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Tanzania Forest Conservation Group

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Special Edition on REDD

Bringing together experiences from four REDD pilot projects in Tanzania, this edition of the Arc Journal looks at different approaches to greenhouse gas accounting for REDD projects in Tanzania; external validation of voluntary market REDD projects; and linkages with a national system.

Do Tanzania's Eastern Arc Mountains have more species of amphibian than anywhere else in the world? Find out more inside....

Applying the Verified Carbon Standard (VCS) in a REDD pilot project in Tanzania: a description of the MJUMITA and TFCG approach.

By Theron Morgan-Brown, MJUMITA

Applying the Verified Carbon Standard to REDD in Tanzania

MJUMITA (Mtandao wa Jamii wa Usimamizi wa Misitu Tanzania – Community Forestry Network of Tanzania) and TFCG are piloting REDD (Reducing Emissions from Deforestation and forest Degradation) in two sites – Lindi Rural district in the East African Coastal Forest biodiversity hotspot and in the Rubeho and Ukaguru mountains spanning parts of Kilosa and Mpwapwa districts. One of the major goals of the pilot project is to help participating communities sell their emissions reductions in the voluntary carbon market. We have chosen to seek VCS (Verified Carbon Standard) and CCBA (Community, Climate and Biodiversity Alliance) verification because these are the most rigorous and marketable verification schemes for the voluntary carbon market. VCS focuses on the verification of reductions in greenhouse gas emissions, whilst the CCB Project Standards aim to verify social and environmental benefits generated by a project. Since the focus of this article is on carbon accounting, we only describe our VCS related Measurement, Reporting and Verification (MRV) activities. Additionally, for brevity, we focus on our Lindi site MRV work, which is close to finalization.

View of the Lindi project site with the forest of the Noto Plateau in the background. Photo by Raymond Nlelwa, TFCG.

The Methodology
We chose the VCS methodology VM0015 as our primary guidance for greenhouse gas accounting. The methodology was developed by Amazonos Sustainable Foundation and the World Bank's Biocarbon Fund. Unlike other VCS REDD methodologies, it can be applied in areas where the post-deforestation land use might include reforestation (unlike VM0007, and VM0009); includes accounting of soil carbon (unlike VM0006); and allows for harvesting of timber in the with-project scenario (unlike VM0009). The methodology aims to be compatible with jurisdiction accounting in nested national REDD approaches. Like the majority of country proposals for REDD at the UNFCCC, VM0015 focuses on measuring and reducing gross deforestation rather than net deforestation. VM0015 is also the only full REDD methodology listed on the UNFCCC's REDD website under methodologies and tools (though an older and less rigorous version than the one approved by VCS).

Baseline Analysis
Like most REDD methodologies, the methodology is based on the assumption that past deforestation patterns will be predictive of future deforestation. As such, we are required to prepare a baseline deforestation scenario for a reference region and to use the scenario, together with other information on drivers of deforestation to model the timing and location of future deforestation. Observed deviations from this model can then be used as a basis for quantifying the projects effect on deforestation.

The reference region is a region that includes the project area forests, leakage belt forests, and other similar forests in an area much larger than the project area that existed in 2000. It must be similar to the project area in terms of forest types, drivers of deforestation, population density, accessibility and geology. By selecting a reference region that is similar to the project area, it is more likely that deforestation trends seen in the reference region will be predictive of deforestation in the project area over the next 10 years. For Lindi, we have chosen a reference region that consists of most of Lindi Rural district and a small portion of Ruangwa District (Figure 1).

The methodology does not specify the exact approach that should be used for mapping historical land-cover change, but directs users to the IPCC 2006 Guidelines for Agriculture, Forest and other Land Use and the GOFC-GOLD Sourcebook on REDD. There are two approaches to mapping land cover change listed in these sources. One approach is to classify land cover separately for different years and then to compare the classifications to detect change. The other approach is to detect change directly from the data without classifying first. We decided on a hybrid approach, where we would have a starting classification from the beginning of the reference period (roughly 10 years ago) and then use change detection to detect deforestation events within areas classified as forest.

Data Selection

We decided to use 30 m Landsat data as the primary data source for detecting and mapping historical land use change because Landsat data is an appropriate resolution, affordable and systematically gathered for all the years of the reference period. For Lindi, we acquired nearly cloud free Landsat imagery for 2000, 2001, 2002, 2004, 2006, and 2008 - all from the month of May. Unfortunately, all wet season imagery for 2010 was too cloudy to use. Thus, we ordered ALOS PALSAR (a cloud penetrating radar) data from the dry season of 2008 and dry season of 2010 covering the entire reference region. Dry season data for PALSAR is preferred because the signal can be affected by moisture levels in vegetation and soil, but is not affected by burns or tree leaf shedding. Finally, through Planet Action, we acquired high resolution spot imagery for parts of the reference region from June 2007 and August 2010 for ground truthing. A good portion of the Lindi Reference region is also covered by cloud free 2009 GeoEye high resolution images on Google Earth.

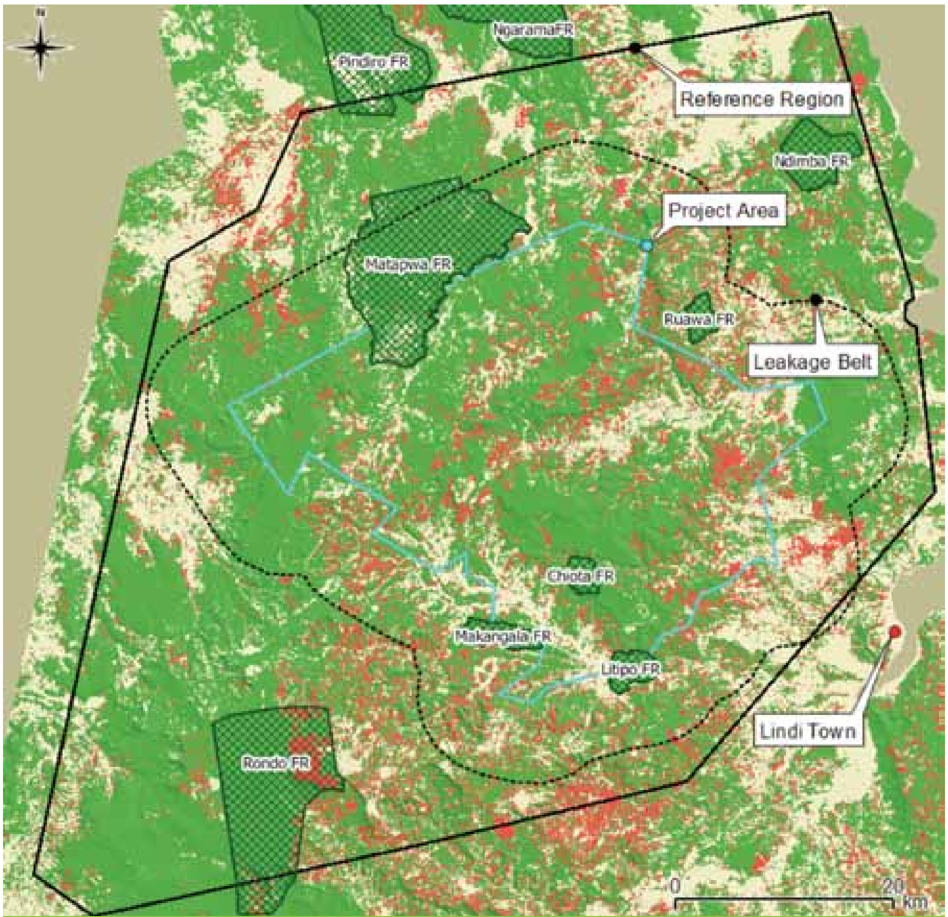

Figure 1: Lindi reference region, leakage belt, project area and historical deforestation. Beige = Non-Forest, Green = Forest, RED = Deforestation 2001 to 2010. Forest reserves (FR) are excluded from reference region and project area.

To better understand the landscape and help interpret high resolution imagery, we also collected ground truthing data from 200 points within the project area.

Pre-processing

We spent a significant amount of time on georeferencing to ensure that the different data products would be compatible. Since the high resolution GeoEye imagery on google earth could not be warped, all other data was warped to match it. Additionally, we performed relative radiometric calibrations on the Landsat data using iteratively re-weighted multivariate alteration detection to identify areas of no change to use as pseudo invariant features following Canty and Nielsen 2008. Finally, we created cloud masks for all the landsat scenes using a combination of decision trees, buffers, and change detection to accurately identify clouds and cloud shadows.

For PALSAR SLC data, we used the SARscape 4.2 ENVI module. We extracted gamma nought values for the SLC HH and HV bands into 25m square pixels using a SRTM DEM and the optimal resolution approach with radiometric calibration and normalization. We used a local incident angle map generated by SARscape to mask out areas of radar shadow and overlay, which was less than 1% of the reference region. For visualizing the data as an RGB image, we also created a HH to HV ratio band to use as the blue band and applied a gamma filter.

Forest Mapping

The first step to mapping forest is to define forest. The Tanzanian designated national authority has not registered a forest definition with the UNFCCC, but the Forest Act of 2002 defines forest as “an area of land with at least 10% tree crown cover, naturally grown or planted, and or 50% or more shrub and tree regeneration cover”. No minimum area or height is specified. Thus, in the absence of clear guidance, we constructed our own definition of forest that was consistent with the Forest Act definition while also being detectable with remote sensing. Over

50% cover of forest regeneration of any height was classified as forest, as were natural and planted woodlands and forests with greater than 30% canopy cover (treating tree canopies in high resolution data as a solid area) within a single Landsat pixel. Below 30% tree cover in high resolution imagery was not distinguishable from other non-forest classes in Landsat and is likely closer to 10% actual canopy cover, and thus was treated as non-forest. Baobab trees were not included as canopy cover because they are not detectable in May Landsat imagery (they don't have leaves) and are rarely cut down.

We chose the 2008 scene as the focal scene for classification since it was the best cloud free image closest to the project start date and we had high resolution data from 2007 and 2009. To select training points, we loaded all available satellite and field visit data into the open-source GIS platform Quantum GIS, with a grid corresponding to Landsat pixels, giving us the ability to rapidly compare data layers, including Google Earth Geoeye imagery that we imported through the OpenLayers plugin. We took residual differences in georeferencing into account when placing training points on the 2008 Landsat scene. To more clearly differentiate between tall and short trees in areas where high resolution data was not available or difficult to interpret, we also examined PALSAR data which is sensitive to biomass levels,

We identified 18 major land-covers including water, bare surfaces, grassland, flood plains, annual cultivation, flooded cultivation, palm plantations, agroforestry, open woodlands, predominately grass fallows, predominately woody fallows, regenerating forest, regenerating coastal scrub, coastal scrub, miombo woodland, coastal woodland (which tends to have woody undergrowth), and coastal forest. Due to the extremely fragmented nature of the Lindi landscape, training points had to be placed carefully. The points were made into 20m buffers and placed so that either 4, 2, and occasionally 1 pixel of the same class was selected. For the final classification, we placed 4250 training polygons which included more than 12,000 pixels.

For classification, we used the Randomforest classification (Breiman 2001) implemented in R (see www.r-project.org) using a script written by Ned Horning of the Center for Biodiversity and Conservation at the American Museum of Natural History and Jeff Silverman of Terra Global Capital. Randomforest has advantages over traditional remote sensing classification techniques because it can use non-spectral and categorical data, which can greatly improve the accuracy of the classification. For data for the training points, we included Landsat bands 1-5 and 7, a digital elevation map (DEM), a slope map, an aspect map, a shaded relief map generated from the DEM based on the sun azimuth and elevation from the specific Landsat scene to help account for topographic shading, an FAO soil type map, and a map of unusually dry areas for the specific scene. After classifying the 2008 Landsat scene (figure 2), the same Randomforest model was applied to the 2001 scene, which was chosen over the 2000 scene as the starting point because it was more similar to the 2008 scene in terms of overall greenness.

Accuracy Assessment

VM0015 requires that the base classification for the deforestation analysis be at least 90% accurate at differentiating between forest and non-forest and 80% accurate at differentiating forest classes. These are very high accuracy requirements, and thus why 12,000 training pixels were required. To achieve the desired accuracy, we combined all non-forest classes into one class and combined forest classes into either high carbon (coastal forest and dense woodland) or low carbon forests (open woodlands, agroforestry, woody fallows, regeneration, and scrub). We gathered data from 499 random points (not used in training) stratified by the 18 original land-use / land-cover types to test the accuracy of the 2008 classification. The confusion matrix is shown in table 1.

Table 1: Confusion matrix for 2008 Landsat classification with combined classes and majority filter

	Non-forest	Low Carbon	High Carbon	Total	Accuracy
Non-forest	135	11	2	148	0.91
Low Carbon	14	155	19	189	0.82
High Carbon	0	24	139	162	0.86
Total	149	190	160	499	r
Reliability	0.91	0.82	0.87		r

As shown in table 1, the 2008 Landsat classification achieves greater than 80% accuracy for all classes. The overall forest / non-forest accuracy is 95%.

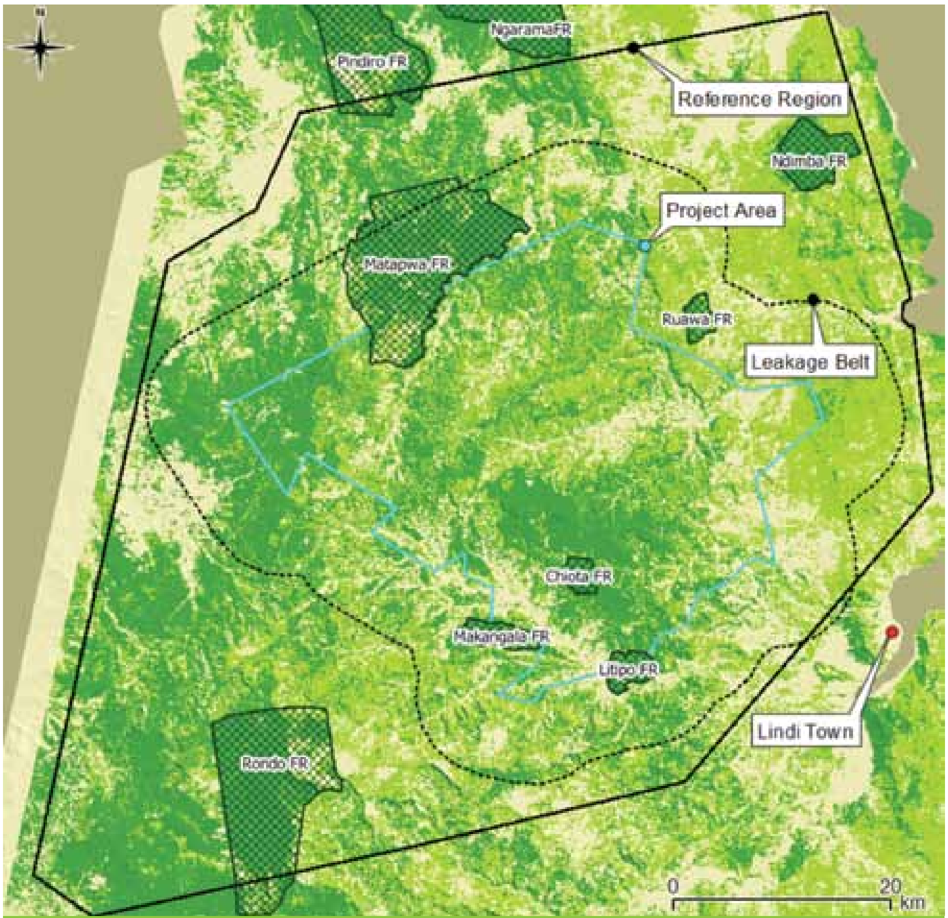

Figure 2: Lindi Reference Region 2008 LU/LC Classification. Beige = Non-Forest, Dark Green = High Carbon Forest, Light Green = Low Carbon Forest. .

Deforestation Mapping

After a satisfactory classification was achieved we began work on change detection to map deforestation up to 2010. While it is possible to compare classifications from the start and end of the reference period to achieve a reasonable estimate of the average deforestation rate, this is not appropriate in an area where significant regeneration occurs post deforestation. Under IPCC and VCS guidelines, such an area is technically ineligible for REDD unless the national forest definition specifies such areas as temporarily un-stocked, which the Tanzanian definition does not. Also, a two point analysis would show these areas as having been degraded, but not deforested and thus would underestimate the deforestation rate. Since REDD project monitoring for reporting carbon emission reductions is likely to be on a shorter time frame – perhaps every 1 to 2 years, not including this kind of short duration deforestation would lead to the incorrect conclusion that accelerated deforestation was occurring in the leakage belt.

To map deforestation in Lindi, we used iteratively re-weighted multivariate alteration detection (IR-MAD) (Nielsen 2007). This method of change detection is invariant to most differences in the data that are constant across a scene such as differences in atmospheric scattering or sensor calibration. Using IR-MAD we compared Landsat scenes from May 2002, 2004, 2006, and 2008 to May 2001. For each year of comparison, the IR-MAD script produces a final output image which consists of 6 bands (in order of increasing coherence) and a chi-square layer representative of the degree of change relative to other pixels. By comparing the IR-MAD bands with actual examples of deforestation shown in high resolution imagery, we determined that values less than -1 in the 6th IR-MAD band corresponded to deforestation while avoiding most change associated with seasonality and degradation, especially if paired with chi-square values higher than 50.

To detect deforestation in Lindi from 2008 to 2010, we used PALSAR data. Other researchers using PALSAR data to map deforestation have found that the HV band is the most sensitive to changes in forest cover. Therefore, we simply subtracted the 2008 HV values from the 2010 HV values. By overlaying the difference image on high resolution imagery, we could see that deforestation was typically identifiable by a decrease in the HV band of more than 0.010 when the resulting 2010 value was less than .017.

Then, we created a decision tree in ENVI that selected the pixels matching the deforestation criteria for Landsat and PALSAR data from locations classified as forest in 2001 in order from 2002 to 2010 so an area could only be deforested once. For the years covered by Landsat data, we also include cloud masks in the decision tree to avoid selecting the few cloud pixels within the Lindi scenes as deforestation. The results are shown in figure 1.

For the deforestation analysis, it was observed that some deforestation was being falsely detected in the Landsat change images in agro-forestry areas in years when farmers cleared understory vegetation. Thus, a final decision tree was create to remove deforestation in areas where the 2001 and 2008 classifications both showed agro-forestry or open woodland.

Accuracy assessment of the deforestation map was complicated in Lindi since significant regeneration often occurs post-deforestation and there is limited high resolution data from the start of the reference period. We compared deforestation mapping using IR-MAD change detection to deforestation mapping as a result of class changes between 2001 and 2008. As expected, we found that more deforestation was detected using the IR-MAD approach since it included years between 2001 and 2008. However, we also found a large disagreement between the two approaches not related to deforestation in the in between years. Only 60% of the areas classified as forest in 2001 and non-forest in 2008 were detected as deforested by the IR-MAD approach, suggesting that the IR-MAD approach was not sensitive to all deforestation events. However, comparing the limited high resolution imagery from 2001-2002 to 2009 showed that the IR-MAD approach was more accurate with almost all areas of disagreement with the classification detected deforestation being the result of misclassification in either the 2001 or 2008.

Deforestation Modeling

Our chosen REDD methodology requires that the quantity and location of future deforestation be projected. Since our historical deforestation rates (see table 2) do not appear to be correlated to improvements to the coast highway or population increase, we chose to use the historical average as the predicted future deforestation rate for the next 10 years, which is 1.97%.

Table 2: Lindi Reference Region Deforestation Rates from 2001 to 2010

Period	Deforestation Rate
2001-2002	2.55%
2002-2004	2.15%
2004-2006	1.61%
2006-2008	1.87%
2008-2010	2.40%

VM0015 requires an 80% Figure of Merit (FOM) for modeling the location of future deforestation in mosaic landscapes, or the best result of three different models. To judge the accuracy of a model, the model is run on a separate set of data not included in the training of the model, which can either be a different subset of the region or a different time period. We chose the subset approach and trained our models using randomly selected 1km squares representing 50% of the reference region and validated them using the model to predict the outcome in the remaining 50% of 1km squares. The FOM is calculated by taking the total area correctly predicted as deforested in a validation data set over itself plus the total area incorrectly predicted as deforested plus the total area incorrectly predicted as not deforested. Since an FOM of 80% is virtually impossible (no example in the published literature), we have used three different models to model the future of deforestation in Lindi, including a Dinamica EGO model (see www.csr.ufmg.br/dinamica/), a Randomforest model implemented in R, and an IDRISI Land Change Modeler model. We are still waiting for the results of the IDRISI model (which is being run by a researcher outside the project), but so far, Randomforest achieved the highest FOM of 24%. The Randomforest model included distance to settlements, distance to roads, distance to disturbance, population pressure (calculated using an R script provided by Jonathan Green from the Valuing the ARC Project), forest type, FAO soil type, slope, and elevation as predictors of deforestation.

Though an FOM of 24% may seem low, it is similar to the FOMs found in published literature for models attempting to model the same percent deforestation. The accuracy at resolutions lower than 30m is significantly higher. For instance, the FOM for the project villages compared to the rest of the reference region is 95%. The model is also conservative and incorrectly places 4% of the observed deforestation outside of the project villages. Thus, if not outperformed by the IDRISI model, the randomforest model should serve as a reasonable and conservative prediction of deforestation within the project area for the next 10 years after which the baseline must be redone.

Carbon Stock Measurement

The methodology accounts for carbon stock losses associated with deforestation, but not degradation as methods for establishing degradation baselines are not well established. It also allows projects to include carbon stock enhancement in emissions calculations, but only in areas of avoided deforestation. Carbon pools eligible under the methodology are above ground live biomass, above ground dead biomass, leaf litter, below ground live biomass, and soil carbon. Due to the nature of the Lindi project site, where changes in soil carbon are difficult to associate statistically with land-use changes and fires frequently remove grass and leaf litter, we chose to only include above-ground and below ground woody biomass.

To assess carbon stocks within the project areas, we used randomly placed plots stratified by forest type. To be able to measure both changes at the village level and project level, we placed approximately 50 plots per village and plan to use a representative subset of the data that accounts for village forest size to calculate project level stocks. Following the NAFORMA plot methodology, we used 30m diameter plots with smaller concentric plots for measuring different tree DBH classes to reduce the effort required to measure smaller trees. Figure 5 shows the size classes measured for each concentric circle. To convert DBH values to above ground biomass values, we used the allometric equation developed for the Kitulangalo Forest Reserve by Mugasha et al. 2002. We calculated root biomass using the IPCC root to shoot ratio for dry tropical forests, which is 0.28. As in the case of the forest definition, baobab trees were not included in carbon estimates.

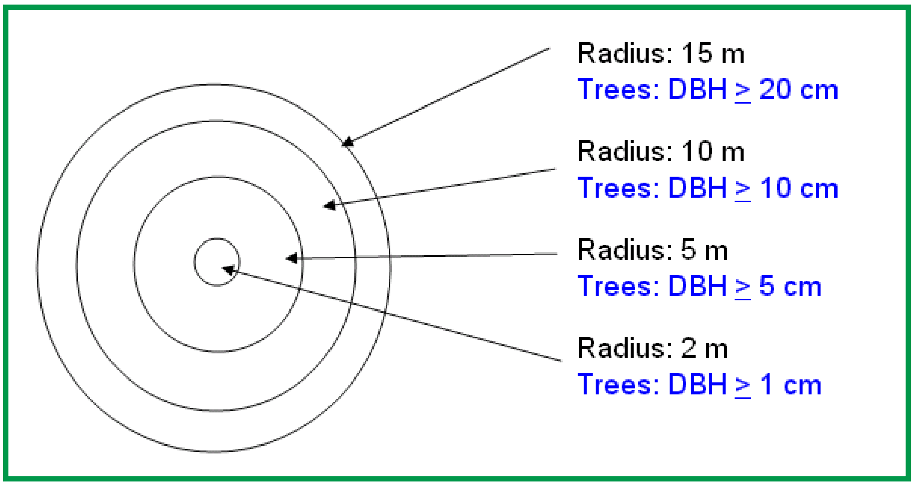

Figure 3: Size classes sampled within concentric plots.

A community member from Mkanga Village training VNRC members from Nandambi Village on the use of GPS. The project has adopted a participatory approach to the carbon stock monitoring work. Photo by Baraka Samweli

To reduce cost and time, most plots were measured by a core group of trained Village Natural Resources Committee (VNRC) members without project staff members. Then, a random 10% of plots in each village were checked by a project staff member. For the villages completed so far, while there is very good agreement on about half of plots, on average project staff members measure about 4 tons C per hectare more than VNRC members, with most disagreements arising from whether or not to include trees on the plot edge. While more agreement would be preferable, since there is little disagreement on the measurement of stem Diameter at Breast Height, individual tree growth should be tracked accurately when the plots are revisited in 2 years enabling the project to claim credit for any carbon enhancement that occurs in areas of projected deforestation. For the villages that have been analyzed so far, the average woody biomass carbon stock (including roots) is 41 tons C per hectare for the high carbon forest class and 20 tons C per hectare for the low carbon forest class.

VM0015 is a gross deforestation methodology, which means that reforestation occurring on non-forest land is not included in the emissions calculations (reforestation and afforestation are not considered part of REDD+). However, VM0015 requires that the average long term (20 years) post-deforestation carbon stocks, which may include reforestation, be considered in emissions calculations for avoided deforestation. In Lindi, substantial woody regrowth is common in fallows. To arrive at an estimate of post-deforestation carbon stocks, we plan to use the observed patterns of regeneration in recently deforested and low carbon forest areas within the reference region to model the likely average long term (20 year) post-deforestation carbon stocks. Though this has not been completed, it is clear that the deforestation rate of regenerative areas exceeds the rate at which they transfer into the high carbon class. Thus, the results of the analysis will likely show that the average post deforestation carbon stock is less than 10 tons per hectare (assuming linear growth from 0 to 20 tons per hectare) meaning that without carbon stock enhancement, avoiding deforestation saves at least 30 tons of C per hectare in high carbon forests and 10 tons of C per hectare in low carbon forests.

Monitoring and Reporting

Before the project can verify its emission reductions using the VCS system, the project must complete a project design document (PDD) and submit it for validation by an approved VCS verification body that will review the PDD in light of the VCS standards and the REDD methodology we have selected. While we are nearly finished with the PDD for Lindi, we will probably wait until 2013 for validation so that the Kilosa PDD, which is further behind, can be validated at the same time. Additionally, waiting will enable us to submit the first monitoring reports to the same organization for verification. With the loss of both Landsat 5 and ALOS PALSAR, it is not currently possible to perform the remote sensing required for the monitoring report. Fortunately, replacements for both of these satellites are scheduled to be launched at the beginning of 2013.
From 2013 going forward, the project plans to submit monitoring reports for verification every two years. We will use the same approach to monitoring deforestation as we did for the baseline, relying primarily on Landsat data and change detection supplemented with ALOS PALSAR data if no useable Landsat data exists. Carbon stocks will be monitored every two years by re-measuring the plots established by VNRC members. Leakage will be said to have occurred if observed deforestation within the leakage belt (which is currently defined in our project as forests falling within a 7.5km belt around the project area) is greater than the amount projected to occur in that area by the deforestation model. However, the methodology does allow for exceptions if it can be established that drivers not related to the project are responsible for the increase.

Conclusion

The Verified Carbon Standard provides the most rigorous system for assessing emissions reductions in REDD projects. We have experimented with different deforestation mapping approaches and discovered that in areas like Lindi, due to seasonality and landscape dynamism, standard approaches to remote sensing lead to erroneous conclusions about the nature of forests and deforestation. Even when using radiometrically corrected imagery captured at virtually the same time of year, as much as 40% of the detected deforestation could be the result of misclassification. Iteratively re-weighted multivariate alteration detection is more robust, especially if combined with classification information. The Lindi landscape also illustrates the need for multi-year REDD baselines in areas with woody regeneration post-deforestation since the observed deforestation rate over time intervals used by REDD projects will be higher than the rate detected using only start and end imagery for a baseline.

Our experience with ALOS PALSAR suggests that L-band radar imagery can be very effective at detecting deforestation in moderately sloped landscapes such as Lindi. In addition to being able to see through clouds, smoke, and haze, PALSAR is also less susceptible to false deforestation detection associated with seasonality.

Finally, as reported by Zahabu 2008, we have also found that with training, random checking, and incentives for accuracy, community members can provide accurate and cost effective measurements of above-ground biomass.

We will continue to share as we learn more and complete the VCS PDDs for Lindi and Kilosa.

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TFCG News

TFCG elects new Chairperson

TFCG has elected John Salehe to be the organisation's Chairperson.

Earlier this year Mr. Patrick Qorro, formerly Member of Parliament for Karatu, stepped down as the Chairperson of the Tanzania Forest Conservation Group. After 16 years as Chair of the organisation, Mr. Qorro requested that members allow him to be released of his role as a chair and expressed his ongoing commitment to remain a member of the TFCG committee. Patrick's commitment to forest conservation and to TFCG have played a critical role in keeping the organisation at the forefront of forest conservation in Tanzania. With his extensive network within Tanzania and abroad, Patrick was able to take TFCG's messages to people at every level of Tanzanian society from the President to communities.

Members of the committee have now elected a new Chair, Mr John Salehe. Mr Salehe has been actively involved in forest conservation in Tanzania including the Eastern Arc Mountains and Coastal Forests of Kenya and Tanzania since the 1980s. After working for several years within government (1977 – 1993), Mr Salehe joined the GEF Cross Borders project dedicated to the conservation of three critically important forests on the borders of Kenya, Tanzania and Uganda. John then moved to WWF where he led the East African Coastal Forest programme for many years. Most recently John has taken up the position of Country Director for the African Wildlife Foundation. John has been a member of the TFCG committee since 1994. He has a vast experience in working with Government, communities and also civil societies. He is a retired (2003) President of the Tanzania Association of Foresters. We are honoured to have him as our new Chair

Sustainable charcoal project launched

TFCG, in partnership with MJUMITA, have launched a new 5 year project aimed at promoting more sustainable charcoal production from community-managed woodlands. The project was launched in June 2012 with finance from the Swiss Agency for Development Cooperation. The project aims to assist communities to produce charcoal in ways that benefit communities; promote sustainable management of village forest reserves; reduce GHG

Did you know?

The charcoal industry in Tanzania is worth over US$ 650 million per year of which about US$ 14 million worth of charcoal comes from the Eastern Arc Mountains.

Over 1 million tons of charcoal is consumed each year in Tanzania. 71 % of households in Dar es Salaam rely on charcoal for cooking emissions; and generate a revenue to help finance community based forest management. The project aims to pilot ways of integrating sustainable charcoal production in forests currently managed with a view to generating revenues from REDD. The project is initially focused on six villages in Kilosa District, close to the Rubeho and Ukaguru Mountains. Working closely with the Swiss Federal Laboratories for Materials Science and Technology and the Centre for Development and Environment of the University of Bern, the project includes a research component that will look at the impact of different charcoal production systems in relation to greenhouse gas emissions as well as their impact in relation to socio-economic and other environmental factors.

TFCG Executive Director Charles Meshack addressing stakeholders during the launch of the Sustainable Charcoal Project in Kilosa.

Bridging the knowledge gap

With support from the Critical Ecosystem Partnership Fund, TFCG has been continuing to share knowledge about the importance of the Eastern Arc Mountains and Coastal Forests amongst communities and other stakeholders. In June 2012, CEPF financed world environment day celebrations in Kilombero and Kilolo Districts. Celebrations included inter-village drama and music competitions focused on the theme of ecosystem values generated by forests.

The Guest of Honour, the Kilombero District Commissioner plants a tree on World Environment Day during celebrations organised by TFCG in Chita close to the Uzungwa Scarp Forest Reserve.

Participatory forest governance in monitoring

As part of the Forest Justice in Tanzania project, MJUMITA have developed and are implementing a participatory forest governance monitoring tool. The monitoring tool is carried out by villagers who have been trained by MJUMITA. So far, results have been returned to MJUMITA by 147 villages from across the country. The results show that most villages are not keeping proper records with regard to participatory forest management and the Village leaders do not regularly report to the Village Assembly on forest governance issues. The tool is providing us with valuable information about the areas where communities need more support in order to improve forest governance. More information about the monitoring tools is available at: http://www.tfcg.org/forestJusticeTanzania.html

Improving water supplies for communities in the West Usambara Mountains

In the West Usambara Mountains, TFCG has been working with communities to improve access to clean water. Whilst many communities in the West Usambara Mountains have been actively managing their forests, they often do not have easy access to the water flowing from those forests. With support from Gorta, TFCG have been assisting communities to manage their water supplies better and to construct improved water points.

The Guest of honor the Lushoto district Commisioner offically opened the storage tank and intake weir constructed by TFCG at Mayo village during the enveronmental day celebration in June 2012.

News of the Arc

Photo: Nectophrynoides wendyae from Uzungwa Scarp Forest Reserve. Photo by Hamidu Seki.

Searching for Africa's rarest frogs in Uzungwa Scarp Forest Reserve.

Andrew Bowkett, Whitley Wildlife Conservation Trust
Adinani Seki, Tanzania Forest Conservation Group

The Uzungwa Scarp Forest Reserve, at the southern tip of the Udzungwa Mountains, is one of the most important forests in Tanzania for biodiversity. Amongst its many unique species are several amphibians found nowhere else on Earth and only ever recorded from tiny areas within the reserve. These rare frogs have been dubbed 'hyper-endemic' species and listed as Endangered or Critically Endangered in the IUCN Red List of Threatened Species. Since 2011 TFCG has been part of a team conducting amphibian surveys in partnership with the Whitley Wildlife Conservation Trust and Trento Science Museum with funding from the Mohamed bin Zayed Species Conservation Fund and EAZA Amphibian Ark.

The survey work has focused on the only known locations for three threatened species: Wendy's forest toad, Poynton's forest toad and Kihanga reed frog. In 2011 we were delighted to find Wendy's forest toad in the location where the species had previously been recorded and also in a nearby valley. However we were disappointed to not find two of the three hyper-endemic species that we were seeking. This result is especially concerning for Poynton's forest toad as the only known site was surveyed on four occasions throughout the study period and there is a possibility that this species may now be extinct. In 2012 we continued surveys with a new team leader Adinani Seki. Due to the difficulty of identifying frog species in the field the team take photographs, GPS locations and habitat data for each and every frog as they walk through the forest at night. This method generates a large amount of data and we are currently analyzing all this information to verify which rare species have been found this year. Our initial analysis of the images shows that Wendy's forest toad was recorded again this year. Unfortunately, the Forest Reserve is threatened by illegal activities such as logging and wood-cutting and these hyper-endemic species are highly vulnerable to disturbance. Therefore, TFCG is also working hard with local communities to reduce these threats and improve protection for this important forest.

Mama Misitu returns to bring improved governance to the forestry sector

On 31st July, representatives from government, civil society and development partners met for the launch of a second phase of the Mama Misitu Campaign. The five year campaign will operate at national level and at district level within 8 priority districts. The project will work with District Authorities, local communities, law enforcement agents and other civil society organisations. Using a combination of awareness raising together with more targeted advocacy, the project aims to bring about positive change in forest governance and reduce illegal harvesting in forests to increase legitimate benefits from forests to adjacent communities.

A Tale of Two Forests

Between 2008 and 2010, 20 % of the high forest of Ruvu South Forest Reserve was cut into planks or turned into charcoal. This destruction is still going on. The reserve is home to one critically endangered primate and many other species endemic to the East African coastal forests. Can the Tanzania Forest Service achieve what the Forestry and Beekeeping failed to do, and stop this destruction before all of the high forest is gone?'

By Theron Morgan-Brown, MJUMITA

In the December 2011 issue of the Arc Journal, we reported on the findings of a deforestation analysis for Ruvu South, Kazimzumbwi, and Pugu Forest Reserves covering the period from 2008 to 2010. The results of the analysis showed alarming deforestation rates in all of the forests and suggested that Pugu and Kazimzumbwi Forest Reserves would be completely deforested within just a few years at the present rates of clearance. In this article, we examine the situation in Ruvu South Forest Reserve more closely and find that while deforestation rates are lower than in the two other reserves, the deforestation has been concentrated in the most biologically unique forest areas and threatens to permanently alter the reserves vegetation. We also examine what has happened in recent years to forest cover in Pande Game Reserve, a 1226 ha reserve 25 km north-west of Dar es Salaam city centre, and discover surprisingly little deforestation, suggesting that more than simple economic forces determine the fate of protected forests near Dar es Salaam.

To get a better understanding of the nature of deforestation in Ruvu South Forest Reserve and the Pande Game Reserve, we classified a cloud free Landsat image from June, 29th 2000. This allowed us to differentiate between forests made up of predominately large trees and other closed canopy scrub forests (see figure 1). The classification was done using Randomforest classification implemented in R with training regions selected from high resolution imagery in Google Earth. Then, we used IR-MAD change detection and a decision tree to compare the Landsat June 29th, 2000 image to a Landsatf July 7th, 2011 image (see the TFCG and MJUMITA REDD article in this issue for more details) and detect deforestation and severe degradation (see Figure 2).

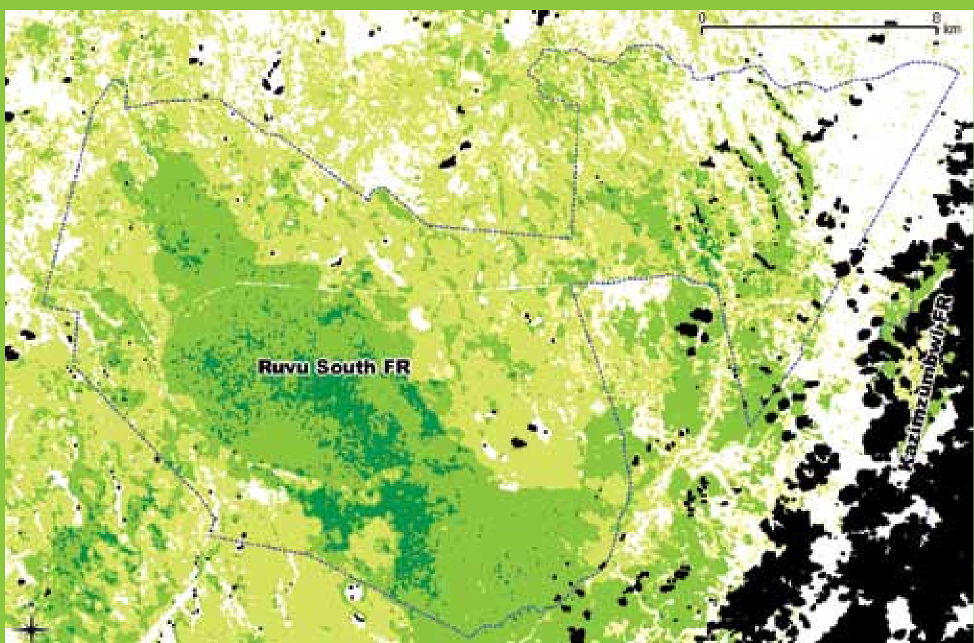


Figure 1. Ruvu South forest cover in 2000. Dark green = High forest. Light green = Thicket forest. Very light green = Wooded grassland. Black = Cloud cover; White= Open areas.

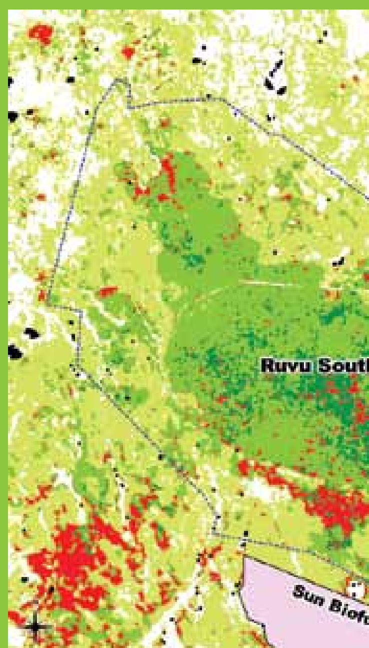
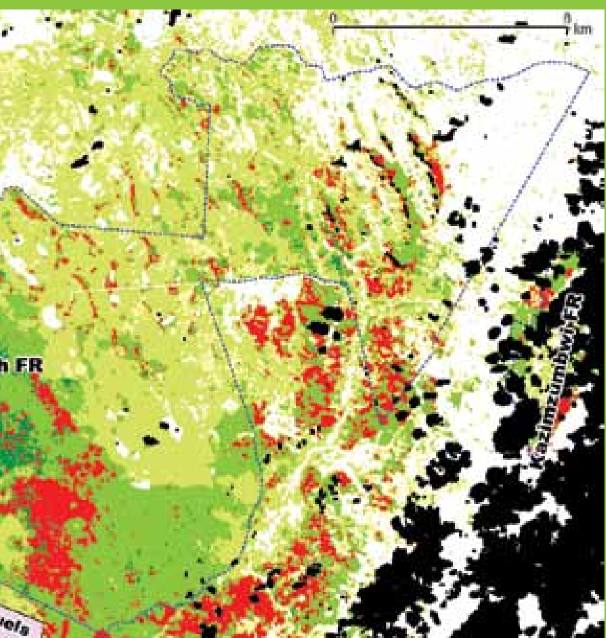


Figure 2. Deforestation in Ruvu S
Red = Deforestation 2001 – 2011
Very light green = Wooded grass

The results of the analysis showed that in 2000, the Ruvu South Forest Reserve had 2,555 hectares of high forest and 11,870 hectares of thicket forest. Between 2000 and 2011, 950 hectares of high forest and 1,640 hectares of thicket forest were deforested or severely degraded. The map also shows that the largest patch of contiguous high forest was nearly completely lost. We also overlaid the deforestation detected from 2008 to 2010 in the previous analysis on the forest class map and found that half of the high forest clearance occurred in the two year span between 2008 - 2010, suggesting that the deforestation rate rapidly accelerated after 2008. Thus, from 2000 to 2011, nearly 40% of Ruvu South's high forest was lost, 20% just between the years of 2008 and 2010. If the rates of clearance in the high forest between 2008 and 2010 persist, all of Ruvu South's high forest will be cleared or severely degraded by 2018. This is especially bad news for some of Tanzania's unique species that are found in Ruvu South, such as the Critically Endangered Rondo galago, which depend on the increasingly rare high coastal forest.

The pattern of deforestation in Ruvu South shows that deforestation can rapidly increase. It appears that the Sun Biofuel development to the south of the reserve that started in 2008 may have improved access for charcoal makers to that part of the reserve and coincidentally, the largest patch of high forest. Since then, charcoal makers have pushed into the heart of the reserve in search of the few remaining patches of high forest and created their own network of dirt roads visible in Google Earth.

However, proximity to Dar es Salaam and accessibility are not the only factors determining deforestation of protected forests. In contrast to the experience in Ruvu South, Kazimzumbwi, and Pugu Forest Reserves, Pande Game Reserve suffered no large scale deforestation and very little degradation between 2008 and 2010 (see figure 3). Given that Pande is very accessible and even closer to the center of Dar es Salaam than Ruvu South, it suggests that management is the main determining factor of the fate of protected forests near Dar es Salaam and that there has been a serious failure in the management of these three Forest Reserves by the former Forestry and Beekeeping Division.



outh Forest Reserve between 2001 and 2011.
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and, Black = Cloud cover; White= Open areas.

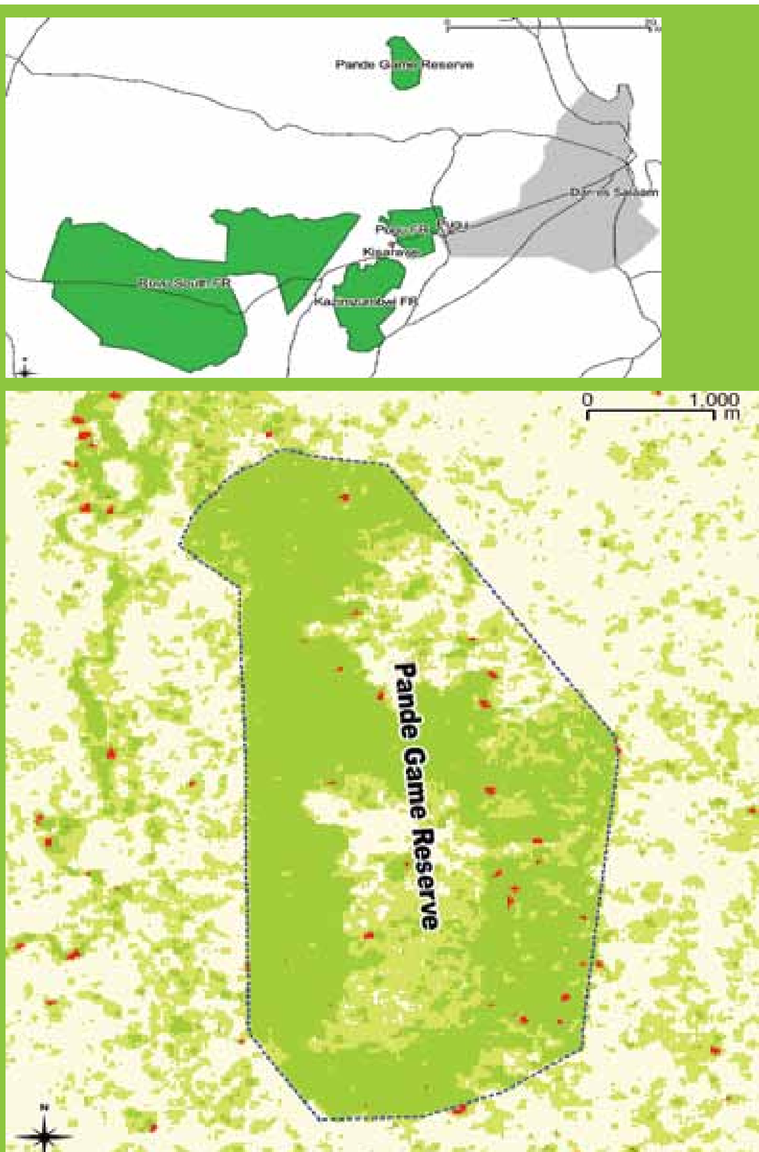


Figure 3. Pande Game Reserve. Land cover and deforestation from 2008 – 2010. Light green = Thicket forest. Very light green = Wooded grassland.

Market-based REDD in northern Tanzania

From concept to certification and sales

Jessica Bede, Program Associate at Carbon Tanzania, Arusha, Tanzania
Marc Baker, Director, Carbon Tanzania, Arusha, Tanzania

A member of the Hadzabe community surveys the Yaeda Valley. Photo by Marc Baker.

There is no doubt that deforestation in Tanzania is a threat to its habitats, which in turn provide livelihoods to Tanzanians, support endemic species of wildlife, and each year attract tens of thousands of tourists. Given the nation's current situation, losing 400,000 ha of forest annually despite a variety of conservation interventions in the past, it is clear that preserving Tanzania's unique ecosystems warrants a diversity of approaches. The growing concern worldwide over the role of deforestation in climate change, in conjunction with the continued development of global carbon markets, provides an opportunity to influence the nature of conservation, inspire better land use decisions and reward communities for sustainably utilising natural resources.

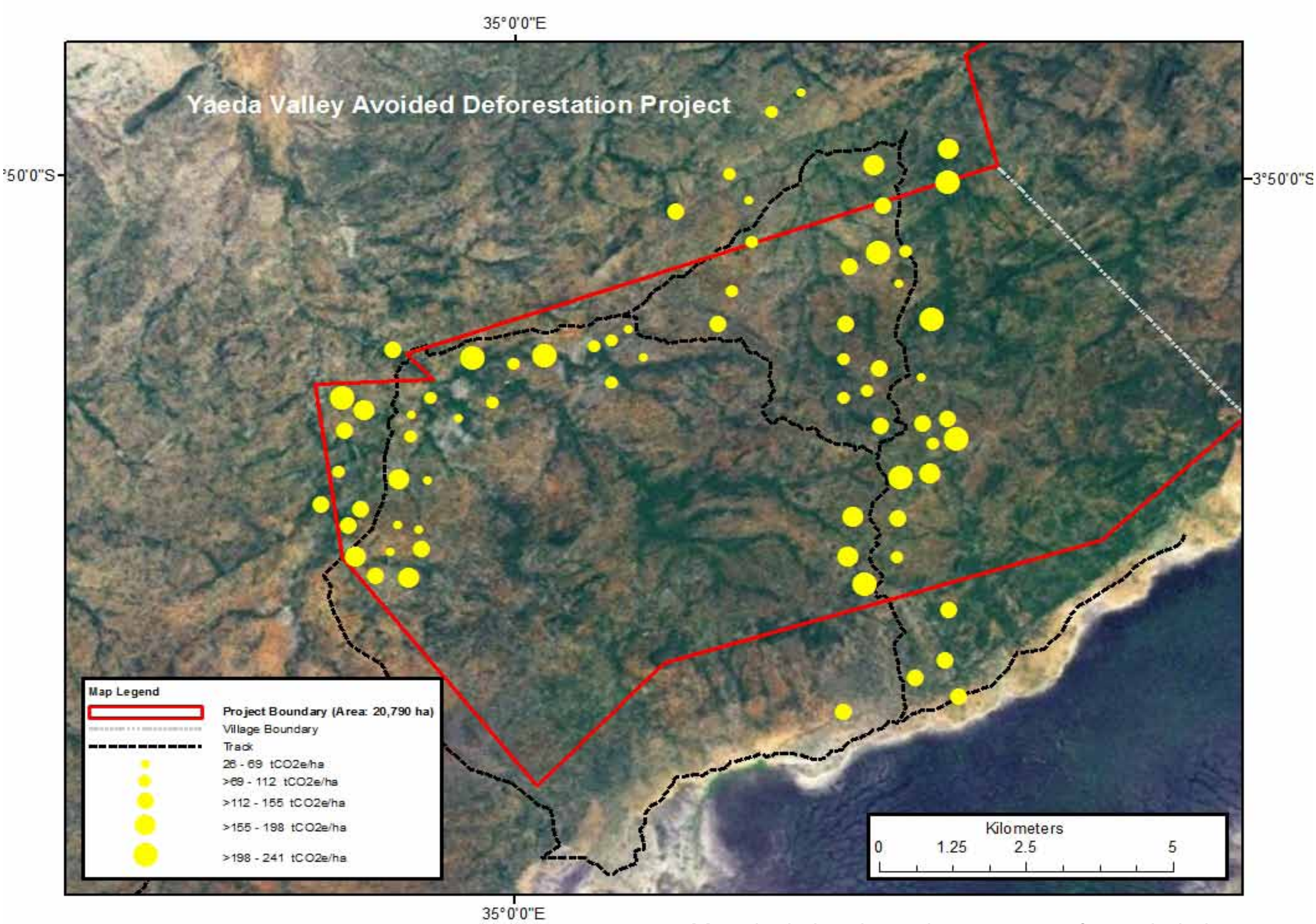
Carbon Tanzania, a registered not-for-profit business, has seized upon this juncture in environmental conservation to initiate a market-based approach to habitat protection and avoided deforestation. Our reduced emissions from deforestation and forest degradation (REDD) project in the Yaeda Valley, developed with and by the Hadzabe, a hunter-gatherer population indigenous to the Central Rift Valley, links communities to carbon finance and empowers them to address drivers of deforestation, thereby protecting their remaining 20,790 ha of *Acacia-Commiphora* woodland habitat and safeguarding their resource-dependent lifestyle. The objective of providing a financial incentive through payments for ecosystem services (PES) is to rebalance land use decisions in favor of conservation.

Market-based carbon financing comes from the sale of carbon offset credits to firms and individuals who wish to compensate for, or "offset", their greenhouse gas emissions that cannot be avoided in the day-to-day operations of their businesses. As the project coordinator, Carbon Tanzania has up until now sold just over 3,500 tonnes CO_2 worth of voluntary credits over-the-counter (OTC) to businesses seeking to fulfill corporate social responsibility (CSR) targets. Most buyers of Carbon Tanzania's offsets are Tanzanian tourism operators who promote sustainable practices and responsible tourism. Sales are expected to expand in the voluntary carbon markets after completing the currently pending certification process with the Plan Vivo Foundation mid-2012.

The values and project development process promoted by the Plan Vivo Foundation are compatible with the vision of Carbon Tanzania's founder, Marc Baker, who has worked in conservation and tourism in Tanzania for eleven years. He introduced the idea of initiating a REDD project with the Hadzabe in the village of Mongo Wa Mono, meaning "mother of all villages", in 2010. The village was at that time finalising a land use plan and by-laws with assistance from Ujamaa Community Resource Team (UCRT), an organisation with the mission of promoting and enhancing communities' capacity to improve their livelihoods and to sustainably manage their natural resources. Working from the framework of the land use plan, Carbon Tanzania collaborated with the Hadzabe community and UCRT to develop a plan for enforcing the new land use plan, thus conserving the habitat and curtailing deforestation and degradation in the area.

Plan Vivo certifies ethical, pro-poor, land-based carbon sequestration offset projects that produce social and environmental co-benefits. Most important to Carbon Tanzania when choosing to certify the project with Plan Vivo was its focus on small-scale, community-based initiatives. Plan Vivo projects are planned, implemented and monitored by communities who make free and informed decisions to conserve and restore ecosystems while improving local livelihoods.

Through a continued process of engagement, Carbon Tanzania and UCRT raised awareness about climate change, carbon markets and wider conservation goals while building local capacity to actualise their land use plan and measure and monitor carbon content as well as additional environmental and social impacts. A highlight of this technical training was the aboveground biomass (AGB) surveys conducted in 2011 where community members learned how to assess the carbon content of sample plots. Existing carbon in the project area was calculated to be 33.4 tC/ha (tonnes of carbon per hectare), or 122.5 tCO_2/ha (tonnes of carbon dioxide per hectare).

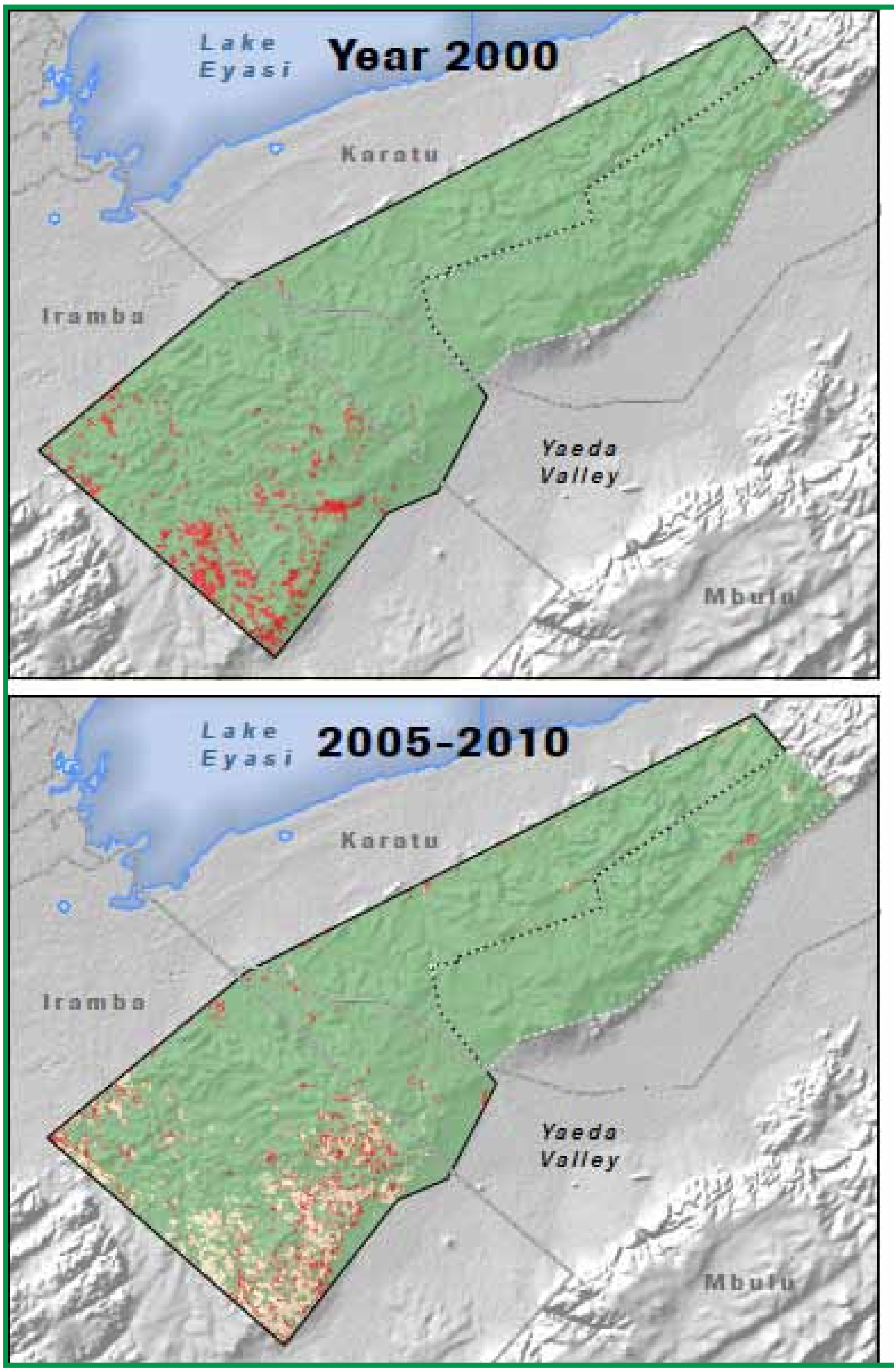


Map depicting the carbon content of sampled plots

Carbon Tanzania will pay the communities a guaranteed price of US$3 per tonne of creditable CO_2, representing 60% of an expected sale price of US$5 per tonne CO_2. If the project coordinator fetches a higher price, further payments will be made to ensure that the community receives 60% of total offset revenue, a stipulation of the Plan Vivo Foundation. The determination of how much carbon is creditable is based on a comparison of the historical deforestation rate to the deforestation rate during the project, with the additional deductions of adequate risk and leakage buffers.

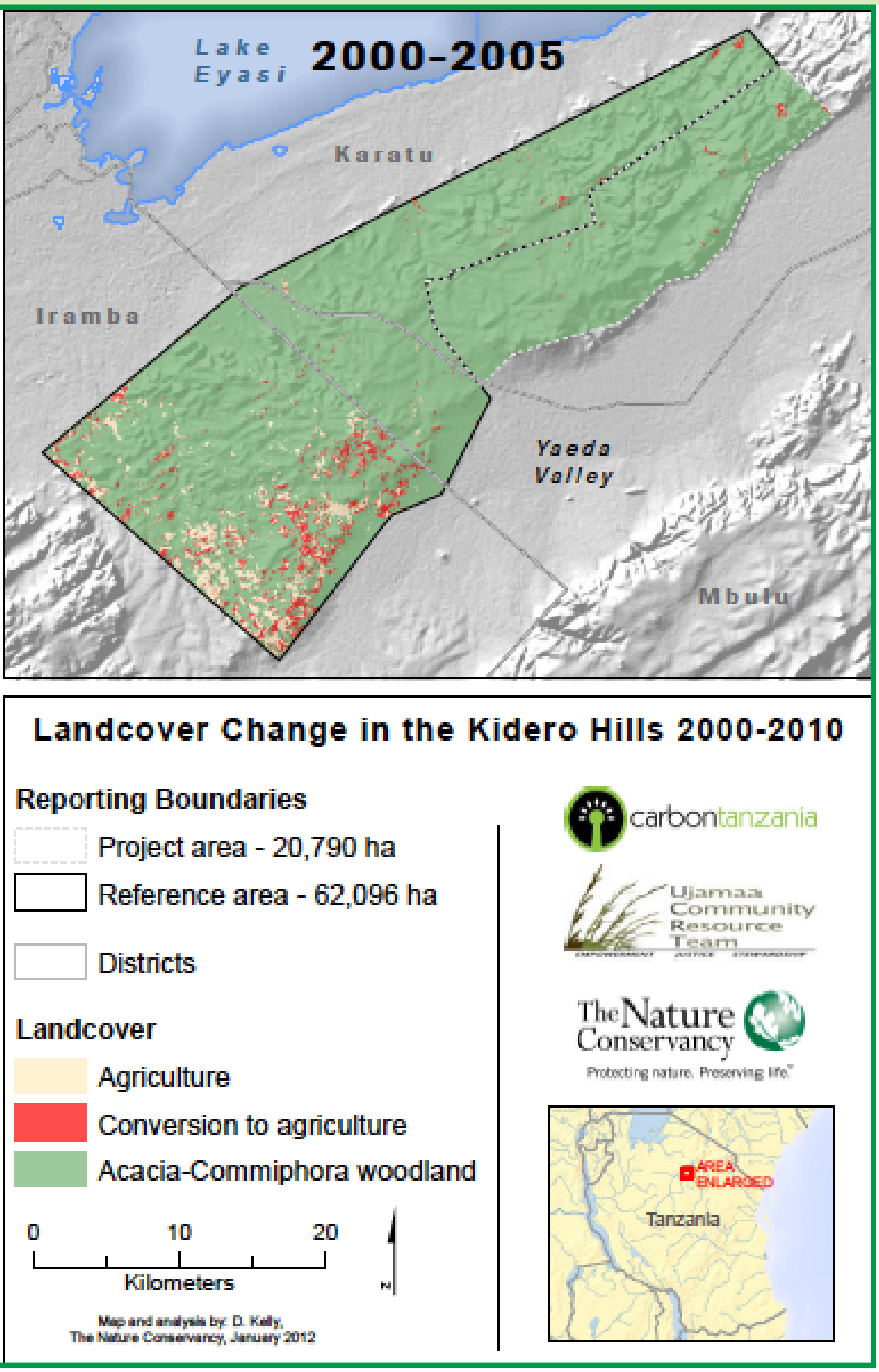
Payments are results-based, in the sense that the amount of carbon credits eligible for sale depends on the participants' success at preventing deforestation, a dynamic process which requires multi level monitoring and a detailed understanding of the deforestation rates within the project area, leakage zone and reference region. Monitoring deforestation also builds upon a crucial challenge, which has been to increase the understanding of carbon accounting and the broader goals of the carbon sequestration project. With this in mind, Carbon Tanzania will utilize an unmanned aerial vehicle (UAV) (see; www.cropcam.com) to monitor changes in land cover. This tool, which can be seen overhead and provide onsite images will lead to a greater understanding of digital imagery among a community to whom the idea of satellite imagery is a non sequitur. Digital camera's with built in GPS help refine monitoring and indicate areas to concentrate enforcement efforts, especially in the case of anti-poaching activities whilst involving communities in ecological monitoring, such as using Timed Species Counts for measuring the frequency of bird species, increases participation.

Preserving the autonomy of the community is vital and is demonstrated in this project in a number of ways, including freedom over how carbon revenues are spent. Attaining buy-in from the community was key to the success of the planning and early implementation phases of the project. This was not obtained immediately but instead earned through transparent and frank discussion as well as a demonstrated commitment of time and resources.



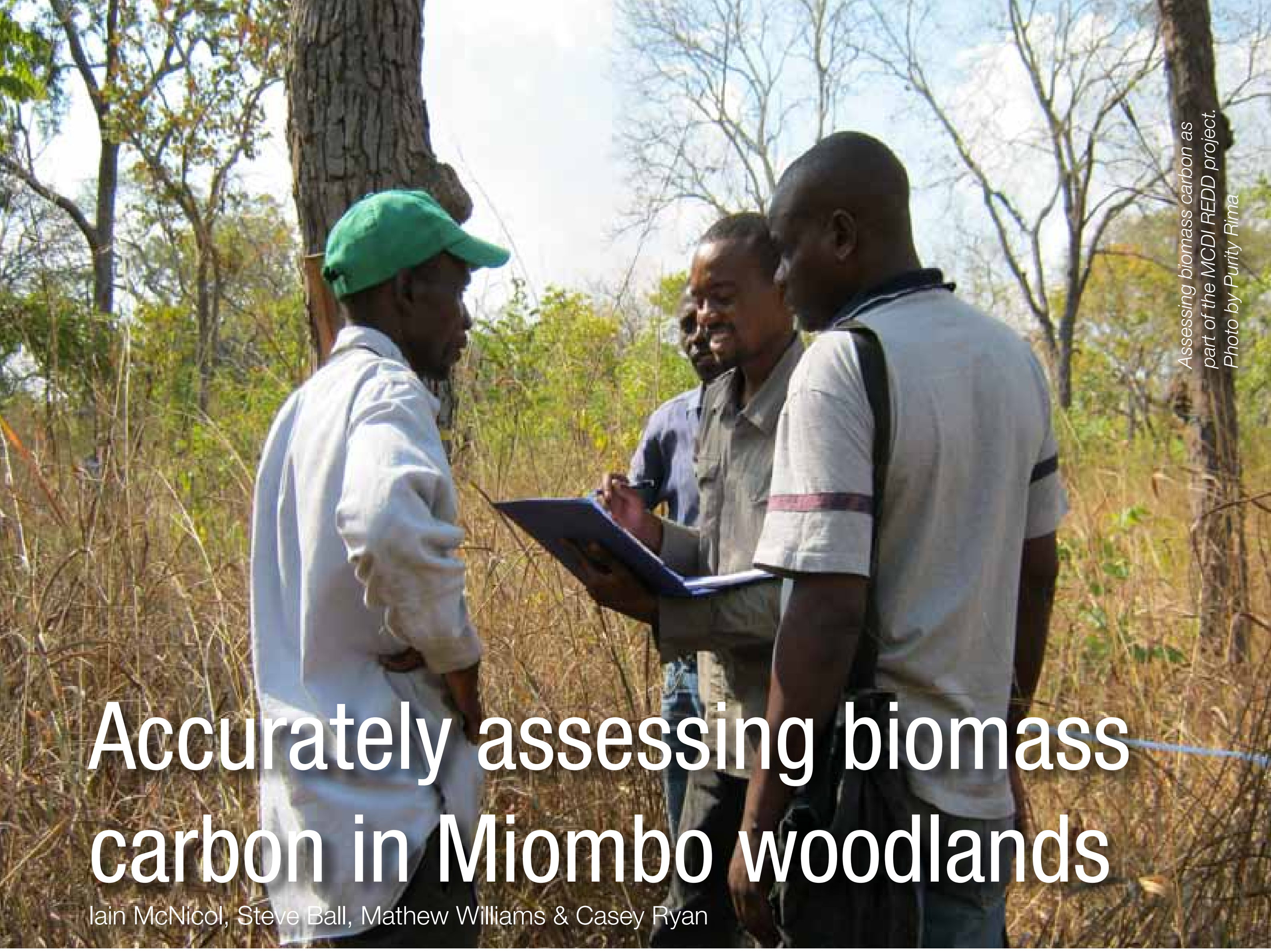
Analyzed satellite imagery depicting conversion of Acacia-Commiphora woodland to agriculture between 2000 and 2010. The average annual loss of 545.8 ha in the reference area equates to a 0.93% historical deforestation rate, slightly less than the national average of 1.2%.

Sustainable natural resources management area within the Hadzabe lands. Photo by Marc Baker.



If important lessons can be learnt from our experience, they are that there is no "one size fits all" approach for planning or implementing REDD projects in Tanzania and that sincere community engagement requires a project coordinator to be dynamic and evolve along with the project. This remains the case even as the project is fully functioning since drivers of deforestation and community needs change over time. Communities and villages will require ongoing support for certain project elements such as credible monitoring, verification and reporting (MRV), marketing and sale of carbon credits and transparent distribution of the resulting revenue and, potentially, legal assistance to defend against certain instances of illegal deforestation or other actions prohibited by the approved land use plan and by-laws. Non-governmental actors who possess adequate technical and contextual knowledge and abide by Tanzania's forest and land laws are well-suited to fill these gaps between local communities, national REDD efforts and carbon markets.

Carbon Tanzania anticipates the Yaeda Valley REDD project to be validated and certified by Plan Vivo in the first half of 2012 and is in dialogue with nearby agriculturalists and pastoralists about expanding the project and the creation of a village land forest reserve (VLFR) that would accommodate a variety of livelihoods, as well as conservation.



Assessing biomass carbon as part of the MCDI REDD project. Photo by Purity Rima

Accurately assessing biomass carbon in Miombo woodlands

Iain McNicol, Steve Ball, Mathew Williams & Casey Ryan

The Mpingo Conservation and Development Initiative's (MCDI) REDD pilot project is unusual. Most REDD projects assume a static area of forest. However, MCDI are more interested in the timber values of the forests in Kilwa in south-east Tanzania (a patchwork of Miombo Woodlands and East African Coastal Forest), which, we calculate, could yield substantially higher revenues than carbon, so long as the timber can be properly differentiated in the market which forest certification does.

MCDI holds the first and so far only certificate from the Forest Stewardship Council for community-managed natural forest in the whole of Africa. However, MCDI needs to expand the area of certified forest in order to achieve the economies of scale which will make the certification scheme self-sufficient in the long run. MCDI has found it hard to raise from donors all the funds it needs to do this. In the language of the carbon markets, MCDI faces an 'investment barrier' to expanding a proven, effective means of sustainable forest management, and if carbon savings can be demonstrated, then carbon offsets can be generated using a REDD+ model, and sold on the global market to cover the costs of expanding PFM and FSC certification.

In the remote forests in which MCDI is working, there are relatively few pressures from the traditional drivers of deforestation in Tanzania: agriculture and charcoal production. Uncontrolled timber extraction is a problem, but is highly selective and thus the carbon losses are relatively low. MCDI is thus focusing on the degradation caused by regular bush fires. These often occur during the middle of the dry season, when farmers are clearing new land, but also the windiest time of year. The combination of high winds and abundant dry grasses lead to hot, extensive fires. MCDI aims to reduce the damage this causes the forest by embarking upon an ambitious programme of early burning in partnership with the communities with whom it is working. This improved fire management is expected to lead to annual carbon savings of the order of 0.5tCha^{-1} or about 2.5% of above-ground biomass. These small changes require an extremely effective monitoring regime to detect.

In collaboration with the University of Edinburgh, MCDI is therefore pioneering new methods of carbon assessment in order to provide scientifically robust estimates of both above and below ground carbon stocks, and monitoring their change over time. To achieve this objective, MRV activities have been broken down into three stages:

1) Forest area pre-assessment to locate potential plot locations and to assess spatial variability,
2) Field measurements from a representative sample of the project area, and
3) Extrapolation of carbon stocks across the district and monitoring changes over the project lifetime.

Viewed at a project level scale, Miombo woodlands are spatially extremely heterogeneous, encompassing open grassland areas (*dambos*), savannah woodland and thicker riparian forest. Stratification is the usual solution to land cover heterogeneity, but the scale at which Miombo varies is too small to be accurately determined by analysis of satellite imagery. Thus instead we need a solution which manages extremely localised variation; large plot size is one answer. Previous fieldwork by the University of Edinburgh in Mozambique shows sample plots need to be at least 1ha in size if the resulting data set is to be approximately Normal (required for most statistical analyses) (Ryan *et al*., 2011).

We adopted a nested 'super' plot design, not dissimilar to the cluster plots used by NAFORMA. Thus our sample plots consist of 1 x 1ha Permanent Sample Plot (PSP), 1 x 9ha Large Sample Plot (LSP) and 4 x 0.2ha circle plots (one at each corner of the LSP). A large fraction of Miombo biomass is found in large trees. This fact allows us to increase the efficiency of surveying such large plots; only stems >40cm DBH are surveyed in the LSP (except where it overlaps with the smaller sub-plots). Nonetheless this survey design requires a lot of effort per plot, so the total sample size must be reduced; in our case to 25 super plots. For the circle plots plus PSPs, however, that delivers an n of 225. So long as the plots are not biased in their location, the width of the confidence interval on carbon stocks will primarily be driven by the number of trees measured and area surveyed. We surveyed a total of 225ha which compares very well with an expected project size of approx. 30,000ha.

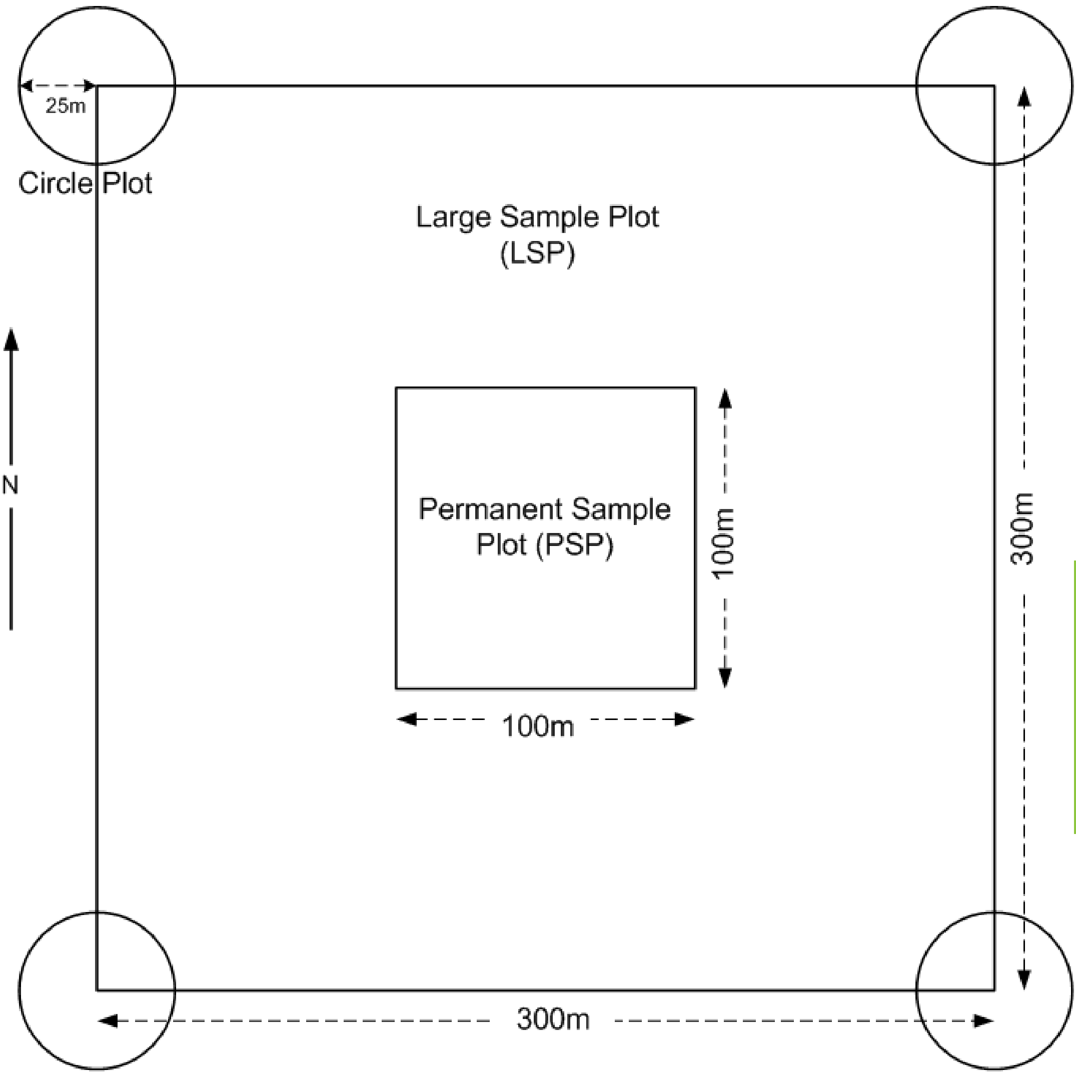


Figure 1. Plot layout showing arrangement of permanent, large and circle plots.

Super plots were located through an initial (experimental) stratification of the landscape based on LandSat imagery. Three discrete strata – Forest, Woodland and Savanna – were mapped based on >100 ground reference points. To maximise surveying efficiency we preferentially sampled the spatially dominant communities. Thus of the 25 sample locations, 14 were situated in woodland, 6 in forest and 5 in savannah. Pragmatism naturally played a role in site selection as it is easier to survey sites close to the road network; however a minimum 1km buffer from the road was implemented in order to reduce the effects of disturbance (as per Williams *et al.*, 2008).

The 25 super plots were established and subject to baseline surveys from October 2010 to October 2011. These were complemented with an additional 43 plots (0.2ha each) that were set up across the district, encompassing a chronosequence of active and abandoned farmland which is being used to quantify losses associated with conversion to agriculture and to analyse how the woodlands recover over time.

To estimate biomass carbon stocks we used the standard approach for a forest inventory, determining the species, and the diameter at breast height (DBH) for each stem using specified DBH thresholds for each plot type. The project employed local guides knowledgeable in botany to assist MCDI field technicians with species identification and to take DBH measurements. To convert DBH into aboveground biomass, the project used a new regionally derived allometric model, obtained from the destructive harvest of 29 trees in Mozambique, which relates tree diameter to stem and root biomass (Ryan *et al.*, 2011a).

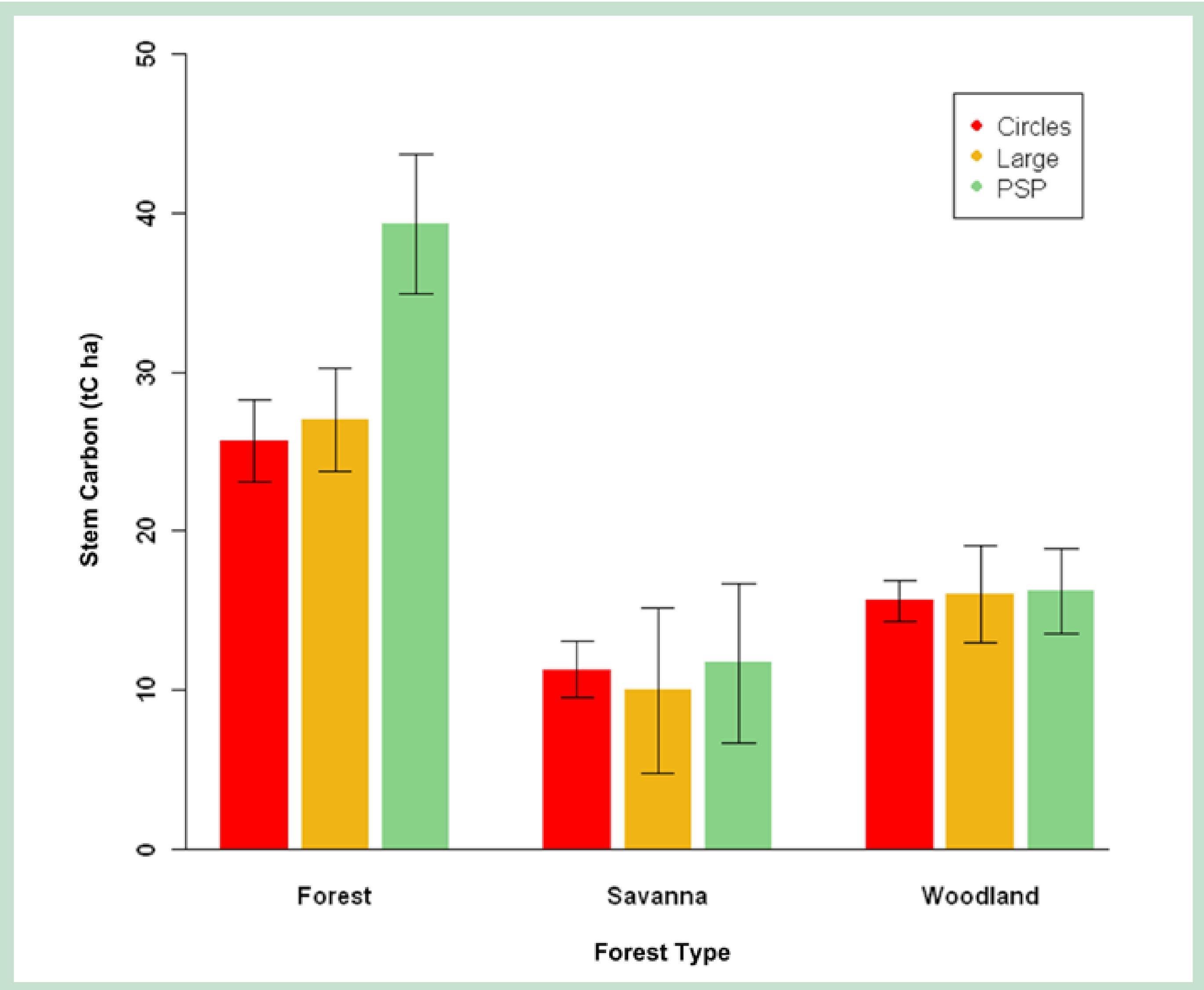


Figure 2. Mean carbon density (tC ha^{-1}) of each land cover type separated by plot typeError bars indicate standard error of the mean (SEM)

The results of the baseline were further processed to align the data from the three different plot types. This showed that across the central Kilwa Landscape the following carbon densities apply:

	Mean stem C density (t ha^{-1})	*Area (000 ha)*	*Total stem C (000 tonnes)*
Forest	28.4	428	12,155
Woodland	15.7	824	12,937
Savannah	11.5	262	3,013
Farmland	9.4	236	2,218
TOTAL		1,750	30,323

Analysis, also showed that, as expected, the biomass figures for the smaller circle plots, and even the 1ha PSPs, were non-Normal, the data for the LSPs are indeed normally distributed.

The final steps in MRV will be to extrapolate the ground based measurement across the project area and to monitor changes over time. Repeat inventories of the 1 and 9ha plots only are scheduled for 2013 and will allow the project to record and monitor natural and anthropogenic changes in C stocks at a high spatial resolution and with careful error assessment.

However, due to constraints on time, effort and resources, it is not possible to directly sample a sufficient number of plots across the district in order to be able to use ground based data alone to directly estimate relatively small changes in carbon stocks. Instead remote sensing data will be used to extrapolate the plot data across the landscape. By combining the field based inventory data with information derived from ALOS PALSAR, an L-Band radar satellite sensor, the project will generate carbon density maps at 25m resolution using the method of Ryan et al. (2011b). The ability to combine the plot based measures with more extensive EO data will ultimately enhance our understanding of the carbon balance of the district as a whole. The inclusion of both relatively undisturbed as well as degraded areas in the sampling strategy will provide extra calibration and validation capacity for the remote sensing data.

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Looking for more information about the East African Coastal Forests?

If you need information about biodiversity, protected areas or conservation initiatives in the East African Coastal forests, cf.tfcg.org is the website for you. The site includes technical reports, maps and other general information about the coastal forests of Tanzania, Kenya and Mozambique. And please do send us any reports or other information about the coastal forests that you would like to post there. E-mail: tfcg@tfcg.or.tz The design and maintenance of the website is financed by the Critical Ecosystem Partnership Fund.

Teacher's manual and biodiversity posters available online

In 2009, TFCG produced an Environmental Education teacher's manual with funding from CEPF. The manual includes 88 lesson plans for teachers in primary schools. The lessons plans are intended to help teachers to integrate environmental education into their teaching. The manual is now available online at: http://www.tfcg.org/publications.html

With a view to sharing the results of our biodiversity surveys with communities, TFCG have produced a series of posters with annotated pictures of some of the plants and animals that we have recorded. These are available at http://www.tfcg.org/publications.html

Enhancing Tanzanian capacity to deliver short and long term data on forest carbon stocks across the country

Neil D. Burgess, Panteleo Munishi, Shadrack Mwakalila, Marion Pfeifer, Simon Willcock, Deo Shirima, Seki Hamidu, George B. Bulenga and Robert Marchant

Introduction

WWF Tanzania Country Office is one of the recipients of Norwegian REDD+ pilot project funding. This project is somewhat different to other REDD+ related projects worldwide, because it is working with the national REDD+ readiness process in the country, and specifically will establish carbon baselines across ecosystems and environmental and management gradients in Tanzania.

Tanzania has a lot of ongoing work on REDD+ and related issues, hence the WWF project has spent time liaising with all other initiatives to ensure that the project's outputs will add value to the national REDD+ process, including other REDD+ pilot projects funded by the Norwegian government. During the course of these discussions, the original project was modified during the inception phase and the work is now fully harmonised within the coordinated REDD+ MRV (Monitoring, Reporting and Verification) work under the national REDD+ Task Force (government and civil society representation and coordination) and the responsible Ministries, Offices and Agencies within government.

The Tanzanian draft REDD+ strategy (GoT 2010) contains 10 strategic interventions and key result areas for REDD+ implementation in Tanzania. The WWF pilot project contributes to five of these:

Key Result Area 1: REDD Baseline Scenario, Monitoring, Reporting and Verification framework established (relates to the need for Forest Carbon Assessment to Establish the Baseline Carbon and Emission Levels)
Key Results Area 3: All stakeholders are engaged in the REDD implementation process
Key Result Area 5: All carbon market options are well understood
Key Results Area 7: Training programme and Infrastructure for REDD developed
Key Result Area 8: Current knowledge and scientific understanding of the target forests and adjacent communities improved through research

The purpose, objective and outputs of the WWF REDD+ project are summarised below:

Purpose: *To contribute core data to the Tanzanian national monitoring, reporting and verification (MRV) system that forms a part of the comprehensive forest carbon monitoring system for the country.*

Expected Outputs
1: Baseline Permanent Sample Plots established
2: Hemispherical photographic survey of Permanent Sample Plots established
3: Utility of LiDar technology further tested in Tanzanian forest habitats
4: Soil carbon surveyed across Tanzanian vegetation types
5: A new database of wood specific gravity data ranging across all biomes in Tanzania
6: A range of future scenarios for changes in carbon stock produced
7: Capacity building, dissemination and communication of project outputs undertaken

Calculating current carbon and testing approaches

The first four project outputs will be derived from 1 hectare permanent sample plots (PSP). The sampling design is based on a series of 120 plots to be established randomly within the 12 broad vegetation types present in the country, including non-forested vegetation types. Additionally, the plots aim to include the main degradation gradient for each vegetation type: from as close to pristine as possible, to heavily degraded. This stratified random approach to laying out sampling plots means that the number of plots can be reduced compared to using a purely randomised sampling strategy. So far 40 plots have been completed in the Miombo woodlands of Iringa and Mbeya Regions and 25 plots have been completed in the coastal forests and one in the mangroves of Kilwa District along the coast.

Collection of data for carbon estimation

Permanent Sample Plots are established using the 1 ha plot methodology used elsewhere in Tanzania and other countries (following the global RAINFOR protocol [http://www.geog.leeds.ac.uk/projects/rainfor/pages/manuals_eng.html]). Each carbon plot is divided into 20 m^2 subplots (Fig.1). Measurements of vegetation structure and environmental traits are carried out in these subplots, collecting data on four of the five carbon pools defined by the IPCC (total aboveground live, coarse woody debris, litter, and soil : http://www.ipcc.ch/ipccreports/sres/land_use/index.php?idp=131).

In every sub-plot, all trees and large coarse woody debris with Diameter at Breast Height (DBH) ≥ 10 cm are identified and measured for DBH and height using diameter tape/calliper. Small trees (< 10 cm DBH) are excluded as they are time-consuming to measure whilst their contribution to the total carbon stock in forest ecosystems is small. Height is measured for a minimum of 10 trees in different size classes (DBH: 10-20, 20-30, 30-40 and >40), belonging to the most common tree species in the area. Species-specific tree structure estimates are used to develop diameter-height allometric models which will subsequently be used for tree volume determination. Trees are identified to species level where feasible; unidentified species are collected and specimens are sent to the Tanzania National Herbarium in Arusha for further identification. Wood core samples are collected from the most dominant tree species in the area for determination of wood specific gravity which are used to determine tree biomass from volume estimates. Whilst tree diameter and height data are relatively abundant in Tanzania, much less data on wood bulk density is available (an important variable for carbon content).

The trees with a DBH > 5cm and the herbaceous, litter and small coarse woody debris (< 10cm DBH) layers are assessed within 20 m^2 sub-plots numbered 1, 5, 13, 21 and 25 (Fig. 1). For the entire 20 m^2 sub-plot, these smaller trees are measured as stated above, whilst the other carbon layers are measured at the innermost corner of each of the corner subplots (1, 5, 21, 25)

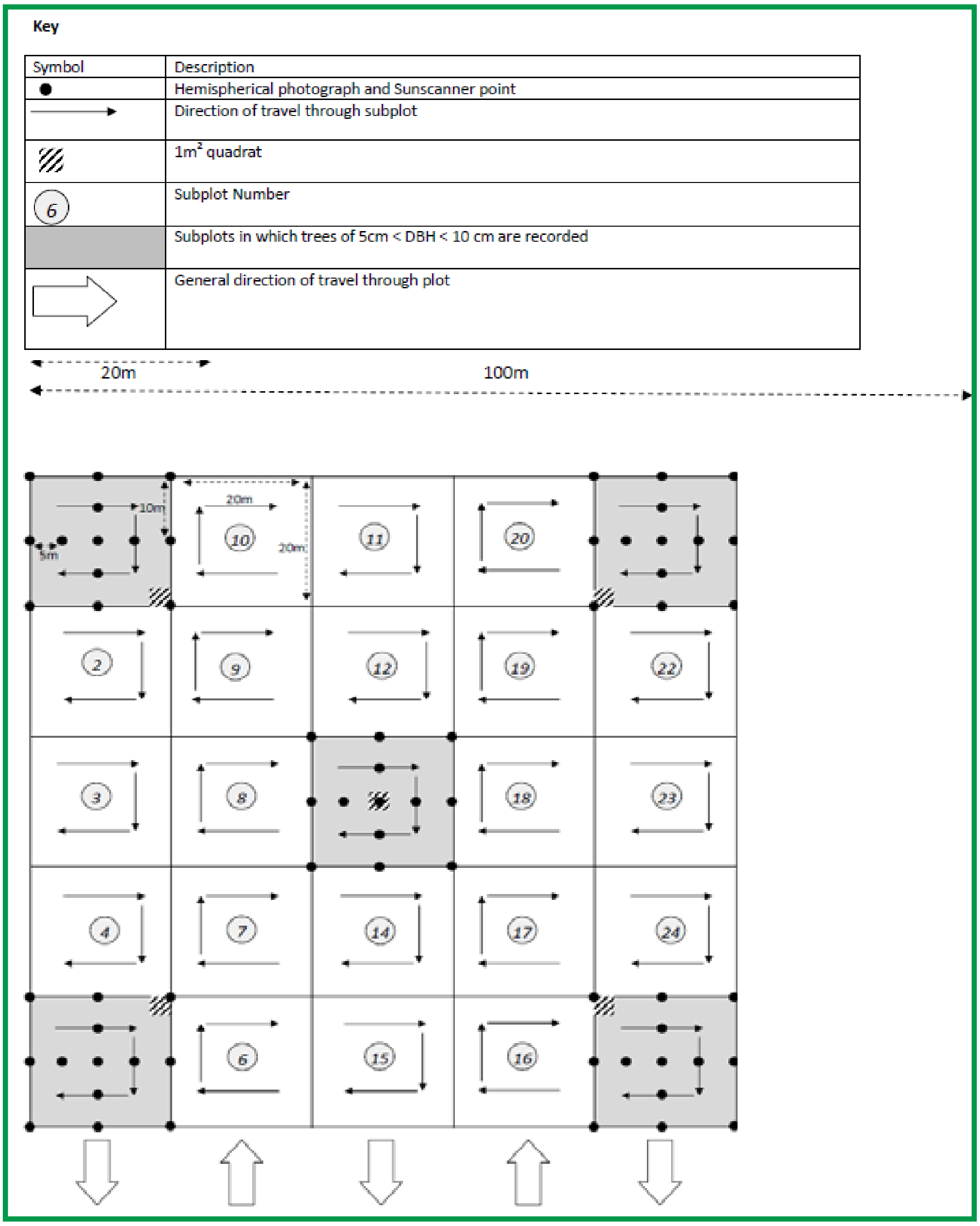


Figure 1. Field Plot design and sampling protocol

and in the centre (13) Using a quadrat measuring 1m ×1m (Fig. 1). Within each of the quadrats, herbaceous materials (cut at the stem base), litter and coarse woody debris (sorted into size and decay categories) are collected and the dry weight determined for biomass assessment and then carbon estimation.

At each subplot information on human disturbance is recorded to enable estimates of the impact of degradation on forest carbon. Disturbance data include the number and estimated age of tree stumps observed in each subplot, and the suspected cause (natural or anthropogenic). Signs of other disturbance (for example, fire) are also recorded.

Soil traits

Soil samples are collected from a soil pit that has been dug to a depth of 1m. The pit is 10-15m from the plot so as to not disturb the plot but close enough to still be representative. Soil samples from the pit are taken across four depth ranges (0-15cm, 15-30cm, 30-50cm and 50-100cm). Samples are then oven dried and combusted. The soil organic carbon is measured and expressed as a percentage organic carbon. Computation of soil carbon density is based on soil mass per unit area obtained as the product of soil volume and the estimated soil bulk density or bulk density estimates from literature.

Biophysical structure

In addition to biomass estimates based on vegetation structure data collected in each subplot, indirect optical measurements are used to estimate vegetation canopy traits including leaf area index (LAI) and canopy gap fraction in five subplots per plot.

Following a standardized protocol, canopy traits are sampled at >12 sampling points per subplot using upward-looking hemispherical photographs and the SunScan – Delta T instrument. The Hemispherical images are processed with CanEye Analysis software to obtain estimates of biophysical vegetation structure, including leaf area index and fraction of vegetation cover within each 1 hectare plot

The current project is providing a unique opportunity to measure landscape scale heterogeneity in vegetation biophysical structure traits at patch/plot level. This will allow the development of algorithms that can link biophysical structure estimates computed at plot level to remote sensing data (see below) that may provide high accuracy information across different vegetation types and land use intensities, and importantly will allow scaling up to the landscape level.

Measuing a Valuing the Arc vegetation plot in the West Usambara Mountains.

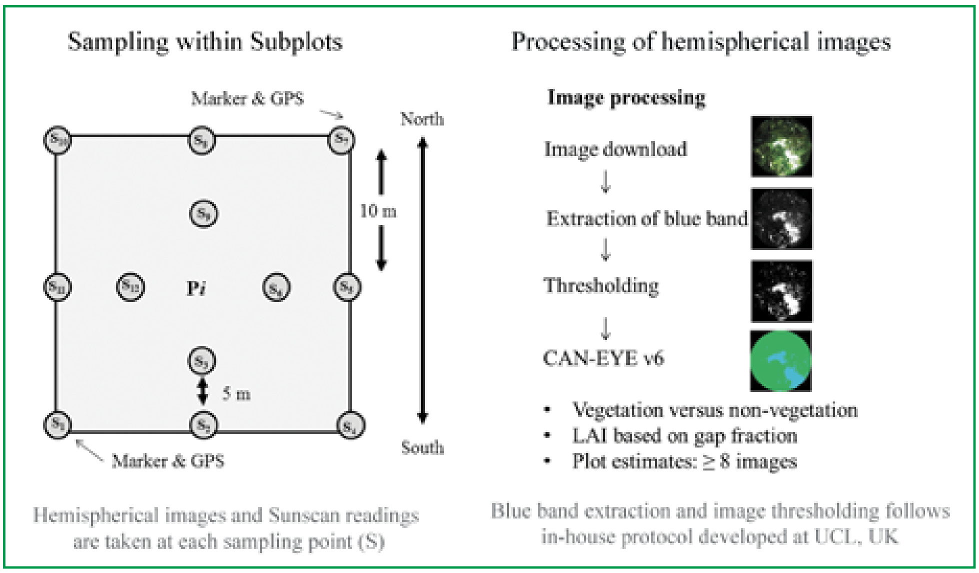


Figure 2: Sampling design in the sampling plots where photographs and Leaf Area Index measurements are taken.

Upscaling from plot to landscape level using remote sensing data

This component of the project is seeking to improve carbon estimations by linking direct on the ground measurements of tree structure, vegetation canopies and light intensity, with data obtained remotely using satellite and plane-carried instruments. In terms of linkage to plane-based technologies, the WWF project will fund LiDar flights over the existing 1 ha plots, and some other smaller plots, within the Udzungwa Mountains of the Eastern Arc. LIDAR flights will cover lowland, sub-montane, montane and upper montane forest types within this mountain block; in total 177 km of transects and close to 8,000 ha of sampled vegetation. Plots are in a wide variety of settings giving significant variation in levels of degradation being sampled.

These detailed data will allow further testing of the utility of ground measurements of vegetation (biophysical) structure), aerial LiDar and satellite-based remote sensing data (SPOT 4 and 5, FORMOSAT-2 and KOMPSAT-2) for establishing REDD+ baselines and monitoring. Combining outputs from field and remote measurements of carbon we should be able to provide relevant input to the ongoing MRV accounting of carbon in Tanzanian ecosystems, whilst additionally allowing for the development of a technology that can measure and monitor carbon effectively in the future.

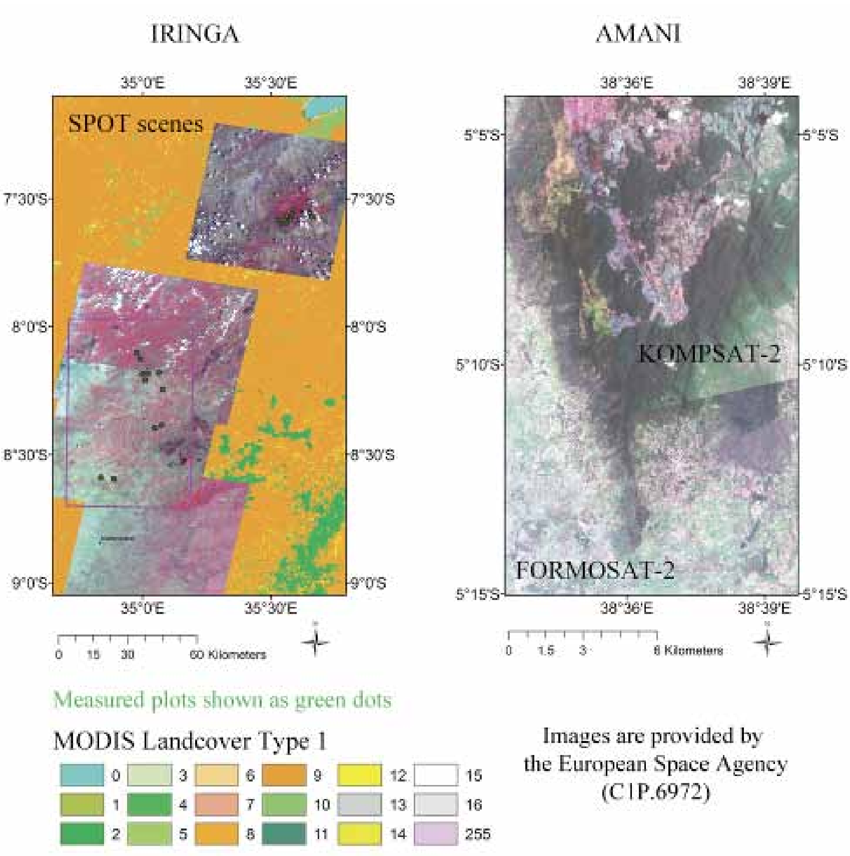


Figure 3. Location of 1 hectare plots sampled in August 2011, Iringa District. 2 – Evergreen forest, 4 – Woodland, 8 – Woody savannah, 9 – savannah, 10 – grassland, 12 – cropland, 14 – cropland/vegetation mix (International Geosphere Biosphere Programme classes = Type 1 in MCD12Q1 product, derived for year 2009).

Generating future carbon scenarios

In this part of the project's work we will build and expand on the past efforts of the Valuing the Arc Project (Box 1) to develop land use change scenarios ('possible futures') that illustrate how and where natural vegetation might be changed in response to climate change, economic development and population growth. These scenarios can show, for example, how farmland and plantations might replace forest, where towns might expand, and how these changes may affect the amount of carbon on the landscape.

In Valuing the Arc (www.valuingthearc.org), around 40% of Tanzania formed a study area to test out these approaches. Valuing the Arc developed a way to translate information from workshop participants into rules within Geographical Information System that will project land-cover change into the future. This approach started with a land-cover map from year 2000, which also included all protected areas, plantations, roads, and locations of human population centres. Two different scenarios were developed from this map: firstly the 'Business as Usual' scenario of land cover and land use change, and, secondly, the 'Green Future' scenario.

The landcover change map under 'Business as Usual' demonstrates a greater conversion of forests to agriculture, and it is assumed that some of this conversion will come from less well protected forest reserves in the lower regions of the country and the lower slopes of the Eastern Arc Mountains. Under the 'Green Future', there is less conversion to agriculture, and reserves are maintained. However, there is still some change of woodland/forests to farmland because of growing human population pressure; despite improvements in agricultural practices, cropland area will thus still be expanding.

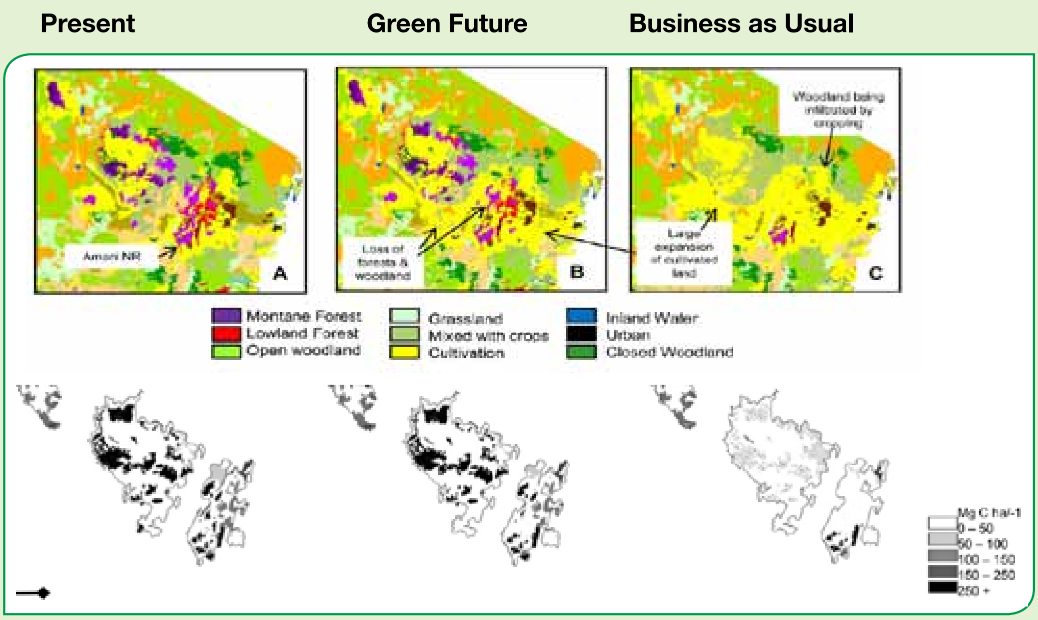
A final step in the process of calculating future carbon and the differences between 'Business As Usual' and 'Green Future' is to link biome-specific carbon estimates to the biomes in the land cover maps. Simple carbon data can already be derived from various freely available sources, but much better data will be available in Tanzania from the work of this project and the much larger National Forest Inventory Programme (NAFORMA) and UN REDD programmes working within the Ministry of Natural Resources and Tourism.

To complete this component of the new REDD MRV project, the team will work to extend the scenario and land use change mapping to national scale, which will entail working in the north, west and south of the country. We will use the landcover map developed by NAFORMA as the baseline and will use workshops and GIS rules to build maps of future landcover in Tanzania, which will subsequently be employed to inform possible carbon futures for the country. When national level carbon plot data become available, they can then be used to add to the landcover mapping work, thereby generating estimations of the carbon that might remain on the Tanzanian landmass under these two different scenarios. It is the difference between these two futures of Tanzania, and the difference in carbon in particular, that will allow the Tanzanian government to make the case for REDD+ payments. The payments would be made if Tanzania is moving towards the Green Future scenario and not following the Business as Usual scenario, which would result in a reduction of carbon emissions and a slowing-down of climate change.

Box 1: Scenarios of Ecosystem Service change in Tanzania

During Valuing the Arc, two scenarios were developed through participatory workshops, key informant interviews and policy analysis. The *Green Future Scenario* reflects an optimistic vision of the future, where Tanzania meets all its stated policy goals to alleviate poverty and manage natural resources sustainably. Reduced Emissions from Deforestation and Forest Degradation (REDD+) policies are successfully implemented. The population continues to grow, but more slowly, and exogenous economic pressures continue. The *Business as Usual Scenario* represents stakeholders' expectations of the future in Tanzania if current policy and practice continue. REDD+ is not implemented at any meaningful scale. There is a growing population and ongoing resource exploitation, leading to environmental degradation and declining family income.

If current trends of resource use in the Eastern Arc Mountains continue, 41 per cent of carbon stocks would be lost from 2000 and 2025. Projections such as this (see figures) helped the Valuing the Arc project illustrate how land use might change due to socio-economic factors, policy and practical realities could affected ecosystem service delivery.



Above. *Land use changes from present to hopeful green future scenario, and Business as Usual future scenario.*
Below. *Consequences of land use changes on carbon storage as an ecosystem service (from Swetnam et al. 2011)*

Michele Menegon holding a twig snake in the North Pare Mountains. Photo by Andrew Perkin

Are the Eastern Arc Mountain forests the most diverse forests in the world?

An interview with Michele Menegon of the Natural History Museum of Trento, Italy sheds light on why this may be the case when it comes to amphibians.

The snake swam rapidly across the surface of the pool. An undulating green line that contrasted with the darkness of the cold, mountain water. Beyond the pond, the forest rose up, a silent backdrop to the drama about to take place. Swimming towards it, herpetologist Michele Menegon reached out and quickly grabbed the unsuspecting reptile behind its neck. 'A boomslang', he reported, holding the animal with gentle respect in one hand as he continued to swim towards the edge of the pool. Carefully clambering onto the shore he lowered the venomous snake into a collecting bag.

Since 1997, Michele Menegon from Italy's Trento Museum of Natural History has been carrying out research on the reptiles and amphibians of the Tanzania's Eastern Arc forests.

'When I first arrived I had no idea how extraordinary these mountains are but over the years we have found that Tanzania's Eastern Arc Mountain forests are one of the most exceptional places in the world in terms of their amphibian and reptile fauna,' Michele explained. 'The rate at which we are discovering new species of amphibian and reptile in the Eastern Arc Mountains is extraordinary. So far there are about 100 amphibian species from the Eastern Arc Mountain forests that have been officially named by scientists. Based on our work between 1997 and 2011, we have identified another 100 species. Of these we have officially described about 30 and we are still working on the other 70 species. So there are now about 200 species of amphibian endemic or near-endemic to the Eastern Arc Mountain forests that we are sure of, plus another 20 that are at the very early stages of our research.'

One of the one hundred or so species of amphibian from the Eastern Arc Mountains that are new to science and that Michele and his colleagues are in the process of describing. Photo by Michele Menegon.

'The rate at which we are recording new species is extraordinary. Only in the Western Ghats in India is there anything like this going on in terms of the identification of amphibians new to science.'

Michele is eager to explain that this is not just his work. 'These findings are the result of many peoples' work including herpetologists from the University of Dar es Salaam, the Natural History Museum in London, the University of Basel, the Zoological Museum of Copenhagen, amongst others. It has really been a collaborative effort involving scientists from around the world'.

The results of the research that Michele Menegon and other herpetologists have been working on over the last decade show that Tanzania's Eastern Arc Mountains are the richest forests in Africa in terms of their amphibian and reptile species richness and species endemism. Relative to the forests of the Congo, Ethiopia and Kenya, the Eastern Arc Mountains are more diverse. And in terms of their endemism, they have a higher rate of endemism, in terms of the number of unique species per unit area, than anywhere else on the planet.

'Something that we have found that is very important in terms of conservation is that there are different species at different altitudes. This means that there is one group of species that live in the forest between 300 – 600 metres above sea level; going up the mountain, another group of species are found between 600 - 900 metres above sea level; and above 900 metres, there is another group of species. Unfortunately in many mountains, the lowland forest has already been cleared and we estimate that dozens of species of amphibian have already gone extinct from the Eastern Arc Mountains over the last 300 – 400 years due to deforestation,' Michele explained.

A new species of Nectophrynoides from the South Nguru Mountains in Mvomero District. Some species of Nectophrynoides are restricted to a single forest valley. This makes them very vulnerable to extinction as a result of deforestation and forest degradation. Photo by Michele Menegon.

Musing as to why these extraordinary rates of endemism have arisen, Michele suggested that 'The Eastern Arc Mountains are like a window on the evolution of life in East Africa over the last 50 million years. Firstly, the mountains are very old. They started to be uplifted 100 million years ago with the most recent uplifting events 5 to 7 million years ago. In between the mountains have undergone periods of uplift and periods of erosion. Similarly the extent of the forest has waxed and waned. This dynamic background has no doubt contributed to the complex evolutionary history of the mountains' herpetofauna. What we are finding is that some of the chameleon species split into distinct species as long ago as over 50 million years ago. Whilst others are still evolving into new species. For example some species of toad from the genus Nectophrynoides, a genus that includes the famous Kihansi spray toad, are just a few hundred thousand years old. That is very recent from an evolutionary perspective. This means that there are both very recent species and some very ancient species. Another characteristic of these mountains that has contributed to there being so many species is that they are like an archipelago of small islands. Each mountain block has its own climatic and geological history that has contributed to different species evolving. Within each mountain blocks, each forest is different. And within a single forest, there are different species at different altitudes. In some cases from one valley to the next there are unique species. For example the toad, *Nectophrynoides wendyae* is found in only 1 square kilometer of a single valley in the Udzungwa Mountains.'

'What we have in the Eastern Arc Mountains is something incredibly interesting in terms of the history of life on our planet. It is an open laboratory where we can learn more about where we come from. Some people have compared the Eastern Arc Mountains with the Galapagos Islands. But they are much richer than the Galapagos Islands in terms of the number of unique animal species. Unfortunately they are not nearly as well known as the Galapagos and so there are few scientists working in the area especially compared with places like Madagascar and the Andes. There is still so much to find out about these forests. We are just scratching the surface in terms of our knowledge of this extraordinary place. We need more Tanzanian scientists to work in this area and we need to let more people know about how extraordinary these forests are.'

If you would like to learn more about Michele's work and the amphibians and reptiles of the Eastern Arc Mountains, please visit the website of the Natural History Museum of Trento at http:// www.mtsn.tn.it/ tropical_biodiversity.

WWF's initiative to restore forest connectivity in four critical habitat corridors with support from CEPF.

Peter Sumbi and Francis Rusengula, WWF Tanzania Country Office

Farmers whose farms were included in the Derema forest corridor are counting on the President to provide them with the alternative agricultural land that they were promised. Photo by Neil Burgess.

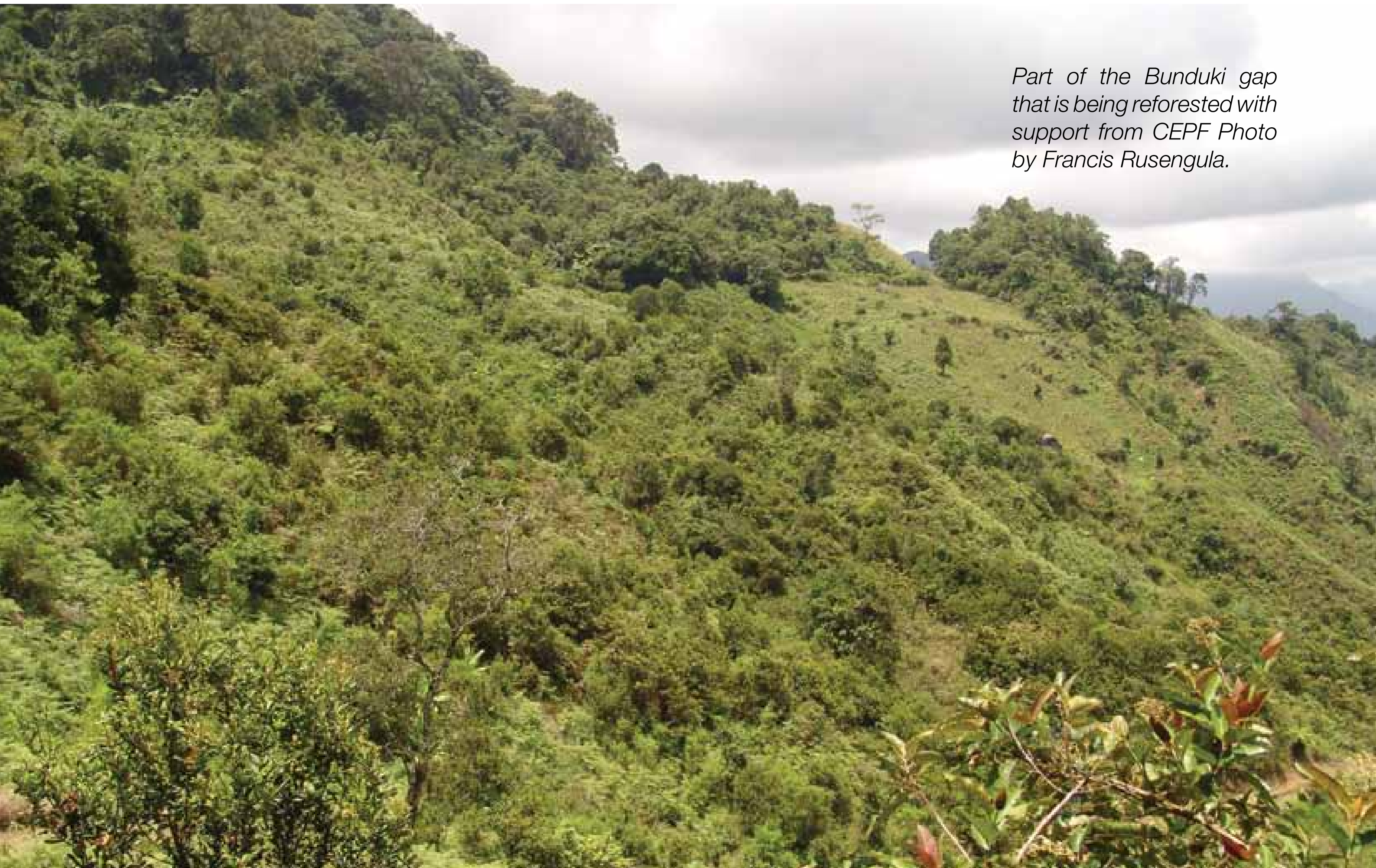
The Critical Ecosystem Partnership Fund (CEPF), a global leader in enabling civil society to participate in and benefit from conserving some of the world's most critical ecosystems, has recently provided additional funding support to a few Civil Society Organisations in Tanzania. Amongst these conservation organisations, the WWF Tanzania Country Office (WWF TCO) through the WWF Eastern and Southern Africa Programme Office (WWF ESARPO) in Nairobi has received a grant. WWF TCO in collaboration with other partners such as the Wildlife Conservation Society of Tanzania, the World Land Trust and other government agencies are implementing a project that aims to enhance habitat connectivity; consolidate protected areas; and generate livelihood gains for communities in the Eastern Arc Mountains and Coastal Forests. The project is implemented in four habitat corridors in the Eastern Arc Mountains namely Derema in the East Usambara Mountains; Bunduki in the Uluguru Mountains; and Magombera and Mngeta forest corridors in the Udzungwa Mountains.

In the Derema forest corridor in the East Usambara Mountains, the project is facilitating 1500 farmers who gave up their farms for the gazettement of the 986 ha Derema Forest Reserve, to acquire alternative agricultural land. The Derema Corridor connects Amani Nature Reserve in the south with Nilo Nature Reserve and Segoma and Kambai Forest Reserves in the north. The project is working closely with the Muheza District council and the Muheza District Commissioner to secure a revocation order from the President for the abandoned sisal plantation at Kibaranga. The Kibaranga Plantation was identified as the site for the land to be given to those who had farms within the Derema Corridor. Once this has been secured, the project will assist in the allocation of individual farm and agroforestry plots to the affected farmers.

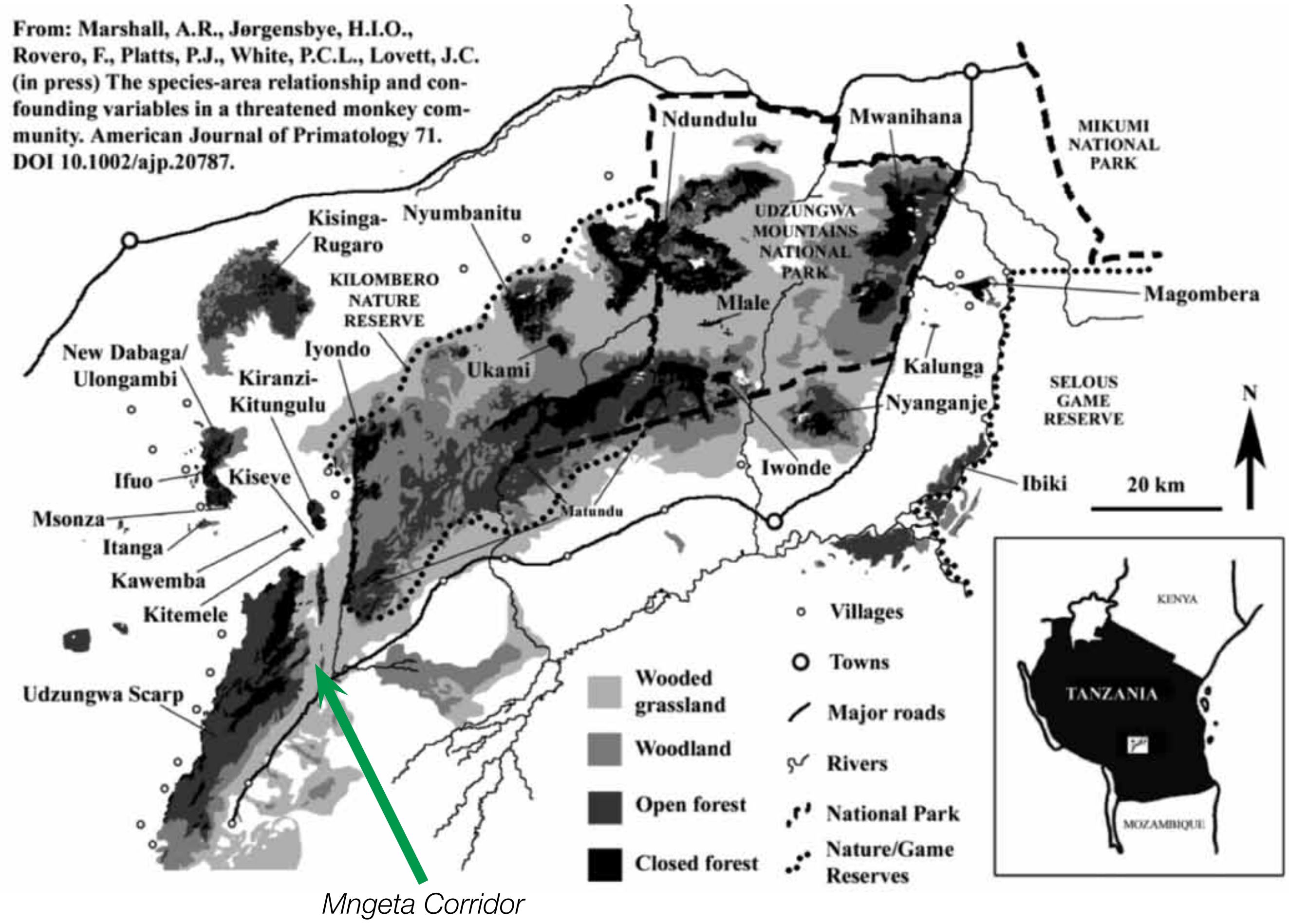
In the Uluguru Mountains the project is consolidating the 106 ha Bunduki forest corridor that connects the northern and southern forests within the 73,000 ha Uluguru Nature Reserve. This work entails development of tree nurseries, boundary tree planting, microfinance, capacity building through training on alternative income generating activities, and facilitating the amicable resolution of boundary disputes within the area.

In the Udzungwa Mountains, the project is facilitating the legal gazettement of the 6,300 ha Mngeta forest corridor between Kilombero Nature Reserve and the proposed Uzungwa Scarp Nature Reserve. This is being implemented mainly by supporting Kilombero and Kilolo District councils and Nature Reserve staff to proceed with the gazettement process. Other initiatives include: carrying out a sensitization and awareness programme amongst the corridor-adjacent communities; corridor location; and preparation of all relevant documents necessary for the final gazettement of this important forest corridor. Besides that CEPF is facilitating acquisition of an area of forest known as the Magombera forest, from the ILLOVO sugar company. This process will enable the legal gazettement of the 1,976 ha Magombera forest and finally ensure that it is annexed to the Selous Game Reserve. This is being done by ensuring that the ILLOVO Company agrees to give land for conservation; that they are compensated; that the area is demarcated; and that all necessary procedures for the gazettement, including the relevant Government notices for annexation, are done properly.

Paul Nnyiti from the Wildlife Conservation Society of Tanzania at one of the tree nurseries supplying trees for the Bunduki gap. Photo by Neil Burgess.



Part of the Bunduki gap that is being reforested with support from CEPF Photo by Francis Rusengula.



Map 1. Forests and protected areas in the Udzungwa Mountains showing the Magombera and Mngeta forest corridors.

The project aims at ensuring that within these four Eastern Arc Mountain landscapes, the forests are connected and that the endemic and rare species that are found within these important but threatened habitats are properly protected. The project began in July 2011 and will operate until June 2014.

The Mngeta River that flows through the Mngeta corridor is an important tributary of the Kilombero River and Kilombero Valley Ramsar site. Photo by Francis Rusengula.

The Mngeta corridor lies between the Kilombero Nature Reserve, as shown in the picture and Uzungwa Scarp Forest Reserve'.

Tanzania Forest Conservation Group

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About the Tanzania Forest Conservation Group

The Arc Journal is published by the Tanzania Forest Conservation Group (TFCG). Established in 1985, TFCG is a Tanzanian non-governmental organisation promoting the conservation of Tanzania's high biodiversity forests.

TFCG's Vision

We envisage a world in which Tanzanians and the rest of humanity are enjoying the diverse benefits from well conserved, high biodiversity forests.

TFCG's Mission

The mission of TFCG is to conserve and restore the biodiversity of globally important forests in Tanzania for the benefit of the present and future generations. We will achieve this through capacity building, advocacy, research, community development and protected area management in ways that are sustainable and foster participation, cooperation and partnership.

TFCG supports field based projects promoting participatory forest management, environmental education, community development, advocacy and research in the Eastern Arc Mountains and Coastal Forests. TFCG works with 130 villages in 14 Districts.

To find out more about TFCG please visit our website www.tfcg.org.

Inside this edition of the Arc Journal

The Arc Journal:

Newsletter of the Tanzania Forest Conservation Group
Editor: Nike Doggart
Founding Editor: Carter Coleman

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'The Critical Ecosystem Partnership Fund is a joint initiative of l'Agence Francaise de Developpement, Conservation International, the Global Environment Facility, the Government of Japan, the MacArthur Foundation and the World Bank. A fundamental goal is to ensure civil society is engaged in biodiversity conservation.'

The Arc Journal is also available online at www.tfcg.org