bird species in each reserve are listed below; these will be the focus of repeat monitoring. Species' habitat affinities clearly emerge, e.g. the Common Drongo was found in all sites, but more commonly in the two woodland sites (Likawage and Rungu), whilst the Square-trailed Drongo was only found in the denser forest (Ngea and Mitaurure).

Likawage VLFR	Rungo FR	Ngea VLFR	Mitaurure FR
Common Drongo	Ring-necked Dove	Square-tailed Drongo	Black-backed Puffback
Ring-necked Dove	Yellow-throated Petronia	Common Drongo	Square-tailed Drongo
Arnot's Chat	Brown-headed Parrot	Crowned Hornbill	Yellow-throated Petronia
Green Wood Hoopoe	Common Drongo	Greater Honeyguide	Black-headed Oriole
Greater Honeyguide	Yellow-vented Bulbul	Eastern Roughwing	Piping Cisticola

Table 5. Common bird species in biodiversity monitoring field sites.

However, the returns on investment from this monitoring strategy are open to question. The forests are already burned regularly, with a significant, though smaller and less strategically planned portion, burning any way in the early part of the dry season. So, impacts from early burning on ground-nesting birds above and beyond those already present in the baseline are likely to be limited. Broader species composition changes will likely be gradual and subtle, occurring over decades-long time frames. At such time scales bird species assemblages will be subject to multiple other forces, not least global climate change itself, which will make it difficult to tease out which species changes are specifically a result of project activities, and which are due to broader changes in the landscape.

Mechanisms to Sell Carbon Offsets

This output area was expected to comprise of three activities. These are listed under *Activities* on 26 of the *Project Overview*, and explained in detail here.

Contributions to National Standards & Debates

Governments have vital roles to play in regulation and rule making, as well as monitoring and establishing safeguards for REDD+. Market mechanisms to establish these foundations, e.g. through robust independent third-party validation and verification schemes such as VCS, CCBS and Plan Vivo, are only ever partial solutions to these challenges, and are usually more expensive to implement.

On the other hand, the private sector, including enterprise-oriented NGOs, are often better and more efficient at implementing and developing specific projects, especially in a landscape as varied as that of REDD+ project development. While it is desirable for all actors – the government, donor partners, non-governmental organisations and other private sector organisations – to seek and roll out models for project development that can be applied across a range of social and ecological situations, the reality is that REDD+ project development will require individually designed project modalities from one site to the next. Organisations like MCDI that have an intimate working knowledge of the communities with which they have partnered, either for a new REDD+ project or pre-existing forest conservation activities, are usually best placed to develop and implement a successful and sustainable model of results-based payments founded on avoiding the ongoing scourge of deforestation and forest degradation. It is important therefore that the case continues to be made for a strong role for the private and voluntary sectors in REDD+ in those areas where it has this comparative advantage of flexibility, agility and economy.

MCDI, together with Carbon Tanzania, have been keeping track of national developments by liaising with partners at Tanzania Natural Resources Forum (TNRF), Tanzania Forest Conservation Group (TFCG), and other REDD pilot projects. This enabled MCDI to establish all the necessary systems to comply with national REDD standards as they evolve. The organisation produced four REDD policy analyses and made these available through its website, including an assessment of the latest version of Tanzania's National REDD Strategy and ongoing international developments.

To ensure that MCDI had sufficient say in these matters, they actively participated in the development of Tanzania's National REDD Strategy and Safeguards, as well as the development of National Standards and systems for sales of offsets from REDD. MCDI and partners were leading contributors to the Civil Society Organisations' reaction to the two formal drafts of the National REDD Strategy. The second draft of the strategy produced in 2012, had only minor changes from the first formal draft and so, equally, the CSO response was initially very much a repeat of the one submitted previously. In the two years that had passed, however, MCDI had learned a lot from their own pilot project. The organisation therefore provided critical text on the importance of dealing with drivers of deforestation, starting with a quantitative assessment of forest carbon losses along the same lines of what they did for Kilwa, and then prioritising ruthlessly to deliver a strategy that does not simply try to do everything. These edits were warmly accepted by other NGOs piloting REDD projects and featured prominently in the briefing note subsequently issued by TNRF.

MCDI attended various national meetings organised by the National REDD Taskforce, on the formation of the National Carbon Monitoring Centre, and by UN-REDD, collecting stakeholder views on the future of REDD+ in Tanzania. MCDI also presented the progress of its project at various national level fora and meetings, including REDD Zonal meetings organised by the National Government and the Centre for Climate Change Impacts, Adaptation and Modelling (CCIAM) projects conference.

Market Linkages

As MCDI comes to the end of the pilot phase of its REDD project, the absence of any international compliance markets for REDD-based carbon offsets generated in Tanzania presents a risk. This was not unanticipated, and accordingly MCDI partnered with Carbon Tanzania to develop market linkages and international carbon exchanges. Carbon Tanzania is currently transacting VERs in the international and national marketplace, and therefore has financial systems and international structures in place to sell any VERs that are produced under this project.

Carbon Tanzania's market for VER sales is divided into two main segments:

- **Direct clients** – institutions and companies that buy VERs directly from Carbon Tanzania and for whom Carbon Tanzania retires the credits directly from their Market Environmental Registry account on behalf of the client. This kind of client relationship represents the primary means of distributing carbon offsets globally, making up 59% of aggregated sales volume and achieving the highest retail price at US $10 - $12 per unit. It is also sometimes referred to as "over-the-counter" sales.
- **Indirect clients –** institutions and companies that buy VERs directly from Carbon Tanzania, and then go on to retire them through their own direct clients. As with any agent-mediated business, the price obtained by the producer in indirect transactions is lower than that which is possible with direct (over-the-counter) deals. Indirect sales are currently mediated in two ways, by international resellers or web-based channel providers.
  - *International resellers* provide a mediation service to the private sector by acting as sales agents, buying from multiple producers and selling to a portfolio of appropriate customers.
  - *Channel Providers* provide a platform for sales of issued VERs to individuals. Most channel providers target the travel industry where they add value by embedding web-based platforms to hotel and travel company websites through which an individual can purchase VERs to offset the emission impacts of their travel or stays at properties.

Once MCDI's carbon credits are ready for issuance, Carbon Tanzania will make them available though these market segments, whilst concentrating sales efforts towards specific clients who are most likely to invest to maximise the value per VER.

Carbon Tanzania's greatest competitive challenge exists in it being able to market and sell the forest-carbon offsets its partner communities generate in the context of an increasing global over-supply of ostensibly similar offsets and declining prices. The organisation is competing with other forest-carbon and other offset producing initiatives globally (e.g. cook-stoves), which all depend to varying extents on the same types of value chain partners. However, there is currently no significant competition for community forest-carbon offset production sites in Tanzania (i.e. there are no other carbon offset trading companies actively seeking to sell forest-based offsets generated in the country) and it is highly likely that this will remain the case for the foreseeable future.

Given its East African location and identity, it makes greatest sense for Carbon Tanzania to find untapped and uncreated local and regional market-segments that it is best placed to exploit, and this is the primary approach that they have opted to take with selling carbon offsets generated by communities through this project. Customers in these East African market-segments also are likely to be willing to pay higher or premium prices for forest-carbon offsets relative to prevailing global prices for two reasons. Firstly, the perceived value of Carbon Tanzania's identity and the co-benefits of rural poverty community development and natural forest conservation arguably makes offsets from this project more attractive. Secondly, these market segments are comprised of direct clients who can be sold forest-carbon offsets at custom retail prices (not at lower wholesale prices) in a young and growing market.

Carbon Tanzania's existing direct clients are primarily tourism operators, tourist outfitters and hotels in Tanzania (as well as schools and tourism retailers based in the US and the UK), seeking to enhance their eco-travel credentials for marketing purposes, to meet corporate social responsibility goals, or to build sustainability into their business. The local credibility of Carbon Tanzania combined with the relevance of the project activities to consumer priorities means that new customers are being added in this segment monthly. Carbon Tanzania made its first direct sale to an end user organisation in the tourism industry in Tanzania in 2007, since which time their sales have continued to grow: 5,044 tCO2e worth USD $50,440 (at $10–12 / tCO2e) were sold between 2009 and 2012, with subsequent demand growing by 65% to 2,935 tCO2e in 2013.

As the sole operator in the local market and with strong client relationships within the tourism sector, Carbon Tanzania exercise significant market power, and there is significant scope to further penetrate the market due to the close industry relationships they have established. The highly differentiated nature of the products they sell also allows Carbon Tanzania to charge a market premium rate of USD $10 per unit. Despite these advantages, however, this is the most costly sales channel as significant time must be devoted to providing after sales services, and volumes can be very low – as little as 10tCO2e in a single transaction – generating high per offset transaction costs.

Although the focus for selling VERs from this project will be maintained in local markets, sales opportunities will also be sought further afield. In 2013, Carbon Tanzania began working with two international resellers and signed a memorandum of understanding with a channel provider, providing them with access to wider international carbon markets. While sales through the channel provider have been slow, deals with the international resellers have driven significant sales growth, making up 39% of the total sales volume during 2013. This is achieved with minimal cost to Carbon Tanzania as the reseller only receives the core carbon offset product and none of the additional services which are provided through the direct sales channel (although purchasing larger volumes allows resellers to command a lower price). Advertising through press releases and project news and updates can be publicised through re-sellers and channel providers, meaning that with relatively minimal effort MCDI's REDD project will be able to attain good visibility, although the use of these remains in their control.

Unlike the direct local market where there is a low threat of new entrants due to lack of technical skills and lack of knowledge of the policy space in Tanzania, the indirect market for VERs carries much higher threats of saturation. Within the next 2-3 years there will likely be an over-supply of REDD offsets into the marketplace. These offsets will require buyers, and so resellers (who do not bear project development costs) may be encouraged to offload them at low prices that do not genuinely reflect the cost of project development, nor offset the opportunity cost to participating communities for undertaking the necessary REDD project activities. Bi-lateral and multi-lateral donor aid projects however have the potential to positively affect market prices for REDD offsets if they act to protect the projects they have initiated, pushing the global community into making a demand-side adjustment for these credits. The main vehicle for this would be the World Bank Carbon Fund, or the similar Green Fund, which may guarantee a minimum price for credits.

With an over-supply of REDD and other offsets imminent, product differentiation will be crucial: MCDI will need to make sure that offsets offered through this project stand out against competitors. MCDI will clearly communicate the added value of deforestation as compared with reforestation to avoid substitution from non-REDD offsets. This project also has the bonus of offering offsets combined with community benefits, combining REDD, PFM, and FSC certification. This is likely to be attractive to companies with multiple objectives under their CSR programmes, such as offsetting carbon emissions while conserving biodiversity and forest habitat. In these cases, REDD+ projects like ours can present cost-effective opportunities for companies to achieve objectives. It will also be important for MCDI to target marketing efforts strategically. Where a company is seeking to enhance their supply chain, management spending will be influenced strongly by the geographic location of the raw materials and products with which the business is concerned. Carbon offsets generated through this project might therefore secure the interest of manufacturers that use tropical timber in the production of their products, such as IKEA, who manufacture furniture, or Gibson Guitars and Lorée, who manufacture musical instruments from tropical hardwoods.

Carbon Tanzania's full strategy for marketing VERs from this project, based on their current and existing clients and sales records, is given in the separate market analysis report.[34]

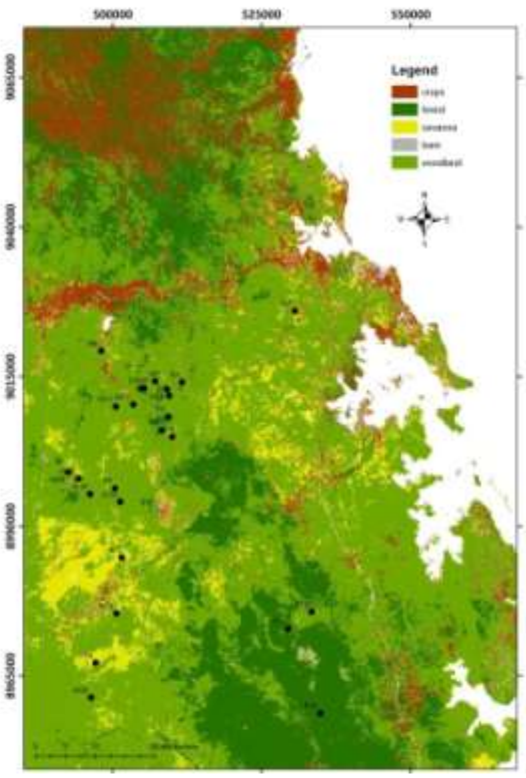
[34] Baker, M and Anderson, J. 2015. *Taking VCS REDD credits to the market: maximizing value in an evolving carbon market.* Carbon Market report, prepared for MCDI by Carbon Tanzania.

Methods for Assessing Forest Carbon

This output area was expected to comprise of six activities. These are listed under *Activities* on 26 of the *Project Overview*, and explained in detail here. In practice elements 3.4 to 3.6 merged somewhat and broke down in slightly different ways to that original anticipated, whilst 3.2 (Assess soil carbon in miombo woodlands in SE Tanzania) turned out to be unimportant for the revised project focus on fire management.

Carbon Stock Assessment & Mapping

A critical early step in the project was to assess the current forest carbon stocks in the project area. This was accomplished through a combination of ground data obtained from the establishment of 25 permanent sample plots and remote-sensing radar data from the Palsar satellite. Satellite data in the visual and infrared spectra provide a poor basis for measuring forest degradation in Miombo woodlands because it is hard to distinguish green grass from green tree leaves. In contrast, L-band synthetic radar data does a much better job because it is scattered by trunks and large branches, and has the added advantage of not being obscured by cloud cover. In rainforests and other thick vegetation where above-ground biomass exceeds 100t/ha the backscatter quickly becomes saturated, and so radar data can only detect degradation when it becomes severe. However, above-ground biomass in miombo woodlands is typically about 50tha, and thus smaller variations are readily susceptible to detection.



The ground data was collected from 25 'super-plots' that cover 9ha each. These were randomly located (subject to logistical constraints) across the central and southern Kilwa landscape, stratified into 3 bands: forest, woodland and savannah, as shown to the right[35].

Using large scale plots was important because Miombo woodland is a highly heterogeneous environment, so data derived from smaller plots may strongly depart from the statistical Normal distribution with too many plots virtually empty of trees. The layout of the super-plots, see Figure 10, was analogous to that used in NAFORMA cluster plots, but more concentric in nature so as to provide a better fit with pixels on satellite imagery and thus serve as effective ground control points in analysis of said images.

[35] Stratification derived from crudely ground-truthed LandSat images. Some plots where later reclassified according to the actual biomass measured.

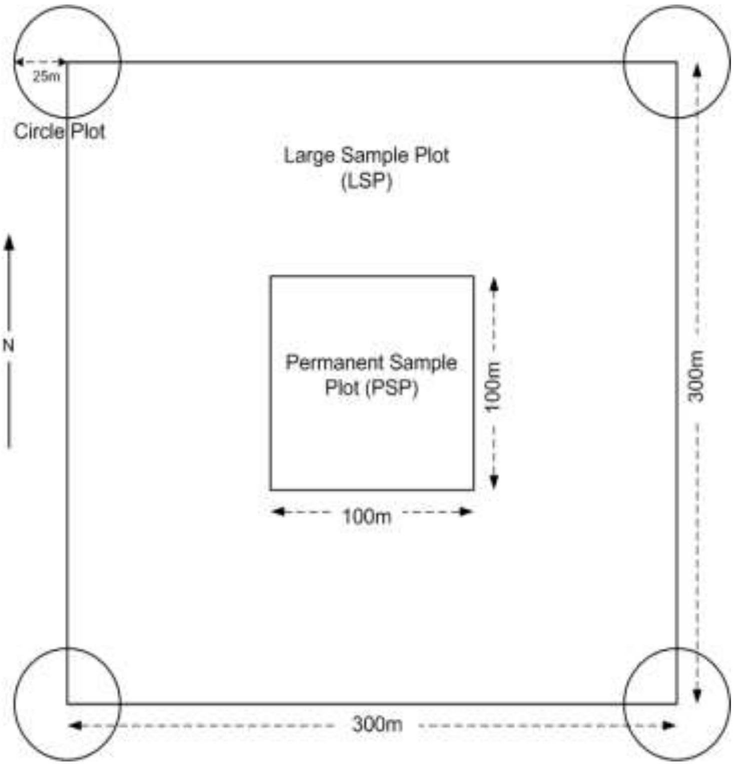


Figure 10. Carbon stock assessment sample plot layout.

The key consideration behind the design of the plot layout is that a high proportion of the biomass in miombo woodlands is typically found within a few large trees[36]. Since surveying these plots requires a lot of effort and expensive man-time, only large trees (DBH ≥ 40cm) were surveyed in the 9ha large plot, with smaller stems sizes (5cm+ and 10cm+ respectively) surveyed in the central PSP and outlying circle plots. This ensures that surveying effort was focused strongly on the biggest determinants of biomass, and covering as large an area as possible (>240ha in total), whilst allowing some finer grained data to be collected for comparison, and delivering maximum logistical efficiency consistent with a poor accessibility in a heterogeneous landscape. A full description of the surveying protocol and explanation of the plot layout is given in the separate inventory report[37]. The sample plots used have been permanently marked, and individual trees mapped within them, to support long term monitoring.

Tree measurements in the PSPs were converted into tree volume, and hence biomass estimates by use of an allometric equation[38]:

$$\log(\mathit{Stem\ Biomass}) = 2.601 \log(\mathit{DBH}) - 3.629$$

Combining the PSP data with the original crude landcover stratification estimate reveals that above-ground biomass carbon in Kilwa amounts to some 30 million tonnes. This breaks down as shown in Table 6:

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[36] In Mozambican surveys the top 3% largest trees contributed 50% of the total biomass, and the top third of trees contained 91% of the total biomass.

[37] McNicol IM, Williams M, & Ryan CM (2011). *Quantifying carbon stocks for REDD+ implementation in Kilwa District.* Forest Inventory Report.

[38] From Ryan CM, Williams M & Grace J (2011). *Above- and Belowground Carbon Stocks.* In: *A Miombo Woodland Landscape Of Mozambique.* Biotropica, 43: 423-432. This equation was used because it is consistent with that used in the GapFire model.

Habitat	Mean Carbon density (tC/ha)	Area (000 ha)	Total Biomass Carbon (000 tonnes)
Forest	28.4	428	12,155
Woodland	15.7	824	12,937
Savannah	11.5	262	3,013
Crops	9.4	236	2,218
Total			**30,323**

Table 6. Estimated above-ground carbon stocks across habitat types in Kilwa District.

These results are illustrated below, showing the variation in estimates produced from the three classes of sub-plot used in the surveys. The Savannah plots were found to be floristically distinct from the Woodland and Forest plots, which were not statistically different in terms of species composition.

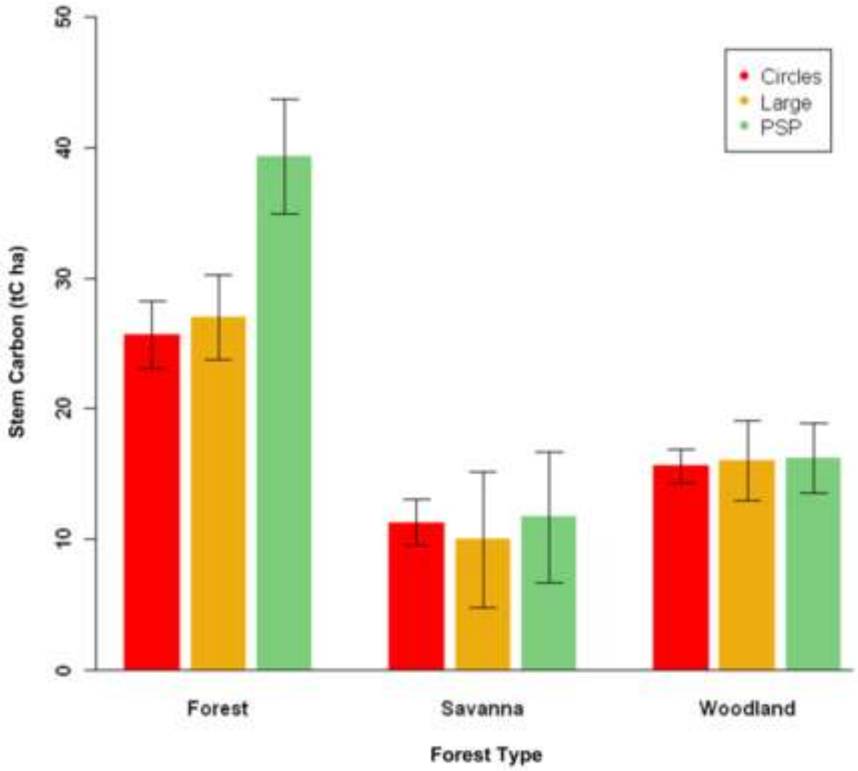

Figure 11. Variation in above-ground biomass carbon between habitat strata and consistency of data.

The PSPs were used as anchor points on the radar data to map above-ground biomass carbon across central and southern Kilwa, as illustrated below. In order to use such data as an input to a robust REDD+ MRV system it is important to know how accurate is the classification: using a boot-strap method, MCDI determined that the map produced is >98% accurate, well within the standard requirements of validation bodies such as VCS. Maps of historical fires (see below) and other research findings suggest that areas of Miombo woodlands with above-ground biomass consistently exceeding 35tC/ha do not burn often, so the VCS method applicability is capped at this level. The resulting maps exhibited a high level of speckling with neighbouring pixels alternately in and outside the applicability criteria; this was clearly inappropriate since the pixel dimensions were only 25m × 25m, and fires will easily penetrate such small patches. So a median filter[39] was applied to reduce speckling and consolidate the map (Figure 12).

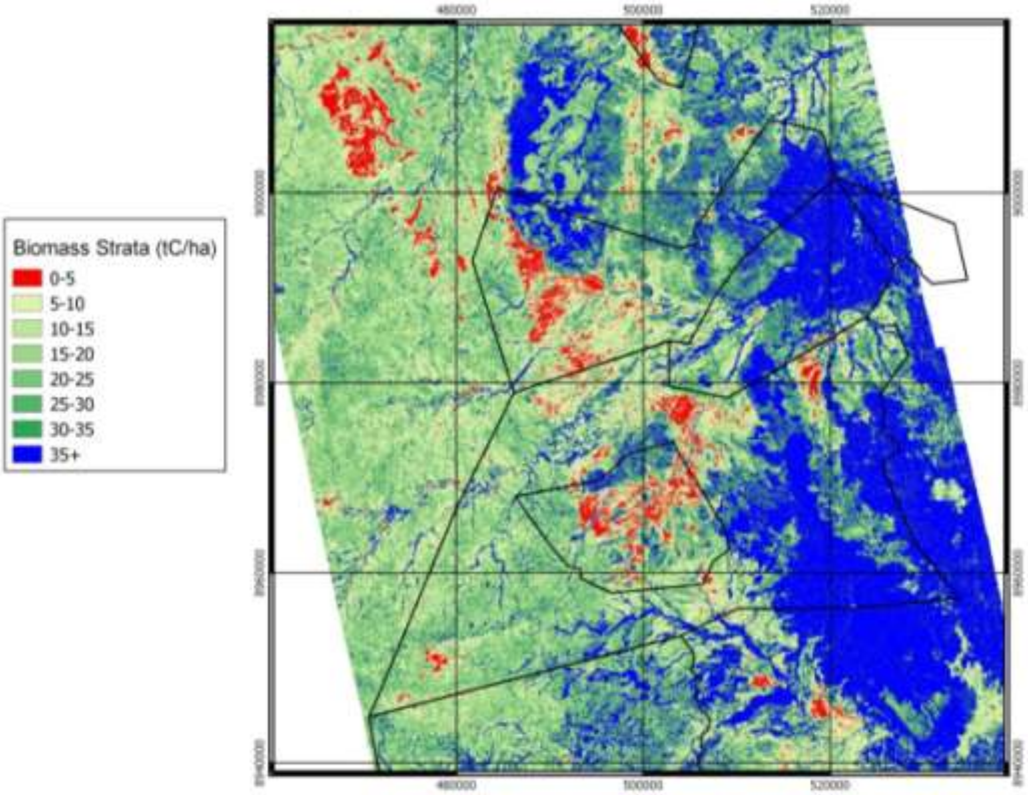

Figure 12. Above-ground biomass distribution in central and southern Kilwa.

Finally, with this map, it is possible to determine the biomass distribution in specific community forests (village boundaries are super-imposed on the above map for reference). These are graphed below.

[39] A median filter reduces the resolution, averaging out values with neighbouring pixels. Importantly it is neutral with regards to the map-wide mean, so total biomass carbon across the landscape neither rises or falls as a result of applying the filter.

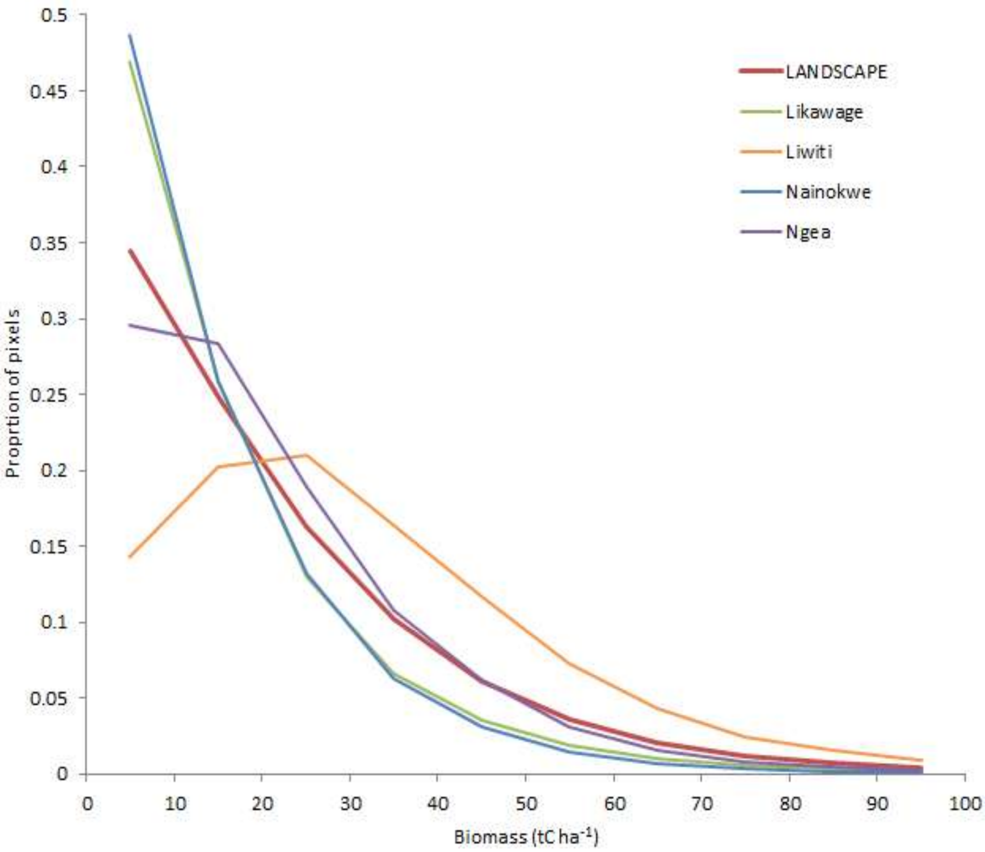

Figure 13. Above-ground biomass carbon variation in selected VLFRs.

Carbon Fluxes in Miombo Biomass and Soil

Rates of Carbon Sequestration in Biomass

The preceding section describes the process of obtaining a snapshot of forest carbon stocks in Kilwa at the start of the project (2010-11). These results define the starting conditions of any model of the forests. In order to predict the impacts of fire on the forests MCDI also need to know the rate of forest growth and hence carbon sequestration in woody biomass. One way to do this is to monitor changes over time (a time series). Another way is to find a series of sites containing differently aged forest (a chronosequence) and infer from those sites the growth curve[40].

To this end, in 2011 forty-three plots were surveyed, 0.2 ha in size, including 9 agricultural fields active from 0 – 5 years (to highlight the effect of deforestation on carbon stocks), 23 secondary forests ranging from 1 – 39 years abandoned, and 11 mature forest plots which acted as reference plots against which the effect of deforestation and rate of recovery were measured (Figure 14). Most useful were those few sites where farms had been abandoned >30 years during the *Ujamaa* period of villagisation in Tanzania; this caused significant hardships to many rural people at the time but did have the happy side effect of providing an accurate date for several long-abandoned farms. Across the chronosequence carbon stocks were found to increase at 0.67 ± 0.09 tC/ha per year in both clay and sandy soil types.

[40] Full findings detailed in McNicol *et al.* (2015) Impacts of land use change on ecosystem carbon stocks and species dynamics across a chronosequence of Miombo woodland stands cleared for swidden cultivation. In press *Ecological Applications*.

Figure 14. Views of different age recovering Miombo woodland post-clearance.

Species composition across the chronosequence unsurprisingly changed considerably with time, with mature Miombo dominants such as *Brachystegia spp.* and *Julbernardia globiflora* only coming through in significant sizes in mature woodland (Figure 15). Species richness for different stages of succession varied (significantly) between sandy and clay soil types, with the oldest fallows and mature woodland plots on sandy soils supporting considerably more species than younger abandonments, whereas on clay soils, intermediate aged fallows supported the greatest number of species. Considered altogether secondary woodland plots (age $\geq$ 10 years) were substantially more species rich than mature woodland habitats, although mature miombo still harboured significant number of endemic species, which are considered to be the more disturbance intolerant species.

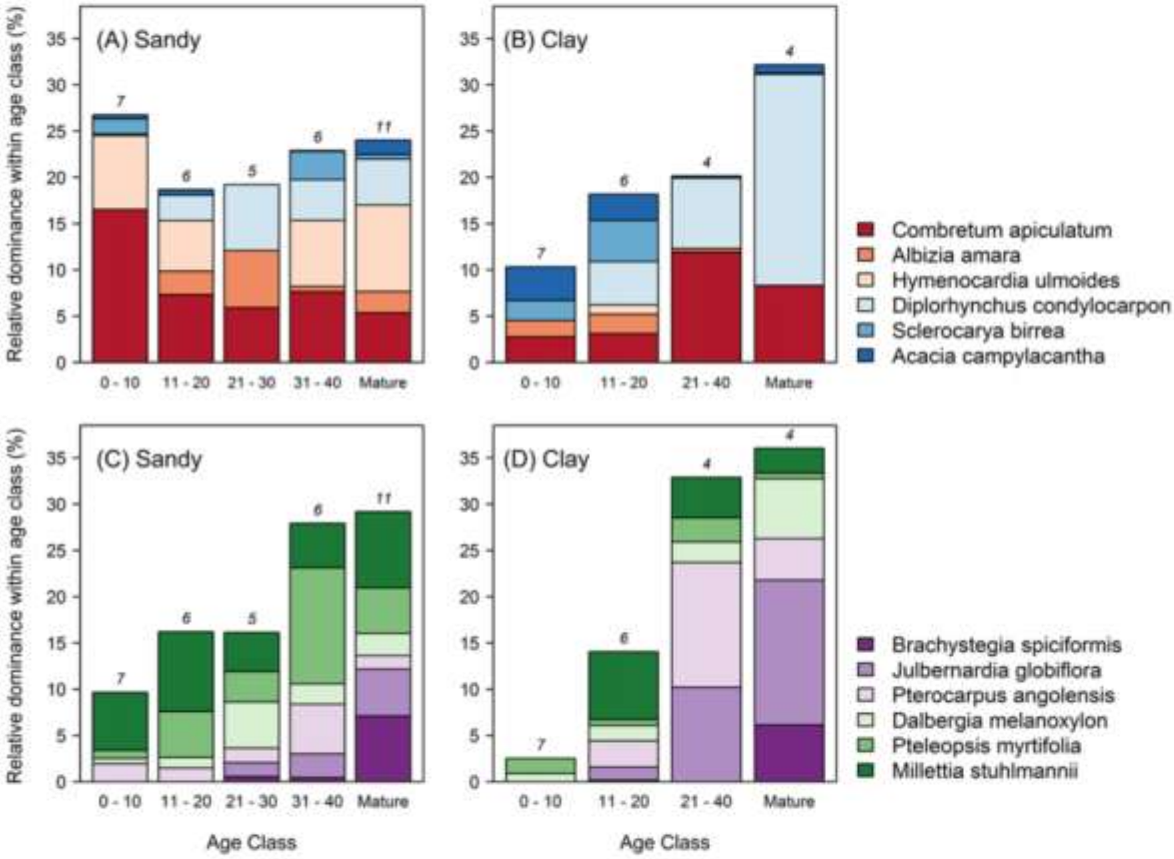

Figure 15. Changes in relative dominance of the 12 commonest tree species across chronosequence sites and soil types.

Soil Carbon Fluxes

Above-ground biomass accounts for only about 25% of total carbon stored in miombo woodlands, and it has been estimated that up to half of the carbon lost when miombo is cleared may be carbon previously stored in the soil. Hence the original project design featured a component to assess carbon losses.

Researchers from UoE examined the effect of a range of environmental variables on total soil organic carbon and soil respiration, and the impact of forest clearance and recovery on them at a sub-set of the above-described chronosequence sample sites. Full findings will be detailed in a forthcoming paper[41]. A brief summary of the main points are as follows:

- Total soil organic carbon was principally explained by soil type (clay vs sandy), but was largely unaffected both by the initial land clearance and the recovery phase.
- Soil respiration rates ranged from 0.05 – 0.49gCO_2/m^2 per hour with an overall landscape mean of 0.22 ± 0.08gCO_2/m^2hr.
- Woodland density (distance to the nearest tree) and soil moisture did not appear to have a significant effect on respiration rates. Neither did total soil carbon content significantly affect respiration, suggesting that respiration is not limited by the quantity

[41] McNicol IM *et al.* (2016) Spatial variability of soil respiration in different aged stands in a savannah woodland ecosystem. *In prep.* for Agriculture, Ecosystems and Environment.

of the available substrate, although this contradicts other studies[42] and could be an artefact of data collection.

- Instead respiration was most closely related with total soil nitrogen (explaining 30% of total variance), with fine root biomass a secondary explanatory variable when other variables were held constant (12% of variance). This signifies that nitrogen is a significant limiting factor to respiration processes and microbial growth in these soils.
- Soil respiration rates were greater in the youngest abandonments (~0.3gCO_2/m^{2}hr), decreasing to a low point in the mid-successional sites (~0.15gCO_2/m^{2}hr), before increasing and levelling out in the older abandonments and mature woodlands (~0.22gCO_2/m^{2}hr).

These findings contradict expectations from previous research elsewhere which suggest land clearance for agriculture reduces soil carbon stocks and the recovery of the surface vegetation increases soil carbon. This decoupling between the aboveground and soil carbon pools suggests that any changes in aboveground biomass associated with changes in fire management is unlikely to have any major impact on soil carbon. Combined with the notorious variability in soil carbon measurements, this was sufficient reason to exclude soil carbon from the model of the impacts of fire on Miombo carbon stocks, and thus from consideration within the rest of this REDD+ project.

Fire History

Critical to any REDD+ project is the baseline scenario analysis of carbon losses against which progress will be demonstrated. In the case of this project, carbon fluxes are estimated using the GapFire model that is described in the section on *Modelling Averted Carbon Emissions* below. The principle input to that model is the fire frequency in the early and late parts of the dry season. For the baseline scenario these frequencies are derived from an analysis of historical fires detected on satellite imagery.

The first challenge in this task is to define precisely the *early* and *late* periods of the dry season so that fires detected can be appropriately labelled. This is difficult since the rains vary naturally from one year to the next. So, whilst the main wet season in Kilwa is normally March and April, extending often up to the middle of May, some years early burning could start in early May and be complete by mid June, after which the landscape could be dangerously dry, whereas in other years the forest may not be dry enough to start early burning until mid June. So ideally MCDI need a measure of forest dryness that can be derived from rainfall data (for the historical baseline), with the early dry season starting when this measure exceeds a certain threshold, and then extending either for a fixed period of time or ending when the dryness measure exceeds a second threshold.

Unfortunately, not only does the timing of the rains vary considerably from one year to the next, but so does the pattern of the end of the rains, as evidenced by the chart below. MCDI were unable to deduce an appropriate threshold from this that would hold reasonably consistently from one year to the next.

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[42] Merbold L, Ziegler W, Mukelabai MM & Kutsch WL (2011) Spatial and temporal variation of CO_2 efflux along a disturbance gradient in a miombo woodland in Western Zambia. *Biogeosciences*, 8, 147–164.

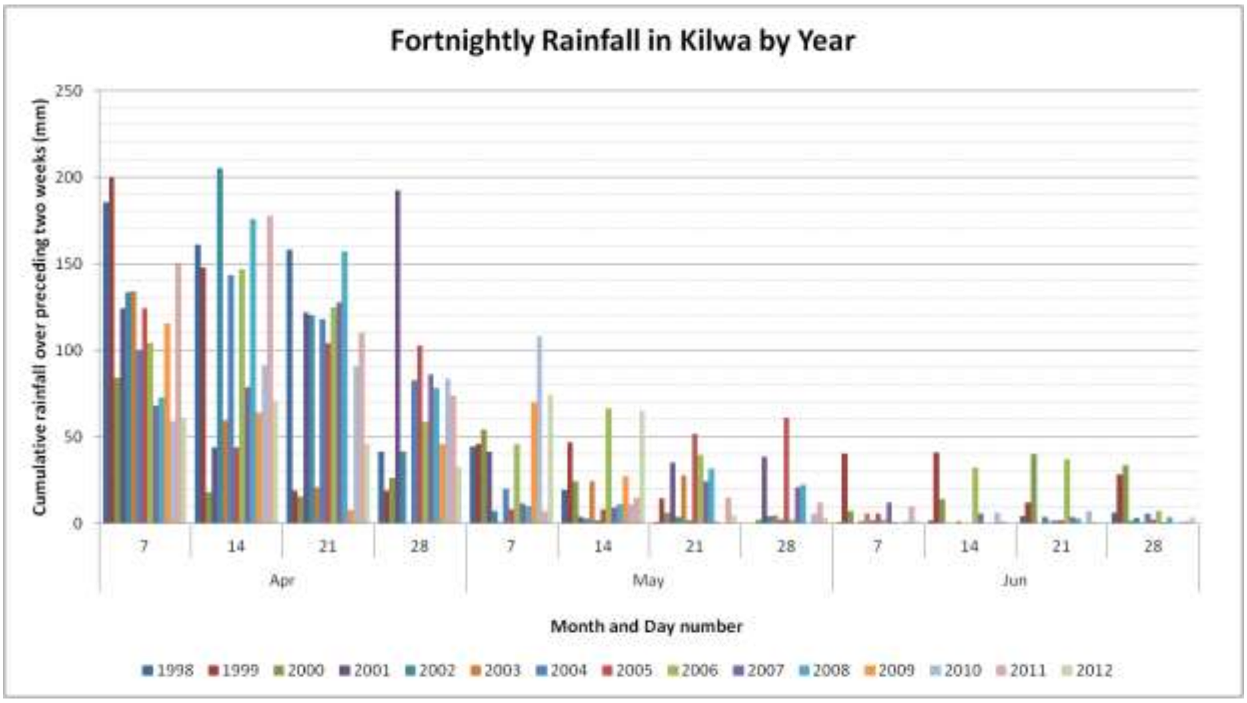

Figure 16. Rainfall variation in central Kilwa 1998-2012. (Source data from TRMM[43])

Hence it settled instead on a fixed cut-off date between early and late dry seasons that would apply across all years, which also has the significant virtue of simplicity. In MCDI's VCS methodology a default date is proposed, but project proponents are also allowed to propose other dates that may be appropriate to the specific area of their project, so long as it can be supported by appropriate local expert opinion and such data is available. The reason for this is that, to a degree, it does not greatly matter exactly when the cut-off date falls: more time to conduct early burning (benefitting the project scenario) will be offset by less fires being assigned to the late season in the baseline scenario (thus resulting in lower carbon losses being modelled).

The default date proposed, and which is appropriate to Kilwa, is 30 June. This will allow 4-6 weeks to conduct early burning in most years (about the minimum time required). This choice, driven primarily by practical experience, is nonetheless supported by good scientific data: it is both the date by which the slow decline in average rainfall from mid-April onwards bottoms out, and the point at which various indicators of fire danger start to climb more alarmingly, as per the graphs below[44].

The cut-off date is the most critical date to define, but two more are required: the *Earliest possible burn date* and the *End of burning season*. These need to be defined in order to provide consistent labelling and, in the latter case, also to enable comparison with monitoring of project activities. MCDI defined these as follows:

> **Earliest possible burn date** = the day at the beginning of the dry season at which the monthly running average rainfall first falls below 33 percent of peak wet season rainfall. (Any fire events detected before this date are assumed to be irrelevant because subsequent rainfall is likely to deliver substantial grass regrowth to fuel forest fires.) In Kilwa this falls on 1st May.

[43] Tropical Rainfall Measuring Mission http://trmm.gsfc.nasa.gov/

[44] This choice of date was nonetheless not without its challenges, see section on *Early Burning Efforts to Date* below.

End of burning season date = the day at the end of the dry season at which the monthly running average rainfall first rises above 33 percent of peak wet season rainfall. In Kilwa this falls on 30th November, although a date of 20th November is used to allow enough time for monitoring of late season fires before the annual Christmas holiday.

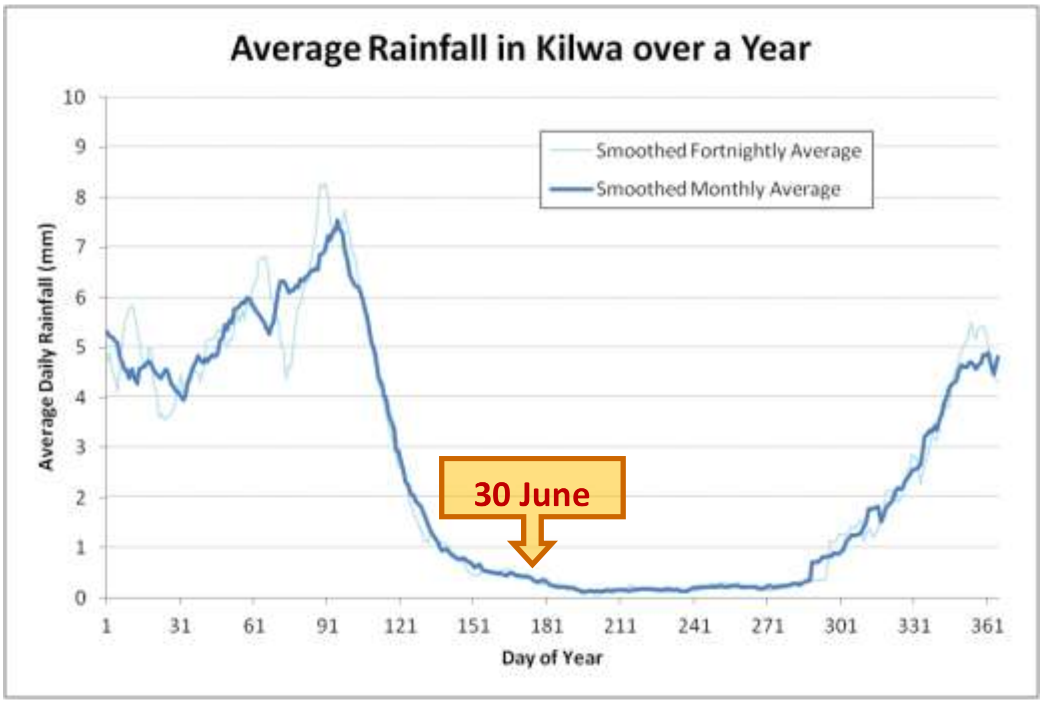

Figure 17. Proposed cut-off date between early and late dry seasons in relation to average rainfall in Kilwa. (Source: TRMM)

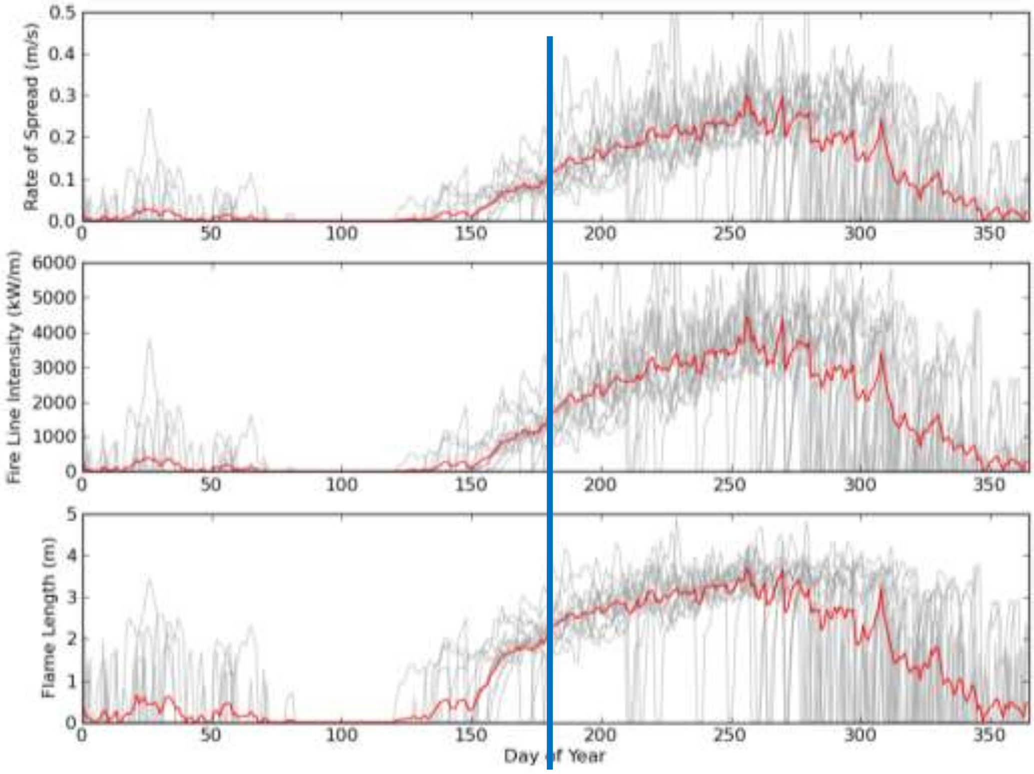

Figure 18. Selected Fire Danger indicators for Kilwa 2001-10 calculated as per the Canadian Forest Fire Danger Rating System with 30 June roughly illustrated.

The University of Maryland manage a regular service to generate maps of fires detected by the MODIS satellite[45]. Unfortunately, this system is not appropriate to MCDI's purposes. The reason is illustrated in Figure 19: many fires are detected in the wooded savannahs of western Kilwa, and relatively few in the more heavily wooded areas in eastern Kilwa. Yet MCDI know that, except for the thickest forests, a large proportion of the woodlands in eastern Kilwa are burned each year, and hypothesise that this discrepancy is driven by two factors:

1. Fires in savannah areas tend to spread further and more quickly and thus are more likely to be detected by MODIS.
2. Even just a partial forest canopy will hide many fires, especially the smaller ones, which may have mostly extinguished by the time MODIS passes overhead.

It is theoretically possible that if both effects could be quantified then one could model the lower detection rate of fires by biomass, and thus derive a reasonable estimate of historical fire frequencies from the MODIS archive. However, no relevant datasets exist to compute this relationship, so an alternative approach is needed.

[45] See http://modis-fire.umd.edu/ for more information.

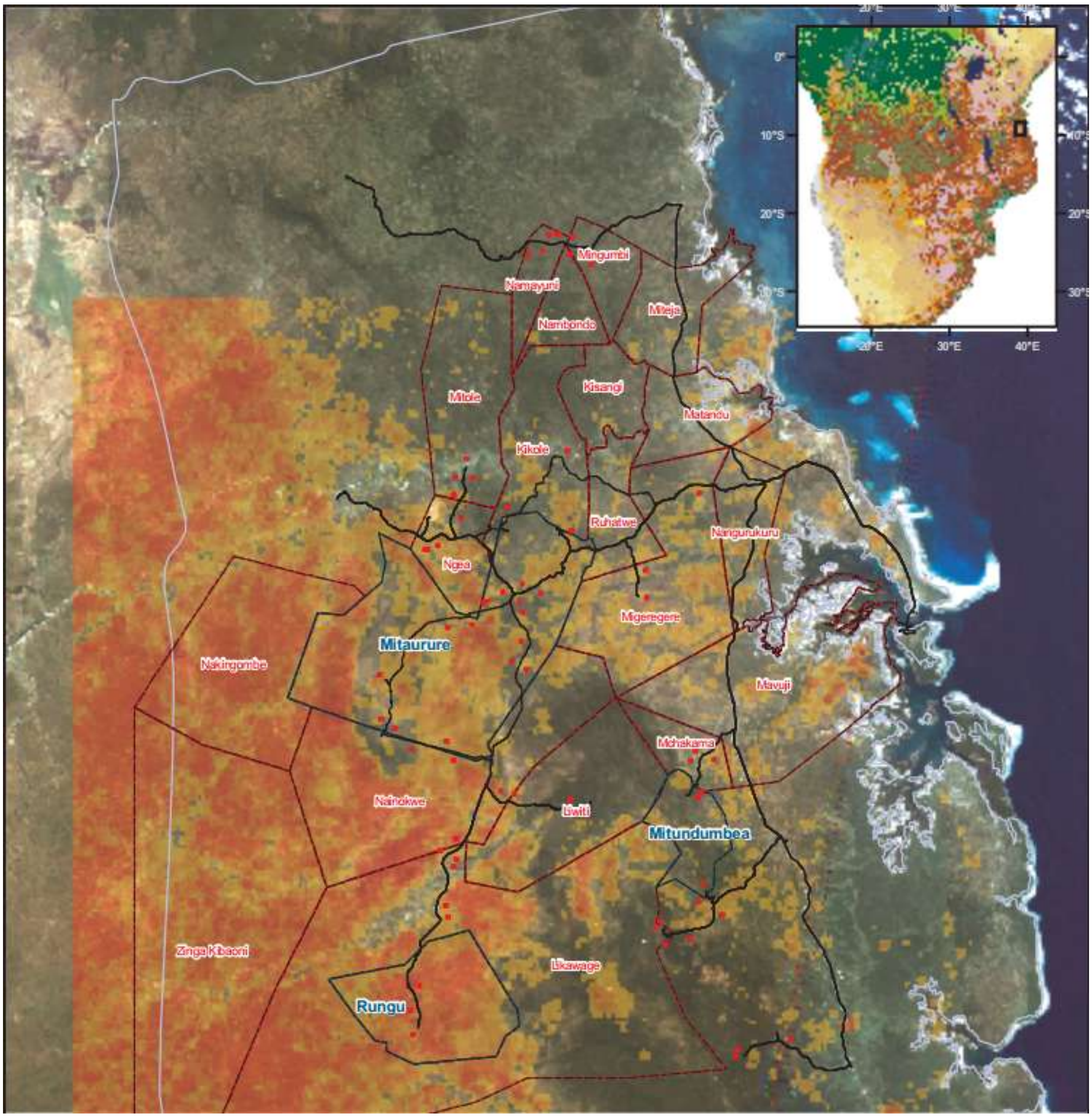

Figure 19. Fires detected by MODIS in 2000-2010.

The MODIS active fire product works by looking for anomalous heat signatures, i.e. it detects fires in the process of burning. An alternative is to look for the visible effects of a fire on the landscape in the form of burn scars. These are easily visible to the human eye, and can even be seen on some Google Earth views; the figure below provides a good example. The same ease of identification to the human eye allows a computer, adequately trained, to undertake the same task, and thus allow its automation. This was the approach adopted to construct the baseline fire history for this REDD project: LandSat images were used instead of MODIS due to their substantially higher resolution (useful for overlaying on the above-produced biomass maps).

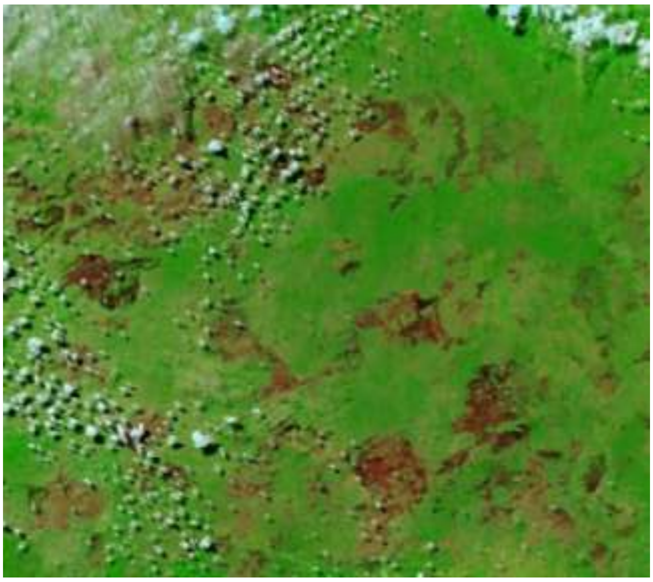

Figure 20. False colour composite (bands) from MODIS showing burn scars (dark brown) amongst natural vegetation (green), partly obscured by clouds (white with dark shadows).

The above figure is a relatively good example of a burn-scar image, with fairly sparse cloud cover that only obscures some parts of the image. However, that is relatively unusual; many LandSat images were historically thrown away due to excessive cloud cover[46]. MCDI collected all available LandSat images from the four scenes that cover part of Kilwa District: many were unfortunately missing, especially in the critical middle part of the year, see *Figure 21*. This constrained the subsequent analysis: attempts to compute specific fire frequencies for individual VLFRs were subject to margins of error too wide for practical use. However, when taken altogether, the data was sufficient to generate fire frequencies for the landscape as a whole, and different strata of biomass, with acceptable margins of error.

[46] Going forward no images from LandSat 8 will be discarded, but where cloud cover is high it will nevertheless limit the images' usefulness.

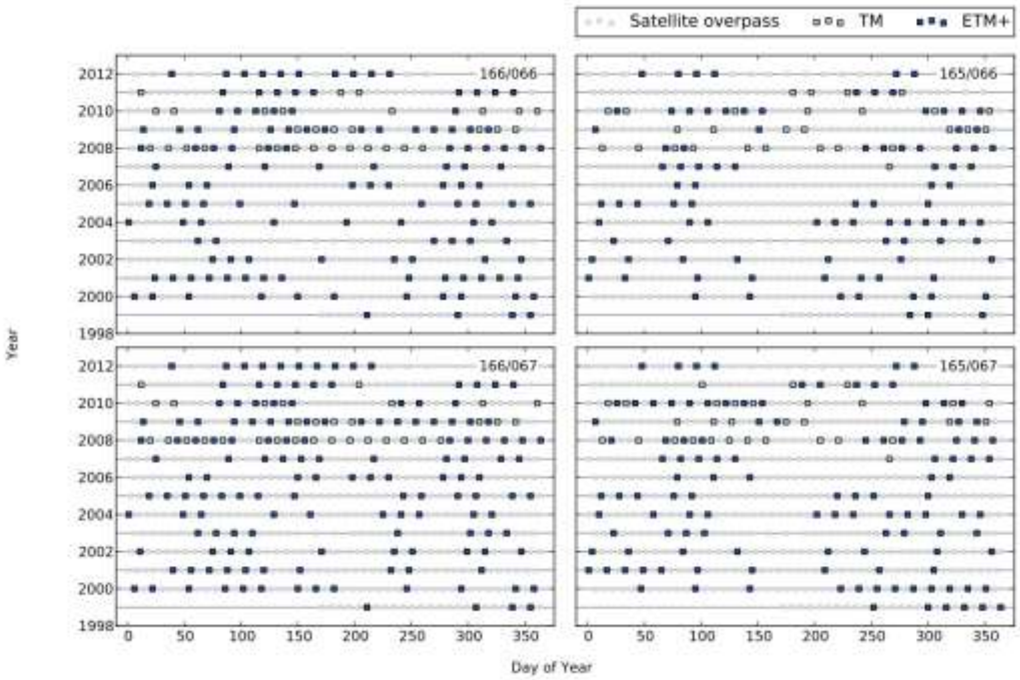

Figure 21. LandSat images obtainable (dark dots and squares) from total LandSat overpasses of Kilwa in 1998-2012.

Prior to running the burn scar detection algorithm all LandSat images were subjected to basic processing (atmospheric correction, cloud masking and conversion to an estimate of surface reflectance), and a variety of spectral indices were calculated which highlight the reflective properties of burn scars (e.g., NDVI, GEMI, MIRBI)[47]. The automated burn scar analysis itself was informed by a training dataset of burned and unburned areas that have been manually identified in remote sensing imagery by a competent operator. The training data included classified pixels across a number of images, spanning different localities, land cover types, seasons and years, and was developed conservatively, with only the central parts of burn scars (where there can be no doubt) labelled as burned in the training data.

The likelihood of a burn was computed for each usable pixel in each image using a supervised image classification algorithm. The classifier derivation incorporated a variable sparsity preference to avoid over-fitting[48]. The classification was carried out as a cross-validation, and boot-strapped with a part of the training data used to guide the classifier, and the remaining training data used to assess accuracy. The algorithm achieved a consistent average classification accuracy of >95 percent on the Kilwa data set.

The output of the algorithm is an estimator for each pixel giving the probability that it was part of a burn scar: most output estimator values are clustered at one or other end of the range (i.e. almost certainly in a burn scar, or almost certainly not), but some pixels have middling values. Current research suggests that any pixel estimated to have a 30%+ chance of being in a burn scar should be treated as having been burned in order to offset the in-built conservativeness of the rest of the computational process. However, in order to satisfy the demands for robustness from third party verification standards like VCS, MCDI adopted instead the manifestly conservative 60% as the minimum estimator value for recording a pixel as having burned.

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[47] In addition to aiding classification, use of these indices mitigates against the effects of varying illumination, acquisition geometries and topographic effects in satellite imagery.

[48] I.e. each new variable had to clearly add significant extra precision to be incorporated into the classifier.

At the end of this process MCDI had a set of classified images with each pixel defined as either burned, not burned, or no data (e.g. due to cloud cover). This was transformed into a record of the fire history for each pixel in each year by considering the following rules:

- All images from before the earliest burn date are ignored.
- All burns after the first detected burn are ignored (even if there was a new fire, the fuel load is assumed to be low, and therefore the fire not damaging).
- Where a *no burn* is followed by a *burn* both within the same period (early or late), then the fire can easily be classified as an early or late season burn.
- Where there is no preceding *no burn* or the preceding *no burn* belongs to an earlier period then the burn is probabilistically classified assuming a uniform distribution between the date of the burn observation and the date of the previous no-burn observation (subject to a limit of three months back in time, beyond which burn scars are not considered detectable) or the earliest possible burn date, whichever is later.
- In addition, pixels recorded as burned for the first time within three months of the end of the late dry season are also classified probabilistically, similarly to above.

Data paucity meant that this probabilistic classification was quite common. This process resulted in one file per scene per year, in which each pixel has one of four values (or a probabilistic combination of all of them, adding up to 100%):

- Early Season Fire (May – June)
- Late Season Fire (July – November)
- No Burn
- No Data (0% or 100% values only)

These scenes are easily stitched together and the results summed across the ten year period over which the analysis was conducted to produce a complete fire history for the project area. The map to the right illustrates the most important dimension of this (late season fires). Similar maps for the early season and no burn outcomes can be produced (see Figure 23).

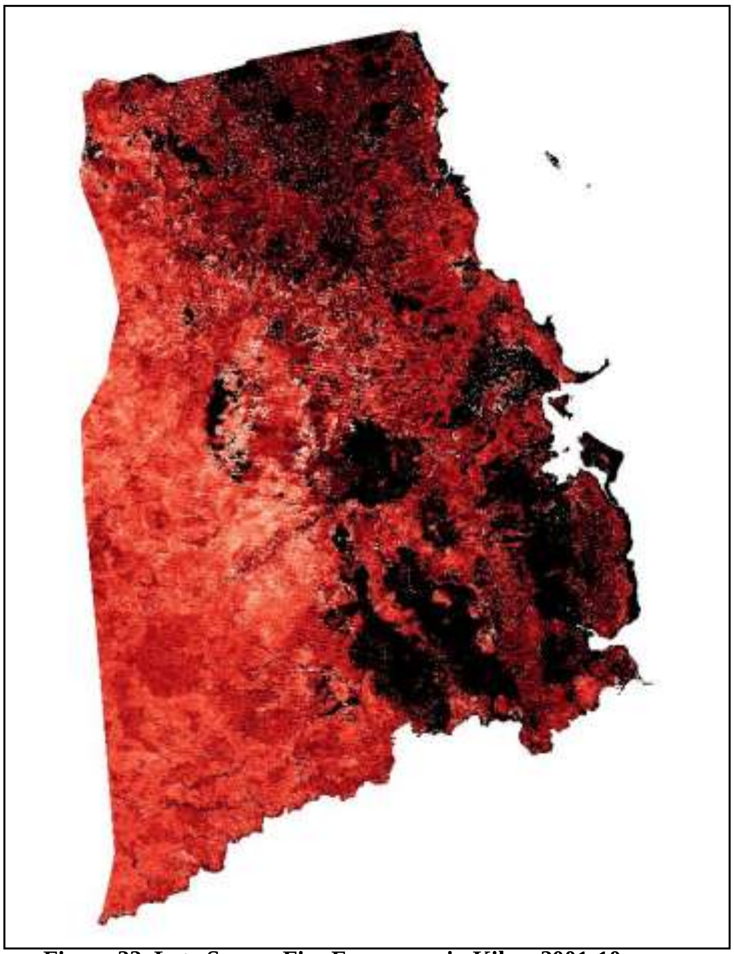

Figure 22. Late Season Fire Frequency in Kilwa 2001-10.
Red = fires, the deeper the red, the more frequent are late season fires.
Black = no data.

Finally, those same maps of fire frequency can be overlaid on to the previously produced biomass carbon density maps to generate fire frequency likelihoods for each biomass stratum, as shown below, thus providing the key inputs required to run the GapFire model.

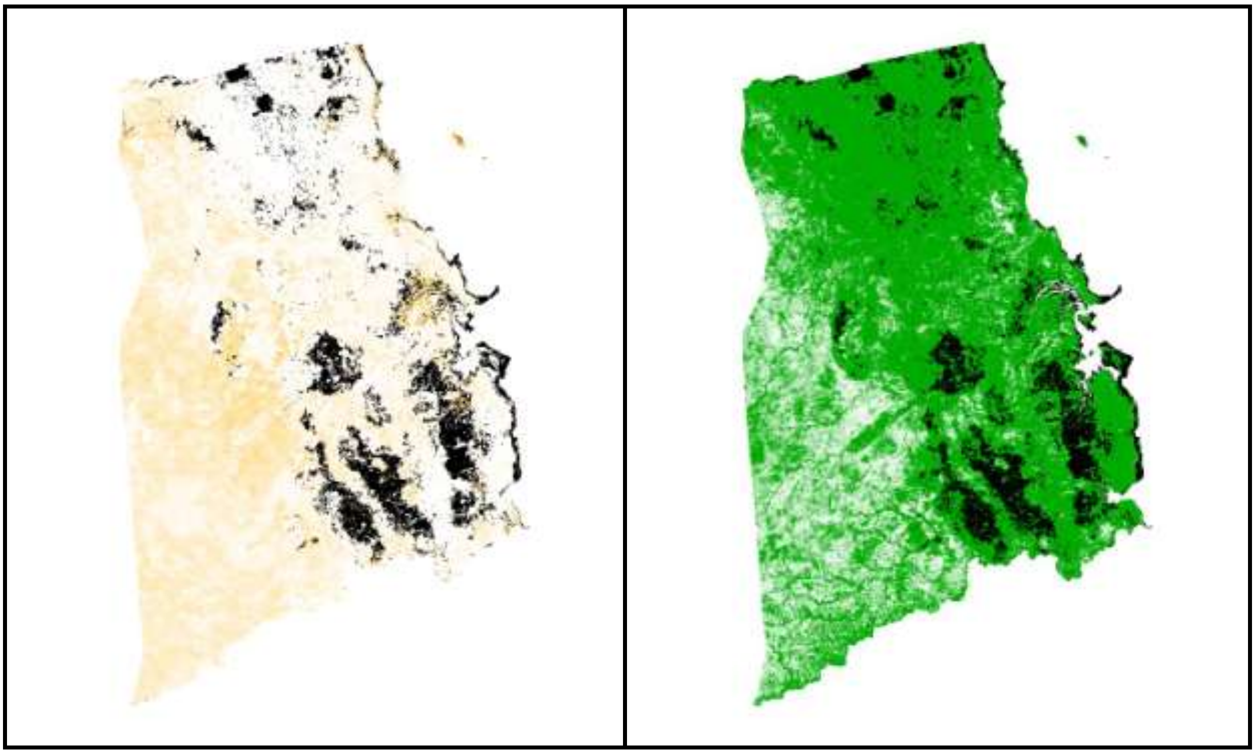

Figure 23. Early Burn and No Burn frequencies in Kilwa 2001-10 (amber and green respectively).

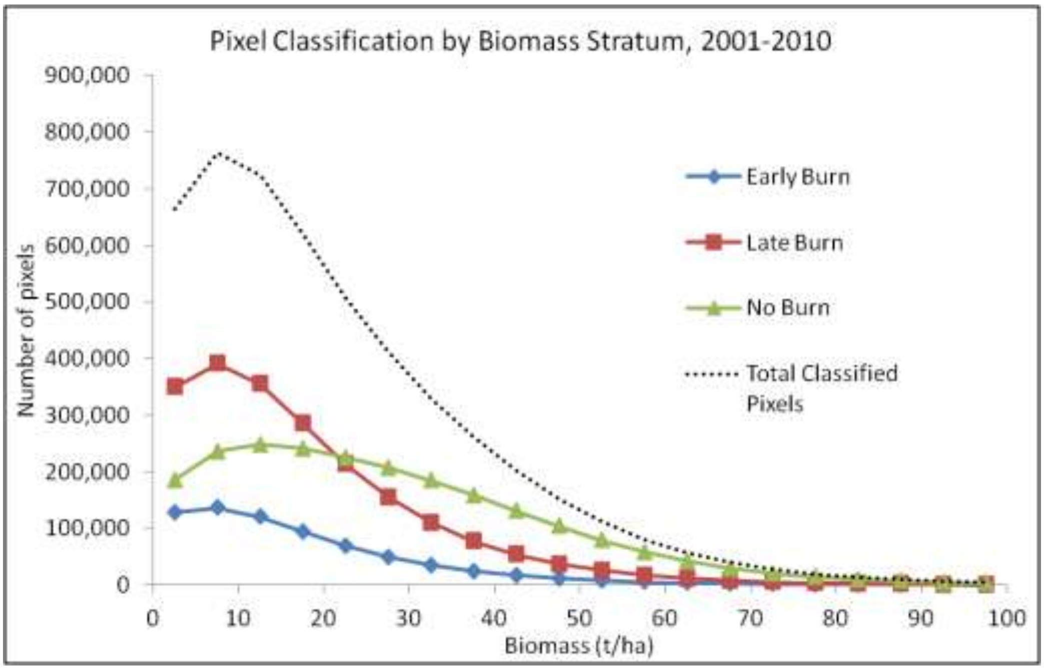

Figure 24. Fires detected in Kilwa 2001-10 by Biomass Strata.

Monitoring Impact of Early Burning

MCDI hypothesise that early burning should have a series of impacts on the forest, one proximate, and the others derived from the previous result(s):

(i) The area of forest burned during the middle and late part of the dry season will be reduced, hence

(ii) The mortality of (large) trees will decline, leading to

(iii) The forest biomass degradation stopping, and probably increasing instead, such that

(iv) Habitat transformations (savannah into woodland, and woodland into forest) may eventually occur.

MCDI set out to monitor directly the first three, with the fourth result being rather more uncertain and likely to take place over substantially longer periods of time (decades rather than a few years). A key consideration in the design was to make the monitoring accessible to local communities so that they could assess themselves their own performance in early burning and the impact of that on the forest. Community involvement in monitoring will also bring down costs in the long run (important for project viability while the international carbon price remains low), although in the short run costs will be slightly higher due to the need to build capacity.

MCDI adopted a transect-based methodology because they are much more efficient at covering large areas of forest than sample plots. Multiple (4+) transects are laid out using a GIS across the forest to cover at least 20km, which is the length needed to ensure a high likelihood of capturing a sample of at least 1,000 large trees (DBH ≥ 30cm) within a 20m wide transect [49].

Burned Area Monitoring

At regular intervals on the transects (50m+, depending on the total length of the transects) there are checkpoints whose locations are predetermined and loaded on to a GPS unit. At each checkpoint the monitoring team record whether or not the ground beneath their feet is burned and take a geo-located photograph using a GPS camera. A random selection of 5% of the checkpoint data from each VLFR are then checked to ensure the photograph supports the data recorded. This quality control mechanism is important for VCS standards, and also greatly reduces concerns about using non-professional surveyors.

[49] Based on the frequency these were found in the permanent sample plots discussed above (25 large trees per hectare).

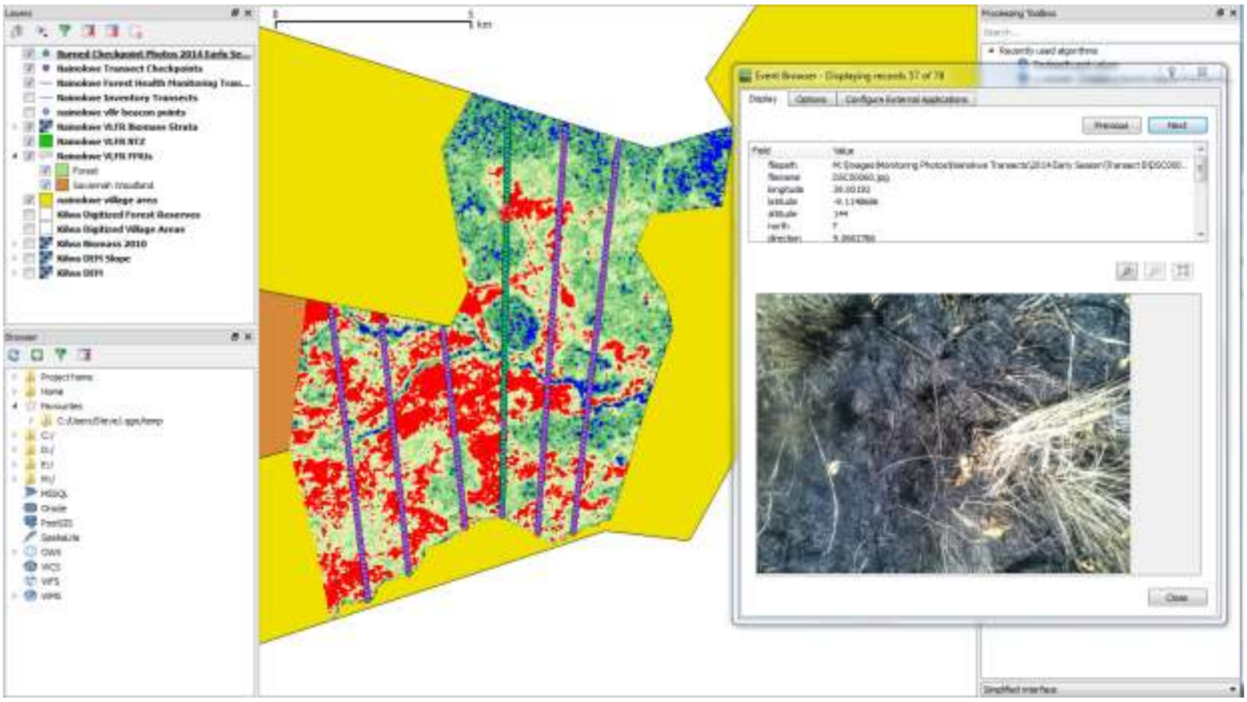

Figure 25. Spatial visualisation of transect checkpoint photos for quality control of burned area monitoring.

This burned area data must be collected twice a year, within one month of the end of the early dry season and again within one month of the end of the late dry season, as defined for the project. The proportion of checkpoints which has been burned provides both the early dry season fire frequency and, by subtraction, the late dry season fire frequency. These numbers can easily be computed in the villages providing communities rapid feedback on how they are doing.

Large Tree Mortality Monitoring

Large trees are hard to monitor in June/July because, even after early burning, the undergrowth is still quite thick, so large trees are best monitored only during the second surveying effort of the year. During the baseline establishment every large tree (DBH $\geq$ 30cm) within 10m either side of the transect line is tagged, location recorded on GPS, and its species and DBH recorded. Thereafter, to save time, it is only necessary to monitor one transect for changes to the large tree population each year, with the transect so monitored rotating from one year to the next.

During repeat surveys the pseudo-map produced of the large trees previously identified provide a guide to locate them relatively easily (see Figure 26). This is important as not all of them will remain: where that is the case, or where the tree has simply died, a tree death is recorded and the reason noted. New large trees that have recently grown large enough to join this category are also tagged and recorded.

The baseline database of approximately 1,000 large trees is important because natural mortality is about 2% a year, so a large sample size is required to detect changes to the mortality rate in any period shorter than a decade. The results derived from this exercise will play an important role in refining the Gap Fire model (see next section), and will also help villagers to understand the proximate impact of their work on forest health.

Tag	Transect: A				Num Trees: 289
			Transect Line		
			START		
			0m		
1	Muhungo (40.8)____	<- 1.4m ->	|		
			128m		
2	Mgongo (58.5)______	<- 2.2m ->	|		
			94m		
3	Mgongo (50.1)_____	<- 1.9m ->	|		
			24m		
4	Mpwipwi (40.7)___________	<- 3.7m ->	|		
			29m		
5			|	<- 2.0m ->	_____Mpwipwi (42.1)
			188m		
6	Mchenga (36.0)_______	<- 2.7m ->	|		
			40m		
7			|	<- 6.7m ->	___________________Mchenga (48.8)
			66m		
8	Mchenga (43.0)______________________	<- 7.9m ->	|		
			242m		
9			|	<- 5.3m ->	______________Muhungo (37.0)
			298m		
10			|	<- 5.9m ->	________________Msenjele (35.7)
			100m		
11			|	<- 2.3m ->	_______Msakala (38.2)
			137m		
12			|	<- 9.6m ->	___________________________Msenjele (34.5)

Figure 26. Sample pseudo-map of large trees found on transects showing tree species (vernacular names) and distances along and off the transect line (figures in brackets are DBH in cm).

Forest Basal Area and Biomass

Ultimately REDD+ is all about carbon sequestration in forest biomass, so the most important measurement is that of total biomass. The DBH measurements of large trees allow basal area and biomass estimates to be computed for each VLFR[50]. Following the path blazed by its highly successful method for determining timber quotas[51], MCDI aims to develop a simplified calculation that will allow villagers to compute approximate biomass directly from DBH measurements obtained in the field without having to refer back to the office or professional foresters. This reinforces that management responsibility ultimately lies within the village, and helps communities to understand better the impact of their own efforts, which is critical to securing long term buy-in and widespread support, as well as bolstering self-esteem which is undermined any time calculations have to be referred back to 'experts in the office'.

Such crude estimates can play an important role in supporting transparent revenue division between different villages that are members of MCDI's group scheme, but will not suffice for VCS which demands greater robustness. To satisfy their requirements, rather than use the large tree only data from the transects, a new map of forest biomass must be generated at least every ten years using a combination of satellite radar data and PSPs as outlined in the section on *Carbon Stock Assessment & Mapping* above. Comparing the results from different data sets should help resolve errors and refine the precision of landscape scale estimates.

[50] Using standard allometric equations, and proportions of biomass found in large trees from PSPs.

[51] In which a look-up table is used to do all the heavy statistical computation.

Monitoring Results

MCDI monitored the impacts of early burning in two VLFRs, Likawage and Nainokwe, in 2014, see example in Figure 27. Due to problems with the extended rains in 2014 (see section on *Fire Management through Wide-Scale Early Burning*) just 7% and 3% of the VLFRs in Likawage and Nainokwe, respectively, were burned that year. As a result late season burns affected 50-60% of the forest in each VLFR, see Figure 28. The proportion of forest affected by early and late season fires in 2014..

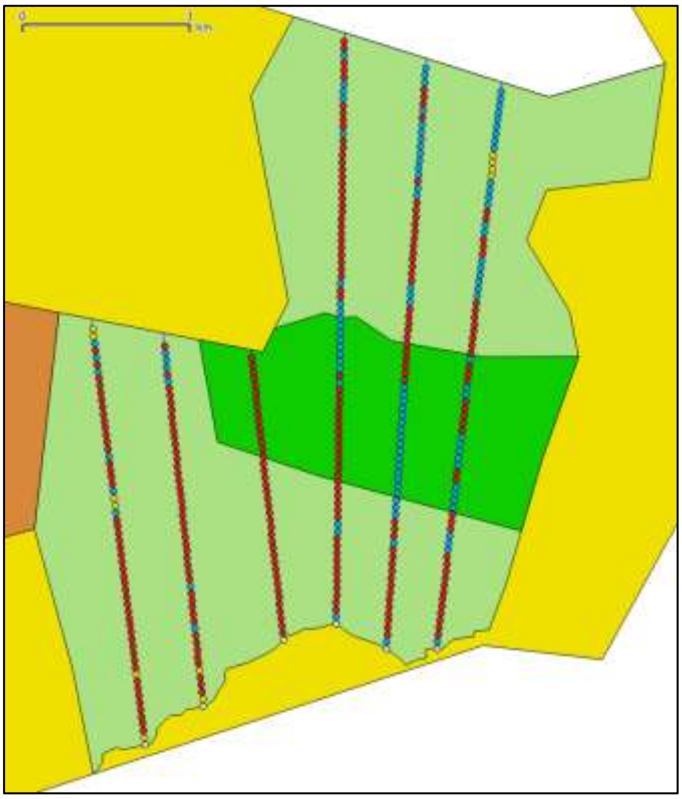

Figure 27. Burned area monitoring results from Nainokwe VLFR in 2014. Dots represent checkpoints: yellow = early burn, red = late burn, blue = no burn.

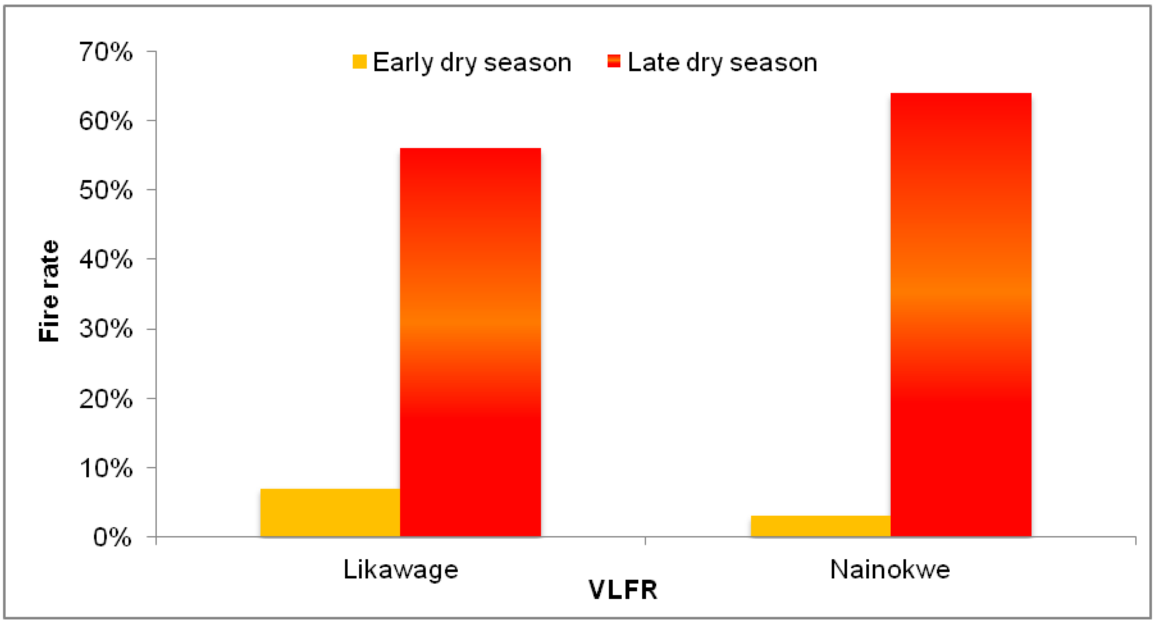

Figure 28. The proportion of forest affected by early and late season fires in 2014.

Modelling Averted Carbon Emissions

The above-described methods to track changes to forest biomass will provide the ultimate measure of the project's success. However, their precision is too poor to operate at timescales much more frequent than decadal. For example, the DBH of a fast growing tree may grow 0.5cm in a single year (hardwood species may often be much slower), but previous MCDI investigations have shown that even professional surveyors taking good care may regularly record DBH measurements that differ by ~1cm, and sometimes up to 2cm, on the same tree on the same day. Furthermore, since mortality is a relatively rare event, the expected carbon benefits from early burning are expected to be <0.5tc/ha per year in woodlands where starting carbon stocks are typically in the range 20-25tC/ha, i.e. an annual adjustment of <2.5%. It would require an exceptionally precise monitoring system to be able to detect such changes on an annual basis.

For a private land owner with deep pockets (or access to bank loans) it might be acceptable to wait 5-10 years for payment, but rural communities will rapidly lose faith in early burning if they have to wait that long to be recompensed. So, in order to derive the annual estimates of carbon savings from community-based fire management, MCDI use the GapFire model, which was developed by their partner, University of Edinburgh, to calculate emission reductions and removals resulting from different fire regimes.

The GapFire Model

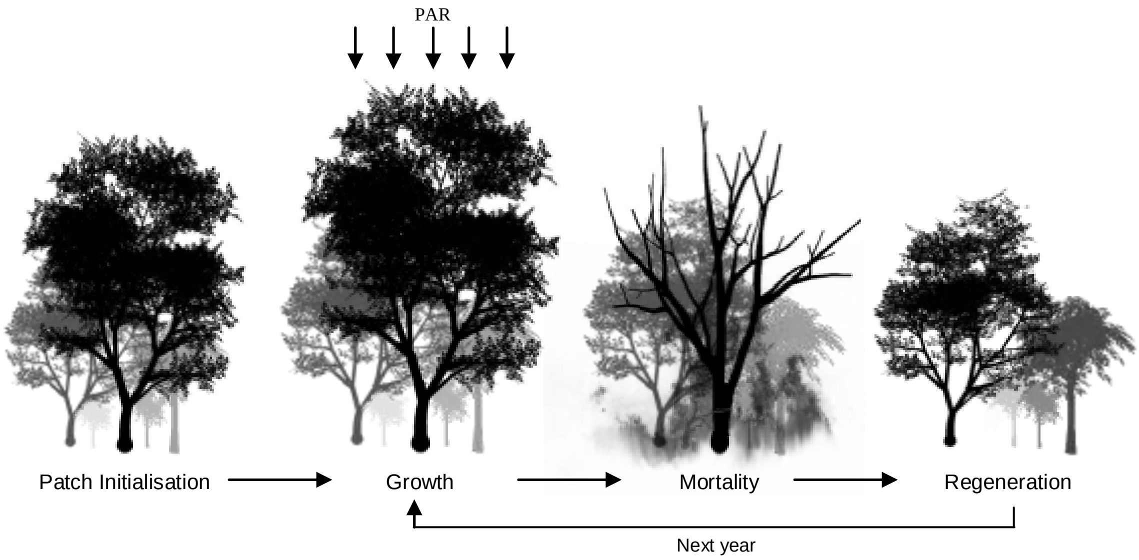

Figure 29. Diagrammatic representation of GapFire, showing patch initialization, growth in response to photosynthetically active radiation (PAR), fire induced mortality and regeneration.

The model name comes from how the death of trees in natural woodlands results in small 'gaps' opening in the tree canopy. These openings in otherwise shaded forest allow for light to penetrate through the forest canopy, stimulating the growth of small trees to re-populate the opening. By explicitly modelling the growth, mortality and regeneration of trees at these forest gaps, the balance between carbon sequestration through forest re-growth and carbon emission from woodland disturbance may be predicted (Figure 29). Gap models are particularly appropriate for describing miombo woodlands where woodland structure is profoundly modified by frequent disturbance events. A gap-modelling approach has advantages from its explicit representation of population structure and variability, its ability to explore the stochastic nature of disturbance events through large modelling ensembles, and because it allows density-dependent feedbacks on growth through light competition.

Model Functioning & Parameters

Gap models work by modelling individual cells or patches that each about the size of a large tree, so in a climax forest most cells are dominated by a single large tree with only a few cells with a gap; in woodlands or non-equilibrium circumstances the number of gaps increases. In order to simplify the model the cells are all modelled independently; thus there is no sense of fire 'spreading' through cells from one neighbouring patch to another (for which there is insufficient data); instead each cell experiences early and late season fires independently with the same probability, which are input parameters. Thus for each model run the following must be defined: historically observed (baseline) and monitored (project) probabilities of Early Burn, Late Burn and No Burn at a patch, each triggering differing tree mortality probability functions, as described below.

The other key input parameter is the starting average biomass. Not all cells are assumed to have the same biomass, instead they are initialised with a collection of large and small stems randomly with a distribution curve derived from the PSP data. So in theory it would be possible to simply run the model once based on the mean biomass of the entire forest area under management. However, since fire history is a partly product of pre-existing biomass (with savannahs more likely to burn than dense woodlands), the model must be run separately per stratum.

Each model run simulates a number of cells. If too few cells are simulated then, the results can be skewed by chance. MCDI's VCS method stipulates a minimum of 100,000 cells should be modelled, which takes about 10 minutes on a fast computer. Smaller model sizes can, of course, be used for testing purposes.

Fire Intensity & Tree Mortality

A key question that had to be answered in constructing the model was how hot are the early and dry season fires in Kilwa? This was estimated using a simplified version of the standard Rothermel model, a semi-empirical model of fire spread that has been widely used to understand variation in fire intensity in a wide range of fire systems. The simplified version adopted (which ignores variable factors such as wind speed) is driven by meteorological data and fuel curing[52] estimates generated from the MODIS archive. This predicted an average early fire season intensity of ~1000 kW/m and a late season intensity average of around 3,000 kW/m (Figure 30)[53].

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[52] I.e. the speed the grass dries out.

[53] Both these estimates are conservative, with the literature suggesting early burns commonly have an intensity of <500kW/m while late season fires range from 500 kW/m to over 6,000 kW/m, averaging around 4,000 kW/m.

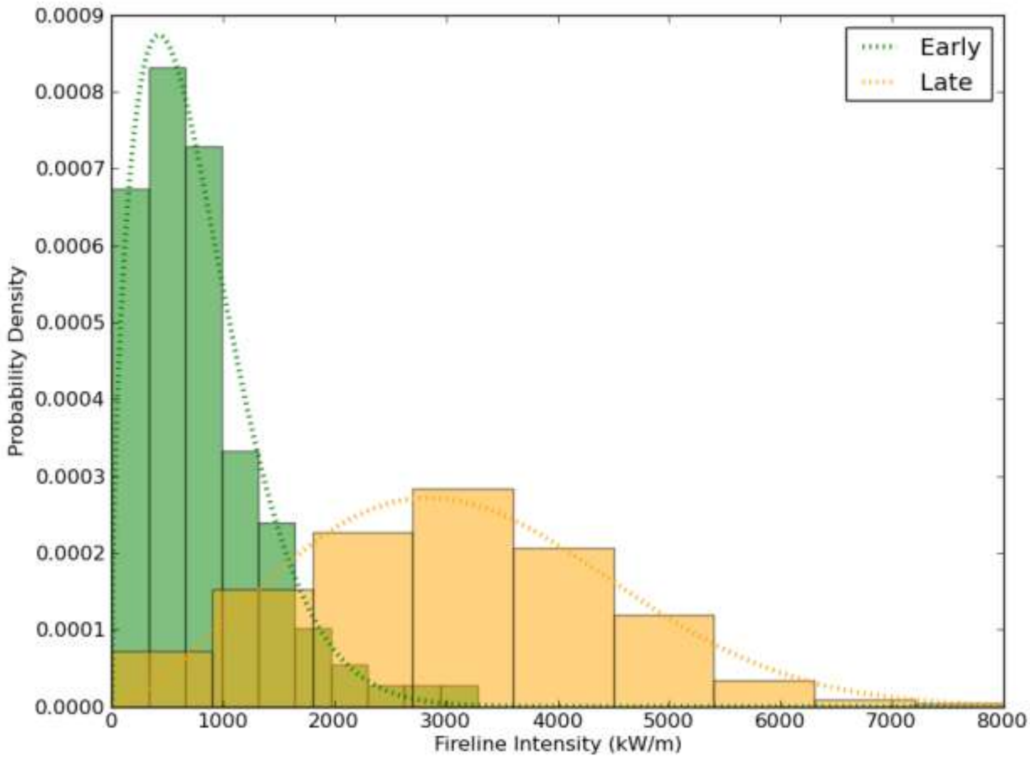

Figure 30. Normalized histograms of early and late fire intensities predicted by the Rothermel model, fitted with Weibull distributions.

Of course, as Figure 30 shows, not all fires are created equal, and thus each year, if a cell experiences a fire then its intensity is generated from the probability distributions illustrated in Figure 30. From the fire intensity the model can then compute for each stem in the cell what is the likelihood of mortality based on controlled burn experiments in Mozambique and Zimbabwe conducted by UoE and others that showed mortality rates for different size trees in different strength fires (Figure 31).

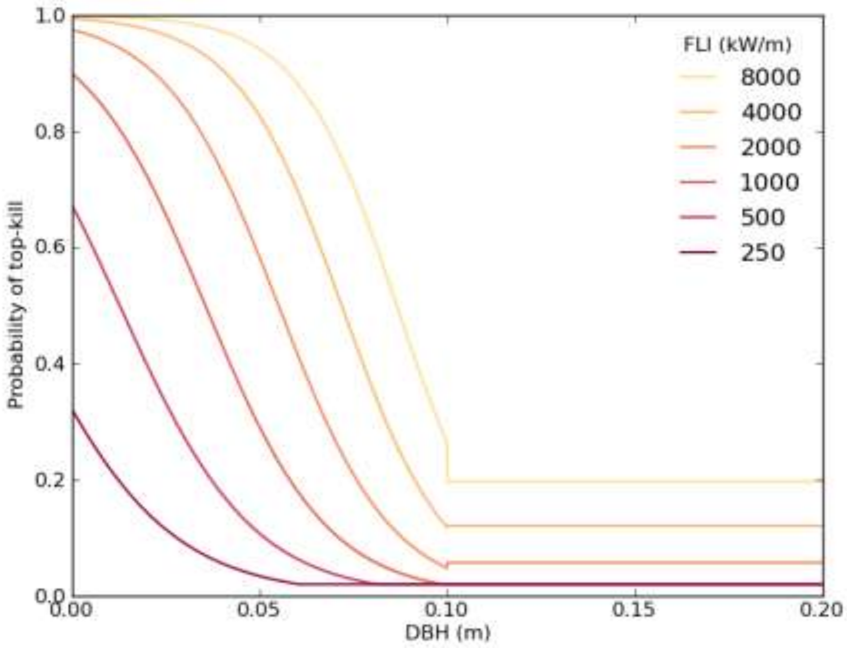

Figure 31. Tree mortality rates (top-kill) from different strength fires (by fire line intensity and stem size).

Model Calibration & Testing

The GapFire model used in this project was developed and calibrated to the Eastern Miombo Ecoregion by researchers at the School of GeoSciences, University of Edinburgh, who have many years of experience researching fire impacts on miombo woodlands in the Eastern Miombo Ecoregion. The model was calibrated to the situation in Kilwa in the biomass distribution curve, adjusting growth parameters to fit the growth rates observed in the chronosequence, and the parameterisation of the Rothermel model.

The model was tested by assessing its sensitivity to variations in each key fixed parameter from 50% to 200% of the central estimate. The parameters to which the model exhibited significant sensitivity (i.e. results varied greatly when the parameter changed) were all except for one parameters for which there is strong scientific consensus and evidence supporting the value chosen within fairly narrow bounds, e.g. the maximum rate of photosynthesis, so the sensitivity to these parameters' values is not a matter for concern. The one exception to this was the late season fire intensity which MCDIhad previously established is conservative with respect to the literature.

Model Output

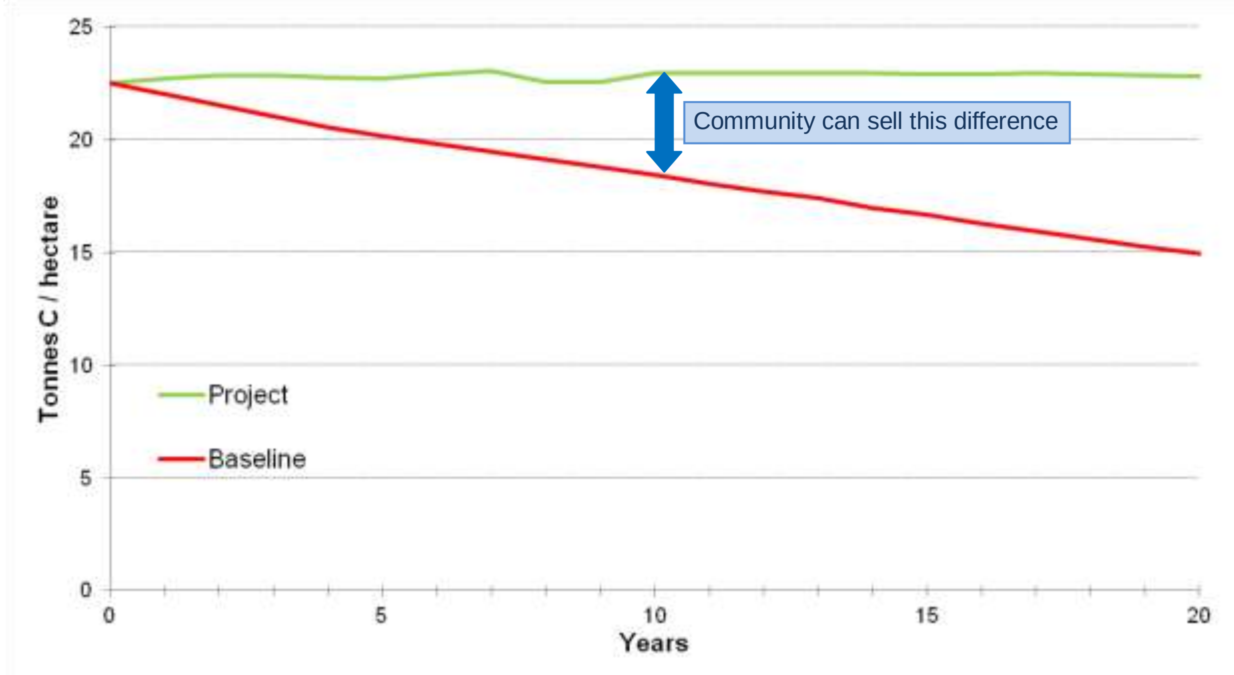

Figure 32. Sample Output from the GapFire model.

The model produces a graphic output showing the predicted changes in the forest biomass carbon over time based on actual recorded fire frequencies and predicted future fire frequencies (which are averaged from the last 10 years). The difference between the two lines is what the communities can sell (less previous sales).

Reducing Carbon Emissions

This output area was expected to comprise of three activities. These are listed under *Activities* on 26 of the *Project Overview*, and explained in detail here.

Drivers of Deforestation in Kilwa

A critical early project activity was to assess the major drivers of carbon losses from forests in Kilwa District[54]. The assessment combined findings from three analytical components:

- A literature review of deforestation in Kilwa
- A field survey of key informants
- Quantitative estimates of each anthropogenic driver of deforestation identified in the previous steps

The first two steps provided the key context; the last step was the all important conversion of those data into quantitative estimates of carbon losses. This was complicated by the severe data deficiency associated with many key variables. The quantification therefore relied strongly on expert estimates. Such reliance introduces a major element of uncertainty, and hence to manage this uncertainty, minimum and maximum likely estimates were made to provide a range around the best guess on each variable. A good example of the procedure is given in , which shows the estimation of carbon losses from charcoal production.

Factor	Min	Central Estimate	Max	Unit
Legal Charcoal Production	7,498	9,372	11,246	bags / year
Illegal Charcoal %	60%	80%	90%	rate of illegality
Legality Rate Multiplier	2.50	5.00	10.00	
Total Charcoal Production	**22,759**	**46,860**	**96,481**	bags / year
Bag weight	45	50	55	kg / bag
Total Charcoal Tonnage	**1,130**	**2,343**	**4,858**	t / year
Kiln Conversion Rate	35%	28%	20%	ratio of charcoal produced to input mass
Kiln Conversion Multiplier	2.86	3.57	5.00	
Woody Mass Tonnage	**3,832**	**8,368**	**18,272**	t / year
Carbon Content	45%	50%	55%	C / t
Total Carbon Lost	**1,904**	**4,184**	**9,195**	tC / year
Stocking Density	5	10	20	t of suitable woody mass per ha
Hectares Affected	*766*	*837*	*914*	*ha*
Carbon Lost per Ha	***2.48***	***5.00***	***10.07***	***tC / year / ha***

Table 7. Step-wise estimation of total and per hectare carbon loss from charcoal production in Kilwa District (min and max product limits computed using Log Normal distribution to reduce range width to some degree).

As can be seen, even after using statistical techniques to constrain the estimated range[55], rather wide ranges result. A similar picture emerged for other drivers of deforestation, which illustrate just how little

[54] For full details see Miya M *et al.* (2012) Drivers of Deforestation and Forest Degradation in Kilwa District, MCDI.

[55] This technique encapsulates the realisation that it if estimates are unbiased then it is unlikely that the true figure for all contributory variables will lie at the same extreme, and the degree to which this applies can be computed by assuming that all minimum and maximum estimates are lower and upper bounds respectively of a 95% confidence interval of a normally distributed variable.

is known in each case as to actual carbon losses. Taken altogether the analysis of the different drivers of deforestation in Kilwa District produced the following estimates for annual carbon losses:

Source	Min	Best Guess	Max
Timber	12,000	28,000	64,000
Charcoal	2,000	4,000	9,000
Agriculture	20,000	44,000	93,000
Fire	0	74,000	450,000
Total	**34,000**	**150,000**	**616,000**

Table 8. Estimated carbon losses in Kilwa District due to different drivers of deforestation (tonnes per year).

However, these numbers are far from the end of the analysis. MCDI's primary goal with this REDD project was to complement its sustainable timber and FSC certification project which MCDI expect to be more lucrative for participating communities than carbon forestry. For this communities ideally want relatively large tracts of forest and woodland which have not been intensively logged in the recent past. These tend to be the least accessible forests of which there is still a substantial area in Kilwa District. For the most part these extensive forested areas are not on particularly fertile land where agriculture is likely to expand in the near future. Were these lands connected with better infrastructure or closer to a major city, agriculture may have expanded to such marginal areas, but, except for along the main north-south road (tarmacked in recent years), with obvious opportunities for easy sales of produce.

Central and southern Kilwa District is still sparsely populated and highly forested. Villages and the farmland surrounding them are islands cleared from the bush rather than the islands of relict forests sitting isolated in a more anthropogenic cleared landscape which are characteristic of other parts of Tanzania. Non-timber forest products, especially woodfuels, can easily be gathered from wooded areas close to villages without having to make longer treks to a specific forest. Thus, at present the only real uses for the larger tracts of forests are logging and hunting, whether for local subsistence purposes or commercially, as part of a government-controlled hunting block.

This situation makes MCDI's proposition to communities much easier. Following a land-use planning exercise they are invited to choose an area of forest for which they have no other significant plans and set it aside as a Village Land Forest Reserve (VLFR). In contrast to some other pilot REDD projects in Tanzania, in which villages are challenged to make the hard choices between forest conservation (funded by REDD) and agricultural extensification, the short-term opportunity costs for villages entering MCDI's scheme are very low. Hence MCDI's approach carries relatively low risk for its partner communities, as they are not being asked to surrender short-term agricultural production options or activities.

These circumstances in Kilwa have consequences for the way that carbon offsets may be generated from an existing deforestation baseline, significantly changing the above calculation. Anticipated carbon losses due to **agriculture** under the Business As Usual scenario are negligible in the targeted forests. An analysis of Landsat images taken in Kilwa between 2000 and 2010 showed actual deforestation in the selected pilot villages for this project to be just 0.2% per year, and most of that was probably outside the potential new VLFRs.

Charcoal is a significant long term threat that provides the major conservation argument for acting now to put Kilwa's forests under devolved sustainable management: extrapolation from Ahrends *et al.* model of demand for charcoal centred on Dar es Salaam[56] predicts major increases in forest degradation resulting from charcoal production in Kilwa from 2020 onwards. Indeed, anecdotal evidence already suggests a significant uptick in charcoal production, especially along the main north-south road, over the last ten years. However, as can be seen from the table above, estimated total charcoal production in Kilwa is still low. The carbon markets will not pay for carbon losses averted ten years in the future, so this driver of deforestation, which was initially expected to be a primary focus of the project, does not actually present opportunities to generate significant carbon offsets over the next 5-10 years.

Timber losses are not insignificant when summed across the entire district, but logging is highly selective, and thus impacts on forest carbon stocks are small proportionately. Moreover, if markets can be found for FSC certified *Julbernardia globiflora* and other species still common in Kilwa, MCDI hopes to support sustainable harvesting across a wider range of species that exceeds the volume currently being extracted from uncontrolled selective logging. Improved forest management can certainly reduce the wastage from the processing of such timber, whilst the volume of wood that ends up in long-lived final products can be excluded from any analysis. Nonetheless net carbon losses due to uncontrolled logging are insufficient on their own to generate significant revenue streams under a REDD project.

Thus MCDI were left only with **fire** as a significant driver of deforestation in the relatively remote forests which provide the greatest opportunities for local communities in Kilwa to generate sustained economic benefits from PFM based on certified timber harvesting. At the time (2010) it was estimated that roughly 60% of the project landscape burns each year[57], mostly during the mid-to-late dry season when new farms are cleared – fire is used as a tool to do this, and often burns out of control beyond the areas selected for farming – and also, critically, when a stiff steady breeze blows, fanning the flames across large areas. A model developed by the University of Edinburgh based on fire experiments conducted in Mozambique suggests that between 0.5 and 1 tonne of carbon can be lost from dry forests as a result of regular (annual) hot fires from a combination of two mechanisms:

- Hot fires substantially increase tree mortality rates. The premature death of just one or two large trees in a year can amount to considerable decreases in carbon stocks.
- Regular hot fires retard regeneration, slowing biomass recovery following large tree deaths.

These findings are summarised in the table below, in which carbon losses from all drivers other than fire are zeroed out (or too small to be differentiated from zero). Note that it differs from the one above in reporting *losses per hectare* of forest.

[56] Ahrends A, Burgess ND, Milledge SAH, Bulling MT, Fisher B, Smart JCR, Clarke GP, Mhoro BE and Lewis SL. 2010. *Predictable waves of sequential forest degradation and biodiversity loss spreading from an African city.* PNAS August 17, 2010 vol. 107, no. 33, pp. 14556-14561.

[57] Remarkably close to the conservative figure of 55% of the landscape that was found burned in our detailed analysis of fire history in Kilwa.

Source	Min	Best Guess	Max
Timber	0	0	0
Charcoal	0	0	0
Agriculture	0	0	0
Fire	0	0.5	1
Total	**0**	**0.5**	**1**

Table 9. Estimated carbon losses in proposed VLFRs in Kilwa District losses due to different drivers of deforestation (tonnes per year per hectare).

Fire Management through Wide-Scale Early Burning

In order to generate carbon offsets, MCDI aims to reduce both fire intensity and fire frequency in the VLFRs, although focusing on fire intensity. MCDI achieve this through a programme of community-based fire management, and pre-emptive early burning in particular (i.e. burning early in the dry season when fuel loads are lower). The basic aim of pre-emptive early burning is to reduce grass fuel loads; this has three direct effects:

⇒ Harder for later fires to catch and spread.

⇒ Any later fires will be cooler.

⇒ Fragments the landscape, interrupting spread of later fires.

Early burning is rarely completely effective, so the aim is not to prevent late dry season wild fires entirely, but instead to reduce their frequency from 40% of the forest burned late in the dry season each year, to 10-20%.

Fires early in the dry season cause minimal damage to the forest:

- Fuel load is low, so fires are cool.
- Cool fires only burn grasses and leave trees unaffected.
- The remaining moisture in some ground vegetation constrains fire spread.
- Cool temperatures means fires self-extinguish over night.

In the programme MCDI designed for this project, communities carry out five management interventions designed to increase woody biomass and regeneration:

1. Preventative early burning around the entire VLFR boundary to create an effective fire break around each VLFR.
2. Preventative burning along both sides of all roads, tracks and paths passing through the VLFR since many fires are lit by local people passing through the forest on these routes.
3. Additional burning to reduce risks around other common fire entry points as may be determined by topography, prevailing winds and local landscape use patterns.
4. Patchwork burning inside each VLFR. (Decades of experience of fire management in places such as South Africa and the American Mid-West have shown the folly of attempting total fire exclusion that leaves dry forests vulnerable to occasional catastrophic fires which are far more destructive than more frequent managed fires. Thus VLFRs are burned on a patchwork basis with the intention of ensuring every part of the VLFR that is vulnerable to fire burns every few years, aiming for an average fire return interval of around three years.)

5. Supplementary additional burns later on where grass fuel loads have returned. This could be either as a result of regeneration – perhaps following isolated rain showers after the end of the main rainy season – or where some of the grasses were too wet or evolved to resist fires and thus had not burned in the main early burn.

This approach is appropriate in a semi-arid environment such as miombo woodlands; the ecosystem is fire-adapted and some species are dependent upon fire as part of their natural lifecycle, e.g. *Pterocarpus spp.* for seed germination. Villagers are for the most part well experienced in the use of fire, so training from scratch is not required; instead communities need training on how to conduct wide area landscape management by fire, and advice and guidance around planning early burning operations.

Fire Management Planning

Fire is a hard beast to tame: one cannot just burn where one wants when one wants; instead fire is apt to behave erratically, in ways that can only partially be predicted. Apart from weather conditions on the day (especially wind direction) there are a number of constraints to deliberate burning:

- Topography shapes where fires come from and how they spread.
- Borders and tracks through the forest present particular vulnerabilities, but also act as natural fire breaks.
- Different areas of forest dry out at different speeds.
- Even different grass species dry out differently.

Hence, planning is critical to the success of any fire management programme. For this project MCDI helps each community to put together a detailed plan as how they will fire within their VLFRs. This starts with an introduction for villagers explaining the importance of fire management, and how local agricultural practices impinge on the frequency of fires and thus the health of the forest. Then the discussion moves on to cover how the impacts of late season fires can be controlled and mitigated by early burning. The step to doing this is development of a participatory map of the forest showing the key features from a fire management perspective; see the example shown in Figure 33.

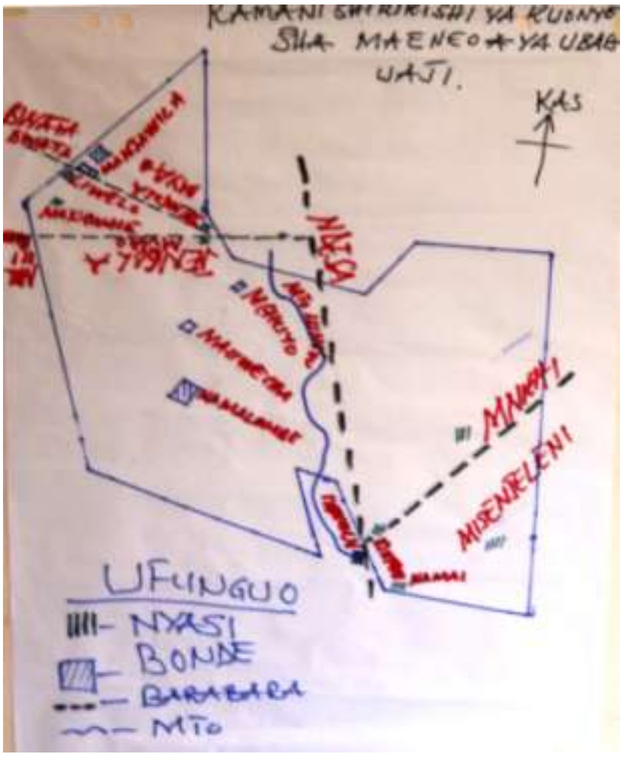

Figure 33. Participatory Fire Control Map of Likawage Long'ou VLFR.

Each Village Fire Management Plan then follows a basic structure[58]:

- Introduction
- Fire Vulnerabilities
    - Length of forest border
    - All roads, tracks and footpaths passing through the forest

[58] See MCDI's template Village Fire Management Plan for more detail.

  - Prevailing wind direction (usually from the East)
  - Notable entry points
  - Areas in the forest prone to burning
- Speed of Drying (fast and slow drying areas)
- Early Burning Protocol
  - Preparations before Burning
  - Type of Burning
  - Burning Operations
  - Post Burning
- Early Burning Schedule
- Participatory Fire Map of Forest

Once the rains have more or less ended and the time for early burning approaches it is important to monitor the rate at which the grass in the forest is drying on a weekly and then almost daily basis so as not to lose critical time within the short 4-6 weeks window each year in which early burning is possible before the grass is too dry to burn in a safe and controlled manner [59].

Wide-Scale Burning

MCDI currently support VLFRs covering more than 100,000ha across Kilwa District. When early burning, MCDI aim to burn 30-40% of each VLFR each year, so need to reach around 10,000ha per week in order to complete it all within the 4-6 weeks window. Such wide-scale early burning cannot be achieved by traditional fire management techniques commonly used in Tanzania. These are highly labour intensive and suited to controlled burning of a few acres at a time when clearing new fields or to establish firebreaks to protect houses and other vulnerable assets. This became clear during trial early burning efforts in 2012.

MCDI therefore hired an Australian expert on fire management, Robin Beatty, to advise on how to burn large areas of forest quickly and efficiently. He introduced the ‘drip torch’ which deposits small drops of burning fuel on to the ground as one walks along. Although the diesel-petrol mix required is considerably more expensive than using matches, this is more than offset by the rapid pace at which fires can be started. An indigenous improvement over previous early burning efforts involved the construction of proper fire beaters from local materials based on a design used in plantations in Iringa. This made it significantly easier to control fires that threatened to cross fire breaks.

[59] See section on *Fire History* for a full explanation.

Figure 34. A drip torch and its use.

This method of early burning also relies on the fact that early in the dry season fires will burn out of their own accord over night when the temperature drops (possibly related to the dew point). Later on in the dry season overnight temperatures do not drop so low, and fires keep going (even if not burning very strongly or moving fast) so that they can last several days. Thus it is generally best to assess progress each day and plan the next fires in the morning, but to do most of the burning in the afternoon. By then any overnight dew on the grass will have dried out, so fires catch more easily, although it can be windier, and caution must be taken with a sometimes swirling wind.

Figure 35. Wide-scale community early burning using drip torch and fire beaters.

Fire is, of course, dangerous, and so there are a few protocol points that must be followed to ensure early burning is conducted safely, with no danger to either life or property. Preparations before burning should therefore include:

- Train the fire crew (refresher training may be appropriate)
- Agree fire crew responsibilities to prevent fires escaping or causing injury
- Ensure all necessary equipment on hand and in good working condition
- Inform people in all nearby villages

And during burning operations:

- No burning should take place when it is too windy to reliably control the fire.
- Only small, well-distributed fires that are easier to control should be lit.
- Burning should be conducted using back fires, lit against the wind.
- Where no suitable natural fire lines or pre-burned areas exist to control each fire, small artificial fire lines should be created so as to avoid spread of fire.

To date all early operations have been strongly supported by MCDI field staff. However, in the longer run MCDI aim to train up community teams to manage this process themselves, thus controlling costs, and allowing early burning to be performed across wider areas.

Early Burning Efforts to Date

In 2013 MCDI trialled early burning in Likawage, with a smaller effort in Ngea and some training for villagers from Nainokwe and Nanjirinji A. The forest at Ngea was found to be too wet without sufficient grass cover to be suitable for early burning: timber extraction will now be the principle revenue earner for Ngea, using support from other grants. Also MCDI had relied on third party assessments of whether the forest was dry enough to burn with the result that early burning started a little late. Nonetheless in the single VLFR assessed (Likawage) community Fire Crews managed to burn 35% of the forest before it became too dangerous to continue; meeting the project target.

In 2014 MCDI rolled out early burning to six villages: Likawage, Nainokwe, Nanjirinji A, Kikole, Kisangi, and Liwiti. In each village this was preceded by a review of the Fire Control Plan and training for those Fire Crew team members who had not previously participated in early burning. Unfortunately this was hampered by late running rains which may have been linked to an emerging *El Niño* phenomenon in the Eastern Pacific. Rainfall records for Kilwa suggest this happens about once every five years, which roughly equates to the frequency of *El Niño* phenomena. No burning was possible before June, and only a little in the first half of June.

This created a significant management challenge because the VCS Methodology requires a defined cut-off date that signals the end of the early dry season when fires are less harmful. When averaged out over many years, rainfall follows a clear pattern (see graph below), but on a year to year basis it is highly variable (see above graph). Neither is it the case that the standard curve is simply shifted about in time from one year to the next: in some years it more or less stops raining, and then there is a small late burst (e.g. see year 2000 above in which there is a ~4 week break between significant rainfall events in May/June). Thus, even if MCDI were able to monitor grass moisture levels with scientific precision to guide early burning, the complexity of rainfall patterns means it would be unable to reproduce that historically as is needed to determine the baseline scenario.

As discussed in the section on *Methods for Assessing Forest Carbon* above, in MCDI's VCS methodology they adopted a fixed date to mark the end of the dry season, to be determined by expert consultation, with a default of 30 June. In about four out of five years it should be possible to complete early burning by that date, but around 20% of the time it will be difficult; it is unfortunate that was the case in this project's first full year of early burning.

However, that does not mean that one should stop early burning on 1st July every year. The VCS methodology uses the GapFire model to predict the GHG emissions averted by early burning, but this is validated at least once every ten years when the carbon biomass map is updated. If at that point the forest is found to store more carbon than predicted, the additional amounts can be monetised and sold as carbon offsets. The purpose of the GapFire model is thus to allow annual claims so that communities can begin earning revenue sooner. Hence, if the forest is still not too dry on 1st July, as was the case in 2014, then early burning can continue until such time as the forest has dried out sufficiently for fires to harm standing trees. Saleable offsets may, however, be a little lower in any such year, as some of those burns will be treated in the model as damaging late season fires.

As well as the late running rains, there were also unseasonal light showers many days in the afternoon. This required MCDI to adapt their early burning method: instead of lighting fires freely in the late afternoon and allowing them to burn out overnight (as will be the case early in the dry season due to night time temperatures dropping below the dew point), more was burned in the middle of the day.

Fire management theory suggests that it is best to avoid burning the same areas of forest each year so as to allow the forest time to recover. However, in practice it is hard to do this. Forest boundaries and other entry points (i.e. along tracks and paths that pass through the forest) need to be burned any way so as to provide protection. Then the topography of the landscape will also inevitably shape fire spread, meaning some parts will burn just about every year without time-consuming and expensive construction of fire breaks (not currently part of MCDI's strategy), and other parts will burn very rarely, such that over time the grassy layer maybe replaced with thicker vegetation. Although anticipated to a degree, this was clearly apparent to Fire Crews in 2014, further exacerbated by the extended rainy season which meant that grasses in areas not burned the previous year were amongst the wettest and slowest to dry out. Meanwhile the areas burned in 2013, slightly drier as a result in 2014, were in danger of becoming a fire risk, so many had to be burned again.

Accessibility to some of the more remote parts of the forests was also a problem. The long term solution will probably require judicious clearance of access roads and tracks: but this will need to be carefully planned so as not simply to open up the forest to illegal logging, and will thus need to go hand-in-hand with additional patrolling. Under FSC rules new roads should also be subject to a basic Environmental Impact Assessment so as to minimise damage to the forest and long term erosion. All these factors combined to limit the area burned in each VLFR in 2014 to an average of 5% against a target of 30-40%. The early burning focused on the fire entry points (forest boundaries and either side of tracks). So long as the majority of these have been burned there are still good chances that this will protect a lot of the forest from more damaging later burns. However, later monitoring showed that 50-60% of Nainokwe and Likawage's VLFRs burned in the mid-to-late dry season in 2014, suggesting that for this hypothesis to hold, then early burning coverage needs to exceed 5%.

Equitable Benefit Sharing

This output area was expected to comprise of six activities. These are listed under *Activities* on 26 of the *Project Overview*, and explained in detail here.

Improving Village Governance

Village leaders capacity to represent their constituents is determined by their ability to listen to and understand constituents' concerns, and to report back to constituents the outcome of meetings and activities at which they have represented the village. Prior to this project, village elected representatives rarely consulted with the wider community on important issues, and even less frequently reported back fully on the work in which they have been engaged. As a result of the measures described here, however, there is evidence that this has improved, and this is discussed in the section *Monitoring Changes in Village Governance* below.

MCDI focused on the Village General Assembly (VGA) – a community-wide meeting which, by law, should occur quarterly in each village – as a key mechanism to improve village governance. Training was provided to Village Council and VNRC members in each village on what it means to be accountable to their constituents, encouraging detailed and regular reporting back to the VGA of all issues and actions related to forest management. MCDI were also able to contribute to improving local governance by regularly attending VGA meetings; this helped for a number of reasons:

- Attendance was higher when communities became aware that someone from MCDI or the District Council would be attending the meeting;
- Community members were more motivated to talk and readier to raise issues;
- Village leaders were more transparent in how they report issues of substance.

MCDI attended each quarterly VGA in each target village, and assisted the Village Council and VNRC to compile reports to the village assembly on their activities over the past year. They worked with VGAs to raise local expectations of the standards of governance, which is crucial to accountability. Attending VGA meetings also provided MCDI with an opportunity to see how meetings are conducted, and how different groups, including women, participate and engage (gender differences and the implications for project implementation are discussed in the section *Cross-cutting Issues* below). It provided a means for MCDI to listen and respond to issues raised by the entire village directly, rather than through village leaders, and helped assess and understand the perceptions of the wider community, especially in relation to mechanisms of benefit distribution from forest management.

However, this is not a sustainable solution; eventually communities and community leaders need to become accustomed to providing this degree of transparency as a matter of course. Therefore, over the four VGAs each year MCDI gradually reduced the amount of assistance provided, such that by the fourth meeting of the year the Village Council and VNRC were able to put together and present their own reports with minimal assistance. In the final year of project implementation, MCDI staff attended just one – the final – VGA.

Transparency in financial management is one of the most important requirements of good governance. After setting aside a VLFR under PFM, communities themselves choose how to spend the money derived from the encompassed natural resources, including timber and carbon offsets through REDD+. A key first step to reduce conflict between the VNRC, the Village Council, and the wider populace as communities begin generating forest-based revenues is to agree on how to split revenue earned from the

VLFRs. VNRCs need to retain enough funds to continue to manage the VLFR effectively, and the Village Council needs to understand that point. Conversely, once adequate profits are being made from the VLFR, the VNRC should hand these over to the Village Council as a dividend to be spent on village development activities. Clarity on this sensitive financial issue is crucial if the village is going to manage its VLFRs successfully, and MCDI advised the VNRCs and the Village Councils in each community to make transparent and properly-minuted decisions on the matter. These were then presented to the VGA for its approval; this is important for accountability, ensuring that all villagers can understand the decisions their elected representatives are taking on their behalf.

MCDI assisted each VNRC to open a separate account at the National Microfinance Bank in Kilwa Masoko. Since rural villagers have very little experience of such financial matters, MCDI also provided a certain amount of hand-holding support to villagers over the first year in transacting affairs at the bank. Basic financial planning skills are a necessity if village revenue is going to be used to the greatest benefit of the whole community. MCDI provided ongoing training to the VNRCs on how to keep financial records, including assisting each VNRC to prepare simple annual accounts and to present them to the VGA. These accounts separate out income and expenditure into a number of easy-to-understand categories, and the wide community were encouraged to question each item so they can understand where it comes from.

Socio-economic Theory of Change

In constructing a theory of change of project socio-economic impacts, MCDI drew upon livelihood impact assessment theory and the CCB Alliance Social and Biodiversity Impact Assessment Manual for REDD+ Projects[60]. A pathway to project impacts on local livelihoods was considered that begins with activities, which then lead to outputs, outcomes and finally impacts. Outputs are the tangible short-term results of the project activities and normally take the form of products or services provided during the project lifetime, e.g. the number of VLFRs identified and established, or the number of VNRCs trained to perform forest patrols or early burning in the forest. Outcomes are the short- and medium-term changes experienced by project villages and local households and/or by the physical environment as a result of the project. Each of these outcomes relates to a broader category of project impacts, i.e. the end results sought by the project, especially as regards net social changes.

MCDI conceptualized the expected impact of the project as improved local governance of forest resources and equitable poverty alleviation, but this is not measured due to the highly complex nature of multi-dimensional measures of development. Instead MCDI focussed on developing rigorous systems to measure the outcomes brought about by project activities on village governance and local households, as described in the sections *Monitoring Changes in Village Governance* and *Socio-Economic Impacts on Households* below. It was expected that the project activities would result in the following social outcomes:

1. Improvement in the rate of local participation in forest management and governance at village level as a result of effective and fair institutional change, increased accountability in decision-making and the collective administration of timber and carbon offset revenues;
2. Fair distribution of the potential costs and benefits related to forest management, as well as increased knowledge about the project and its activities;

[60] Richards, M. & Panfil, S. 2011. Climate Community and Biodiversity Alliance Social and Biodiversity Impact Assessment Manual for REDD+ Projects: Part 1 – Core Guidance for Project Proponents. Climate, Community & Biodiversity Alliance, Forest Trends, Fauna & Flora International, and Rainforest Alliance . Washington, DC.

3. Elevated household income due to increasing participation in project activities, such as patrolling and controlled early burning; and,
4. Reduced households' vulnerability and improved adaptive capacity resulting from the potential investment of additional income in livelihood diversification and household assets.

MCDI developed a theory of change for each of these outcomes, and came up with appropriate indicators to allow progress to be monitored against achieving the desired change, as detailed in *Table 10* below. Broadly speaking, it was hypothesised that the longer a villages' involvement in project activities, the more likely it would be that local households would:

a) Be knowledgeable about project activities, and more likely to perceive the project positively; and
b) Show a higher level of wealth, controlling for other explanatory variables. This is because it is expected that households from early participant villages would have derived higher economic returns via different types of project fees. Such fees can translate into increased savings, increased number of material assets or increased housing quality.

Impact	Outcome	Indicators	Theory of change
Improved forest governance	Governance & participation	Forest governance scorecard	The project is expected to contribute toward better forest governance and higher levels of participation in decision-making, which should lead to a better distribution of PFM benefits. This should also contribute to mitigate potential elite capture of benefits and promote procedures for transparency and accountability in forest management, including benefit sharing.
Poverty reduction	Income	Household income; Housing quality index; Durable goods.	In the short term, the project should bring small financial incentives for participation in research surveys, project meetings and employment opportunities. In the medium to long term, it should bring new income streams from timber sales, and maybe from carbon offset revenues. Since early participatory exercises revealed that spending on housing and assets is a top priority at household level, MCDI consider improvements in durable assets and housing quality as important and locally relevant indicators of poverty reduction.
	Vulnerability & adaptive capacity	Livelihood diversity; Human capital (education years); Social capital (institution count).	Alongside income and assets, local communities prioritize reduced vulnerability to environmental and economic shocks. It is hard to measure this directly so it is theorized that the project should reduce vulnerability by measures that increase the capacity to adapt to and recover from shocks. Livelihood diversification is seen as a way of reducing exposure to specific hazards. The project may help to diversify livelihoods via new employment opportunities and income streams. Human and social capitals are asset classes that typically survive intact and facilitate recovery from shocks. Increased income from project activities may also enable families to send children to school.

Impact	Outcome	Indicators	Theory of change
Equity	Distribution	Project cost/benefit assessment (by gender, wealth, location); Income distribution (Gini coefficient).	The project should contribute to a better understanding of the project benefits and potential costs across households over time. Ideally, the project should avoid becoming a source of income that leads to increasing income inequality across households.
	Procedural	Project knowledge (by gender, wealth, location); Participation (by gender, wealth, location); Change to accountability and control.	Procedural equity is an outcome in itself (normative benefit - it is the right thing to do), leads to better decisions (substantive benefit), and better acceptance of decisions (instrumental outcome). The project should thus over time contribute to improved levels of knowledge about MCDI activities and foster participation in project meetings and forums, differentiated by gender and wealth and location. The project should lead to an increased sense of empowerment over local resource use, and increased local control over forest resources.

Table 10. Expected social outcomes of the project.

There are three different approaches that are commonly used to document positive and negative social change resulting from project activities, as follows:

1. *Expected with-and-without project scenarios.* This involves the identification of a baseline scenario of social change without the project and plotting an expected (and eventually measured) social change against this baseline.
2. *Matched with-and-without project monitoring.* This involves use of control villages selected for their similarity (match) with participant villages. By monitoring both sets of villages, one looks for changes that take place in participant villages but not in control villages, or at least not to the same degree. Where supported by the 'theory of change', this provides strong indication that observed changes are indeed the result of the project activities.
3. *Before-and-after monitoring.* This involves a baseline study in each participating village, so that change over time can be observed.

MCDI do not have available time series data for social indicators such as housing conditions, durable assets, income levels or food security for the project villages, and are not confident that asking people to employ memory recall for reconstructing past trends in these and other indicators will lead to accurate data; this rules out option 1. A combination of option 2 and 3 above was therefore used. Although MCDI do not have baseline data required for before-and-after monitoring, he organisation began implementing PFM in some villages as early as 2004, and therefore it was able to differentiate between 'early entry' and 'late entry' villages, depending on how long they have been implementing PFM/FSC, and more recently REDD+ early burning activities, and control villages.

This was done in the 15 villages listed in Table 11 below, each of which was classified into one of three categories, as follows:

- **Early-entry** – these four villages had worked with MCDI prior to its REDD+ pilot project (i.e. prior to 2010) and had already benefited from timber sales in different years;
- **Late-entry** – five had either signed a REDD+ agreement and started piloting controlled early burning activities – but not yet developed their PFM/FSC processes – or were in the process of doing so

- **Control** – six villages were selected as controls. The control villages were selected because they matched with participant villages in respect to their population size and position relative to the main Kilwa-Dar road.

Name	Popn	PFM	FSC	Timber sold	REDD+ preparation
Early Entry					
Kikole	1,271	2004	2009	2009	Conducted early burning in 2014
Kisangi	847	2005	2009	2011	Conducted early burning in 2014
Liwiti	238	2009	2010	2011	Conducted early burning in 2014
Nainokwe	386	2009	2010	2011	Conducted early burning in 2013 and 2014
Late-Entry					
Likawage	2,638	2010	2013	None	REDD+ preparation since 2010; conducted early burning trial in 2013, and early burning in 2014
Mandawa	4,132	2010	2014	None	REDD+ preparation since 2010
Mchakama	1,313	2010	2014	None	REDD+ preparation since 2010
Mitole	2,730	2010	None	None	REDD+ planned
Ngea	423	2010	2014	None	REDD+ preparation since 2010; conducted early burning trial in 2013
Control					
Mtyalambuko	1,923	-	-	-	-
Ngorongoro	No Data	-	-	-	-
Nakiu	1,703	-	-	-	-
Mtandi	719	-	-	-	-
Nandete	3,395	-	-	-	-
Mbwemkuru	1,243	-	-	-	-

Table 11. Villages sampled during household surveys and participatory governance assessments.

Monitoring Changes in Village Governance

Protocols for Monitoring Village Governance

Project activities are expected to contribute to, create new, or improve existing community-based institutions for forest management. In this context, MCDI considered it critical to monitor for both positive and negative results of project activities on village forest governance and people's livelihoods. This is also important in light of emerging global REDD+ guidelines, which require REDD+ projects to respect the institutions, knowledge and rights of local communities, and operate with their full and effective participation[61]. Although MCDI committed to demonstrate rigorous systems for monitoring governance and social impacts arising from the project, there were previously no clearly established methods for assessing such work. MCDI therefore worked with its partners at the University of East Anglia to develop a new method to score villages' governance.

[61] Appendix I of the 16th Conference of the Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC).

The first task was to assess the local institutional governance processes that were happening in the communities engaged in PFM; this information would then be used to establish a protocol that could be repeatedly used to monitor the process over time. MCDI did this using a participatory action research approach[62], which allowed data and insights to be generated on how the communities were performing, and to ensure that the quality of the data generated could be verified by corroborating responses from different community members. The method also allowed the communities to be included in the process, helping raise their self-awareness and strengthen their functioning. There are however flaws to adopting such a technique, as it necessarily depends on a mixture of some objective measures, but mainly on the subjective perceptions of local people. The success of the approach is also highly dependent on the skill of the facilitator to test and validate community perceptions by probing responses and requesting example-based evidence to confirm them.

The governance scoring system (see Table 12 below) was initially developed in 2010, following a week of visiting villages to develop, refine and pilot the method. It consists of a series of indicators which are assessed under nine criteria covering different aspects of good governance. These were developed from CIFOR literature on forest criteria and indicators[63] and adapted using research methods applied for community forestry in Nepal[64]. They include considerations of accountability, transparency, corruption, open communication, financial and management competence, and faithfulness of representation.

Criteria and Indicators		Scoring thresholds		
		+	~	-
Criterion 1. User Organisation & Cohesion				
A.	Is there a VNRC in the village (2011: & is everyone involved?)	All included	Almost all	Exclusions or no group
B.	Does everyone in the village participate in the VNRC activities (including meetings)? (2011: Are all the **legitimate forest users included** in the PFM Group, and does the Council take into account the **needs** of all legitimate forest users?	Yes	Mixed	No
C.	Does the Council take into account the **needs** of all legitimate forest users? (2011: Besides the VNRC **is there another forest management group** (eg. group of villagers involved in PFM)? If so what are its main objectives?	Yes	Mixed	No
D.	Whose forest is it? Is there a **sense of ownership** of forest amongst villagers?	strong	moderate	weak
E.	What do you do when outsiders enter your forests illegally? Do you **assert control** (i.e. obstruct / apprehend / punish?)	Challenge & exclude	Moderate efforts	Open access
F.	Do all the villagers who use the forest **cooperate** in looking after the forest?	>2/3 united	1/3-2/3	<1/3 united
2. Communication & Awareness				
A.	Are all forest users fully aware what PFM is about and who is or should be involved?	>2/3	1/3-2/3	<1/3
B.	Are users aware of roles & responsibilities regarding the use and conservation of the village forest?	Fully	Somewhat	Not
C.	Does the community know what REDD+ is? [new question in 2014]	Fully	Somewhat	Not
D.	Did all villagers understand the MCDI REDD project agreement and agree to it? [for villages where this applies]	Most-all	Some / majority	None-few
3. Decision-making & Implementation[65]				
A.	Is there regular committee & assembly interaction? Eg. How many village general assembly meetings held last yr?	V. good 4	Medium-good 2-3	Poor 0-1

[62] Chevalier, J. M. and Buckles, D. J. 2013. Participatory Action Research: Theory and Methods for Engaged Inquiry. London: Earthscan

[63] Prabhu, R., Colfer, C.J.P., Dudley, R.G. 1999 *Guidelines for Developing, Testing and Selecting Criteria and Indicators for Sustainable Forest Management* http://www.cifor.org/acm/methods/candi.html

[64] Springate-Baginski, Oliver, Om Prakash Dev, Nagendra Prasad Yadav and John Soussan 2003 *Institutional Development of Forest User Groups in Nepal: Processes and indicators* in Rural Development Forestry Newsletter 26 (ODI: London)

[65] In future assessments this could be usefully split into 3 sub-criteria for VNRC, VC and VGA, which may show varying results, and which would be interesting to track separately (some institutions often function more effectively than others).

Criteria and Indicators		Scoring thresholds		
		+	~	-
B.	Do ordinary villagers attend general assembly discussions?	>2/3	1/3-2/3	<1/3
C.	Is the decision making inclusive of whole village community? Eg Number of people not in leadership positions recorded as speaking in general assembly? *Check records	Good > 10	Medium 5-10	Poor 0- 4
D.	Does each *sub-village* have discussions contributing to VNRC, Village Council and/or General Assembly etc?	Yes	Somewhat	No
E.	Are the specific concerns of the different sub-villages considered in general village meetings?	Yes	Somewhat:	No
F.	Are the agreed decisions at the VNRC, VC or VGA meetings actually implemented? [Check last year's record book]	>2/3	1/3-2/3	<1/3
G.	Is there any political interference / factionalism affecting forest management?	No	Somewhat	Yes
H.	Communication – are decisions taken in VNRC, VC, VGA meetings clearly communicated – e.g through a notice-board? [new question in 2014]	Yes	Somewhat	No
4. Forest Management				
A.	What percentage of the village forest reserve boundary is marked?	>95%	25-95%	0-25%
B.	How has the village forest reserve changed over the last 5 years?	Improving	Stable unchanging	Deteriorating
C.	How have the other village forests changed in the last 5 years?	Improving	Stable unchanging	Deteriorating
D.	Is the forest protection effective? E.g. enforcement of management plan measures; protection against outsiders extracting, timber felling, grazing, fire etc.	Fully effective	Moderately	No
E.	Do you have a forest management plan? If so to what extent implemented?	Fully implemented	Partly implemented	Not implemented
5. Forest product access & distribution				
A.	Are villagers' household forest product needs met? E.g. fuelwood, fodder, any other basic needs	Easily fulfilled	Hard but possible	Difficult or not possible
B.	Can villagers still easily collect/harvest forest products for sale/business?[66]	Easily	Moderate	Difficult
C.	Can villagers' use the forest equally? Or do some villagers or outsiders have preferential access for some reason? (May include bushmeat)	Fair / pro-local	Moderately fair	Unfairly pro-outside
D.	Are forest products used sustainably or are they declining? (That is all forest products from surrounding forests)	Stocks secure	Moderate stocks / at risk	Stocks declining
6. Gender and Equity Consideration				
A.	Do women actively participate in village meetings? What is the % of comments coming from women in VNRC, VC and VGA?	>33%	10% < 33%	<10%
B.	Are the rights, duties, punishments the same for everyone?	Yes always	Mostly	No, unfair
C.	Are the needs of the families that depend more on the forest, either formally or informally (eg charcoal makers, timber harvesters, honey producers, etc) specifically considered in forest management and use?	Favourable consideration	Somewhat	No
7. Economic / Fund development				
A.	Is the use of the forest generating cash for the village? If so, what are the sources of this cash?	Significant	Modest	No
B.	Is the money obtained from the village forests for the benefit of the community managed transparently by village authorities and the VNRC?	Full transparency & general knowledge	Some understanding	Unclear
C.	Is the use of money coming from forest use agreed openly by everyone in the village council (or VGA)?	Very democratic	Moderate	Unclear
D.	What % of forest management incomes / profits are used for community development? (*see project plan)	Significant (>45%)	Modest (<45%)	None
8. Conflict management				
A.	Are there any disputes among community members and/or between community members and the government regarding forest management? Community Forest	No	Moderate	Significant
B.	Are the conflicts discussed above managed & resolved effectively?	Effectively managed	Moderately	Poorly
9. Linkage and Network development				
A.	Are the regional or national forestry departments supportive and helpful? E.g. Have they offered training for sustainable forest management/backup for enforcing rules?	Helpful	Neutral	Cause problems

[66] Note the answer may properly be no, since commercial use of the forest is regulated

Criteria and Indicators		Scoring thresholds +	~	-
B.	Does your village work with other organisations related to forest management? E.g. Non-governmental organisations, logging companies	Good links	Moderate	None-Poor
C.	How beneficial is the relationship of the village with these other stakeholders for the management of your forest?	Very satisfactory	Satisfactory	Not very
D.	How is the VNRC's relationship with the Village Executive Officer?	Friendly & Cooperative, proactive support given	Moderate: basic cooperation, no significant disputes	Poor: non-cooperative and/or significant disputes

Table 12. Scoring system used to assess village governance.

The scoring method was piloted in several villages in late 2010, and, once finalised, was then rolled out to perform governance assessments in 15 villages in 2011, and then again in 2014. The villages involved with governance monitoring were the same as those selected for household surveys for poverty assessment (see *Table 11*), i.e. four early-entry villages, five late-entry villages and six control villages. This allowed changes in the quality of forest governance to be assessed over time, as well as differences between villages in respect to the length of time they have been supported by MCDI.

The scoring was done through group discussions – including members of the VNRC and wider community – lasting around 90 minutes. The nine criteria were introduced in turn, and indicators discussed in the order they appear above. The group was also encouraged to discuss what actions can be taken to improve this score in the future, and these, along with any additional key issues raised, are noted down. Inevitably, like Transparency International's global corruption ratings, the system suffers from a fair degree of subjectivity, but nonetheless scores are sufficiently robust to allow comparisons between villages in similar situations, and to show changes over time.

To facilitate analysis, each score was given a numerical value (a negative score was given a value of -1; a neutral score was given a value of 0, and a positive score was valued at +1), and these were summed to provide an overall value for each criteria (based on the sum of its indicators), which is then divided by the number of indicators to produce an index. To compute the final score for each village, the final values for each criteria were summed and then divided by nine (the number of criteria), also resulting in an index. This approach means that new criteria, indicators and/or villages can be added in successive monitoring without compromising backward comparability.

Detected Changes in Village Governance

Detailed results from the participatory governance assessment scoring system are presented in a separate report, with a summary given in Table 13 below. Overall these revealed that governance in MCDI-supported communities is indeed better than that in control villages. Moreover, the quality of village governance in MCDI-supported communities improved between 2011 and 2014, when villages that had been engaged in the project for a long time (early-entry communities) advanced from an average score of 0.3 to 0.5; more recent entrants to MCDI's programme of good governance (late-entry communities) also performed better, improving from an average of 0.0 in 2011 to 0.1 in 2014. By contrast, the quality of governance in control villages seemed to deteriorate in the same timeframe.

	Early-entry			Late-entry			Control		
	2011	**2014**	**Change**	**2011**	**2014**	**Change**	**2011**	**2014**	**Change**
1. User Organisation & Cohesion	0.9	0.9	***0.0***	0.2	0.3	***0.1***	0.0	-0.1	***-0.1***
2. Communication & Awareness	0.4	-0.3	***-0.6***	-0.5	-0.4	***0.1***	-1.0	-0.8	***0.3***

	Early-entry			Late-entry			Control		
	2011	2014	Change	2011	2014	Change	2011	2014	Change
3. Decision-Making & Implementation	0.1	0.3	***0.1***	-0.3	0.2	***0.5***	0.0	0.4	***0.4***
4. Forest Management	0.4	1.0	***0.6***	-0.8	0.0	***0.8***	-0.8	-0.5	***0.3***
5. Forest Product Access & Distribution	0.4	0.9	***0.5***	0.8	0.8	***0.1***	0.5	0.4	***-0.1***
6. Gender And Equity Consideration	0.0	0.0	***0.0***	0.3	0.0	***-0.3***	0.0	0.0	***0.0***
7. Economic / Fund Development	0.5	1.0	***0.5***	0.3	-1.0	***-1.3***	0.0	0.0	***0.0***
8. Conflict Management	-0.3	0.8	***1.0***	0.3	1.0	***0.7***	0.5	-0.3	***-0.8***
9. Linkage And Network Development	-0.1	0.4	***0.5***	-0.5	-0.1	***0.4***	0.5	-0.3	***-0.8***
Overall Mean Criteria Score	*0.3*	*0.5*	***0.3***	*0.0*	*0.1*	***0.1***	*0.0*	*-0.1*	***-0.1***

Table 13. Average governance scores for project and control villages in 2011 and 2014.

The scoring system also allowed changes in nine specific aspects of village governance to be analysed between villages and over time, as follows detailed below.

1. **User Organisation & Cohesion:** Early-entry villages were all well organised, and maintained this good standard between 2011 and 2014. Late-entry villages also largely performed well and improved during the project; however, several constraints to full participation where identified, including limited community awareness and understanding. The long distance to the VLFR was also raised as a constraint in some late-entry villages, which can limit widespread sense of ownership, as well as cooperation in forest management, including collective action against illegal activities. Control villages seemed to struggle to organise cohesive governance systems, and these deteriorated over time.

2. **Communication & Awareness:** Early-entry villages performed only moderately well, with Liwiti doing quite badly, and perceived community awareness about the project deteriorate quite substantially over time. It is unclear why this happened, although it could be because project support shifted to other priorities (e.g. capacity building for timber harvesting and early burning) or because villagers' own expectations increased, and therefore they scored themselves more stringently nearer to the end of the project. An additional indicator to assess communal understanding of the REDD concept was added in the 2014 assessment, and no village did well in this respect. This is not surprising as REDD is a complex concept to grasp, and could have led to the poorer scores in the second round of monitoring. Late entry villages performed slightly worse than early-entry villages in both years, but nonetheless improved between 2011 and 2014. Control villages were the least well performing of the three groups, although the limited data available did indicate a slight improvement in their performance over time.

3. **Decision-making & Implementation:** Early-entry village governance systems had reasonably good decision making processes, and there improved during the course of the project. This is probably a reflection of regular practice during Village Council, VNRC and VGA meetings, leading to improved decision making processes. By contrast, several late-entry villages performed poorly, and this was attributed to limited awareness among the community. Record keeping was also weak in these villages, although there was a general consensus among participants that decisions made during meetings are being implemented. With the absence of VNRCs, the control villages were generally

not meeting to plan forest-related activities, although there was one exception where the WWF supported village forest management.

4. **Forest Management:** Early-entry villages performed moderately well and their forest management practices improved during the project; by 2014, all received positive scores for forest management. Late-entry villages on the other hand performed poorly at the start of the project, but by 2014 had also improved substantially; this was largely as a result of demarcating VLFR boundaries and more effective forest protection. Although control villages improved slightly between 2011 and 2014, their forest management remained poor at the end of the project. These trends are a good indication that engagement with project villages is having a positive impact on local forest management.

5. **Forest product access & distribution:** Early-entry villages scored well, and their already good performance improved substantially in the three years between 2011 and 2014. Late-entry villages also performed strongly, and improved slightly during the study period. Control villages also performed well in terms of equal forest product access and distribution within the community; this is to be expected as, in the absence of VLFRs, their forests are effectively open access.

6. **Gender and Equity Consideration:** Neither project village nor control village governments performed well in respect to gender and equity. They did not perform very badly either, although this could be because cultural biases meant that women were not particularly prone to complain about poor gender equity in the focus group discussions. The quality of governance at promoting equity, including gender equity, changed relatively little during the project, although two late entry villages deteriorated slightly; the reason for this is unclear.

7. **Economic / Fund Development:** All early entry villages were doing well at developing funds, reflecting good village dynamism around revenue generation and allocation. By contrast, there seemed to be no real dynamism for fund development across the late-entry villages, probably due the absence of forest-based revenues even by the end of the project. This criteria was not applicable to control villages.

8. **Conflict management:** In 2011, some conflicts between villages – e.g. village boundary disagreements between Kikole and Kisangi – meant that some early-entry villages performed badly. However, these issues had largely been resolved by the end of the project, meaning that they scored well on this aspect of governance. This was also the case for late-entry villages. Limited data was available for control villages making it difficult to draw conclusions.

9. **Linkage and network development:** All villages had limited institutional linkage between the VNRC and external entities also concerned with forest management (i.e. District and National Forestry Officers, NGOs and timber traders) at the beginning of the project. This changed substantially positively in early-entry villages and less so in late-entry villages, while perceptions of linkages deteriorated in control villages. This is a strong indication that project interventions had a positive impact on village government interaction with external partners, and was probably largely driven by timber harvesting in early-entry villages which necessarily involves direct engagement between VNRCs, District Authorities and timber buyers.

In addition to changes detected through formal scoring, qualitative reports from MCDI’s field staff suggest an increase in the number of people attending and speaking VGA meetings in many project villages, and in the nature and standard of debates taking place. Under MCDI’s prompting, the frequency of VGA meetings in target villages increased from less than two at the beginning of the project to between three and four per year in 2014. All early-entry and late-entry villages passed the target threshold of at least three VGA meetings in 2013 and 2014 (previously the average was 1.9), at least 40%

of which would not have happened without MCDI's program to improve governance. The organisation actively encourages this good practice by sharing results during its Annual Stakeholders' Fora; in a bid to develop positive peer group pressure, a prize was issued in the 2013 Forum to the village with the most VGA meetings held in the year.

Tracking PFM Revenue Expenditure

Good financial management and equitable benefit sharing are important aspects of village governance, and to some extent are expected to be brought about by transparent and accountable management institutions, such as regular VGA meetings. MCDI assessed this by auditing PFM revenue expenditure up to June 2012 – mid-way through the project – in four villages that had sold timber (only one: Kikole, is also a pilot village in this REDD project). As well as tracing records of expenditure, the views of the wider community were canvassed through focus group discussions that specifically excluded village leaders. Each use of PFM profits was explicitly discussed with two focus groups, disaggregated by gender.

In the 3 years between July 2009 and June 2012 the four villages earned just over TZS 35m/- (or about USD $22,500). Of this, MCDI were able to locate records of expenditure of 23m/-, with 1.75m/- remitted to KDC as their share of revenue, and around 10m/- in declared balances (although in practice these were hard to verify). Of the 23m/- spent, between 39% and 65% went on 'process' expenses (i.e. forest management, committee running costs, transport costs going to the bank etc.) in each village, and therefore between 35% and 61% were realised as profits. The average profit margin (profits divided by management costs) was 102% across all villages. The focus group discussions revealed that, on average, 86% of profits were spent on outcomes considered widely beneficial (>90% in 3 out of 4 villages), with both men and women approving of the vast majority of expenditure. The one exception was Kikole village where one focal group (men) was highly critical of how the Village Council had managed some of these profits, especially when spent on projects initiated but then not finished, e.g. a new house for the village midwife.

Socio-Economic Impacts on Households

Monitoring Household Impacts

Three dependent variables were used to investigate the possible effect of the project on:

1. Total number of durable goods (solar panels, cars, motorbikes, bicycles, televisions, radios, and mobile phones or other goods worth more than a phone) owned by the household;
2. Total monthly expenditure; and,
3. Total income.

For each dependent variable three different types of comparisons were made. In the first one, early-entry and late-entry villages were grouped together and compared against control villages. In the second analysis, control villages were dropped to compare early-entry against late-entry villages only. Finally, in the third analysis, all villages were grouped together and changes in the durable goods, monthly expenditure and total income compared over time (between 2011 and 2014). Control variables were household characteristics indicators (i.e. household size, modified dependency ratio and highest education level reported), household assets variables (i.e. total acreage, number of fruit trees, number of livestock and percentage of land used for sesame production); household income (i.e. income from crops and income from forest products) and a village level variable (i.e. 'mean durable goods', 'mean expenditure', and 'mean total income').

Household surveys were decided upon as the most appropriate method to collect data on tangible and intangible aspects of household wealth, and thus to assess the impact of project activities on poverty. A ‘household’ was defined as a family unit sharing at least one meal a day, which may or may not include several physical housing units. The ‘main’ house where the family meal took place was taken as a reference unit for the housing quality indicator. MCDI required two respondents for each questionnaire, a man and a woman (in most cases, this was husband and wife) which allowed them to consider project knowledge and participation in respect to gender. A full assessment of the impacts of the project on gender equity is given in the section on *Gender* below.

The specific protocols for socio-economic assessment were drafted in 2010 and field tested in three villages, following which the final protocols and questionnaires were produced, circulated to partners, and finalised in early 2011. Data were collected by a team of MCDI staff, trained by academics from the University of East Anglia. A baseline survey of households was performed in the second half of 2011, and followed this up with a repeat survey with the same households in the first half of 2014; this approach allowed the impact of project activities to be assessed over time. MCDI revised the monitoring protocols used in the baseline data collection to incorporate lessons learned from that first iteration. The revised questionnaires were then trialled in two villages, and households were re-surveyed using the improved questionnaire in 2014.

Targeted households were selected through random sampling, stratified by wealth class. In 2011, focus groups were used for participatory wealth-ranking exercises in each village to identify three classes of wealth, using housing assets as indicators (see table below). This proved a simple way of classifying wealth, and panel data analysis confirmed that housing assets were indeed significantly correlated with income. Households were randomly selected from each class of household in proportions that represented the profile for the village as a whole.

Wealth ranking from participatory exercise			
Wealth indicator	Poor (2011 mean)	Medium (2011 mean)	Rich (2011 mean)
Housing Index	5.83	6.87	9.17
Land acres	3.05	3.74	5.08
Durable Asset count	2.84	3.75	4.80

Table 14. Wealth classes used to stratify household surveys in project and control villages.

MCDI aimed for at least a 20% sample of households in each village, but given budget constraints ended with a floor of 20 households and a cap of 30 households for each village. A total of 452 households were surveyed, which approximately represents 10% of all households in the 15 villages surveyed. The findings detailed below should therefore be treated with caution, since the samples should have been ideally larger for greater statistical power.

Household Impacts Detected

Project activities are expected to generate new sources of income for communities – through timber and future carbon sales – and support villagers’ development aspirations. However, technical hurdles in other aspects of the project, particularly in finalising the VCS method (see *Methodology Approval* above) meant that sales of offsets did not happen before the second round of monitoring, thus delaying accumulation of direct financial benefits to participating communities. Therefore, whilst some improvements in governance scores between 2011 and 2014 were expected (see *Detected Changes in Village Governance*), few changes were anticipated in householders’ wellbeing. Instead these two sets of data prior to the start of revenue flows should give a clearer picture of the background ‘noise’ present in the baseline data, and thus the size of changes needed to be regarded as significant.

Nonetheless, positive changes in livelihood outcomes were likely to be more significant in early-entry villages than late-entry villages, given that MCDI have worked with them for longer, participated in more meetings, and because they have already benefited from timber income. It was also expected that, overall, all MCDI-supported villages would show comparatively higher levels of income, assets, housing conditions, and a more detailed understanding and positive perception of forest management and governance institutions than control villages.

Overall and on average, households in 2014 had more income than in 2011. It also appeared that MCDI-supported villages did better than control villages, with comparatively substantial gains in income between 2011 and 2014, even when adjusted for inflation (see *Table 15.* Mean household income (TSh) by village group, village and year (mean, standard deviation and sample size, respectively). 2014 data deflated using Consumer Price Index changes. below). This recorded income data was also supported by respondents' more subjective assessment of changes in their household economy across years, with supported village respondents much more likely to report improvements in their household situation than control villages, as illustrated in *Figure 36.* Perceived change in household economic situation by village group between 2011 and 2014. below. The differences in income were not statistically significant, however, and it is difficult to link improvements in household income directly to project activities.

Group	Summary Results (TSh)			Village Mean (TSh)	
	2011	2014	Village	2011	2014
Early Entry	373,504 *(± 369,240, n=113)*	492,432 *(± 591,496, n=101)*	Kikole	478,000	597,000
			Kisangi	284,000	520,000
			Liwiti	395,000	601,000
			Nainokwe	276,000	248,000
Late Entry	353,825 *(± 465,294, n=136)*	477,049 *(± 566,345, n=124)*	Likawage	554,000	586,000
			Mandawa	402,000	611,000
			Mchakama	232,000	394,000
			Mitole	323,000	500,000
			Ngea	181,000	246,000
Control	317,021 *(± 422,854, n=130)*	318,308 *(± 435,128, n=166)*	Mbwemkuru	343,000	522,000
			Mtandi	359,000	272,000
			Mtyalambuko	227,000	246,000
			Nakiu	525,000	591,000
			Nandete	180,000	129,000
			Ngorongoro	162,000	153,000

Table 15. Mean household income (TSh) by village group, village and year (mean, standard deviation and sample size, respectively). 2014 data deflated using Consumer Price Index changes.

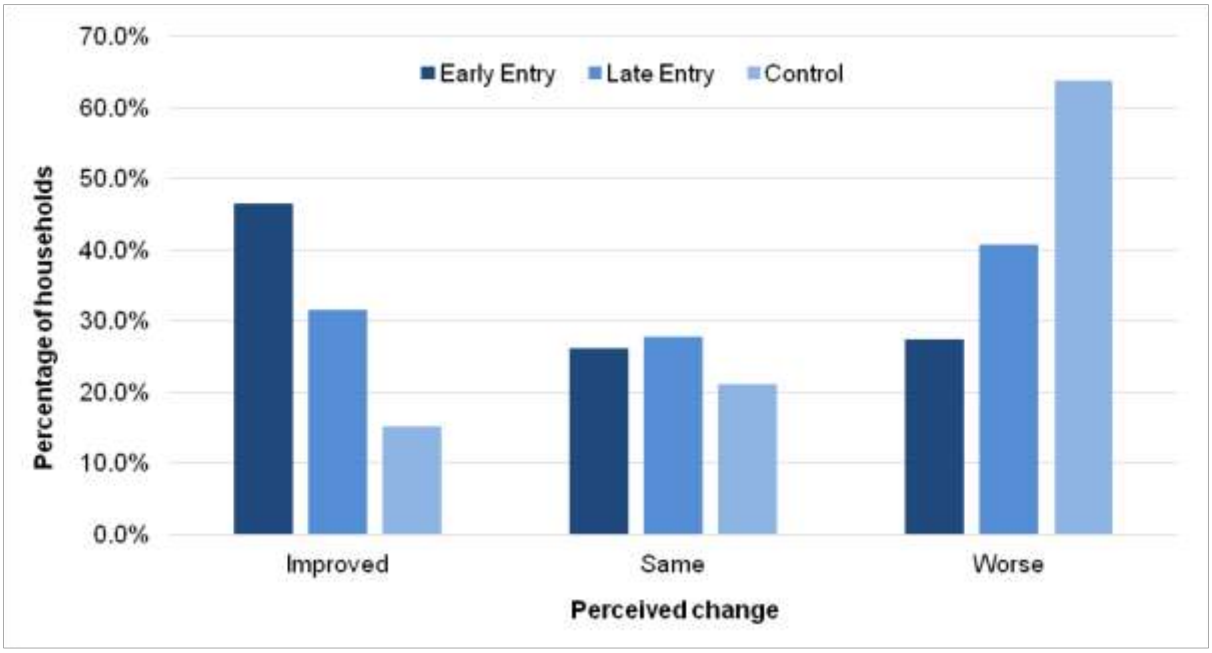

Figure 36. Perceived change in household economic situation by village group between 2011 and 2014.

Durable goods identified included solar panels, cars, motorbikes, bicycles, televisions, radios, mobile phones or other goods worth more than a phone. Households in project villages, on average, had no more durable goods than those in control villages, as the figure below illustrates. Nonetheless, at village level, the average number of goods per household increased over time, particularly for households holding five or more goods, a trend that was observed for most villages, including controls. Although it would be misleading to attribute these changes only to the project, they do confirm a positive trend toward an increase in durable goods at the household level, which is very positive from the overall perspective of poverty reduction.

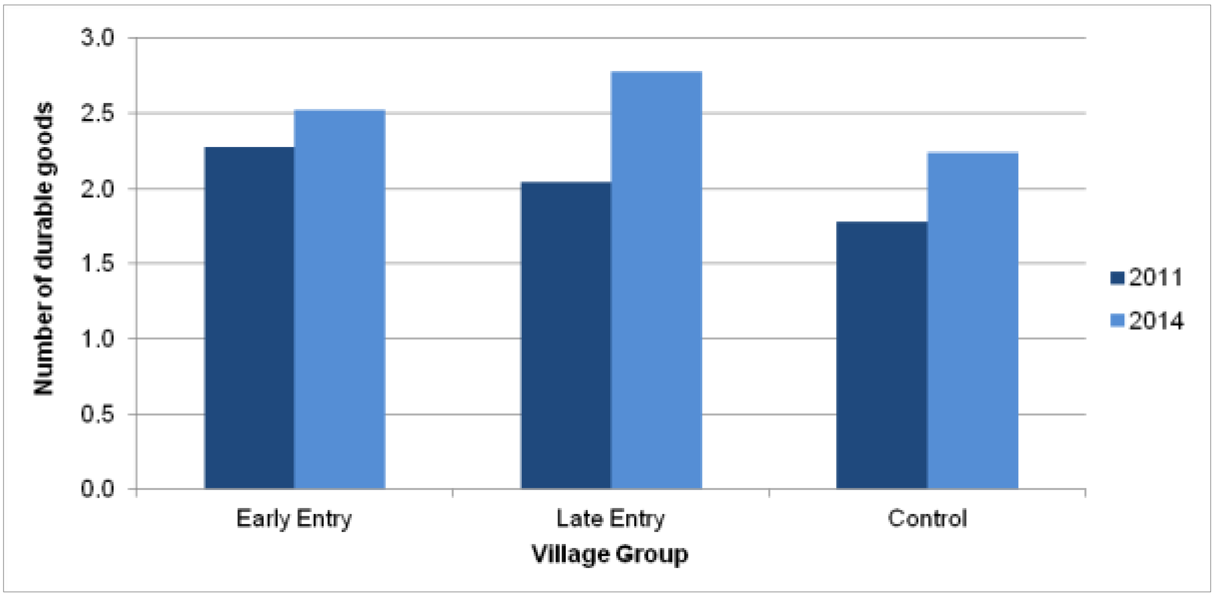

Figure 37. Average number of durable goods per household, by village group and year.

MCDI considered fair distribution of project benefits in the sense of differences in wealth between households, using the Gini coefficient as a key indicator of equity in benefit sharing. Small rises in wealth inequality occurred across all villages, including controls. MCDI speculate that the proportion of total village income that is concentrated in the wealthier households is arising due to a transition towards a cash crop economy based on sesame; the income that can be gained from sesame presents a significant opportunity to those households who command the labour and working capital to invest in expanded production, widening the income gap with those who do not control the assets to expand sesame production. This is somewhat supported by the observation that the early-entry villages are the ones who have most expanded their cash crop income and have also most increased their inequality, but this would need further research to confirm.

In addition to economic benefits and improved wellbeing, MCDI expected to see an increase in project knowledge and participation over time and in villages that had been engaging with MCDI for longer. This was indeed the case. In general, there was better local knowledge of MCDI and its activities among households in early-entry villages compared to late-entry villages, and knowledge also improved in 2014 compared to 2011. Social membership was investigated by asking each household to indicate if any of its members were part of the Village Council, the VNRC, other village committees, a savings or a women's group, and others. The frequency to which each household reported one or various was not recorded, but simply indicated the average number of organizations mentioned by the surveyed households. Somewhat surprisingly, all villages show substantial decreases in membership averages between 2011 and 2014. Such consistent, rapid and large decreases do not make sense, and MCDI's best explanation is that the questions were interpreted differently in the two survey rounds. Comparisons across years are therefore considered unsafe and interpretation should be restricted to differences within years. By 2014, households in early entry villages and controls were involved in more organizations than late entry villages. This makes sense since the project activities not only encouraged the formation of the VNRC in early- and late-entry villages but MCDI also promoted greater involvement in other existing village committees, such as the budget committee.

Household participation in project activities was generally higher in late-entry villages than early-entry villages (see Figure 38 below). This is somewhat surprising as early-entry villages have been working with MCDI for longer, and therefore local people would be expected to be more aware and engaged in project activities. This difference is most notable with project meetings, and therefore could reflect more local participation in start-up meetings, which might be perceived as more important. Overall, people's engagement in the most demanding activities was lower than attending meetings, which is logical. It also reflects that more time-consuming activities that require training involve fewer people to reduce management costs and create specific capacities among certain individuals.

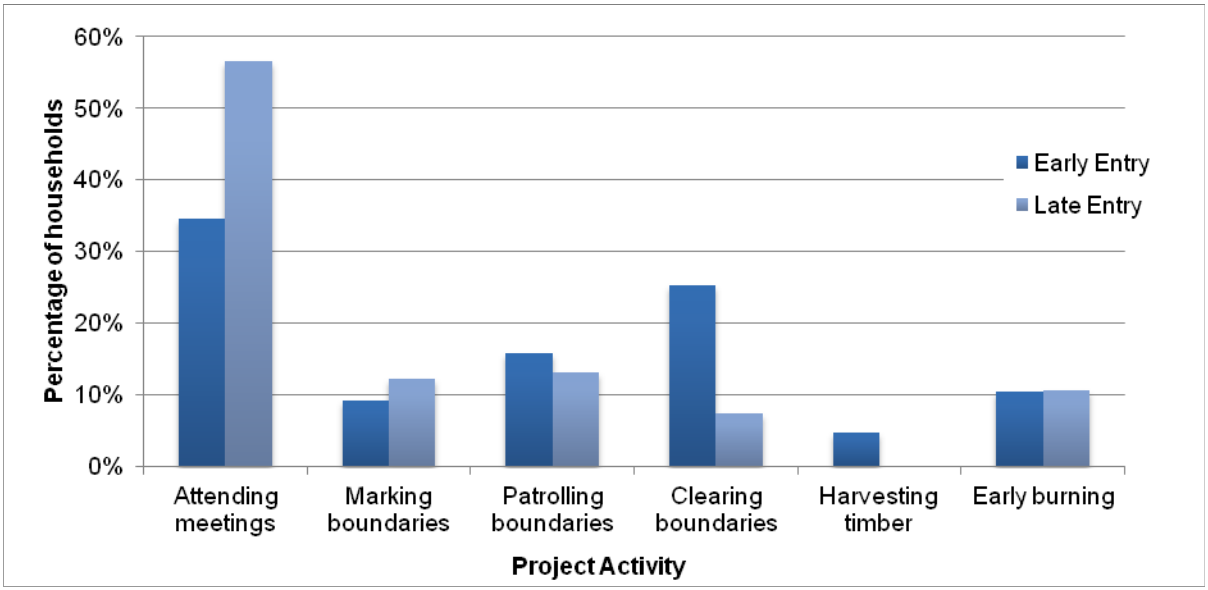

Figure 38. Percentage of households that participated in project activities.

The graph below illustrates the percentage of surveyed households acknowledging to have benefitted from MCDI fees, regardless of the activities resulting in such payments. Average percentages of benefited households are higher in early-entry villages, which is to be expected given that MCDI have been working with these communities for longer and have thus conducted a wider variety and number of activities.

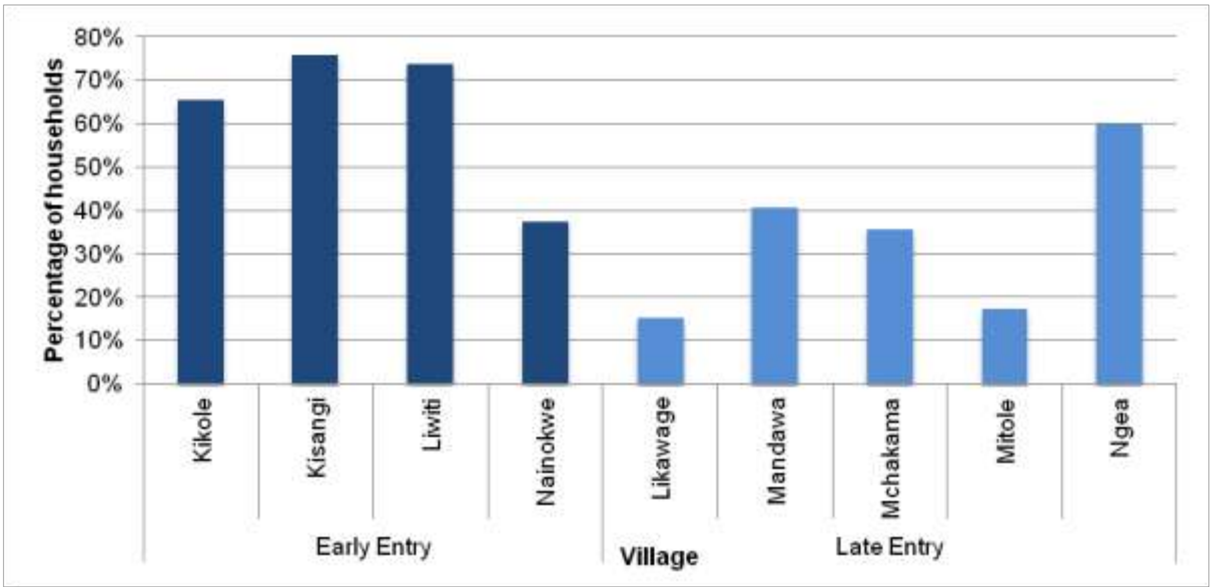

Figure 39. The percentage of households that received direct fees from project activities.

Although these findings suggest that, at this stage, there is limited demonstrable wealth effect from the project, they are also a reflection of the reality that village economies are much larger than just forestry, and market-based income in most villages was instead dominated by sales of sesame and other cash crops such as cashew. Thus it is hard to isolate the effect of forest incomes given these bigger changes occurring at the same time, across all villages. Furthermore, many of the pathways to household economic benefits from forest management activities are indirect, through investment in public goods such as improved water provision, healthcare and schooling. These are long-term investments geared towards building important and flexible assets related to human capital. It is therefore expected that it would take a longer period of time to see these effects materialise. This being said, it is encouraging that households in villages supported by MCDI reported that their lives were better off in 2014 when compared to 2011, whilst those in control villages said that things had worsened. This is a strong indication that the project is providing benefits to peoples' wellbeing in ways that are not directly linked to cash income at the household level. For example, previously local people in Kikole had to travel long distances to collect water; since generating income from timber sales, however, the village council used the money to build a well in the village. This means that time which used to be spent travelling to collect water can be put towards other activities. A full analysis of the households is given in the separate socio-economic report produced by UEA.[67]

Qualitative Perceptions of Change

MCDI tracked community perceptions of the project using a qualitative monitoring system called Most Significant Change (MSC). MSC is a method of systematically capturing stories about changes that have happened as a result of a programme, together with evidence for these changes which can be used as anecdotal evidence for the successes, or shortfalls, of the project.

Unlike when using traditional surveys, the MSC system does not involve asking specific questions to identify if there has been a change in the state of a particular indicator. Instead, the facilitator asks an open question: *'What has changed?'*. The results are therein based on the opinions of the participants; this necessarily means that there is a heavy reliance on subjectivity, and is why stories should always be verified with evidence. However, it also means that MCDI are able to capture unexpected changes brought about by the project, not just those covered by the precise indicators, which are often developed based on expected changes. Gathering information about stakeholders' perceptions (as opposed to hard facts) is in itself one of the benefits of the system, as what people believe to be happening is arguably more likely to affect their behaviour. For example, if a village experiences high crop failure due to insufficient rainfall one year, but local people perceive that their harvest was less successful because of an increase in the abundance of crop raiding animals (even if there is no evidence to support this) they might be less likely to support PFM and/or be less concerned about people poaching wildlife in their VLFR. Importantly, MSC is not designed to be used alone, and it was used in conjunction with other conventional, indicator-based monitoring methods, such as household surveys (see section *Socio-Economic Impacts on Households*) and governance assessments (see section *Monitoring Changes in Village Governance*). These approaches complement each other, and comparing and contrasting the different findings helped to form a clearer picture of what changes happened in the villages during the course of the project, how people perceived these changes, and what role project activities had in bringing about these changes and/or affecting people's perceptions of them.

There is however some structure to the information gathered using the MSC system. The monitoring is conducted through a series of focus group discussion in each of the project villages, and a simple form used to report the data. Participants are asked to report what had changed since the previous round of monitoring, provide examples as evidence to back this up, and to discuss reasons why the change might have occurred. Through group discussions, the team then decide which stories are the most significant, ranking them from most- to least- important, and categorize them into themes. Each change is then considered to determine whether it occurred fully or partially as a direct or indirect result of the project.

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[67] Corbera, E; Martin, A; Villaseñor, A. and Springate-Baginski, O. 2015. *An analysis of forest governance transformations and livelihood impacts through workshops and household panel data (2011-2014).* University of East Anglia, Norwich.

MCDI began by performing MSC on a quarterly basis in each village, but in 2014 decided to reduce the frequency of monitoring visits from quarterly to biannually. This is because the focus groups seemed to struggle to come up with changes that had happened in the three preceding months, and instead were reporting events (e.g. painting the VLFR boundary, or a visit from a District Officer), which is not what MCDI were after; MSC is designed to measure actual change, not simply reporting what activities have been carried out. Changes take time to come about, and therefore it was found that six months was a more appropriate interval for monitoring. MCDI performed these biannual meetings during February and August as, by August, most local people have finished selling their crops, leaving them more time to afford to participate in project activities.

The discussions are led by a facilitator from MCDI, and involved representatives from the Village Council as well as the wider community. Each focus group contained around 30 participants, one third to one half of whom where women. It was important to involve Village Council members in the process as they are likely to be the most knowledgeable about what is going on in the village. By contrast, VNRCs were deliberately excluded from the monitoring where possible. This was to avoid an emphasis on stories about the project and the forest, which is not the aim of the monitoring. Instead, MCDI wanted an accurate reflection of exactly how significant the project activities were perceived in relation to other changes happening in the village; reports from VNRC members may have provided a biased outlook on this.

Once monitoring has been completed in all project villages, all stories of change are collated and ranked a second time by MCDI staff. This is done using a weighted approach: each story is assigned a score based on (a) the number of villages in which the change was reported, plus (b) the significance of the change. The sum of these scores is then converted to an index which is used to rank the stories in order of importance for reporting. MCDI incorporated these stories of change into project reports, and used the lessons learned to improve project implementation through adaptive management. In addition to being a useful monitoring and management tool, providing qualitative insights into the affect of project activities in the villages, MSC also promotes collaboration and teamwork amongst participants. This provided an opportunity to see how well the Village Council members work together, and how they interact with and listen to members of the wider community.

As would be expected from the rural farming communities supported by MCDI, the majority of stories of change reported for the duration of the project were related (directly or indirectly) to agriculture. Towards the end of the project, however, changes brought about as a direct or indirect result of forest management activities became more commonplace; four out of eight of the stories in 2014 could be directly or indirectly linked to the project:

1. Decreased illegal logging in five villages as local people began to realise benefits from timber sales and therefore are playing more active roles in forest management by reporting illegal activities to the VNRC;
2. Maternal health care improvements in Nanjirinji A, resulting from a programme that provides expectant mothers with TSh 50,000/- towards labour fees, using revenue from timber sale;
3. Concerns among villagers in Mitole about the location of the proposed VLFR, thought to be brought about as a result of delayed benefits from forest management; and
4. Revenues from timber sales put towards building a police post in Nanjiriji A, thus improving local security.

The monitoring highlighted both the positive and negative changes to local people's welfare brought about by dynamics in the agricultural sector. A consistent theme was related to cultivation of the cash crop, sesame, which has risen in value over the last few years, bringing about a number of changes. In 2012, recent investments in sesame cultivation were reported to have resulted in food shortages in several villages, but were counterbalanced by expansions in the area under cultivation in Likawage and Mandawa, facilitated by hiring a tractor. By 2013, representatives in all communities reported that local people were expanding their farms to capitalise on the added returns from growing and selling sesame. Many families used the extra income to improve their houses, while others opted to use the money to purchase motorbikes to simplify transport within and outside the village. The increased revenue also provided local farmers with the capital to invest in herbicides (e.g. "Round-Up"), making it easier and more efficient to clear land for cultivation. Furthermore, the number of seasonal migrants requesting permission to cultivation on village land in Likawage, Nanjirinji A, Mandawa, Mitole and Mchakama increased compared to previous years. Consequently, local claims were that forested areas outside VLFRs are being transformed for cultivation at a faster rate than previously; more than double the amount of forest in one village had been cut down to farm sesame in late 2013 than in the previous year. This is something that MCDI will need to keep an eye on, as encroachment might become an issue if the area of cultivable land becomes scarce in coming years.

By 2014, dynamics in the agricultural sector, including sesame prices but also seasonal variability – unusually prolonged rains in early 2014 resulted in widespread subsistence crop failure – in particular, continued to be an important driver of local communities' welfare. However, the stories shared also included a number of topics related to project activities, a good indication that it is perceived as bringing about notable changes to people's lives. These included positive changes brought about as a direct result of village development projects using profits from timber sales, but also changes brought about as an indirect result of these benefits being felt by the community. For example, in Kisangi this resulted in more local people playing an active role in forest management by reporting illegal activities in the VLFR.

In contrast, some local people in Mitole – a village which has yet to benefit from their VLFR – decided that they are no longer happy with the location of the proposed VLFR as they want to be able to use some of the land inside for farming. Many of these people attended the VGA meeting when the location of the VLFR was agreed upon, and MCDI believe that their change in mindset has been partially brought about because of delays in benefits being realised from PFM; regrettably, due to factors beyond MCDI's control, it will have taken over four years to get Mitole to the point where they have a certified VLFR from which they can begin generating income from timber and carbon offsets. This highlights the importance of a principle that MCDI emphasise throughout its work: that it is vital to support communities to benefit from their forests as soon as possible, as without such benefits local people can become demoralised, diminishing local incentives to promote forest conservation.

Dissemination of Lessons Learned

The final output area for this grant called for MCDI's REDD project achievements disseminated with policy recommendations for national and international audiences. This was expected to comprise of four activities. These are listed under *Activities* on 26 of the *Project Overview*, and explained in detail here.

Presentation of Results

Local Dissemination and Engagement

A key event in MCDI's calendar is its Annual Stakeholders Forum. At each forum the latest results and achievements from MCDI's work, including this project, are presented to representatives from each village where it works, local councillors, District officials, and invited other stakeholders. Each village also presents briefly on their own progress to support peer-to-peer learning, and promote enthusiasm for MCDI's work as newer villages hear of the achievements of those who are more experienced, and the benefits they are accruing. Each year MCDI then presents its own plans for the future and receives feedback from all stakeholders present. Finally the forum provides an opportunity to hold MCDI and other local actors to account to promises they made in previous years. The expansion of the number villages supported by MCDI under this project led to an commensurate increase the number of stakeholders; in order for everyone to be heard some forum meetings were thus extended to two days.

In grappling with the conceptual complexity of REDD+ these gatherings were extremely useful for MCDI to introduce many of the key concepts of the REDD+ project to local stakeholders and test out their initial reception. Thus for instance, the Stakeholders Forum in early 2011 was when opposition to the original Carbon Contracts proposed by MCDI first really crystallised, and thus catalysed the later adjustment in strategy. The following year's forum was used to introduce early burning to communities and other stakeholders as a REDD+ activity, providing a platform for the subsequent development of this key component of the project, with the draft Village Fire Control Plan Template presented and endorsed during the forum of 2012.

National Dissemination and Engagement

MCDI is not an advocacy organisation, preferring to focus on service delivery in support of the communities with whom it works. Thus, as noted above, much of MCDI's contributions to the evolving national debates on REDD+ were funnelled through other national partners such as TNRF, TFCG and Mjumita, or were made at the invitation of National REDD+ Taskforce at various workshops held at different times on the various elements of the Tanzanian government's own REDD+ efforts. However, sometimes, as is the case with MCDI's FSC certificate[68], MCDI is the only NGO with significant interests on a topic, and in such cases MCDI takes the initiative to raise awareness and advocate directly with appropriate parts of government on specific issues around its unique approach.

Such was the case with the early burning work that is central to this project. Hence in late 2014 MCDI organised a workshop in Morogoro to present the key points of its early burning programme, and lessons learned to date. The workshop was chaired by Dr Felician Kilahama, Chairman of MCDI's Governing Board, and ex-Director of Forestry, whose presence undoubtedly helped to secure an audience of high ranking officials from FBD and TFS, the National REDD Taskforce, and senior researchers from SUA and TAFORI, as well other NGOs (TFCG, Mjumita and WWF). The workshop was one of the most

[68] The only one held in Tanzania in relation to natural forest.

successful ever held by MCDI, with significant interest registered by many in the approach taken, and its applicability elsewhere in Tanzania, and a lively but positive question and answer session at the end.

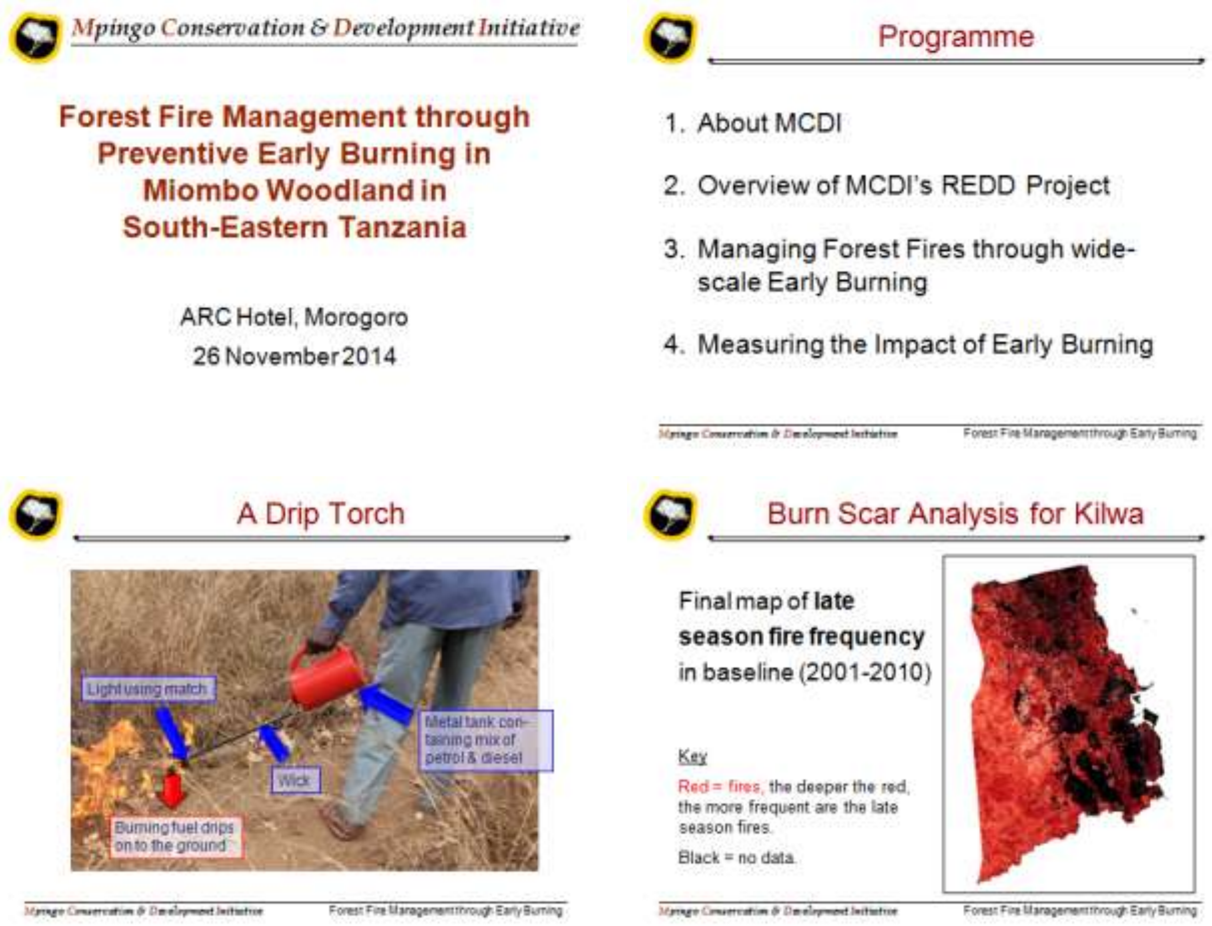


Figure 40. Selected slides from workshop on Forest Fire Management held in Morogoro, Nov 2014.

Training on REDD+ Methods

One of the major difficulties presented by REDD+ is that it is often technically complex, especially in the MRV dimension, and that was no different in this project. Often this requires key inputs from international experts (MCDI worked with three international universities in this project), and it is therefore important to transfer some of this expertise to people in country, and build capacity to manage future project activities as independently as possible. In this project the primary focus was MCDI's own staff, with internal and on-the-job training being the main instruments to develop the necessary skills.

The first task for MCDI was to introduce REDD+ to its own staff and to develop in-depth understanding of the key elements of the project design, including the analysis of the drivers of deforestation. This early understanding was critical for MCDI staff to act as effective ambassadors in promoting REDD+ with project communities.

The most important partner, in terms of technical expertise brought to the project, was the University of Edinburgh. Whenever UoE staff visited the project site they always worked closely with MCDI staff, not just involving them in the field work, but also developing understanding: why were certain methodological elements incorporated, and involving them in the actual design work around key elements such as the forest biomass monitoring method.

A lot of the technical elements of this project rely to at least some extent on GIS-based analysis. So MCDI also invested in providing training for its staff in how to perform key tasks in GIS such as mapping VLFRs. This process is ongoing, with skills being built up over time, and then used in the field in order to build familiarity and embed within working practices. For a few more advanced staff were introduced to some of the techniques involved in analysis of satellite data. All GIS operations to be performed by MCDI were also documented thoroughly with step-by-step instructions and copious screenshots so staff can remind themselves of the exact procedure each time they perform it, e.g. Box 1 below.

Box 1. Sample step-by-step documentation of a REDD+ task in GIS, checking that checkpoints used for monitoring burned area are representative of the forest as a whole.

Checking VLFR Coverage

MCDI's project design requires that no part of the forest should be too far from a checkpoint, proportionate to the size of the VLFR. This requirement is defined through two criteria:

- No part of the VLFR should be more than 20% of D_{max} away from a checkpoint.
- No more than 20% of the VLFR should be more than 10% of D_{max} away from a checkpoint.

To determine whether proposed transects meet these criteria buffer zones around the transects need to be examined in relation to the VLFR as per the following procedure.

1. Firstly an approximate value for D_{max} needs to be found. For this it is important to note that the exact D_{max} does not need to be known, just a distance that does not exceed the maximum diameter of the VLFR, and thus clearly fits inside the VLFR. Here there are two options:

   a. Use the distance measurement tool to measure the distance from two points just inside the furthest apart vertices of the VLFR polygon. This will mostly suffice unless you are really having to try hard to squeeze maximum effectiveness out of as few transects as possible.

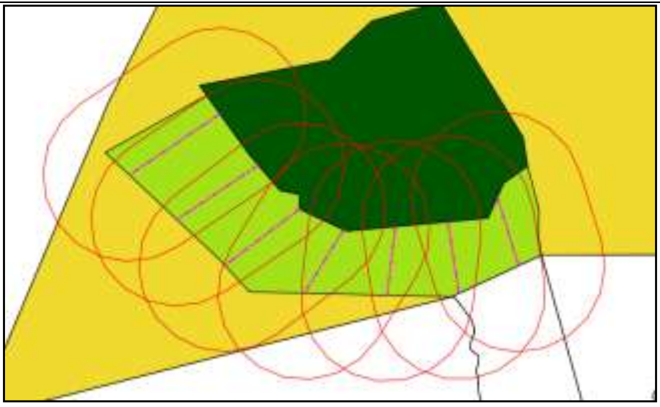
   b. Create a temporary poly-line shape file. Set snapping to snap to the VLFR boundaries and vertices. Draw one or more lines from opposite vertices. Use **Vector** menu > **Geometry Tools** > **Export/Add geometry columns** to find the exact length of each such line. Choose the largest distance: this is the largest possible D_{max}.

   Make a note of the D_{max} on a piece of paper. No need to write it down as it can always be recreated if necessary.

2. Calculate what 20% of D_{max} is and then generate a buffer zone using **Vector** menu > **Geoprocessing Tools** > **Buffer(s)** and save the file appropriately in M:\GIS\PFM\etc. (The file shold be kept because it is evidence of satisfying a condition.)

3. Visualize it on the map in some way: I find a no-fill approach is the most appropriate, see below (red lines show the buffer, dotted purple lines the proposed transects). As long as the entire VLFR fits inside the buffer zones then the first condition has been fulfilled.

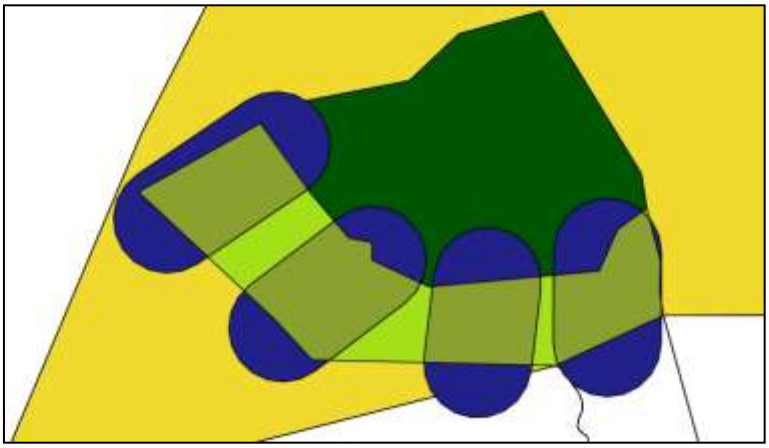
Box 1. Sample step-by-step documentation of a REDD+ task in GIS, checking that checkpoints used for monitoring burned area are representative of the forest as a whole.



4. Repeat step (2) but with 10% of D_{max} as the buffer distance, again saving the file, appropriately named, in M:\GIS\PFM\etc.

5. Again a simple visualisation may suffice to satisfy yourself that this smaller buffer zone covers at least 80% of the VLFR. If that is not certain you should do the following:

   a. Clip the buffer file with the boundaries of the VLFR with **Vector** menu > **Geoprocessing Tools** > **Clip**, see below.



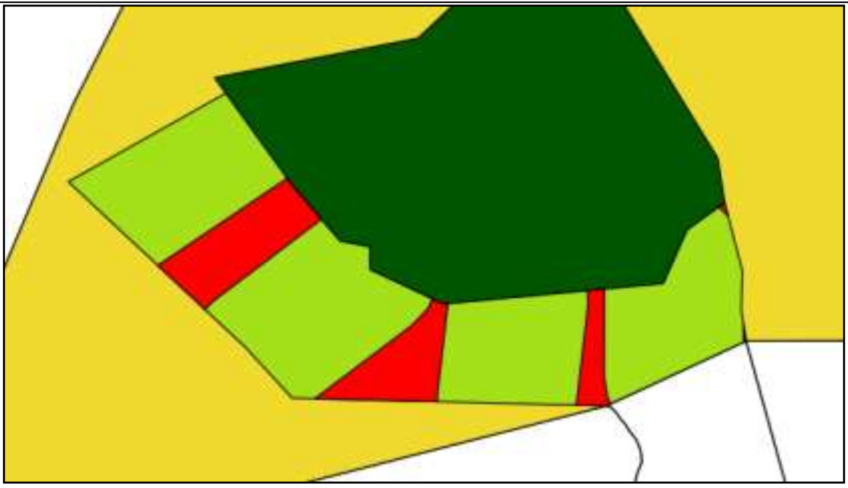
   b. Delete existing area fields; use the **Table Manager** plugin for this.

   c. Calculate the area with **Vector** menu > **Geometry Tools** > **Export/Add geometry columns**.

   d. If the area if at least 80% of the total VLFR area the condition is satisfied.

6. Note there is an alternative approach to Step (5), in which you use **Vector** menu > **Geoprocessing Tools** > **Difference** to compute the area of the VLFR excluded from the buffer zone. This needs to be less than 80% of the total VLFR area for the condition to be satisfied.

Box 1. Sample step-by-step documentation of a REDD+ task in GIS, checking that checkpoints used for monitoring burned area are representative of the forest as a whole.



7. If either condition fails you need to move the transects around a bit or add more until they are satisfied.

Finally, as the project drew to a close, MCDI staff and board members were trained on the overall shape of the REDD+ project and some of the key elements of the VCS methodology. The expectation here is not that staff should be able to design their own methodology in future, but should understand the overall design, know why certain aspects function as they do, and to be able to implement the day-to-day elements of the project without requiring outside assistance.

Documentary Outputs Produced

VCS Methodology

- Avoid Forest Degradation through Fire Management. VCS Methodology.
- First Assessment Review by SCS
- Second Assessment Review by DNV

Project Reports

- Drivers of Deforestation and Forest Degradation in Kilwa District
- MCDI REDD Policy Analysis 2010
- MCDI REDD Policy Analysis 2011
- MCDI REDD Policy Analysis 2012 Update
- MCDI REDD Policy Analysis 2013 Update
- Village Fire Management Plan Template
- Carbon stocks assessment in Kilwa 2010-11
- GapFire Model Description
- REDD+ Village Governance: Three years in review 2011 - 2014
- An analysis of livelihood impacts through household panel data 2011-14
- PFM Revenue Audit 2009-2012
- Ecological baseline for monitoring changes to biodiversity following early burning

An additional report: the_Fire History for Kilwa 2000-10 will follow a little later, and serve as a key foundation for the Project Design Document that will be the central document in achieving VCS & CCB validation for the project.

Journal / Conference Papers

Published / In Press:

- McNicol *et al.* (2012) Accurately assessing biomass carbon in Miombo woodlands. *Arc Journal 27*.
- Ball & Makala (2014) Making REDD+ work for communities and forests: lessons for project designers. *IIED Gatekeeper 155*.
- Khatun *et al.* (2015) Participatory Forest Management in Kilwa District, Tanzania: insights on governance, benefit sharing and implications for REDD+. In press *Environment and Planning A.*
- McNicol *et al.* (2015) Impacts of land use change on ecosystem carbon stocks and species dynamics across a chronosequence of Miombo woodland stands cleared for swidden cultivation. In press *Ecological Applications.*

Drafted:

- Khatun *et al.* (2015) Fire is REDD+: Offsetting carbon through early burning activities in south-eastern Tanzania. Submitted to *Journal of Peasant Studies*.
- McNicol *et al.* (2015) Spatial patterns in aboveground woody biomass: links to forest structure, tree species composition and diversity in African woodlands. In prep. for *Plant Ecology and Diversity*.
- McNicol *et al.* (2015) Environmental determinants of aboveground woody biomass across an African woodland landscape. In prep. for *J. Biogeography*.
- McNicol *et al.* (2016) Spatial variability of soil respiration in different aged stands in a savannah woodland ecosystem. In prep. for *Agriculture, Ecosystems and Environment*.

Envisaged:

- Bowers *et al.* (?) Tree productivity and persistence in a heterogeneous East African landscape. Journal TBD.
- Bowers *et al.* (?) Fire dynamics and woody biomass stocks in miombo woodlands. Journal TBD.
- Bowers *et al.* (?) Early burning in miombo woodlands for climate change mitigation. Journal TBD.

Student Theses

- Joshi (2011) Integrated Analysis of Forest Cover Change and Land Use Decisions at a Village Level in Kilwa, Tanzania. MSc thesis, University of Edinburgh, UK.
- Hauf (2012) Mitigating forest fires in Kilwa District – investigation of anthropogenic drivers. BA thesis, Cambridge University, UK.
- Tucker (2013) Carbon stocks, diversity and the miombo: forest regeneration after shifting cultivation in Tanzania. BA thesis, Cambridge University, UK.
- McNicol (2014) The biomass and biodiversity of African savanna woodlands: spatial patterns, environmental correlates and responses to land-use change. PhD thesis, University of Edinburgh, UK.

- Bowers (expected 2015/6) Fire dynamics and carbon cycling of miombo woodlands (TBC). PhD thesis, University of Edinburgh, UK.

Cross-cutting Issues

Governance

It was anticipated that poor leadership at the village level would be a significant constraint on the project, and this expectation was met to some degree. For example, poor collaboration between the Village Council and VNRC members in Mchakama resulted in little effort being placed on forest management. In 2012, Mchakama's VNRC confiscated 10 litres of petrol and a chainsaw from illegal loggers caught in the VLFR, but the Village Council refused to cooperate in taking any further action and returned the confiscated items to the alleged offenders. Communities also recognised their own governance shortfalls towards the beginning of the project, with Mchakama villagers complaining about the lack of Village General Assembly meetings due to poor leadership by the village chairman. It is for reasons like these that MCDI put a lot of effort into improving village governance, clarifying the roles and responsibilities of the Village Council and VNRC, and emphasising strongly the importance of quarterly VGA meetings.

Fair and transparent governance systems will become even more vital as communities begin earning more from forest product sales, meaning that there is more at stake, more incentives to steal money for self gain, but also more to be benefitted from wise decision making and equitable benefit sharing. Communities themselves decide how to spend the money derived from their VLFRs, and MCDI support them to make these decisions wisely and in ways that are transparent to the entire community. It was found that encouraging Village Councils and VNRCs to present annual budgets during VGA meetings is an effective way to do this, as it encourages accountability and provides the wider community with an opportunity to scrutinise local government decision making. For instance, a proposal from the VNRC to increase their meeting allowance was dismissed by the VGA in one village, evidence that quarterly VGAs present an important tool to ensure that entire communities – and not just a few leaders – are truly benefiting from project activities. In MCDI's experience, however, communities require sustained support to ensure that these good governance practices are maintained. The organisation therefore continues to provide training to Village Councils and VNRCs in how to be accountable to their constituents in managing revenues from VLFRs.

As the benefits from the forest begin to be felt by the wider community, it is expected that more local people will begin to play active roles in forest management. There is already evidence that this is happening in four villages (Kisangi, Kikole, Liwiti and Nainokwe) that have began generating income from timber sales. During MSC monitoring, representatives from these four communities claimed that illegal activities were encountered less frequently during forest patrols in 2014 than previously[69]. Local Village Councils explained that this is because local people are beginning to realise benefits from forest product sales, and therefore are acting as stewards of their forest by reporting illegal activities to the VNRC. One participant in Kisangi explained that: *"Everyone in the village is a fellow soldier. If you are seen or caught with pieces of timber, they have to report [you] to the VNRC or Village Council".* This is a very promising outcome, and serves of an example of the role the project has played in incentivising local people to promote forest conservation.

Gender

Gender plays an important part in forestry as men and women in rural areas are apt to use forests differently; men tend to use a wide area of forest for hunting small game, an infrequent activity, whereas

[69] See the section *Qualitative Perceptions of Change* for details on the methodology.

women and children are the primary firewood gatherers and so visit the nearest forest on a daily or weekly basis. However, this distinction is much more apparent and important when forest resources are relatively scarce and thus far away from the village than when they are both close and abundant, which is the case in much of Kilwa District. Resource scarcity is rarely an issue in the project villages, and so perceptions of the forest are principally shaped by the negative impact of local forest cover: that it is a haven for wild animals that raid crops (e.g. elephants and monkeys) and pose significant danger to life (e.g. elephants and lions). These perceptions are not greatly differentiated by gender, and so, unless resource scarcity should arise, there is no significant distinction in rural men and women's attitudes towards the forest.

Nonetheless, it is important that institutions are in place to ensure that the views of both men and women are considered equally in decision making. There are regulations to this effect on local governments in Tanzania: at the community level, the various organs of the village government must, by law, comprise at least one third women. MCDI emphasise this rule when elections are held and MCDI refuse to work with villages that do not elect a committee in compliance with the requirement. Although this creates an enabling environment that is conducive to gender-balanced decision making, the rule in isolation has no direct influence on the proportion of female members of governing organs that are nominated to attend external meetings, or on the proportion of women the wider community that attend meetings called by the Village Council. For example, there were no women in attendance at MCDI's 2011 Annual Stakeholders' Forum. MCDI worked with communities to improve women's representation at the event in successive years: 13 village representatives in the 2012 Forum were women and this rose to 15 in 2013; by 2014 the number of female attendees had more than doubled compared to the previous year.

Even with adequate female attendance in meetings and governing organs, culturally, it is usual for Tanzanian women to be deferent around men to a certain extent. This is by no means as bad in Kilwa as it is in some other parts of the country; there are certainly some strong women in the villages where MCDI work and there are plenty of female-headed households, a situation which does not imply any shame for the woman concerned. Nonetheless, MCDI have a policy of encouraging elected female committee members to participate actively in decision making, and the importance of gender equity is, and will continue to be, emphasised during the training that MCDI provide to improve village governance (see section *Improving Village Governance*).

MCDI also monitors gender equity in project villages explicitly during its participatory governance assessment (see section *Monitoring Changes in Village Governance*), which allows the organisation to track the success of training at bringing about positive changes in village governments. Specifically, people are asked: *"Do women actively participate in village meetings? What is the % of comments coming from women in the VNRC, Village Council and VGA?"*. No villages performed badly during these assessments, although there is certainly room for improvement. In 2011, eight out of the 10 villages surveyed[70] said that more than 10% but less than one third of the comments during VNRC, Village Council and VGA meetings came from women, while more than one third of comments were made by women in only two villages; no villages claimed that women contribute to less than 10% of discussions. This dynamic had largely remained the same three years later, except in those two villages which had previously reported women's involvement in over 33% of discussion, to between 10% and one third in 2014, which is not thought to be significant, but just an artefact of the subjectivity of the data collection method. Overall, it should be acknowledged that changes in village governance – particularly in relation

[70] These included villages previously supported by MCDI's timber and FSC certification project.

to gender equality – are likely to be brought about gradually, and thus take longer periods to materialise in formal assessments than the three year gap between the surveys conducted.

In addition to monitoring gender equality through governance assessments, MCDI used household surveys to assess and monitor equity in the distribution of project cost and benefits, knowledge of the project, and project participation among male and female villagers. Specifically, MCDI focused on the relative proportions of men and women attending village meetings and actively participating in (other) forest management activities – e.g. forest patrols and early burning activities – which also serve as an additional means of income generation for participants.

Household surveys in 2014 revealed that just under half of households in early-entry villages that had received longstanding support from MCDI had participated in project-related meetings, and that women were more likely to participate than men. This is illustrated in Figure 41 below. There were no striking gender differences in participation in other project-related activities, except for marking boundaries and harvesting timber, which are more physically demanding. It was surprising however to find that that women reported more involvement in early burning activities than men, despite it being a risky and more labour intense activity. Between 50 and 60% of households reported attending meetings in the five REDD project villages that had been working with MCDI for a shorter length of time. Gender differences across activities were small, although men dominated participation in marking and patrolling boundaries, as well as in early burning activities.

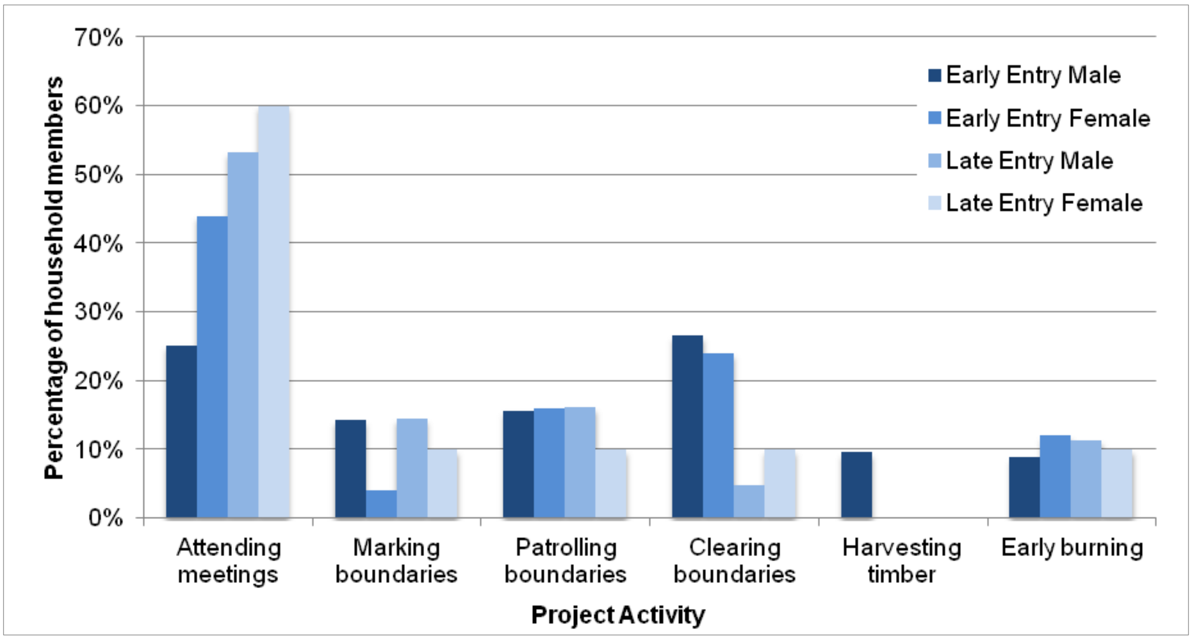


Figure 41. Percentage of male and female household members in early- and late-entry (i.e. REDD project-supported) villages that participated in project activities.

Across all project villages, the percentage of local people that knew about MCDI and could explain the project activities increased between 2011 and 2014, although the overall percentage of people who had not heard of MCDI, or who knew about MCDI but could not describe its activities, remained higher among women than men. Encouragingly, however, a trend toward increasing project knowledge among women across all villages was observed. In Ngea, for example, women who had only heard of MCDI in 2011 were able to explain its activities in detail by 2014. In Likawage there was a very slight decrease in the number of female respondents who knew about the project activities in detail, but this was offset by a proportional increase in those who had heard of MCDI. Across all villages, larger proportions of female villagers had heard about MCDI and were able to describe its activities in communities that had been supported for longer. This is a promising indication that the project is bringing about positive changes that both engage and boost awareness among local women, but it also reinforces that this is a process that takes time.

As well as to encourage community-wide participation and knowledge dissemination, training on good governance is designed to ensure that the benefits from forest management are shared equitably within each village, including among vulnerable community members such as women, children and the elderly. MCDI have been largely successful in this respect, and some of the village development options chosen have quite strong pro-women angles. For example, in 2014 one village introduced a support programme for expectant mothers who are now eligible to receive TSh 50,000/- (around USD $30) towards labour costs, and over 70 women have already benefitted from better maternal support. Other developments such as school buildings, dispensaries and water boreholes are beneficial to both women as well as men; arguably a new borehole is more beneficial to women and children than men, as they traditionally adopt the role of fetching water in project villages.

Despite a number of villages building school classrooms and purchasing uniforms using money from forest product sales, the proportion of both male and female children always attending primary or secondary school was lower towards the end of the project, in 2014, than in 2011. MCDI currently have no explanation for these observed trends, although a similar pattern was observed in control villages, suggesting that school attendance may have decreased in general in Kilwa in 2014 for reasons unrelated to the project. MCDI will in any case be cautious with this observation, and monitor school attendance again in forthcoming years. The assumption that villages' involvement with the project may indirectly lead to reduced vulnerability through increased schooling rates for both boys and girls will require a longer term assessment frame.

In summary, MCDI continues to adopt a gender-aware approach in all its work, opting for this as a better alternative to specific ('box-ticking') activities aimed at gender issues, which can often result in further emphasising the perceived differences between men and women. . Nonetheless, throughout the project MCDI have come to appreciate that gender inequality is a complex and often sensitive issue to tackle, and that PFM – which is ultimately a programme designed to promote responsible forest management by rural communities (i.e. empowerment at the village level) – is probably not the best vehicle for women's empowerment in rural Kilwa. Furthermore, attempting to overturn gender relations in rural communities at the same time as introducing radical new concepts like REDD is unlikely to be conducive to the success of the latter. So instead MCDI seek first to do no harm, and secondly to support women's involvement in every aspect of the project, in a straightforward manner that mainstreams gender awareness into each and every activity undertaken. In this way MCDI hope to support a quiet step change in women's status in project villages whilst focusing everyone's attention on the central goal of delivering community wide benefits from sustainable forest management.

Biodiversity

With its explicit aim to increase carbon stocks this project can be classified as a habitat restoration initiative; in this case, restoring the ecosystem to something closer to when human population densities were much lower and anthropogenic fires significantly rarer. By definition a significant shift in species composition would be expected, although many such shifts will take many years to complete. As the conserved areas shift from savannah to woodland and from woodland to forest those species which prefer more open habitats are likely to decline at the expense of those which favour closed forests.

Restoration normally implies that species composition shifts are actively desired, and thus not something requiring mitigation. Most rare and endemic species found in Kilwa are associated with the denser East African Coastal Forests with the exception of a few large mammals, such as kudu and African wild hunting docs, which favour savannah woodland complexes, and which are primarily seasonal visitors from the populations in the greater Selous-Niassa ecosystem. Hence the balance of species composition changes is likely to increase rather than decrease biodiversity.

Miombo is a fire-adapted ecosystem, and many species are fire tolerant to at least some degree. Fires lit early in the dry season will be cooler and thus a shift towards this kind of fire management is likely to favour those species which are less fire tolerant. However, the timing of burns is also important, e.g. for those bird species which nest on the ground. Should early burning coincide with one or much ecologically critical processes it could disrupt them and threaten the species involved. This threat, though, will be substantially mitigated by the patch-work burning approach in which only a portion of the forest is burned each year (except for the boundary strips). The timing of burns may somewhat influence species compositions amongst herbaceous plants, e.g. the grasses which make up a significant proportion of the fuel load.

The challenge with long term monitoring of biodiversity is separating out multiple causative variables. For instance some form of climate change is now believed inevitable. Elephants are a key-stone species affecting Miombo woodland structure; so trends in elephant poaching in the Selous are also likely to have a major impact on the forests of Kilwa. To what extent might changes subsequently observed be a result of climate change or fluctuations in elephant populations, or due to the new fire management regime? Such questions cannot easily be answered with control sites because spill-over effects are much more likely with biodiversity than with simple biomass, especially for the larger, more mobile, mammalian and avian fauna which are more easily monitored. In contrast to the better studied and less diverse ecosystems of the temperate zones, simply not enough is known about the ecology of tropical biomes to correctly interpret many monitoring results, which often leave more questions than answers.

That said, MCDI's existing community-based monitoring scheme is already well suited to simple longitudinal monitoring of the anticipated changes. The selected indicator bird species were chosen as proxies for high quality forest, and thus their numbers can be expected to go up. As discussed in the section on *Biodiversity Monitoring* above, MCDI complemented this with additional expert-led monitoring of overall bird species assemblages, and of ground-nesting birds. Small mammals were also monitored, to add to the various indicators of large mammal presence which are currently collected by communities. In time MCDI hopes to add further taxonomic groups to its monitoring programme to provide a broader view of long term ecosystem compositional changes.

Project Impact

Carbon Sequestration

The aim of early burning is not to prevent all late season fires, but to reduce their frequency substantially. The baseline fire history for Kilwa shows late season fires affecting 41% of the landscape on average; MCDI aims to reduce that to 10-20% per year.

The extent of early burning will vary from year to year, as was shown simply in the stark comparison between proportions of VLFRs burned in 2013 (35%) and 2014 (5%). Over time, with appropriate support to communities, one would expect early burning effort and effectiveness to improve, but such changes will only be noticeable over several years, with the greater part of variance from one year to the next determined principally by variations in rainfall patterns. As has been remarked in the section on *Fire Management through Wide-Scale Early Burning* above, wetter seasons will constrain early burning, but can also be expected to reduce late season fires as well, since some parts of the landscape may never dry out that much, and business-as-usual fires will not spread as far, probably leading to more fires being lit, but greater fragmentation of the landscape, protecting other parts of the forest.

Thus it is difficult to predict with great certainty the impacts on carbon sequestration on the forest. However, the GapFire model allows rough expectations to be derived, based on point estimates of likely late season fire frequency after early burning. If a uniform reduction in late season fire coverage to 15% is assumed (and early season fires increasing from 14% to 30%) then GapFire predicts an average additional 0.43tC will be sequestered per year per hectare of typical Miombo woodland (with mean initial biomass of 22.5tC/ha), see Figure 42. If late season fire frequency is reduced to 20% (and keeping other variables constant), the additional annual carbon sequestration is reduced to 0.35tC/ha, but it increases to 0.56tC/ha when late season fire frequency is limited to 10% of the landscape.

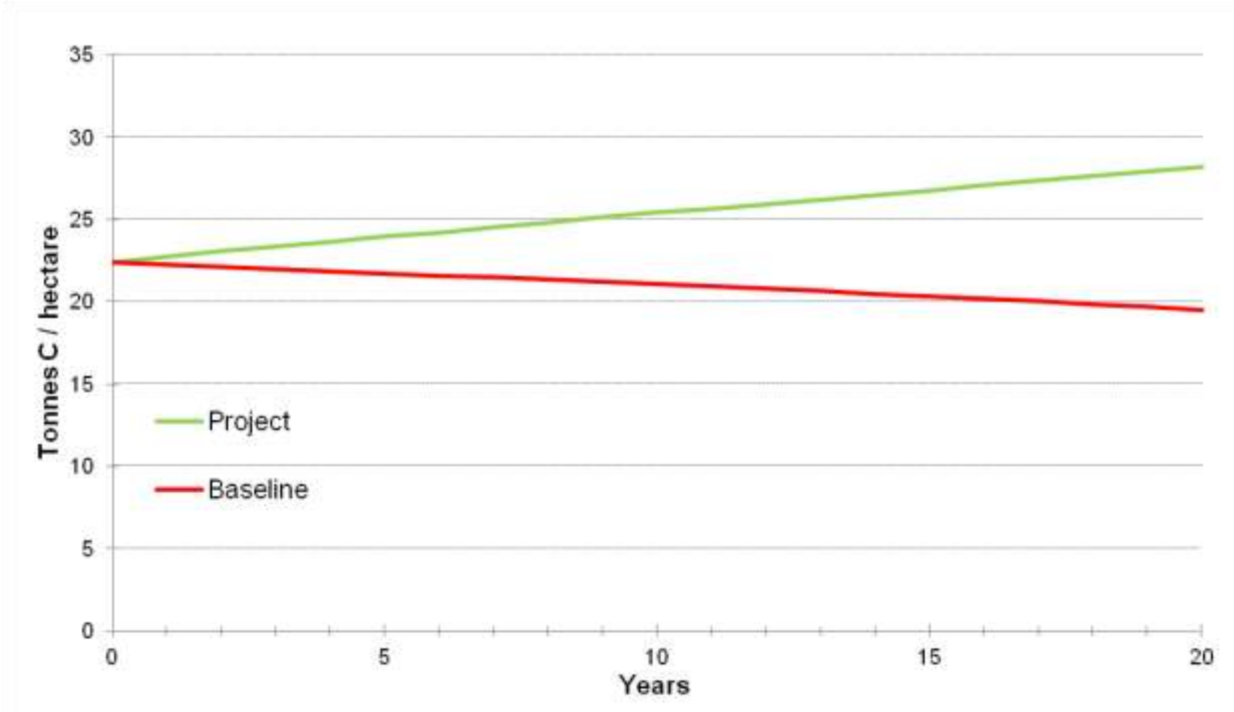


Figure 42. Carbon sequestration under baseline and project scenarios (41% and 15% late season fire frequency respectively).

Impact at the Project Site

Progress achieved by the project on each of the key impact indicators are set out in Table 16.

Impact Indicator	Target	Current
CO_2e saved against baseline	28,000t	At least 27,600tCO_2e from early burning in 2013 assuming 0.43tC/ha saved; negligible gains from 2014.
Forest area under PFM	50,000ha	96,112ha
% of PFM profits spent to the benefit of local people	80%	86% average approval rate reported by 4 villages to have sold timber. (Approval rate 92% if weighted by revenue.)
Villages / rural people benefiting from PFM	12 villages / 18,000 people	PFM fully operational with revenue earned from timber sales in 5 villages with 8,118 people. PFM expansion complete in 4 further villages with 9,711 people and revenue generation set to begin in 2015. PFM expansion was delayed in one additional village due to a soon-to-be-resolved issue in respect to the VLFR boundaries, but should also be fully operational and earning in 2015. In villages with PFM completed 85% of households stated they had benefited as a result of the project.
% people in participating communities with positive view of PFM and REDD	66%	At least 78% of respondents thought the project would have positive benefits.

Table 16. Project achievements against target indicators.

At a rough market price of $5 per tCO2e, the 27,600tCO2e sequestered are worth almost $140,000, or approximately $22 per person per year in the two villages where the early burning was most successfully conducted. This is approximately $100 per household per year, a not insignificant sum in an area where most households earn less than $1 per day.

Impact Beyond the Project Site

The VCS methodology is not just central to this project, but also to replicability elsewhere. The methodology will be usable by any would be REDD project proponent working in dryland forests and contemplating working with fire as one of the major drivers of forest degradation. To limit potential queries, and thus speed initial approval, the VCS method as submitted is confined to use within the Eastern Miombo Ecoregion. But it could be easily and cheaply adapted to other dryland forest situations by those with enough data and understanding of said regions.

Even without that, it seems that simply having the VCS methodology published and approved could itself generate significant interest for new REDD. Early burning and CBFiM will be transformed from a laborious revenue drainer (and thus rarely implemented fully) to a revenue opportunity for forest managers across the 2.8 million km^2 of southern Africa that is covered in Miombo woodlands.

Sustainability

Enterprise Feasibility

MCDI modelled the expected emissions reductions and revenues flows that could be generated as a result of the project over a ten year period.

The first viability assessment was based on the original project concept that revenue generated through carbon offset sales would be used as a tool for PFM expansion, i.e. as sufficient revenue is raised it would be invested in further expanding the scheme to new villages, see *Appendix I: History of Project Development* for more details. In this project design the total emissions reductions, as well as project viability, depend upon the price of carbon. Assuming a fairly conservative $5 per tonne of CO_2e, Total Net Emissions Reductions (TNER) over ten years were expected to be in the range 520-560,000tCO_2e, whereas at $10 per tonne, expected TNER ranged from 950,000 to 1,850,000tCO_2e over ten years, with up to 400,000ha of forest protected as a result[71].

Price ($/tCO2e)	**3.25**	**5**	**10**
Total Net Emission Reductions (TNER) up to year 10	418,949	563,414	1,849,153
Hectares in project in year 10	24,000	48,000	324,000
Total cumulative cash earned up to year 10	-15,475	745,021	8,233,778
Net Present Value (5% discount - government)	-24,162	513,488	5,542,191
Net Present Value (15% discount - commercial)	-29,390	268,062	2,739,151
Cash balance in year 10 (after investment in new project areas), available for re-investment in year 11	-15,475	445,021	3,633,778

Table 17. Original estimates of TNER and project viability under various price scenarios.

However, clearer understandings of the likely costs as the VCS methodology was developed, taken together with the continuing low price of carbon and lower than expected timber sales under MCDI's FSC certificate scheme, meant that project concept had to be abandoned, to be replaced with one in which timber and carbon are treated as complementary revenue streams that together support sustainable forest management. MCDI developed new models of how to achieve this, again considering various plausible scenarios to gauge expected community profits and under what conditions MCDI itself would break even[72], see Table 18 for a selection. This analysis shows that in the current context neither timber sales nor REDD+ on their own were likely to allow MCDI to break even, but a combination of the two should suffice.

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[71] See Fehse & Rivard (2012) Forest Carbon Project Feasibility Assessment: The MCDI Grouped REDD Project on Fire Management in Village Land Forest Reserves, Kilwa District, Tanzania. Unpublished report for MCDI.

[72] As an NGO, MCDI has no interest in making profits from the services that it provides, but planning to break even exactly is likely to lead to regular (small) losses, so instead MCDI should aim to make a small surplus that can be reinvested back into its core social mission, and expand the number of rural it communities supports.

Scenario	Timber Sales Volumes (m³ / year)			REDD	Finances		Results	
	Mpingo	High value non-mpingo	Low value non-mpingo	Carbon Price	Community Split	MCDI Split	Community Profits *	MCDI Surplus *
Timber Only	750	2,000	1,000	–	40%	34%	$16,678	-$100,787
Timber+FSC	1,250	2,500	1,500	–	40%	34%	$23,753	-$28,621
REDD Only	0	0	0	$5.00	40%	34%	$9,221	-$137,111
Target w/out major buyer	1,000	2,000	1,000	$6.00	40%	34%	$31,551	$90,648
Target w major timber buyer	1,000	4,000	3,000	$6.00	42%	30%	$42,134	$188,280

Table 18. Key characteristics of MCDI cost recovery under various scenarios.
*** Profits are per village (assuming 12 villages), MCDI surplus would be reinvested to support more communities.**

Risk Analysis

Political Framework

There is a significant risk that international negotiations and/or development of national policies and processes will not be compatible with the proposed scheme for carbon credits. Although total incompatibility is unlikely, the impact could be severe. MCDI managed this risk by developing the project to fit with both compliance and voluntary markets, with similar anticipated gains for avoided carbon emissions, forest conservation and poverty alleviation whichever route to market is taken. MCDI also played an active role in contributing to national policy analyses, using its experience to inform key policy developments and ensuring that they are (sufficiently) aligned with the approach of this project. The design of the scheme moreover will provide a strong fallback position for Tanzania as a whole if the aim of REDD+ readiness is not achieved within a short time frame. This is a possibility as the government has not yet settled on clear policy priorities by which it expects to deliver nationwide reduction in forest carbon losses.

Land Tenure

Although village boundaries in Kilwa District have been surveyed by the Ministry of Lands, still some inter-village boundaries remained in dispute at the beginning of the project. PFM and REDD+, introducing as they do control over and the potential to earn rents from resources located within those boundaries, tend to exacerbate boundary disputes. MCDI worked proactively with Government Authorities, communities and other stakeholders to develop and implement collaborative and transparent solutions, e.g. by facilitating discussions between the affected villages so that they could reach properly minuted solutions. This was done with some success: an existing boundary dispute between Kikole and Kisangi has now been resolved; by contrast, work that was commenced in Nambondo village had to be abandoned as a serious boundary dispute with a neighbouring village threatened to turn violent. Inconsistent boundaries as displayed on government maps were also a source of confusion in tackling these issues, but appropriate diplomatic representations has ensured that progress has been made, with both the Regional and District Commissioners playing constructive roles. MCDI will nonetheless require continued support from Kilwa District Council's Land Office to resolve these.

Villages' land tenure may also be threatened by external investors requiring large land areas, e.g. for biofuels cultivation; the low population density in Kilwa District makes it a prime target for such investments. Indeed, it was as a result of recent large land deals in the area with a biofuel company had not worked in their favour that the villages were reluctant to enter into contractual agreements with MCDI early on in the project (see section on *Carbon Contracts*). MCDI therefore sought to develop VLFRs as soon as possible in order to strengthen each village's land tenure claim.

In practice, this was not as efficient a process as initially hoped, as the approval of management plans was held up due to limited time during District Full Council meetings. Nonetheless, MCDI successfully supported four of the five project villages to establish VLFRs by the end of the project, with one remaining pending a soon-to-be-resolved dispute in relation to the VLFR boundaries[73]. MCDI nonetheless have a good enough relationship with the communities it supports and sufficient success stories from the five villages that are benefitting from timber sales to overcome this.

Can Community-Based Fire Management be successfully implemented?

Fire management programmes have a mixed record of success at best within East and Southern Africa. However, many such programmes that have struggled are based around protected areas, and thus in a context of confrontation between local people and PA managers where the challenge essentially revolves around government PA managers attempting to prevent burning events caused by local resident people. For example, MCDI's partner FFI were advisers to the management of Niassa Reserve in northern Mozambique, and also investigated fire management options with regards to carbon markets. There, however, they were pessimistic of success due to local hostility to the existence of the reserve which constrains local livelihood opportunities. In contrast, MCDI's work in Kilwa is founded upon a high level of trust between MCDI's staff and the communities they support. This trust has been built up over many years, and bolstered by actual revenues earned by communities from their forests. Communities trust that, by and large, MCDI is on their side, will be there for the long haul, and is ready to respond flexibly to their issues and concerns, and to help where possible.

Nevertheless, launching the programme was still a significant logistical challenge, but MCDI had the right foundations to work from. MCDI generally expected the communities to work with them rather than actively undermine efforts, and this was the case. Moreover, local people regularly use fire in a broad range of activities; they were for the most part experienced in its use and understood intuitively how bush fires behave. Thus the early burning programme required little in the way of education, despite the use of drip torches adding an additional technical element to the process, and more just a channelling of energies combined with appropriate quality assurance checks to ensure a thorough job had been done.

Irrespective of their cooperation in this project, wide-scale early burning is nonetheless an expensive and labour intensive undertaking, and will not be performed without local people being adequately rewarded. Therefore, it is essential that local people begin generating income from the carbon offsets generated through fire management as soon as possible.

Will the fire management programme lead to significant changes in forest carbon stocks?

MCDI have little doubt that this programme of fire management will lead to higher carbon stocks in the forest, but the question is how much and over what period of time? These are questions that MCDI cannot answer until they implement the project. Individual fire experiments are difficult and costly, and usually cover only relatively small areas of forest; even running such an experiment for ten years in Kilwa before launching this project would give only limited insight to the likely results. This project thus has substantial value as a large scale controlled experiment in the effects of early burning on dry forests in East and Southern Africa, and arguably represents value for money purely on that basis.

[73] The dispute in itself is thought to be a partial artefact of delays in VLFR approval, with resultant delays in the benefit flow to the community installing doubt in local people about the viability of the whole process.

Annual changes of 0.3-0.5tC/ha in aboveground biomass are anticipated, and depending on a reasonable carbon price (~$5 and upwards) the project should be feasible with carbon stock changes as low as 0.25tC/ha per year. Thus there is room for error in projections without entirely jeopardising the project, although less so if carbon prices that are lower than $5 are secured, which is a real possibility given current market trends. Even should the changes anticipated fail to materialise, the lessons learned about fire management in dry forests in the tropics should be well worth the investment.

A related risk is that leakage, expected to be negligible, will become significant if MCDI's assessment of cultural or lifestyle factors around use of fire has not been fully understood. This will be evaluated on an ongoing basis, and the project adapted accordingly if necessary.

Carbon Stocks Assessment

The results of soil carbon assessments were too variable to use as a baseline and so they were excluded from the project method (although the impact on the project is expected to be positive). Instead MCDI focussed on carbon stored in above-ground tree biomass and wood products (i.e. wood removed during selective logging).

Lack of precision in carbon assessments of above-ground tree biomass, especially when conducted by local communities, was managed by computation of confidence limits. Tree girths in PSPs were subjected to a re-measurement control process in which the average plot-scale measurement plausibility rate (after allowing for expected tree growth) is at least 90%, and never less than 85%[74]. Aggregation of carbon credits across multiple forests will further reduce uncertainty.

These carbon assessment methods developed needed to be approved by VCS in order to access international voluntary carbon markets. MCDI managed this risk by aligning its methods as closely as possible with existing approved VCS methodologies such that the approval process for its own method would be as easy as possible.

Uncertainty in future tree growth rates (i.e. rates of carbon sequestration) could be mitigated by banking a proportion – to be decided – of initial carbon credits rather than selling them immediately on to the market, although that could introduce other risks of not meeting community expectations.

Can changes in carbon stocks be measured effectively?

At the lower end of expectations, MCDI may be looking for changes in stem biomass of around 1% per year. This is difficult to measure and distinguish from natural fluctuations, so the project is dependent upon modelling. The theoretical underpinning of UoE's GapFire model is fundamentally sound, and has been supported by other fire experts spoken to, but specific estimates of carbon emissions may still be erroneous. UoE attempted to ameliorate this by taking a clearly conservative approach wherever possible, and evaluating the model as best as possible against available data for Kilwa. The VCS methodology would not have been approved without these efforts, and thus MCDI can be confident that independent experts have taken sufficient precautions against modelling errors.

Market Conditions

The continuing low price of carbon offsets on international voluntary markets remains a significant constraint on project ambitions. Although the 2013 UNFCCC CoP did give official approval to REDD+,

[74] Where the mean measurement plausibility rate is less than 85% in one or more plots these plots should be included in subsequent analysis if it is conservative to do so (i.e. lower growth is detected) and excluded where they would lead to greater carbon gains being detected. We defined 'plausibility' as variation between -1cm reduction and +1.5cm gain in tree girth measurements, after allowing for expected tree growth.

international funding remains unclear, and slow progress with Tanzania's national REDD+ strategy means there is no feasible alternative to the voluntary markets for carbon offset sales in the short to medium term.

That all said, MCDI and its partners have given significant attention to how to market the carbon offsets that they expect to generate. VCS and CCB validated offsets are expected to be sold for around $7 per tCO_2e through a mixture of bespoke channels and larger sales on exchanges; it is believed that this project will yield a decent return for communities even at this low price.

Sales, Governance and Equitable Benefit Sharing

Expectations in villages race ahead of the capacity to deliver. This is a problem that MCDI already faced in 2009 with a long waiting list of villages to join its group certificate scheme, and pressure from local councillors to expand the area of its operations. MCDI initially envisaged that this project would help respond to that pressure by ultimately driving the expansion of its PFM+FSC certificate scheme. However, the continuing low price of carbon offsets on international voluntary markets also remain a significant constraint on project ambitions, meaning that revenue from carbon will be likely limited to acting as a complement to timber revenues from sustainable PFM, rather than funding expansion as originally envisaged.

If village constituents are not strong enough to hold their leaders to sufficient account then local elites are open to capture most of the benefit from forest revenues. This will lead to loss of popular support for the project, undermining or even collapsing PFM and REDD+ efforts within a community. Conversely, strong forest governance and effective use of forest revenues will further incentivise and strengthen forest conservation outcomes, as reinforced by broad-based, tangible and impactful economic and social benefits at the local level. This risk was managed by providing strong support to regular village assemblies and to local CBOs to act as a local counterbalance to the village government. In the absence of revenues generated from carbon offsets, the direct result of these efforts on financial management of that revenue stream cannot yet be determined. There is nonetheless significant evidence that MCDI's support is having positive changes to village governance. Participatory governance assessments revealed that, on average, village governance improved in all MCDI-supported villages during the project timeframe. Furthermore, 86% of profits in the four villages that had began generating income from timber sales were considered to have been spent on outcomes that are widely beneficial (>90% in 3 out of 4 villages). See section on *Detected Changes in Village Governance* for more details.

Project Sustainability

It is likely that without some additional financial support for perhaps 1-2 years MCDI will face significant difficulties in sustaining and rolling out this project to achieve the economies of scale for success. E.g. in the early years a lot of investment is needed to develop community capacity in early burning and monitoring impacts (critical to the process of selling carbon offsets). Some of the governance support and social monitoring aspects will also be hard to sustain without donor support since communities may, reasonably, decline to pay for those costs out of revenues they have earned. In addition, with the international carbon price remaining low, PFM expansion will remain an investment cost to be primarily met by donors.

Staff Loss

Loss of knowledge and experience following departures of key staff is always a risk when implementing technical projects such as this one. Neither recruitment nor staff retention are easy: MCDI operates in an environment in which the talent pool is relatively small for which there is acute competition, and where competition can be expected to get worse with the ongoing development of the oil and gas sector in Tanzania. This risk was managed within MCDI, the lead partner and a small organisation, by regular and thorough documentation of project activities and lessons learned. MCDI's management team is also a tight unit which meets regularly and constantly shares thinking on key issues.

MCDI's Monitoring Officer, who took the lead on burned area monitoring, left in the final year of the project to work for an oil and gas company. MCDI were able to respond to this challenge efficiently and effectively so that it had minimal impact on its core operations. This was made easier by the length of notice provided by the Monitoring Officer, which was enough for him to train up another staff member, and MCDI's new Monitoring Manager, to see the monitoring through to the end of the project.

The Chief Technical Adviser and co-founder of MCDI, who played a leading role in the development of the project, also left to work for another organisation at the end of 2014. Again, this is something that MCDI had been planning for some time, and so appropriate measures were put in place to minimise the impact of his loss on the organisation's core functioning. An appropriate replacement was employed early in 2014, who was trained up to take on many of the responsibilities of MCDI's emeritus Chief Technical Adviser (and employed as their new Technical Adviser in the start of 2015); this will eventually include taking the lead on the REDD Project Design Document. Both the emeritus Monitoring Officer and Chief Technical Adviser continue to provide technical and advisory support to MCDI remotely, a clear sign of their sense of responsibility and respect for the organisation and the work it does. In the case of the Chief Technical Adviser, this also meant putting significant input into this report.

Scalability

This project's design is extremely well suited to large scale roll out, with consequent economies of scale. Factors contributing to this are:

- Negligible leakage
- Zero opportunity costs for land owners / managers
- Widespread applicability in dryland forests across southern Africa

Recently, when looking at new areas for PFM expansion outside of Kilwa District, MCDI has incorporated carbon revenues into its projections of possible community returns. In particular voluntary carbon markets are much more open to new entrants than local timber markets, and actively embrace projects such as MCDI's which bring strong co-benefits. Ultimately, with good marketing, timber sales should eventually predominate over carbon offsets, but in a conservative market that will take time to achieve. Even if prices are slightly lower, carbon markets will happily soak up excess offsets through bulk sales on exchanges.

It is expected that the project will become an important component in MCDI's overall strategy of sustainable and *financially self-sufficient* forest management; expanding the project area will help deliver economies of scale. By working with forest adjacent communities and ensuring the bulk of the benefits flow to these communities, MCDI will provide a strong incentive for them to look after the forests and deliver the carbon savings which lie at the heart of REDD. Permanence will be achieved through a combination of timber rents and REDD payments, thus reducing risks compared to REDD-only approaches to sustainable forest management.

The project itself should be directly replicable in other districts in south-eastern Tanzania with substantial timber stocks. Beyond that major elements should be replicable across the Miombo belt of east and southern Africa (some 2.8 million km^2), and more broadly across tropical dry forest ecosystems. The new VCS method will be accessible to anyone wishing to fund fire management in such ecosystems via the carbon markets. Finally the fundamental lessons of how to organise a community-based fire-management project and how to effectively monitor impacts of fire in dryland forests will be valid around the world.

Conclusions & Way Forward

Project Progress

MCDI started with a successful community forestry project focused on sustainable timber extraction, certified by the Forest Stewardship Council and initially looked to REDD+ to help fund its expansion. But the approach they eventually found, based on improved fire management, was far from that originally envisaged. Throughout MCDI and its partners reacted to the serious complexities in the science with a focus on developing robust and credible solutions, emphasising quality over timeliness in project deliverables, and focusing on the big picture potential benefits obtainable from project innovations to forest managers across the 2.8 million square kilometres of Miombo in southern Africa, and in dryland forests elsewhere in the world.

In the process, MCDI learned that REDD+ project developers need to identify which specific cause or causes, collectively known as 'drivers', of deforestation they are tackling and explicitly quantify how much carbon emissions will be abated after allowing for leakage. They must also understand market needs, as encapsulated in the various carbon offset validation schemes. Working with communities – as many REDD+ projects will – introduces further complications; project designers must balance carefully the need for openness and clarity against the dangers of being too specific when in fact project details, such as the value of carbon credits, are uncertain.

MCDI's REDD project required a longer and more detailed design phase than is usual in forest conservation projects, an approach that they would recommend for other project managers, even if stakeholder pressure favours early project activities 'on the ground'. This design phase was important to fix key criteria and assess the overall project feasibility, before starting to implement the project. Some trial and error was inevitable, as it is in any new project development, especially in a new market like REDD+. It is nonetheless hoped that project developers elsewhere may learn from MCDI's experience, and use this case study to smooth their own project development process.

The slow progress of approving MCDI's proposed methodology by VCS hampered MCDI's ability to bring VERs to the marketplace by the end of the five year funding cycle for their REDD pilot project. Rather than the sales of carbon offsets, had the new methodology been a declared goal at the outset, MCDI are confident the project would still have been seen as a valuable contribution to REDD readiness in Tanzania and thus funded, and the project would have been declared a clear success.

Project Achievements

Despite not delivering on its original goal of supporting sales of carbon offsets within the project lifetime, the project has nonetheless delivered a number of significant successes.

1. 25,681 hectares of forest brought under community management and protected from degradation by illegal logging and charcoal production.
2. A more realistic approach to participatory land-use planning in Kilwa District.
3. Introduced wide-scale early burning by drip torches to Tanzania, an idea that may now be taken up in the National Fire Strategy.
4. Support communities to burn over 6,000 hectares of their forests, reducing forest carbon emissions by an estimated 27,600tC.
5. Measured forest carbon stocks across Kilwa District.

6. Assessed fire frequency in different strata of forest within Kilwa District, establishing an approach that can be used to derive the forest fire history in other parts of southern Africa.
7. Designed a method by which communities can monitor for themselves fire frequency and above-ground biomass in forests they manage.
8. Adapted the GapFire model to serve the purposes of a REDD+ project.
9. Compiled a brand new VCS methodology for REDD+ by fire management in dryland forests, the first such methodology of its kind, and one of the first to use a computer model as the basis for calculating VCUs.
10. Laid a baseline for monitoring the impacts of early burning on avian biodiversity in the forests of central and southern Kilwa.
11. Improved village governance in project villages, with the frequency of village general assembly meetings increasing from an average of 1.9 to between 3 and 4 per year.
12. Devised an innovative approach to monitoring the quality of village and forest governance in rural communities.
13. Established a baseline against which to measure the socio-economic impact at household level of anticipated revenue flows from REDD+ and other PFM mechanisms.
14. Assessed the market for carbon offsets from the project, and how to market them in future to get the best possible prices
15. Contributed significantly to the evolution of REDD+ debates and policy formulation within Tanzania.

The overall goal of the project was that institutions and selected local communities in South Eastern Tanzania should be REDD ready by the end of the project. With all of the above successes, this goal has largely been achieved.

Lessons Learned

A widely welcomed paper published as a result of this REDD+ project was entitled: *Making REDD+ work for communities and forests: lessons for project designers* (Ball & Makala 2014, *IIED Gatekeeper 155*). The key lessons that were shared by MCDI in the report are: (1) to identify which driver of deforestation will be tackled early on; (2) that project design clarity is needed before trying to sign carbon trading contracts with communities; and, (3) to focus on working to meet carbon market requirements. Two additional lessons also emerged over the course of the project, and these are detailed below.

Partnering with Universities

Indeed, this project had to deal with many challenges associated with being at the bleeding' edge of innovation. REDD itself is a relatively new concept, and the framework both in the international regulated market and within voluntary markets have changed considerably in the last five years. No-one has ever attempted to quantify forest fire impacts on a project scale previously, and the data available to do so was patchy, necessitating new approaches to be brought to bear. To meet these challenges MCDI teamed up with world-leading academics at the University of Edinburgh, University College London and the University of East Anglia. Working with such partners brings additional advantages:

1. It is substantially cheaper due to their ability to leverage PhD student labour.
2. Academic commitment to getting the right answer improves both quality of final design and supports project credibility, something MCDI believe helped a lot in gaining approval for their VCS methodology.
3. The potential to leverage longer term partnerships.

However, one disadvantage is that universities are less able to concentrate resources to meet project delivery deadlines. This impacted project management, with multiple slippages, as deliverables were held up, particularly delaying progress on the VCS methodology which required the science all to be crystal clear before much could be written.

Working with Uncertainty

A regular challenge encountered in developing this project was the lack of definitive information on key questions. This occurred right at the beginning of the project when most of the variables needed to quantify in order to compute forest carbon losses in Kilwa from different drivers of deforestation and forest degradation were largely data deficient, e.g. the proportion of charcoal that is produced without permits. To resolve this MCDI relied on expert estimates (mostly from its own staff), but were explicit about the level of confidence these had, resulting in extremely wide confidence intervals calculated for carbon losses from each driver. This elicited some criticism at the time as “not being proper science”, but in fact these ‘back of the envelope’ calculations were critical to enable the project to move forward, and indeed the different orders of magnitude in carbon losses were clear despite the large uncertainties.

Another major area of uncertainty is in how the forest reacts to different fire regimes. Miombo and other dryland forest experts are unanimous that frequent late season fires have a deleterious effect on forest biomass, but exactly how much was unknown. A big part of the problem is that the behaviour of individual fires is extremely unpredictable – just ask any fire-fighter – and so a lot of the research done on dryland forest fires is at regional or national scales, where the aggregate impact of lots of fires is tractable to statistical analysis. One possible reaction to this would be to wait until the research picture was clear enough to derive reasonably precise estimates of carbon losses from fires. However, that eventuality is many years away at best, and in the meantime dryland forests in Kilwa and the world over will continue to lose carbon to uncontrolled bush fires. Better, therefore to find a way to work through this uncertainty; the overall public benefits of tackling this problem now almost certainly outweigh any risks from miscalculation of carbon fluxes, especially if care is taken to be conservative at every step as demanded by VCS.

MCDI were lucky in that their partners at the School of Geosciences at the University of Edinburgh already had a model, called GapFire, that they had developed to understand the results of various fire experiments they had conducted in Mozambique[75]. UoE’s conclusions from their earlier GapFire model work informed the estimates of carbon losses due to forest fires in the analysis of drivers of deforestation that was a critical early step in project implementation. UoE staff and students subsequently worked hard to adapt the GapFire model to the Kilwa context and the needs of a REDD project. One important step in this was use of the Rothermel model to estimate the intensity of fires at different times of the year; key variables such as wind speed could not be known or the probability distribution derived, so had to be excluded and the model simplified. This is just one example of a basic limitation of using any model: it will always be a simplification of reality, hence real world results will almost always differ from those

[75] This was somewhat fortuitous since their expertise on forest fires had not been a major factor in MCDI’s selection of UoE as a project partner when the original project design was proposed in 2009.

predicted by the model, you just hope that the margin of error will not be too great, and careful model evaluation (as was performed on the GapFire model) is important to minimise such margins of error.

An important implication of this is that the predictions of avoided forest carbon losses as a result of early burning that will underpin sales of carbon offsets will almost certainly be inaccurate to some degree. Adopting a conservative approach, as mentioned above, will go a long way to ensuring that the strong balance of probabilities is that model inaccuracies will be on the low not high side. The decadal repeat assessment of forest biomass will therefore play a critical role in laying bear these inaccuracies, and also serve as a basis for model refinements to reduce future inaccuracies. Thus the project is not only a sensible approach while the scientific understanding of the impacts of forest fires improves, but should also be playing an important role in addressing the current gap in knowledge.

Way Forward

The original proposal envisaged selling the first carbon offsets generated by the project within 3-4 years of project commencement. However, REDD+ turned out to be even more challenging than first thought, with the first such sales still likely 1-2 years off for this project. That said, the new VCS methodology provides an excellent foundation to proceed to the next stage, and MCDI remains intent on realising that original ambition.

To succeed with this, MCDI probably needs another 2-3 years of funding to cover the following key steps:

- Embed early burning more strongly within the framework of local PFM implementation it has successfully developed.
- Develop a simplified calculation that will allow villagers to compute approximate biomass directly from DBH measurements obtained in the field.
- Expand carbon density map to neighbouring Palsar scenes in order to include southern and western portions of Nanjirinji A's VLFR, the biggest VLFR supported by MCDI (61,500ha).
- Write a detailed Project Design Document.
- Obtain validation to both VCS and CCB standards.
- Enter into three way contracts with communities and Carbon Tanzania for the sale of offsets.
- Market offsets to customers prepared to pay a premium price for the strong biodiversity and community development co-benefits associated with the project.

Additional investment would allow MCDI to roll out the project further to achieve the ideal economies of scale for success. E.g. in the early years a lot of investment is needed to develop community capacity in early burning and monitoring impacts (critical to the process of selling carbon offsets), and, with the current low carbon price, it seems unlikely that such costs can be rapidly recovered. Some of the governance support and social monitoring aspects will also be hard to sustain without donor support since communities may, reasonably, decline to pay for those costs out of revenues they have earned.

Future Partnerships

This project has proven an excellent vehicle for MCDI to develop new partnerships with a range of national and international actors. Carbon offset sales through Carbon Tanzania should, obviously, be self-sustaining. But beyond that MCDI has developed strong collaborative relationships with two British universities: UoE and UEA, which MCDI expect to be sustained beyond the duration of the project grant from RNE.

Both universities are attracted to MCDI as providing a solid field base partner, a stable well-managed community forestry initiative, a thorough understanding of local communities and their lives, and intellectually capable staff. Forest fires are an increasingly hot topic for academic research; this project thus provides excellent foundations on which to build and focus academic interest. MCDI is motivated by the opportunities these kind of partnerships offer local staff, the intellectually enriching nature of research work, and the additional quality control on monitoring data that is generated when it is also being used as the basis for published papers. If these partnerships can also generate financial resources to support that ongoing monitoring that is a further benefit.

Selling Carbon Offsets

In the short term at least, it seems likely that material benefits for communities from the project will be constrained by the price of carbon. The failure thus far to achieve international agreement on climate change mitigation has both eliminated the option to convert the project to deliver carbon credits into the official regulated market, and exerted significant downward pressure on the carbon price in voluntary markets. Agreement at the UNFCCC CoP in Paris at the end of 2015 could help lift that pressure, but any official regulated market still looks some distance away, and would depend on the Tanzanian government establishing the necessary frameworks together with credible policy initiatives to support an effective nationwide REDD effort.

MCDI's partner, Carbon Tanzania, has been marketing and selling VERs from its Yaeda REDD project for over two years, and has focused on realising the maximum value for carbon offsets on both the local (Tanzanian) and global market. A key lesson from that experience is that, given the current market where supply is largely in excess of demand, it is important to invest in very clear, convincing marketing and communications materials that sell the qualities (co-benefits) of a REDD+ project in a manner that commercial customers can understand: biodiversity, community and economic benefits need to be laid out clearly in order to attract buyers who seek very strong impacts from their CSR / sustainability spends. Hence the need for MCDI and Carbon Tanzania to invest to meet the future marketing needs of its REDD+ project to maximise the revenue obtainable.

Expected Benefits

If the project can deliver the expected additional carbon sequestration of 0.43tC/ha/yr then at USD $5 per tCO2e annual earnings will amount to $7.8 per hectare. If this were implemented across the entire 111,347 hectares of VLFRs in Kilwa now supported by MCDI, this would generate an annual income of $750,000 or about $170 per household, increasing income by about 50%.

In order for the project to be sustainable, however, this cannot all accrue as profits: communities have some labour costs to meet, and MCDI has more substantial support costs it would need to recover. MCDI's central goal is to reach financial self-sufficiency for its programme of support to commercially viable PFM in Kilwa and elsewhere in southern Tanzania, thereby freeing it and the communities it supports from reliance on fickle donor funding.

MCDI has modelled how to achieve this using a combination of timber (with or without premiums from FSC certification) and REDD+ revenues[76]. MCDI reckons that it likely will need to receive 30%+ of

[76] MCDI (2014) *How can Sustainable Forest Management by Communities be Financially Self-Supporting?* Confidential internal report, MCDI, Tanzania.

total PFM revenues to break even, a split that local community leaders and other stakeholders have endorsed in order to secure the long term support all agree is necessary[77]. MCDI analysed various different scenarios to gauge expected community profits and under what conditions it would break even[78], see Table 18 for a selection. This analysis showed that in the current context neither timber sales nor REDD+ on their own were likely to allow MCDI to break even, but a combination of the two should suffice.

Unlike many REDD projects, the lack of any significant opportunity costs for communities[79] means that the project can succeed with a relatively low carbon price of $5-7 per tCO2e. But the project is much riskier at such price ranges, with substantial revenue from timber sales required in addition to achieve overall enterprise viability, whereas a price of $10 per tCO2e or higher would bring both substantially greater benefits to communities and a more stable cost recovery base for MCDI.

Conclusions

In many regards Tanzania was a strange choice by the Norwegian government as a country in which to invest in REDD+: forest carbon stocks are far lower than in many other tropical countries since the vast majority of forests are dryland forests which store vastly less carbon that climax rainforest, whilst the country has less technical capacity to overcome the myriad complexities of REDD+ MRV than middle income countries such as Brazil and Indonesia. However, Tanzania has one of the strongest frameworks for supporting PFM around the world, and it is therefore laudable that the Norwegian government chose to engage strongly here with a comprehensive programme to support the development of REDD+ readiness in the country.

The results have been mixed: the government of Tanzania has yet to elucidate clear policy priorities by which it expects to deliver nationwide reduction in forest carbon losses, whilst progress in developing national MRV systems and capacity have been slow, and, in NAFORMA, are based upon an expensive forest resources monitoring system that was not originally designed to meet the requirements of REDD+. For REDD+ to be successful at a national level, it may therefore be useful for the government to look carefully at two key lessons of this project: careful identification of a specific driver of deforestation that is susceptible to policy-based mitigation, and designing an MRV system to suit the specific characteristics of the planned interventions.

In contrast some of the pilot REDD+ projects developed by local NGOs, including this one, have shown real promise and delivered substantial achievements on the ground. Now that Norwegian funding is coming to an end, it is a real challenge for these pilot projects to survive in a market environment that has deteriorated markedly since the optimism of 2008-9. Thus, whilst on the one hand MCDI congratulate the Norwegian government for having the vision to support REDD+ in Tanzania in the first place, the organisation urges them and the rest of the donor community not to be blinded by the disappointments and abandon the successes of that effort whilst they are still only half way to the finish line, or else much of that investment may be ultimately wasted. One option that might attract donors concerned to see

[77] Other portions would be paid as tax and shared with the District Council.

[78] As an NGO, MCDI has no interest in making profits from the services that it provides, but planning to break even exactly is likely to lead to regular (small) losses, so instead MCDI should aim to make a small surplus that can be reinvested back into its core social mission, and expand the number of rural it communities supports.

[79] Communities do need to contribute their time to carry out early burning and forest monitoring, but the interest shown by villagers in securing opportunities to get such work suggests that such opportunity costs are minimal, with temporary waged work being strongly attractive to many, see Khatun *et al*. (2015) Fire is REDD+: Offsetting carbon through early burning activities in south-eastern Tanzania. Submitted to *Journal of Peasant Studies*..

results would be to purchase carbon offsets at a higher price than that currently obtainable on the market[80], or offer to match all revenues received from carbon offset sales (incentivising marketing investments).

A particular challenge faced by many of the pilot projects was the absence of frontier deforestation in much of Tanzania. This is relatively easy to detect, and although construction of a plausible baseline scenario can still be a real challenge, technically such REDD+ projects are far less challenging to manage, allowing REDD+ proponents to focus on the central problem of combating the socio-economic drivers of deforestation. But in dryland forests, forest degradation is a much more common mechanism for forest carbon losses, and that requires technically sophisticated methods to measure changes to carbon stocks. Indeed, in this project the processes involved are so complex and non-linear that MCDI used a computer model to deliver the key estimates of carbon fluxes under different fire regimes.

Equally important to a successful REDD+ project as the technical MRV component, is a strong acceptance of REDD+ and solid foundation in good local governance, especially in a country like Tanzania, where many communities live in and around their forests. Many critics of REDD+ focus on the importance of Free, Prior-Informed Consent (FPIC), but REDD+ is so hard to understand as a concept that it is an almost impossibly high hurdle to clear in places where the average educational attainment is low (a characteristic of many places where REDD+ is proposed). Research conducted as part of this project by MCDI's partners in target villages shows that although many villagers are aware of the project on a basic level, they are mostly unable to link early burning to REDD+, or explain what forest carbon is.

If they are to compensate for that, REDD+ proponents need to enjoy strong levels of trust within rural communities, and to act as champions for the communities interests when needed. REDD+ concepts and project activities need to be simplified down so that they can be understood as best they can, and communities should play as big a role as possible in monitoring their own achievements (a particular plus point of the burned area monitoring method adopted in this project). When benefits flow communities need to be encouraged to hold their leaders to account over how revenues are managed, and conversely leaders themselves persuaded to view such accountability as a positive tool not a negative constraint. The good news is that whilst efforts to tackle local community governance in isolation are likely to quickly run into resistance from local elites, the potential income on offer from REDD+ provides an opportunity for everyone to benefit, and thus leaders are far more open to new approaches. In this way REDD+ can serve as a vehicle not just for general economic development and poverty alleviation in poor, forest adjacent communities, but also as a means to improve especially the lot of women and other marginalised groups within these communities.

However, such hopes are tempered by two key themes emerging from MCDI's and other REDD+ pilot projects in Tanzania: that REDD+ is massively complicated by its requirements of additionality and leakage avoidance, and that economic viability is contingent on higher prices for carbon than prevail at present. The complexities of REDD+ become easier to manage at bigger scales, and economies of scale mean that the significant costs of MRV can be more easily borne, but initiatives that start small are more likely to be successful than those that aim for nationwide reach from day one, particularly in countries where human capital is scarce. Price constraints, meanwhile, are self-evident, and a critical brake on global ambitions for realising support for effective forest management based on the important ecosystem services forest provide, especially where opportunity costs of foregone forest clearance are high.

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[80] E.g. many experts think a global carbon price of \$20/tCO2e will be ultimately necessary to drive the kind of changes to business as usual required to avoid catastrophic climate change from global warming of more than 2°C.

As for this project, MCDI have succeeded despite the complexities, and, with negligible opportunity costs, it can sustain much lower carbon prices than many other REDD+ projects. Hence it is believed that the novel fire management approach to REDD+ should not only succeed in southern Tanzania, bringing a much needed additional revenue stream to rural communities, but that it also has huge applicability to dryland forests elsewhere in the world, and especially in the miombo biome that covers much of southern Africa. It is thus MCDI's hope that it has lit a small fire of its own, that, if fanned by the winds of renewed worldwide concern about global climate change and interest in REDD+ in particular, could spread out rapidly from its origins in Kilwa, and play a significant part in building not just Tanzania's REDD readiness, but that of many other countries too.

Appendix I: History of Project Development

The original project concept as outlined in the 2009 proposal to RNE was to use REDD receipts to drive expansion of PFM and MCDI's FSC group certificate. Under MCDI's existing model of certification for timber values it was projected that locally captured revenues per hectare of forest could reach up to $14 per year, with some villages earning annual sums in excess of $100,000. MCDI viewed this as a strong incentive for forest conservation on its own, and thus, under the *Additionality Principle*, once an area of forest has been added to the group certificate, community forest managers should not be able to benefit additionally from selling credits for the carbon stored in the forest that is being used for sustainable timber production. However, with forest cover being gradually lost across Tanzania, without this protection, forest on public land is threatened with degradation and eventual clearance. Conversely, MCDI faced an investment barrier of an estimated $35,000 per village to expand its FSC group certificate to new areas to cover forest inventories, village-level organization, and development of approved management plans.

This was the baseline (zero intervention) scenario against which carbon savings could be generated. Carbon offsets would be sold based on the carbon stored in village forests over and above that which could be expected to be lost from the gradual deforestation that is the zero intervention scenario. An addition envisaged that villages whose forests have already been substantially logged could benefit from some interim revenue flows while they wait for their timber stocks to recover. This original project vision is encapsulated in Figure 43 below.

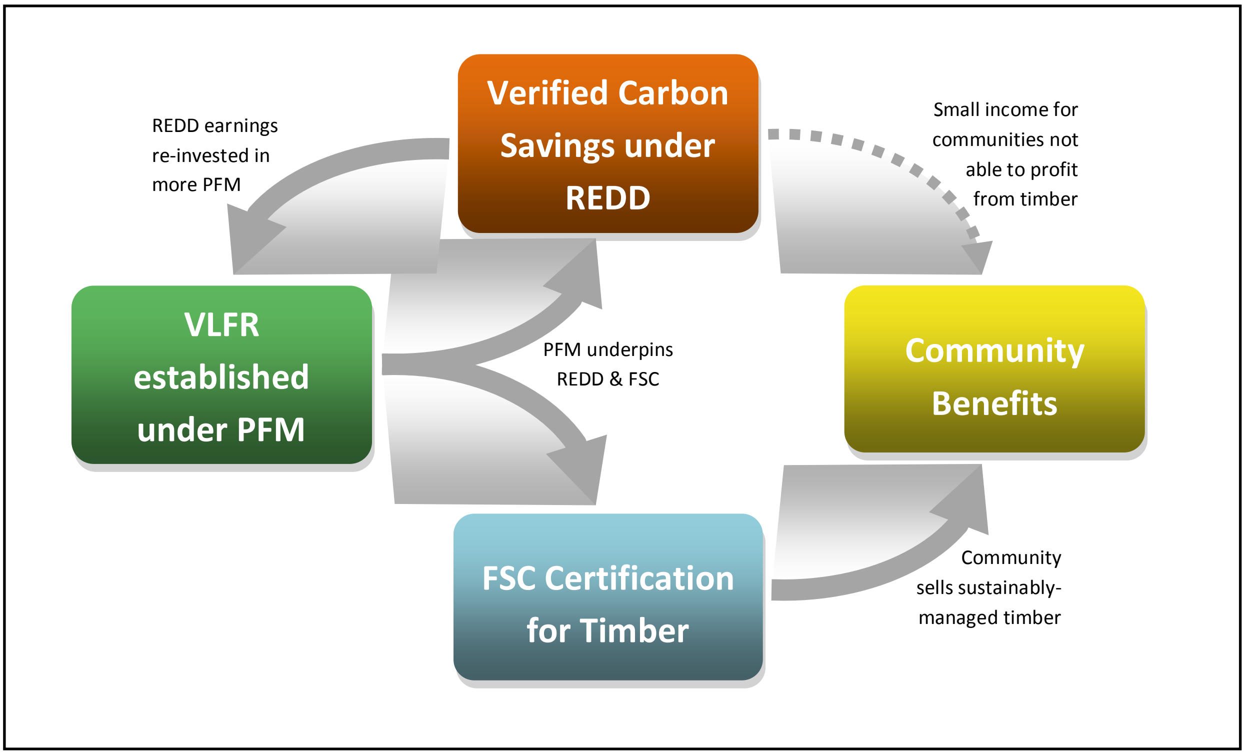

Figure 43. Links between PFM, REDD and FSC as given in original project proposal.

This was a very attractive vision, suggesting that REDD+ could catalyse the expansion of PFM and sustainable timber utilisation. It was described in more detail in the Project Scheme Outline that was produced in 2010.

It may be that this vision may yet come about, but despite exponential sales growth timber markets have proven harder to crack than MCDI had hoped, with only one VLFR, in Nanjirinji A village, yet covering its full marginal cost of operation (including MCDI support). Conversely the well-documented travails of international carbon markets have reduced possible REDD revenue to such a level that rapid recovery of PFM expansion investment costs would not be easy.

MCDI encountered a further complication when it attempted to introduce carbon contracts linked to this idea; the initial PFM expansion funded under this grant came from a traditional donor, and villagers knew that. Not having agreed to such an enterprise-oriented approach to PFM in the first place, it therefore appeared that the profits from REDD+ were not so much paying back their own 'debt' but helping another village entirely, to which the first village might suggest should be funded from some other grant. This might be a rather passive view of aid in which the job of beneficiaries is simply to receive (and problematic in how easily it segues into aid dependence), but it is the prevailing view of most rural communities and many other project stakeholders.

It may still be possible to finesse the politics around REDD+ as a catalyst agent to support the rapid expansion of commercialised PFM along a social enterprise model, but with the economics of both timber and REDD+ on their own somewhat gloomier than had been expected in 2009, the project morphed to view timber and carbon instead simply as complementary revenue streams in a unified, holistic programme of sustainable forest management. Under such an approach, MCDI look at each VLFR as an independent enterprise, and seek to maximise returns on investment by tapping every available revenue stream.

Appendix II: Logical Framework

Project Summary	Measurable Indicators	Means of Verification	Important Assumptions	Actual Outputs
GOAL: Institutions and selected local communities in South Eastern Tanzania are REDD ready by 1st January 2014				
PURPOSE: Pilot the integration of new financial flows from carbon offsetting activities under REDD with PFM and forest certification, leveraging these revenues as a catalyst to further expand sustainable forest management and use in SE Tanzania.	28, 000tCO_2e saved and first *ex-ante* offsets sold by end of project; mechanisms for transparent management of sales established. New methodology for delivering REDD+ credits through fire management. 80% of PFM profits benefitting local people, and 66% of community members favourable towards PFM and REDD. PFM expansion underway funded by REDD revenues with another 25,000ha of forest and seven rural communities (~10,000 people) into MCDI's FSC group certificate by end of project.	Receipts issued for carbon credits. Project records and reports.	Mechanisms established for the voluntary market can be adapted to the regulatory market. REDD revenues suffice to begin expansion. Methods developed are applic-able beyond the project pilot area.	At least 27,600tCO_2e saved, but *ex-ante* offsets not sold due to delays in securing approval of VCS methodology for delivering REDD+ credits through fire management. PFM profits from certified timber sales generated in four villages and 86% spent on outcomes considered widely beneficial. PFM expanded to five communities with 25,681ha of forest included in MCDI's FSC group certificate. This was financed using reallocated project funding rather than REDD revenues as planned.
OUTPUTS: 1. Combined group certificate, validation and verification scheme covering timber and carbon-based products open to widest possible variety of community-managed forests in Tanzania.	Combined group certificate including third party validation of carbon benefits of project. New VCS-approved methodology made available for generating REDD+ credits through fire management.	Certificates obtained. VCS and CCBA records. Project records and reports.	Certified scheme attracts buyers on the international voluntary market.	VCS methodology passed through double review process and formal approval from VCS expected imminently. Delays in securing methodology approval meant that third party validation of carbon benefits was not achieved by the end of the project. Four new villages nonetheless included in MCDI's FSC group scheme.

Project Summary	Measurable Indicators	Means of Verification	Important Assumptions	Actual Outputs
2. Mechanisms to sell carbon credits for expansion of group certificate and/or forest recovery, and compatible with developing national REDD standards.	Sales system established and compatible with national approaches. Website for transparent sales management established. First *ex-ante* offsets sold by end of project.	Receipts issued for carbon offsets. Functioning website. Project records and reports.	Sales of offsets eventually suffice to fund PFM expansion. Project design and web-based sales mechanism are compatible with new national standards.	MCDI partnered with an intermediary sales agent, Carbon Tanzania, who determined that identifying key markets and routes through which offsets will be sold once project validation is achieved was a more urgent requirement than a novel website. This reflects a difference between the voluntary markets, with robust but expensive independent third-party verification underpinning market confidence, and putative regulatory markets where ultra-transparency would be a much cheaper way of establishing credibility of claims.
3. Efficient, scientifically robust and cost-effective method for participatory assessment and monitoring of carbon stored in forests including soil carbon.	Method for participatory C assessment developed and trialled. New method requires less than half time investment of current method. Protocol for verification of C assessments by remote sensing developed and trialled. Combined method is able to estimate C stocks to 75% confidence level.	Carbon assessment records submitted to 3rd party certifier. Project records and reports. Published journal papers.	Method is acceptable to 3rd party certifier. Carbon assessments show sufficient carbon to generate substantial revenues from REDD. GIS data analysis is sufficiently simple that it can be systematized.	Method for assessing and monitoring carbon stocks developed, trialled and submitted to VCS for approval. Not enough known about soil carbon to quantify, although effect expected to be positive. Four relevant papers published/in press or drafted to support the method.

Project Summary	Measurable Indicators	Means of Verification	Important Assumptions	Actual Outputs
4. Drivers of deforestation controlled and reduced.	Analysis of local drivers of deforestation. Programme for control of significant drivers designed and implemented.	Carbon assessment records submitted to 3rd party certifier. Project records and reports. Published journal papers.	Analysis of drivers of deforestation remains valid in the short to medium term; significant new threats do not emerge.	Analysis of local drivers of deforestation performed revealing key drivers (in order) are forest fires, agriculture, charcoal production, and illegal logging. Programme of fire abatement through early burning designed and implemented.
5. Best practice established for equitable management and sharing of economic benefits from forest conservation across the entire community.	At least 50% of community members receive material or in-kind benefits equal to at least 10% of their annual income by end of project.	Socio-economic surveys of households in participating communities. Feedback collated through Most Significant Change system. Project records and reports. Published journal papers.	Community benefits are sufficient to attract continuing support for PFM and REDD.	Prolonged project approval and validation process by VCS delayed carbon offset sales and benefit flow to communities. Nonetheless 86% of financial benefits from certified timber sales put towards projects considered widely beneficial; 39% of households consider themselves better off by the end of the project.
6. Achievements disseminated with policy recommendations for national and international audiences.	Methods and best practice documented and disseminated based on project experiences. Annual policy analyses published with recommendations.	Published analyses. Project records and reports. Published journal papers.	Recommendations are well-received and acted upon.	Four annual policy analyses published with recommendations well received. Four papers published/in press, four drafted, three envisaged, and five student theses.

Project Summary	Measurable Indicators	Means of Verification	Important Assumptions	Actual Outputs
ACTIVITIES: 1.1. Preliminary policy analysis and detailed scheme outline.	Analysis and outline produced within 6 months of project commencement.	Report submitted to RNE and REDD Taskforce.	Scheme can be put into action without encountering policy blockages.	Detailed scheme outline and first policy analysis produced in 2010 (within 6 months of project start), submitted and published on MCDI website. Scheme outline was subsequently removed from MCDI website after design was changed in 2011/12.
1.2. Sign carbon agreements with selected pilot communities.	Carbon agreements signed with all pilot villages.	Signed agreements in village and KDC records.	Communities adhere to their responsibilities as outlined in the agreements.	REDD project cooperation agreements signed with all villages and chosen over contracts which caused concern among communities and were scrutinised as being too 'business like'. However, detailed contracts will be required before sales of offsets can begin.
1.3. Develop REDD Project Design Document.	First full draft complete by end Y3.	Draft submitted to RNE and REDD Taskforce.	Design is compatible with 3rd party certification standards.	PDD development postponed due to delays in securing VCS methodology approval.
1.4. Achieve carbon validation to industry-leading voluntary market standards (VCS and CCBA).	MCDI receives 3rd party carbon validation by end Y4.	Certificates held by MCDI. 3rd party certifier records.	Validation can be successfully maintained and leads to saleable carbon credits.	Delays in securing approval of VCS methodology meant that project validation could not be achieved before the end of the project.
1.5. Confidence-building preliminary steps to PFM including land-use planning.	VNRCs formed in all pilot communities by end Y2. Village Land Use Plans completed in all pilot communities by end Y2.	Village and KDC records.	Steps lead to full PFM and FSC certification later.	Facilitated land-use planning and PFM in five villages. Although land use planning was completed, land use plans for four villages have not yet been signed off by KDC.

Project Summary	Measurable Indicators	Means of Verification	Important Assumptions	Actual Outputs
1.6. Complete PFM expansion to all pilot villages including FSC certification.	Have at least 10 villages inside combined group certificate scheme by end of the project.	3rd party certifier records. MCDI group certificate records.	Expansion does not overstretch MCDI's management capacity.	PFM expansion was completed and VLFRs certified in four additional villages by the end of the project, bringing group certificate scheme membership to 11 villages. One village did not complete the process due to internal land disputes which need to be resolved first.
1.7. Monitor participatorily avifauna biodiversity and threats to biodiversity in community forests.	Estimated population counts of indicator species. TRA scores for each VLFR.	Project records and reports. 3rd party certifier records.	Indicators show positive, or at least non-negative trends, supporting sales of carbon credits.	Participatory avifauna biodiversity baseline set in partnership with Carbon Tanzania and report produced. Monitoring in communities shows non-negative trends in three indicator bird species.
1.8. Design new VCS method and support it through the double approvals process.	New VCS method approved by mid Y4.	VCS list of approved methods.	MCDI can successfully implement the new methodology.	VCS method designed and approved shortly after end of project.
2.1. Participate in development of national standards and systems for sales, monitoring, assessment, reporting and verification of carbon credits.	One or more project partners present in at least 75% of relevant national meetings and workshops.	Meeting minutes and workshop proceedings reports.	Project partners listened to, and views taken on board where appropriate.	MCDI and project partner, Carbon Tanzania, attended >75% of national meetings and workshops on REDD, as well as various international dialogues.

Project Summary	Measurable Indicators	Means of Verification	Important Assumptions	Actual Outputs
2.2 Establish all necessary systems to comply with national REDD standards as they evolve.	MCDI ready to comply with national REDD standards by end of project.	Project records and reports.	National REDD standards are completed by end of project. Standards are not incompatible with project design.	Development of clear policy priorities and national REDD standards not completed by end of project. MCDI participated in relevant national dialogues and policy analyses, and developed project and systems to comply with international standards set out by VCS, reducing risk of non-compliance with national standards once finalised.
2.3. Develop market linkages through Carbon Tanzania and international carbon exchanges.	At least some credits sold by end of project.	Receipts issued for carbon credits. Project records and reports.	Markets accessed are sufficiently large to fund expansion.	Market linkages available through Carbon Tanzania assessed and report produced. Delays in approval of VCS method meant offsets were not sold before end of project, although Carbon Tanzania is ready to sell project offsets as and when they become available. Market value of REDD-based carbon offsets is low, but should still be sufficient to cover project costs and limited expansion.
3.1. Assess stem and root biomass carbon in miombo woodlands in SE Tanzania.	Baseline assessment produced inc confidence limits by end Y2.	Project records and reports. Published journal papers.	Variability in stem and root C stocks manageable.	Stem and root biomass assessed; root biomass deemed insignificant. Two papers published/in press, plus two drafted.

Project Summary	Measurable Indicators	Means of Verification	Important Assumptions	Actual Outputs
3.2. Assess soil carbon in miombo woodlands in SE Tanzania.	Baseline assessment produced inc confidence limits by end Y3.	Project records and reports. Published journal papers.	Variability in soil C stocks manageable.	Not enough known about soil carbon in miombo to quantify, although project impact is expected to be positive.
3.3. Develop participatory method for assessing biomass.	Method developed and trialled by end Y4. Results published.	Project records and reports. Published journal papers.	Community members are able to use method unsupervised for future monitoring of C stocks.	Method developed to facilitate community involvement in C stock assessment. However, VCS method ultimately relies on synthetic radar satellite data for this purpose, see 3.5 and 3.6 below.
3.4. Monitoring effects of fire on forest biomass and carbon balance.	Method refined and tested by end of project. Results published.	Project records and reports. Published journal papers.	Community members are able to use method unsupervised for future monitoring of C stocks.	Method developed for monitoring tree mortality under different fire regimes that can be used by communities under supervision, and potentially with practice unsupervised.
3.5. Spatial analysis of regional biomass by fusing remote-sensing satellite data with ground surveys.	Results of analysis against biomass carbon published by end Y3.	Project records and reports. Published journal papers.	Remote-sensing data has sufficient resolution to generate meaningful results.	Data from PSPs used to anchor data from satellite-based synthetic radar sensors (PALSAR) in order to derive highly accurate biomass estimates (>95% resilience to variations in bootstrap sample).
3.6. Develop simple and efficient protocol to allow for remote verification of participatory carbon monitoring.	Protocol developed and trialled by end Y4.	Project records and reports. Published journal papers.	Remote-sensing data has sufficient resolution to generate meaningful results.	Same approach used in 3.5 can be used to verify participatory monitoring of C stock changes.
4.1. Analysis of local drivers of deforestation.	Thorough, participatory analysis completed by end Y1.	Report submitted to RNE and REDD Taskforce.	Drivers of deforestation are susceptible to intervention.	Analysis revealed fire as the most significant local driver of forest C losses.

Project Summary	Measurable Indicators	Means of Verification	Important Assumptions	Actual Outputs
4.2. Design programme for community-based fire management in community forests.	Programme design completed and trialled in at least one community forest by end Y3.	Design set out in draft PDD.	Programme can be successfully rolled out (not too manpower intensive for MCDI).	Community-based fire management programme designed and trialled in two community forests in Y3, and rolled out to six VLFRs in Y4. Development of PDD not completed due to delay in VCS approval.
4.3. Implement community-based fire management in community forests.	Programme has commenced in at least 4 villages by end Y4.	Project records and reports. Village records.	Programme successfully controls fire in community forests.	Community-based fire management rolled out to six villages in Y4. However, an unusually prolonged rainy season meant that then impact was negligible.
5.1. Identify and test best methods for participatory poverty assessment.	At least 2 different methods for participatory poverty assessment trialled in pilot villages by end Y1.	Report submitted to RNE and REDD Taskforce. Published journal papers.	Participatory methods yield meaningful results.	Method for participatory poverty assessment developed in partnership with researchers from University of East Anglia.
5.2. Pilot protocol for best financial management at village level with mechanisms to deliver democratic benefit sharing, with benefits felt across the community.	Protocol developed, trialled and documented by end Y2. At least 50% of community members experiencing benefits by end of project.	Report submitted to RNE and REDD Taskforce. Published journal papers.	Communities cooperate willingly, and take up protocol for long term use.	Financial management protocols developed and implemented in project villages, using Village Assemblies to ensure transparent financial reporting. 86% of PFM profit expenditure considered beneficial to wider community (>90% in 3 villages) and 39% of households better off by end of project.

Project Summary	Measurable Indicators	Means of Verification	Important Assumptions	Actual Outputs
5.3. Develop methods and establish baseline for participatory assessment of village governance.	Method trialled and documented, and governance scores produced by end Y1.	Report submitted to RNE and REDD Taskforce. Published journal papers.	Assessments encourage better governance by community leaders.	Method developed to assess village governance using a participatory scoring approach. Baseline governance scores obtained in Y1.
5.4. Monitor changes in village governance.	Annual governance scores produced in Y2-Y4. Audit of PFM revenues received to date in Y3.	Project records and reports. Published journal papers.	Assessments encourage better governance by community leaders.	Participatory governance scoring system used to assess governance in Y2 and Y4. Audit of PFM revenues conducted in four villages and report produced. Governance scores improved in project villages, suggesting that project activities encouraged better governance by leaders.
5.5. Monitor households' socio-economic status over length of project.	Results of biannual surveys reported in Y1, Y3 and Y4.	Project records and reports. Published journal papers.	Household indicators show measurable change over project duration.	Households' socio-economic status monitored in Y2 and Y4. Limited wealth impact of project detected, probably due to delays in carbon offset sales.
5.6. Monitor communities' perceptions of project progress and impact on their lives.	Stories of change collected from each participating village.	Project records and reports.	Community members supply representative stories which honestly reflect changes experienced.	Biannual stories of most significant change collected in project villages. More stories relating to project impacts were reported later on in the project; in late 2014, 4/8 stories could be directly/indirectly linked to project activities.
6.1. Publish annual policy analyses throughout life of project.	Analyses produced each year.	Analyses submitted to RNE and REDD Taskforce.	Analyses are useful in informing development of national REDD standards.	Annual policy analyses produced and published on MCDI website.

Project Summary	Measurable Indicators	Means of Verification	Important Assumptions	Actual Outputs
6.2. Document achievements and methods developed, and disseminate to national and international audiences.	Separate reports on each output by end of project. At least 3 journal papers submitted for publication and presented at conferences.	Reports submitted to RNE and REDD Taskforce. Published journal papers.	Methods and protocols developed are usable by other projects.	Project achievements disseminated locally during MCDI's Stakeholders Forum, nationally during a workshop with high-ranking officials, and through 11 journal papers submitted/in press, drafted, or envisaged.
6.3. Knowledge on carbon assessment transferred to Tanzanian partners.	At least 2 MCDI staff trained in advanced carbon assessment techniques and analysis.	Report on training workshop.	Staff trained continue to work on REDD activities within Tanzania.	Internal and on-the-job training provided to MCDI staff, with stepwise training materials developed for future reference.
6.4. Final report compiling all policy recommendations together with methods, experiences and lessons learned from pilot project.	Comprehensive final report summarising all project components, results achieved, lessons learned, and policy recommendations produced by end of project.	Report submitted to RNE and REDD Taskforce.	Report is useful to other REDD practitioners.	Comprehensive final report produced and submitted to RNE.

Appendix III: Summary Financial Report

Financial Performance

The tables below show the financial expenditure of the Project for 2014 (Table 1), and the financial expenditure against budget over the entire course of the Project (2010-2014), Table 2.

Table 1. Financial expenditure for 2014

Output	Budget for 2014	Expenditure to 31 Dec 2014	Variance against Expectation
1. Combined group certificate scheme	150,263	154,745	+3%
2. Mechanisms to sell carbon credits	3,010	0	-100%
3. Method for participatory carbon assessment	20,452	20,936	+2%
4. Controlling drivers of deforestation	62,539	62,381	0%
5. Benefit sharing best practice	42,150	42,547	+1%
6. Results dissemination	30,219	29,810	-1%
Capital Costs			
Staff	54,079	54,014	0%
Administration	29,175	29,175	0%
Total	**391,887**	**393,607**	**0%**

Table 2. Financial expenditure against budget over entire course of the Project (2010-2014)

Output	Budget	Expenditure	% Remaining
1. Combined group certificate scheme	435,233	366,065	16%
2. Mechanisms to sell carbon credits	47,923	26,363	45%
3. Method for participatory carbon assessment	433,181	428,372	1%
4. Controlling drivers of deforestation	71,699	121,583	-70%
5. Benefit sharing best practice	195,378	232,283	-19%
6. Results dissemination & policy recommendations	82,854	67,251	19%
Capital Costs	117,325	117,378	0%
Staff	321,904	347,892	-8%
Administration	157,627	157,656	0%
TOTAL	**1,863,123**	**1,864,843**	**0%**