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SPECIAL EDITION

This edition of the Arc Journal includes a series of articles summarising the results of a five year ecosystem services research programme called 'Valuing the Arc'.

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Valuing the Arc

What was the Valuing the Arc Programme?

Neil Burgess, University of Cambridge and WWF-US; Andrew Balmford, University of Cambridge; Shadrack Mwakalila, WWF Tanzania; Philip Platts, University of York, University of Cambridge; Taylor H. Ricketts, WWF-US; Marije Schaafsma, University of East Anglia; and Ruth Swetnam, University of Cambridge.

Valuing the Arc (VTA) was a research programme that ran from 2007 to 2012 and mapped, modelled and valued ecosystem services within and flowing from the Eastern Arc Mountains, with the objective of informing decisions for sustainable management of the remaining natural habitats. The services we focused on were carbon, water, nature-based tourism, timber and non-timber forest products (charcoal, firewood, poles and thatch). Biodiversity modelling and calculation of the various costs of conservation were also undertaken to provide context. All services were mapped and modelled based on land cover and population around the year 2000, and hence this is a somewhat historical view of the service values as Tanzania's economy has changed rapidly over the recent years.

Partners in the project were Sokoine University of Agriculture and the University of Dar es Salaam in Tanzania, the WWF offices in Dar es Salaam and Washington DC, and the following British Universities: Cambridge, York, East Anglia, Leeds and Cranfield.

The project was overseen by a project steering committee that consisted of members of the Tanzanian government.

The methods and results generated by VTA have been published primarily in the form of scientific papers, which are available on the project website (see below). This special issue of the Arc Journal aims to make summary results more widely available to conservationists, economists, policy makers and the general public in Tanzania. Further information on the programme is available through www.valuingthearc.org and www.naturalcapitalproject.org, with general information about the Eastern Arc Mountains on www.easternarc.or.tz.

Valuing the Arc was funded by the Leverhulme Trust (http://www.leverhulme.ac.uk/). Additional funding was provided by the Packard Foundation (http://www.packard.org/), the Royal Society (http://royalsociety.org/), Arcadia, and a Royal Society University Research Fellowship.

Photo by Andrew Perkin 2013

Where did the Valuing the Arc programme operate?

Philip Platts, Andrew Balmford, Neil Burgess, Shadrack Mwakalila, Taylor H. Ricketts, Marije Schaafsma and Ruth Swetnam.

The Valuing the Arc Programme (VTA) defined the boundaries of the Eastern Arc Mountains (EAM), and the Tanzanian watersheds that drain them, as the basis for its work. Precise delineations of mountain extent considered not only elevation, but also steepness of slope, terrain roughness and summit prominence relative to base heights. The boundaries maximise inclusion of preclearance and present-day forest extent, and known distributions of rare mountain flora within a minimal – yet consistently defined – mountain area (Figure 1).

Accordingly, the 12 EAM blocks in Tanzania span 5.2 million ha and elevations from 121 m to 2,626 m above mean sea level. Less than 10% of the mountain area is forested - less than a third of the preclearance extent. Three quarters of the remaining forest area is under some form of management: half designated for catchment protection or multi-resource use (Forest Reserves) and the rest gazetted for nature conservation (Nature Reserves and a National Park). Smaller areas are under participatory management schemes, whereby local communities are either jointly (together with government) or solely responsible for managing natural forests for sustainable use and conservation. In comparison, only 21% of the EAM woodlands are formally protected.

Population density in the EAM is higher than the national average for Tanzania, with 2.3 million people living in the mountains in 2002, and lowland settlement high near the mountain base (Figure 1). Population densities are highest in West Usambara and North Pare, followed by East Usambara and Uluguru. Three of these blocks are also amongst the most important in terms of species richness and endemism.

Beyond the mountain boundaries, VTA conducted many of its analyses across the Tanzanian watersheds that drain the EAM (Figure 1), including those of the Sigi, Pangani, Wami, Ruvu, Rufiji and Kilombero Rivers. This wider region covers 34 million ha and contained around 13 million people in 2002, including the administrative and commercial capitals of Dodoma and Dar es Salaam, as well as Arusha, Morogoro, Moshi and Tanga.

The EAM and its watersheds have been inhabited by farmer and pastoral communities for millennia. A range of tribes, mainly from the ethnic Bantu group, and communities live in and around the forests of the EAM, including the Hehe in Iringa, the Gogo in Dodoma, the Luguru in Morogoro and the Sambaa in Tanga. Forest conversion for agriculture has changed and shaped the ecology of the EAM over thousands of years, but especially over the past few centuries. During the German and British occupation, from the late 1800s to early 1960s, timber resources were exploited on industrial scales and large forested areas were cleared for cash crops, such as sisal and rubber (lowlands) and tea and conifer trees (mountains).

Nowadays, 70% of households in the EAM depend mainly on agriculture for their income, growing mainly maize, beans, bananas and cassava. Slash-and-burn farming or shifting cultivation is still practised. Although most residents have primary school education, 30% live below the national poverty line, less than half have access to improved water sources, and only 10% have access to electricity. Local inhabitants of mountain settlements do however benefit from wild-harvested goods such as firewood and charcoal for energy, building materials (poles and thatch), medicines and food (fruit, tubers, honey and bushmeat). Collection of these non-timber forest products represents, on average, around 12% of rural incomes. Moreover, for many people living in the EAMs, the forests and woodlands have spiritual, cultural and historical meaning.

In the surrounding watersheds, people do, however, benefit from the regulation of hydrological flows to downstream agricultural areas and major population centres, where the water is used for hydroelectric power generation as well as for drinking and industry. Many living outside the EAM are also using timber sourced from the mountains. The production of charcoal, by slowly burning cut trees, is common in the lowland areas (and some mountain regions) and forms the primary energy source in Tanzania's urban areas. Increasingly, people visit the mountains for recreation and relaxation, and many people have ancestral homes in the mountains, returning from the cities for weekends and holiday periods. Globally, society benefits from the capacity of woody biomes in the EAM and its watershed to mitigate climate change, through the carbon sequestered and stored in their biomass.

Further details on the definition and extent of the Eastern Arc Mountains is found in the paper by Phil Platts and others published in the Journal *Environmental Conservation*

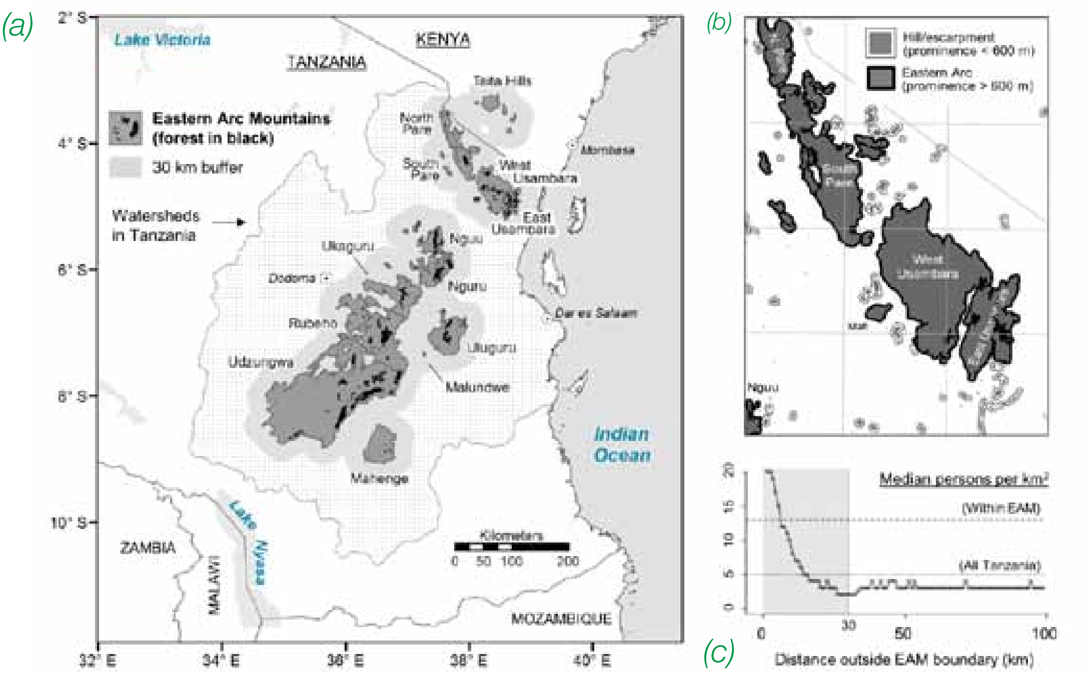

Figure 1
Precise delineation of the 13 EAM blocks and the Tanzanian watersheds that drain them (a). The Taita Hills in Kenya are part of the EAM definition, but were not studied by VTA. Topographic features were identified using elevation, slope and terrain complexity, and distinguished as mountainous according to their prominence (summit minus base elevation) (b). Population density is higher than the average for Tanzania, and decreases with distance from the mountains (c). GIS files are freely available at: http:// datadryad.org/resource/ doi:10.5061/dryad.c5310

Photo by Flemming Pagh Jensen

Many unique and rare species are found in the Eastern Arc

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The Eastern Arc Mountains (EAM) exhibit extraordinarily high biodiversity and new species are regularly described from the region. Species inventories at coarse scales, such as lists of species within protected areas, are available, but finer-scale species' distribution data are much needed to assess and prioritise on-the-ground conservation. However, collecting and analysing such data can be a time-consuming and expensive exercise.

Estimates for the number of strictly and regionally endemic vertebrates in the EAM were published in 2007 (170 unique species of mammals, birds, amphibians and reptiles). In addition, a re-analysis of the mountains' vascular plant biodiversity has now produced a list of known species, adhering strictly to the limits we defined for the EAM. This shows that the number of vascular plant species in the EAM is 4066, of which 508 species (609 taxa, including subspecies and varieties) are endemic and 486 species (12%) have been assessed in a threatened category for the IUCN Red List (count last updated January 2014).

Within the Valuing the Arc programme, distribution records of animals from the EAM were compiled and, with the help of experts who have undertaken considerable field work in the mountains and who know the species' ecological requirements well, were refined to exclude areas of unsuitable habitat. This approach allowed distribution maps of birds, mammals, reptiles and amphibians to be produced, which summarise the biological patterns in ways not seen before. We included only species of conservation concern – those that have small range sizes, are endemic or near-endemic to the mountains, or are threatened with extinction. In total, 118 animal species were included: 57 amphibians, 76 birds, 14 chameleons and 41 mammals. These were combined with bioclimatic distribution models for 316 endemic plant species.

PATTERNS OF RICHNESS AND RARITY

Species richness was generally highest in the East Usambara, West Usambara, Uluguru, and Nguru Mountains and on the eastern flanks of the Udzungwa Mountains (Figure 1a). Mammals of conservation concern are noticeably less restricted in their distributions than other taxa. Notably, the same mountain blocs that are important for vertebrates are also important for plants (Figure 1a-f).

In addition to richness, we also mapped range-size rarity, in which the importance of an area is greater if it contains species with smaller ranges. This was calculated for each pixel as the sum of the inverse of the range size of every species present. The patterns remain broadly similar, but areas of the Mahenge Mountains and the rain-shadow zone in the western part of the Rubeho, Udzungwa and Ukaguru Mountains are characterised by higher range-size rarity and are potentially of higher conservation priority than when richness alone is used (Figures 1a & 2).

These maps are based on modelled distributions. If used as the basis for conservation action then sites should be carefully assessed to check that they do actually contain the species predicted to occur there. Species of conservation concern are hardest to model as we have few records upon which to base models and the species are often highly specialised to particular environmental conditions which may not be adequately reflected in existing environmental datasets.

PROTECTION IN THE LONG-TERM

How well does the current 10,500 km^2 network of EAM reserves cover species of conservation concern? On average, 66% of species' ranges are included. The reserve network captures many of the most important areas for biodiversity, reflecting the fact that much of conservation planning has been based on information about species' distributions. If we want to know how best to complement the existing reserve network, then we should consider currently unprotected areas in the West Usambara and Udzungwa Mountains that show high biodiversity importance. However, an important goal of conservationists is the persistence of biodiversity in the long-term. Conservationists in the EAM are therefore also trying to establish corridors to link protected areas. Although these corridors may not represent core habitat for threatened species, as mapped above, their function is to promote long-term persistence through enabling species dispersal and migration, which is likely to be especially important in the face of climate change.

Finally, we can consider the EAM from a global perspective. A recent analysis for the UNESCO World Heritage Convention (see http://www.unep-wcmc.org/biodiversity-wh_975.html) shows that the EAMs are the most important World Heritage Site 'gap' in Africa. Five sites in the EAMs (Udzungwa Mountains National Park and Kilombero Nature Reserve in Udzungwa, Mkingu proposed Nature Reserve in Nguru, Mamiwa Kisara Forest Reserve in Ukaguru, and the Uluguru Nature Reserve) are amongst the top 100 most irreplaceable protected areas for threatened mammals, amphibians and birds globally. The analyses of diversity and rarity patterns presented here, combined with an assessment of the current protected area network, provide vital information that can be used to maintain the ecological integrity of the EAMs for future Tanzanian generations and the global conservation community.

Further information about this research can be found in Jonathan Green's PhD thesis on 'Incorporating costs and processes into systematic conservation planning in a biodiversity hotspot'.

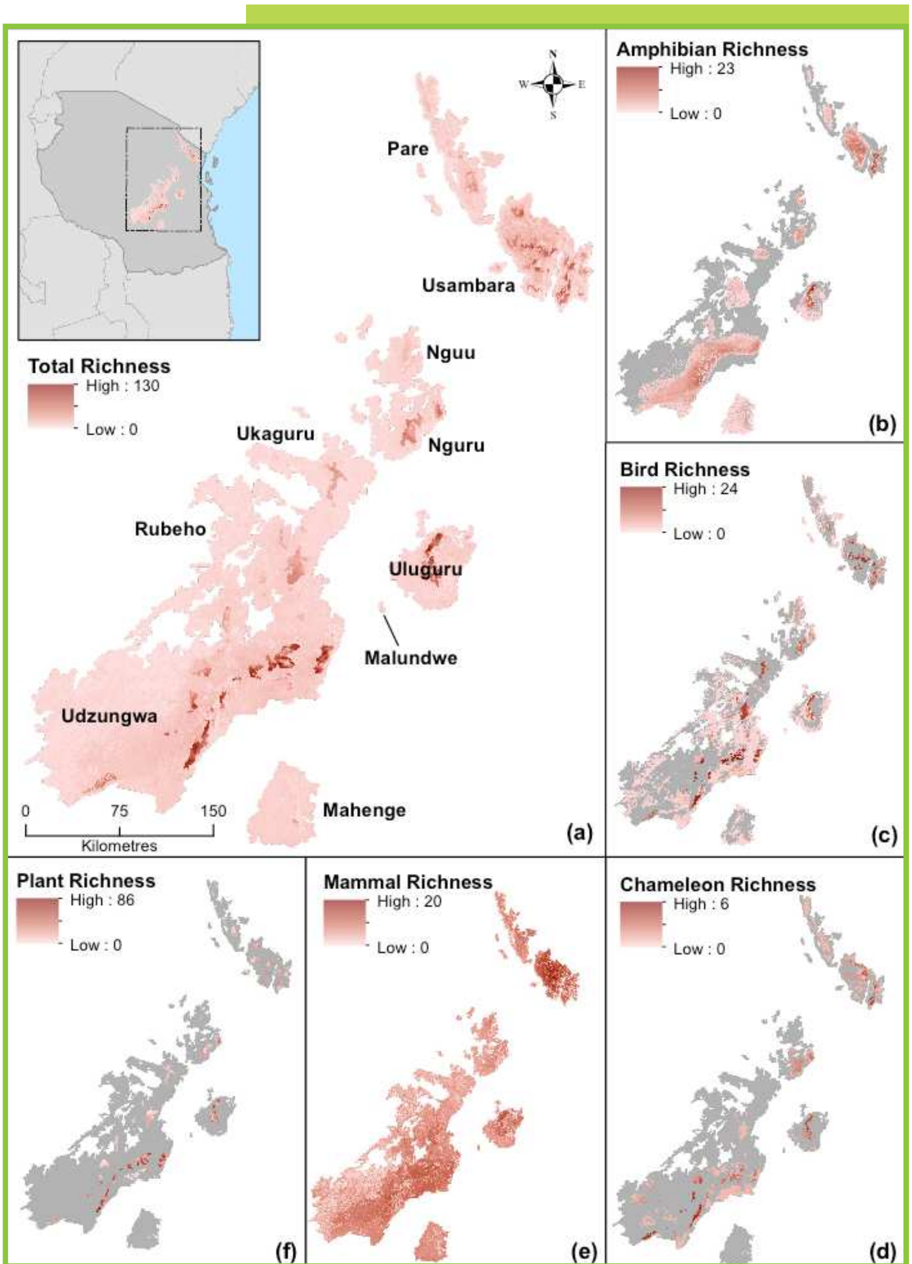

Figure 1. Maps of species richness for taxa of conservation concern (a; 504 species). Individual maps are also shown for amphibians (b; 57), birds (c; 76 species), chameleons (d; 14 species), mammals (e; 41 species) and plants (f; 316 species [forest only]).

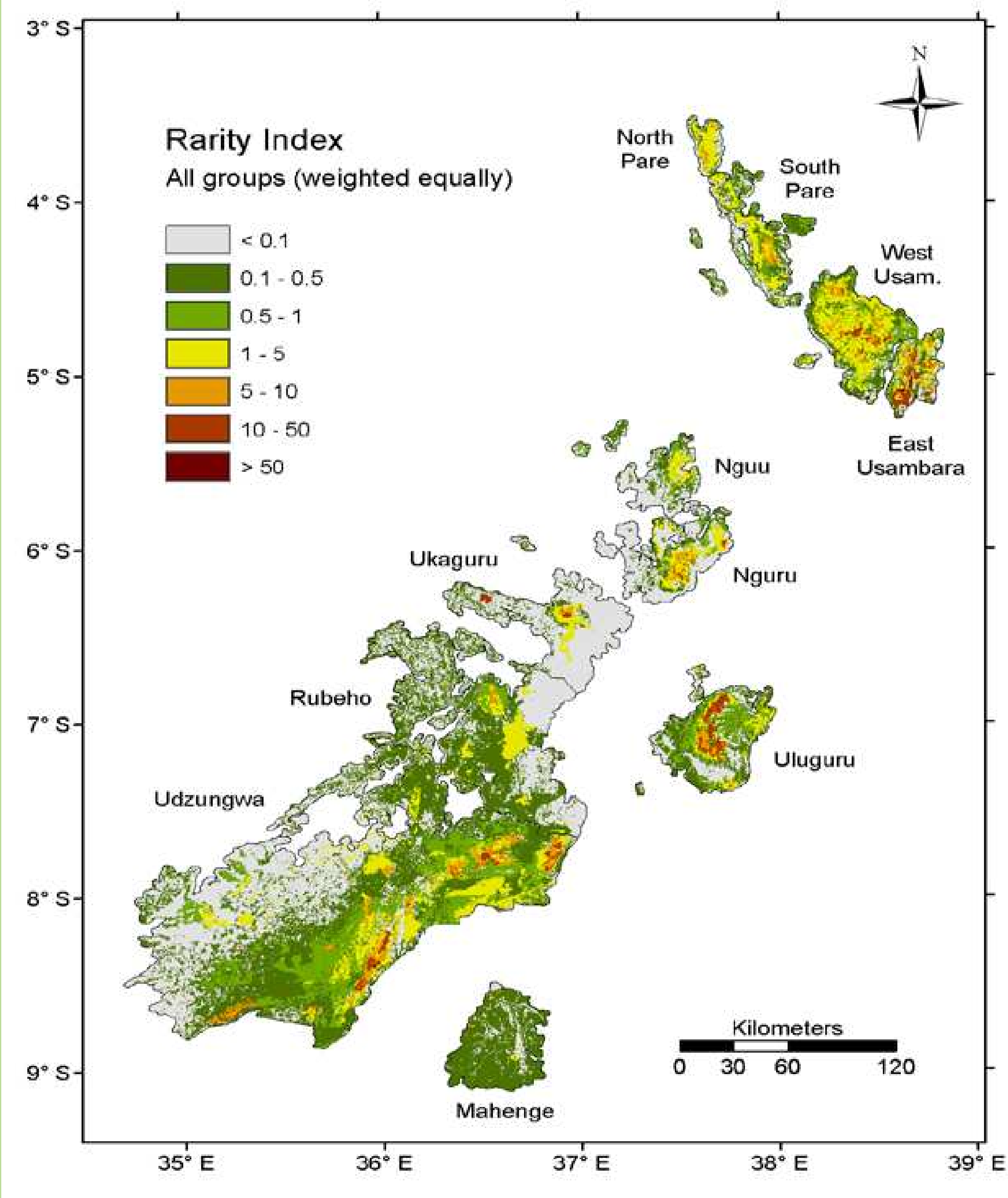

Figure 2. Range size rarity accounts for the size of a species' range and gives greater weight to areas that host larger numbers of species with smaller ranges.

Figure 3. The Checkered Sengi (left); Pygmy Chameleon (right) and near-endemic Forest double-collared sunbird Nectarinia fuelleborni photographed in the Udzungwa Mts (title photo) are all found in the EAM. Other taxa are less well understood, particularly insects for which few spatial data exist. Photo credits: Rasmus Gren Havmøller (Sengi and Chameleon) and Flemming Pagh Jensen (Sunbird).

Forests helping to reduce climate change

Simon Willcock, University of Leeds, University of Southampton; Neil Burgess; Simon Lewis, University of Leeds; Robert Marchant; Andrew Marshall, University of York; Boniface Mbilinyi, Sokoine University; Pantaleon Munishi, Sokoine University; Oliver L. Phillips, University of Leeds; Philip Platts; Marije Schaafsma; Deo Shirima, Sokoine University; and Ruth Swetnam.

Changes in the world's climate are threatening livelihoods across the globe. In Tanzania these changes are likely to include more extreme wet and dry seasons, drier interior regions, wetter coastal regions and higher temperatures nationwide. There is now an overwhelming consensus that much of this climatic change is caused by human activities, with fossil fuel combustion and removal and burning of vegetation being major drivers of change.

Anthropogenic destruction of tropical forest is thought to be responsible for between 10% and 30% of global carbon dioxide emissions, thus contributing to climate change. One of the strategies to slow the rate of climatic change is to reduce the conversion and degradation of woody landscapes, where growing trees absorb carbon from the atmosphere and store it as biomass.

The Valuing the Arc programme undertook a series of detailed studies regarding carbon storage and uptake (sequestration) across forests and woodlands in the Eastern Arc Mountains (EAM).

We first embarked on the establishment of plots to measure aboveground carbon for understanding basic trends in the two main woody habitats, miombo woodland and moist forest (Figure 1). The miombo work was the first example of robust carbon estimates for this habitat type. Furthermore, the forest work allowed us to examine fine scale trends in carbon storage, revealing significant impacts of elephants (in those mountains where they occur), people, soil, climate and topography. The work also highlighted the importance of incorporating individual tree heights into calculations of stored carbon.

At the landscape scale, we devised a simple and repeatable method to estimate carbon storage values and associated 95% confidence intervals for aboveground live carbon, litter, coarse woody debris, belowground live carbon and soil carbon. The method uses a combination of existing inventory data and systematic literature searches, weighted to ensure the final values are regionally specific. We estimated that the Tanzanian watersheds of the EAM stored 6.33 (95% confidence interval range: 5.92–6.74) billion metric tonnes of carbon in the year 2000, equivalent to over 80% of global anthropogenic CO_2 emissions for the same year, of which 1.58 (1.56–1.60) billion tonnes were held in live vegetation. Subsequently, we developed a regression relationship between aboveground live carbon storage and disturbance, climate and soil variables using 1,611 tree inventory plots distributed across EAM forests and woodlands, which produced an overall carbon estimate comparable to the literature-based approach, of 1.32 (0.89-3.16) billion tonnes of carbon in live vegetation across the EAM watershed (Figure 2). Taken together, these new results revealed that most previous Africa-wide or global studies that had lacked sufficient regional data had under-estimated carbon storage in the region by an average of 50%.

Our results suggest that around a third of the carbon is found within protected areas of the EAM, with the highest density within Forest Reserves, Nature Reserves and the Udzungwa Mountains National Park. Although forest contained the most carbon per unit area (Table 1), woodland contributed most to the overall total carbon stored. This is because the area of woodland is much larger than forest.

Table 1: Carbon stored in aboveground live vegetation in the Eastern Arc watersheds using the regression approach

Habitat	Mean (tonnes carbon per hectare) and 95% confidence intervals	Total (billion tonnes carbon) and 95% confidence intervals
Sub-montane forest	189 (95-588)	0.06 (0.03-0.20)
Lowland forest	182 (152-360)	0.03 (0.02-0.05)
Montane forest	130 (62-702)	0.02 (0.01-0.14)
Upper montane forest	166 (69-533)	0.02 (0.01-0.05)
Forest mosaic	121 (55-485)	0.01 (0.00-0.02)
Closed woodland	100 (70-331)	0.18 (0.13-0.61)
Open woodland	51 (38-165)	0.49 (0.47-1.60)

In terms of carbon change across time, historical and remotely-sensed land cover maps suggest that, between 1908 and 2000, 74% (2.8 million ha) of forests were lost, driven by a five-fold increase in cropland area. We estimate the associated carbon release to be 0.94 (0.37-1.50) billion tonnes carbon. However, this mostly occurred in the first half of the twentieth century. Between 1949 and 2000, forest area increased by 0.30 million ha within protected areas, compared with a decrease of 0.16 million ha elsewhere, suggesting that legal protection has succeeded in reversing deforestation trends. As protected forests regenerated, they sequestered 4.77 (3.84-5.70) tonnes carbon per hectare, whilst elsewhere in the watershed there was a net carbon emission of 11.89 (7.21-16.57) tonnes carbon per hectare as conversion to cropland continued. The net loss of carbon storage capacity between 1949 and 2000 decreased by 471,400 tonnes as a result of these changes in forest area. This is equivalent to a loss of ~ USD 39 million in financial terms (based on a carbon value of USD 82/tonne carbon).

In summary, the amount of carbon stored in the EAM watersheds is considerable and higher than previously thought, showing that the region is not just biologically rich, but also an important area for climate change mitigation. We have quantified dramatic changes in land cover over the 20th century, with forest area declining rapidly at first, followed by a modest recovery after the establishment of protected areas. Continuing investment in forest management in collaboration with local communities is vital to reduce future emissions and concomitant climate impacts.

Further information on the storage of carbon in the Eastern Arc forests is found in the article by Simon Willcock and others in the Journal PLoS One

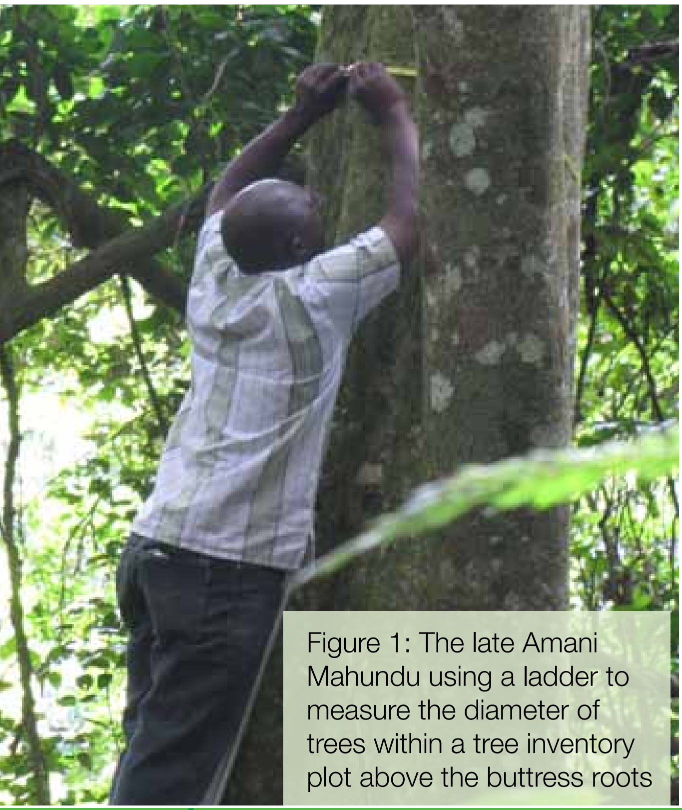

Figure 1: The late Amani Mahundu using a ladder to measure the diameter of trees within a tree inventory plot above the buttress roots

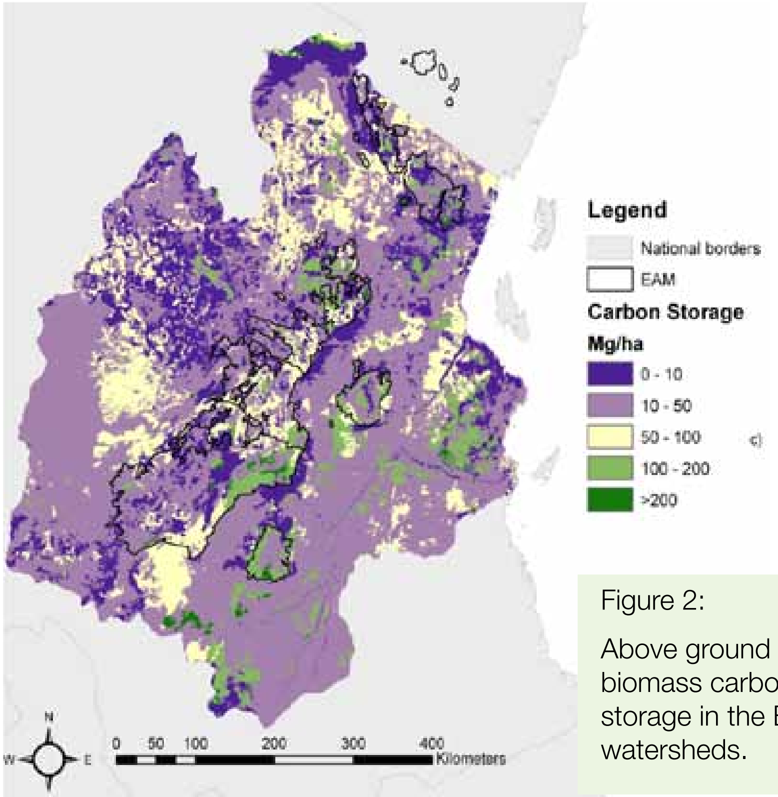

Figure 2:

Above ground live biomass carbon storage in the EAM watersheds.

Local people depend on firewood and other products collected from the forests

Marije Schaafsma; Andrew Balmford; Ian Bateman, University of East Anglia (UEA); Pieter van Beukering, Amsterdam; Neil Burgess; Shabani O. Chamshama, Sokoine University; Andy Edge, University of Cambridge; Brendan Fisher, UEA; T. Freeman, Cranfield University; Victor Geofreyl; Rhys Green, University of Cambridge and RSPB; Aloyce Hepelwa, University of Dar es Salaam; Antares Hernandez-Sirvent, University of Oxford; Sebastiaan Hess, Amsterdam; Eifon Jones, University of York; George Kajembe, Sokoine University; G. Kayharara; M. Kilonzo, Sokoine University; Kassim Kulindwa, University of Dar es Salaam; Jens F. Lund, Copenhagen; Seif Madoffe, Sokoine University; Robert Marchant; Lawrance Mbwambo; Henrik Meilby, University of Copenhagen; Sian Morse-Jones; Yonika M. Ngaga, Sokoine University; Philip Platts; Paulette Posen, UEA; Ruth Swetnam; Ida Theilade, University of Copenhagen; Thorsten Treue, University of Copenhagen; Kerry Turner, UEA; and Vincent G. Vyamana, Sokoine University.

Understanding the distribution, amounts and economic values of Non-Timber Forest Product (NTFP) collection helps us understand the benefits that local communities obtain from Eastern Arc Mountain (EAM) habitats. It can also inform decisions on areas set aside for sustainable use or conservation in the area.

In Tanzania, rural households rely mainly on agriculture and natural resources for their livelihoods, with NTFPs being widely used for firewood and charcoal for cooking, for house construction and various other household uses. Firewood, poles and thatch are mainly collected for domestic consumption purposes and contribute to non-cash household income, whilst charcoal is usually traded. Thereby, NTFPs provide a source of cash income for poor rural communities, or a safety net when agricultural yields are low. For 13% of households surveyed in the EAM blocks, the main source of household income is forest related, including timber and NTFP collection.

We assessed NTFP extraction in the EAM, based on information collected in over 2000 households in 60 villages. These surveys were combined with geographical information to produce spatially explicit models that relate household NTFP use and production to household and environmental characteristics. These models were then used to estimate the overall NTFP production in the EAM area.

In the rural areas of the EAM blocks, firewood provides the main source of cooking fuel for most households surveyed. In economic terms, firewood collection contributes just under TSH 16,000 to the annual household budget, and the flow of benefits is in total TSH 36 billion per year (USD 25 million). Whereas the rural community relies mainly on firewood for cooking, the urban population commonly uses charcoal (75% of households in Dar es Salaam and 54% in other urban areas). Now that coastal forests around major cities are largely exploited, charcoal production is increasingly moving into the woodland and lowland forests of the EAM. Our calculations suggest the annual revenues of charcoal producers in and around the EAM is TSH 21 billion per year (USD 15 million). The volume of charcoal production in the EAM is equivalent to approximately 11% of the combined demand for charcoal in Dar es Salaam, Tanga and Morogoro, and therefore forms an important part of the national energy supply. Actual charcoal production rates in the EAM are expected to be even higher, as our analysis excluded charcoal producers from far outside the EAM blocks and respondents may have underreported illegal charcoal production.

Another important NTFP for many rural families is poles, used for the construction of houses in 60% of our sample. The total economic value of pole collection is TSH 2.2 billion per year (USD 1.6 million) – lower than for firewood and charcoal, which are collected more often. The commercialisation of pole cutting is small with only 6% of collecting households selling their poles, mainly to neighbours. Some households now prefer to build brick walls, but bricks are currently more expensive than poles and only available to richer families. Moreover, they require firewood for burning the bricks, thereby not lessening the pressure on forests and woodlands.

Half of the sampled households have thatched roofs. Thatch is collected from woodland and swampy areas and is widely used because it is available, cheap and a traditional building material. Thatch collection has the lowest economic value of the NTFPs considered, at TSH 220 million per year (USD 0.16 million). Thatch was not found to be traded on a regular basis.

We calculate that the total benefit flow of charcoal, firewood, poles and thatch from the EAM has an estimated value of USD 42 million per year. This is roughly equivalent to TSH 26,000 per capita per year (USD 18) on average over all people living in the EAM (2.3 million). Compared to statistics of mean rural expenditure and income per capita, NTFP collection contributes an average 12-15% of rural incomes.

Although these sums are considerable, they provide an incomplete picture of the total value of NTFPs in the EAM. Other products that are collected, but are omitted from this analysis, include fruits, bushmeat, vegetables, mushrooms, medicines and honey. Moreover, the poorest community members in particular depend relatively more on forests than the richer members. Cash and non-cash NTFP income constitutes up to a quarter of the total household income of the poorest quartile of rural households. However, the richer households are able to engage in the commercial NTFP trade and generate higher absolute revenues from these activities.

These benefits are unlikely to sustain into the future, however. We compared the biomass of extraction (mapped at the location of the households) at a 5 km^2 scale to the availability of above ground carbon (i.e. in trees with a diameter at breast height > 10 cm) to provide a preliminary assessment of the sustainability of NTFP offtake. Based on the low growth rates for tropical hardwood species in the literature, we assumed that below 1% offtake would probably be sustainable (green), 1-2% would be critical (yellow), and more than 2% per year would be unsustainable (red, purple). The general pattern shown here is a first indication of the level of sustainability of current NTFP harvesting. It indicates that extraction levels are likely to be unsustainable where population density is higher, such as near cities and roads: the Uluguru Mountains near Morogoro, the Iringa Region, and areas near Korogwe and Muheza are being rapidly depleted.

Based on these results and our interviews with households and local and international experts, we raise concerns over the current level extraction of firewood, charcoal and poles. Reduced availability of firewood has led to the use of alternatives such as maize husks and other crop residues, but also live wood. Pole extraction negatively impacts on forest regeneration as well as understorey vegetation and fauna. Given the low growth rates of forests and woodlands, and the relatively inefficient charcoal production methods, charcoal production tends to be unsustainable wherever it takes place.

Initiatives to produce charcoal sustainably, such as by making charcoal briquettes from agricultural residues or sawdust from sawmills, or introducing fuel efficient stoves to reduce demand, are deemed financially feasible according to existing projects, such as that managed by TFCG. But they have not been adopted and scaled up to the level where they reduce pressure on remaining forests and woodlands. Similarly, more efforts and governmental support is needed to establish plantations to substitute wild-harvested wood for construction and energy. Additionally, non-forest and non-fossil fuel based energy policies are needed for Tanzania to build a more sustainable and green economy.

For further information please see the paper on non-timber forest products by Marije Schaafsma and others in the Journal *Global Environmental Change*

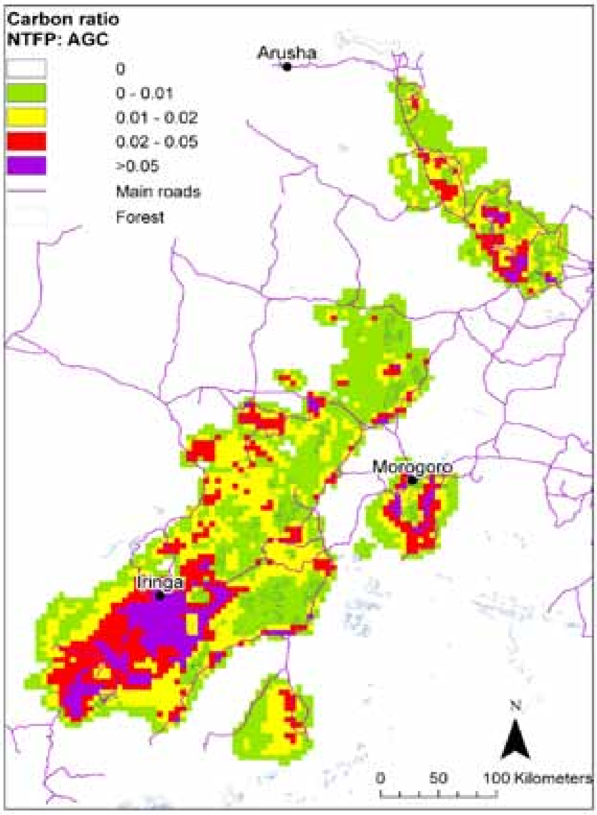

Figure 1. Maps of aggregated household extraction of charcoal, firewood and poles were re-sampled into a 5 km^2 map of above ground carbon biomass (AGC). Households reported to source their wood-based products on average within a 8 km range from their home location, so aggregating results to a 5 km^2 grid is a very rough way of going from where the household lives to where in the surrounding area the household extracts the NTFP.

High value timber is declining

Marije Schaafsma; Antje Ahrends; Andrew Balmford; Neil Burgess; Lena Jeha, University of York; Mariam Kitula, Sokoine University; Joseph Makero, Sokoine University; Rogers Malimbwi, Sokoine University; Robert Marchant; Yonika M. Ngaga; Stephen Ngowi, Sokoine University; Philip Platts; Ruth Swetnam; Thorsten Treue; Kerry Turner; and Simon Willcock.

Tanzania has a long history of forest management and timber harvesting. Within the Eastern Arc Mountains (EAM), industrial logging of the natural forest took place between the 1950s and 1980s in the East and West Usambara, northern Uluguru, Ukaguru and lowland Udzungwa (Figure 1). There was also some earlier logging from the German period (late 1880s-early 1900s) in the East and West Usambara. In 1985, however, the Tanzanian government placed a ban on logging of natural forest in all central government (catchment) Forest Reserves in these mountains.

Figure 1. African mahogany (*Khaya anthotheca*) in the Kilombero valley lowland forests in 1954. The most valuable (Class I) timbers such as this are now commercially extinct in many areas, and are being substituted by alternative species.

Outside the catchment reserves, in both forest and woodland areas, logging remains legal on the basis of licences. Despite this strong policy framework, the timber sector in Tanzania is beset with challenges and illegality. Estimates (from interview data) suggest that less than a quarter of timber royalties are collected by the government. Moreover, even in the catchment reserves where logging is banned, logging is widespread.

Hardwood extraction from natural forests and woodlands in Tanzania is an informal industry and most timber is pitsawn in the forest, and carried out as planks for onward transport by road to towns. These hardwood planks are mainly turned into furniture for domestic use, such as the production of tables, chairs, doors, doorframes, window frames, beds and wardrobes.

The Valuing the Arc Programme has tried to assess the magnitude, distribution and sustainability of hardwood extraction across the Eastern Arc. Work is ongoing to model the current stock of large tree species, recent levels of offtake, and the rate at which felled trees are replaced by regrowth. Mindful that spatially detailed stock estimates, particularly for the most valuable species, could be subject to misuse by the

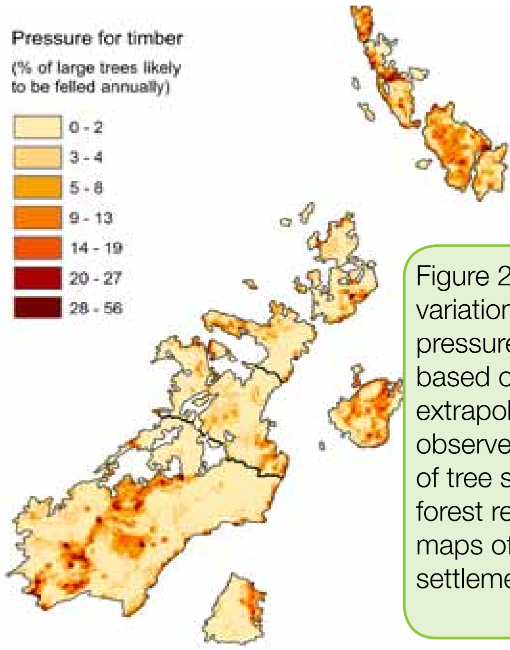

Figure 2. Spatial variation in logging pressure on the EAM, based on a statistical extrapolation of observed frequency of tree stumps in forest reserves using maps of human settlement and roads.

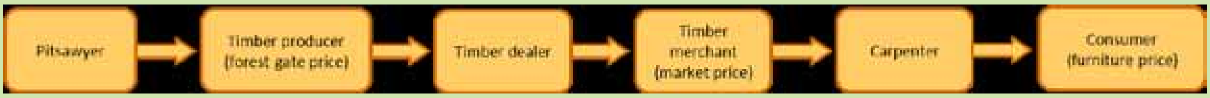

Figure 3. Actors along the hardwood value chain. In some more rural areas, the chain is shorter and pitsawyers or carpenters act as producers and dealers, but multiple intermediate actors are involved to get hardwood to the main cities.

illegal trade, we focus here on presenting the spatial variation in pressure exerted on the forests (Figure 2). Furthermore, we present information on demand-side estimates of the timber trade, the value of this industry and the distribution of beneficiaries across society.

In 2011 we visited timber markets and carpenters across the region to gather information on timber use, species, volumes, consumers and sources. This included the major urban areas (Dar es Salaam, Iringa, Morogoro, Tanga) and a number of smaller towns (Dumila, Gairo, Ilula, Kilosa, Korogwe, Mafinga, Maguha, Mikumi, Mkundi, Muheza, Mvumi, Ruaha, Rubeho). In these locations, we interviewed 50 carpenters, four pitsawyers, 20 timber dealers, a chainsaw technician and two sawmill owners. This information was combined with national census data on income levels and household demand for hardwood.

The analysis suggests that 2.2 million timber planks are being harvested annually from woodland and forest in the EAM. We calculated that timber dealers (combined) receive around TSH 15 billion (USD 10 million) per year from sales of planks, of which around half is profit and personal wages. Although some of this revenue is likely to be used for collusion with officials, the profits of illegal timber trade per dealer are high, which explains the ongoing harvesting.

To understand who else benefits from this industry, we studied the timber value chain from the forest production site, through the transport routes, to the points of sale in towns and cities (Figure 3). Local pitsawyers receive a fixed price per plank of around TSH 2500 (USD 1.7), which generates annually around TSH 3.6 billion (USD 2.4) million in revenues to the villages across the region. Sawyers stated that their pay is low whilst the work is tough, but that they need this income to complement their farm yields and thus sustain their families. Total earnings for local villagers who carry planks from the forest amount to TSH 1.5 billion (USD 1 million) annually. Timber dealers and transporters are often expected to pay village officials, forest and police officers at checkpoints as they move timber from the villages to towns, which we estimate generates annually around TSH 1.9 billion (USD 1.2 million) in total cash payments to these officials. Most hardwood timber is sold by the dealers to carpenters to produce household items. Carpenters sell the furniture items onto customers for a total of TSH 30 billion (USD 20 million) annually. With TSH 7.5 billion (USD 5 million) in costs, they make TSH 7.5 billion (USD 5 million) per annum in profits and personal wages. Most carpenters stated, however, that the competition is tough and their daily earnings low.

The market data also provide insight into the timber sector and indicators of the sustainability of the harvesting. Firstly, all dealers said that it was hard, if not impossible, to make a profit when all required licences were obtained, especially when other dealers are operating illegally. This is a key factor explaining why, despite systems being in place, they are rarely followed and government revenues from timber harvesting are much lower than expected from the volumes of timber being harvested. Secondly, harvesting in many EAM reserves is illegal. The dealers cannot declare the items and are forced to accept a risk of capture and fine (and pay bribes) at various points along the transport routes. Third, our evidence from the market suggests that the availability and size of planks of high-value species (from the forest *Podocarpus* spp*.*, *Millicia excelsa, Khaya anthotheca*; and from the woodland *Pterocarpus* spp*.*, *Afzelia quanzensis* and *Baphia kirkii*) has dramatically declined, with an increase in species such as *Brachystegia,* and the use of fruit trees such as mango for timber. High-value species are still on the market, but are only affordable to richer customers in large towns, especially Dar es Salaam. Finally, lower grade timber species are being increasingly used, now that high-value species are becoming scarce. For the latter, even when available, typical plank dimensions are decreasing and trees are harvested before maturity. Interviews with foresters and conservationists working in the region over 20 years confirm these trends.

Dealers, forest officials and pitsawyers stated that the profits of high-value timber are such that they will venture deeper into forest and catchment reserves as stocks decline. Although our biophysical stock models suggest that some of these high-value species are still present within gazetted areas, the evidence of increasing scarcity shows that rapid policy action is required to conserve these forest patches, especially given the range of non-timber services they support (e.g. NTFP provision, nature-based tourism and water regulation). Simplifying the procedures for legal harvesting, and decentralising forest management in combination with a property right system based on sustainable-use conditions, may provide ways forward.

For further information please see the paper on timber value chains by Marije Schaafsma and others in the Journal *World Development* .

Nature tourists enjoy the mountains and their wildlife

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Tanzania is one of the most popular tourist destinations in Africa, especially for its wildlife safaris, the spice island of Zanzibar, and trekking on Mt. Kilimanjaro. The number of tourists is increasing annually: between 2000 and 2010 there was a 56% increase in international tourists, from 501,669 to 782,699. International tourism contributed USD 615 million to the Tanzanian economy in 2005 and USD 1.75 billion in 2010, making it the largest source of foreign exchange and constituting about 8% of Tanzanian GDP. In comparison, domestic tourism in Tanzania remains small, with low household income the primary constraint, but it is growing in line with the emergence of an urban middle class.

Most tourists currently visit national parks and the coastal regions of the country. However, it is known that a smaller number of specialised tourists visit the Eastern Arc Mountains (EAMs) for the cool mountain climate, to search for rare and endemic species (especially birds), for the spectacular scenic views, and the different culture compared with the lowlands. Scientists and school children also visit the mountains to study, and to hike to the top of the some of the challenging, but accessible, mountain tops - for example the 2,200m Bondwe peak in the Uluguru Mountains, just outside Morogoro.

In order to quantify the number of international and Tanzanian tourists visiting the EAMs, and to generate a provisional assessment of the value of this tourism, we collected visitor data during 2009-2010, from 48 hotels across the EAM (Figure.1). Every mountain block provides some form of accommodation apart from Nguu in Kilindi District and the remote Malundwe (in Mikumi National Park). In our sample of EAM hotels we interviewed the hoteliers and recorded the numbers of international and Tanzanian visitors, the occupancy of the available rooms, and the accommodation price. The hoteliers were also asked to estimate the proportion of visitors who had come to the area for its natural characteristics. To complete our estimation of visitor numbers we used travel guidebooks to identify a further 72 hotels that were located within 30 km of the EAM.

Using data collected from the sample of 48 hotels we developed a simple model that linked the number of accommodation nights to characteristics of each hotel and its surrounding area. This model was used to estimate accommodation nights for the other 72 hotels within the EAM region. In total, we predict that around 70,000 accommodation nights are used annually across these 120 hotels. About 30% of these accommodation nights are by international visitors and the remainder are Tanzanians. We calculated that 29% of the Tanzanian and 49% of the international visitors were motivated to visit the EAM because of the nature-related attractions, such as the forests, waterfalls and wildlife. We therefore estimate that almost 25,000 people are staying overnight in the EAM annually as ‘nature-based tourists’.

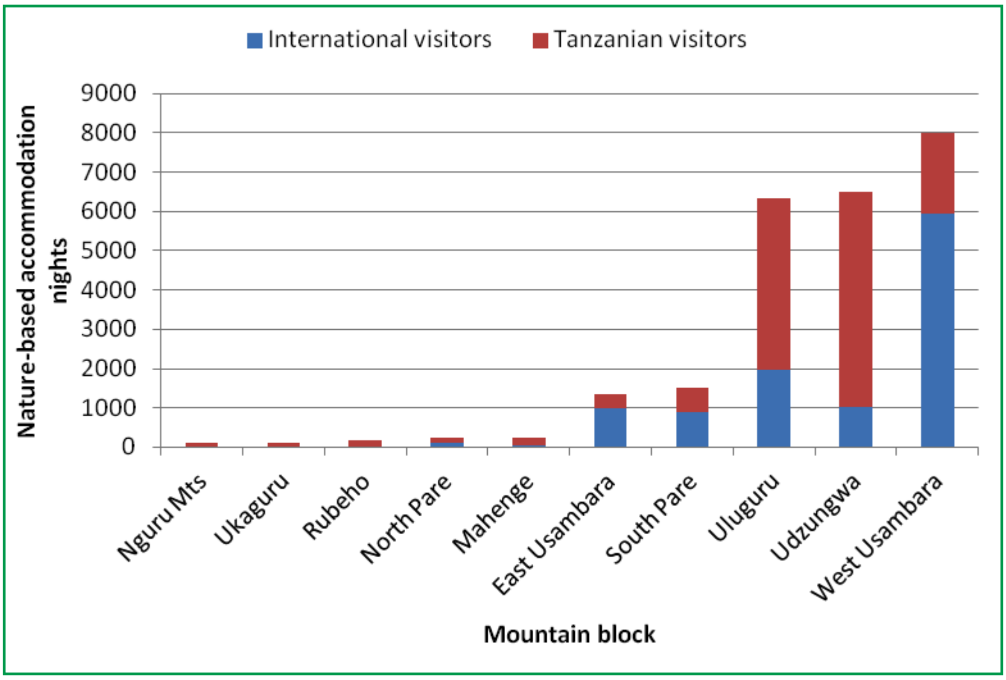

Figure 1. Number of nature-based accommodation nights per mountain block.

By linking accommodation nights in the EAM to the prices of the rooms in the different hotels we estimate that the total annual revenue from nature-based tourism being generated is around USD 1.7 million. This is a conservative estimate of the total value of nature-based tourism in the area, as we did not include other sources of profit, such as food, trips, park fees, transport, etc. The bookkeeping in some hotels may also be inaccurate, with more people staying than is declared in the accounts. Moreover, our estimate focuses only on the benefits derived by the hoteliers; it does not reflect the welfare that people derive from visiting the park, i.e. the non-market value of the pleasure of their experience. .

Even given that we have probably underestimated EAM tourism, it remains clear that the visitor numbers and revenues of nature-based tourism in the EAM are small compared to those of large game parks in Tanzania. The most visited site in the EAM is the Udzungwa Mountains National Park, which received about 2,500 visitors in 2007, increasing to around 5,000 visitors in 2012 (Udzungwa National Park pers. comm., May 2013). Amani Nature Reserve receives between 1,000 and 1,500 visitors per annum, and the Uluguru Nature Reserve perhaps receives similar numbers. In comparison, Serengeti National Park attracts about 300,000 visitors per year, and an estimated 35,000 visitors climb Mount Kilimanjaro annually. The Serengeti National Park on its own generates USD 20.5 million in park revenues, and Kilimanjaro National Park is reported to generate over USD 50 million once the value of the park fees, payments to porters, hotels, and other payments into the local economy are taken into account.

In conclusion, despite these relatively small numbers of nature-based tourists visiting the EAM and the limited revenue flows, tourism does provide an important source of funds to TANAPA, the Tanzania Forest Service, and selected communities and individuals who are working as guides and being employed in the sector as well as hoteliers. The fact that tourism numbers and revenue flows are increasing annually provides the potential for further growth in the sector, which is part of the governments strategy for the development of the National Park and Nature Reserves across the EAM region.

For further information on the number and motivation of tourists visiting the Eastern Arc, and some idea of how ecotourism might develop into the future, see the paper recently published by Julian Bayliss and others in the Journal *Ecosystem Services*

Water for everyone

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Photo by Dorthe Friis Pedersen

Around one in ten Tanzanians source their water from rivers originating in the Eastern Arc Mountains (EAM). In Dar es Salaam, the main water source is the Ruvu River, flowing from Uluguru Nature Reserve, from which around 300 million litres are extracted daily. Moreover, at least half of Tanzanian hydroelectricity is generated from EAM rivers.

The EAM contain moist forest assemblages as well as large areas of miombo woodland at lower elevations and on drier leeward aspects. These biomes are believed to play significant roles in the regulation of hydrological flow, flood mitigation and soil conservation. Despite this hypothesised importance, the interactions between river flow, habitat type and land use are not well understood. To explore these complexities, the Valuing the Arc programme (VTA) parameterised a detailed, daily water model called SWAT to model the hydrology of two focal catchments: the Sigi in Tanga Region and the Ruvu in Morogoro region. In addition, we developed a broader scale, monthly model (WatR) to tentatively explore hydrological flow across the wider VTA region.

Detailed model

The Soil and Water Assessment Tool (SWAT) is a physically-based watershed model, operating on a daily time-step. SWAT implements two phases in the simulation of hydrology: the land phase and the routing phase. The model describes the hydrological response of each land parcel according to detailed information on local climate, topography, soil and land cover. Plant growth, rooting depths and agricultural practices were also considered, in order to determine the relative proportions of water reaching the river channel via surface runoff, movement through the soil column or baseflow (via ground water). The second modelling phase routes water though the river network, based on what is contributed by each sub-basin, subject to local abstraction and irrigation for cash-crops such as rice, sugar and vegetables.

In the Ruvu catchment (14,000 km^2), SWAT was calibrated using daily rainfall data from sixteen weather stations spanning the years 1995-2004, as well as information on river flow from two points along the Ruvu river for the same time period: Kibungo (gauge 1H5) and Morogoro Bridge (1H8, the watershed outlet). Model performance was good at 1H8 and moderate at 1H5. Independent testing in the Sigi catchment, which is much smaller (<1000 km^2) and subject to different land use and rainfall patterns, suggested a stable parameterisation, able to cross-predict between catchments. This in turn suggested a stable parameterisation, able to cross-predict between catchments and under scenarios of land cover change.

Broad-scale model

The broad-scale model ('WatR') uses similar principles to SWAT, but is less rigorously process-based, has larger sub-basins, and uses a monthly – rather than daily – time-step. Direct overland runoff, which leaves the sub-basin within one month, is a function of soil type and land cover. If the remaining water is insufficient to meet the transpiration requirements of plants, then moisture is absorbed from the soil. Conversely, if transpiration requirements are fulfilled, then water infiltrates the soil column. When soils are fully saturated, surplus water is either discharged through the soil (leaves the sub-basin within two months), or infiltrates the soil to recharge groundwater, discharging more slowly to the main river channel. As in SWAT, the contribution of each sub-basin is routed through the river network, adjusting for local abstraction and irrigation.

This WatR procedure was implemented using widely available spatial datasets, allowing for rapid assessment of hydrological flow across the entire watershed region of the EAM (Figure 1). The model was calibrated in the Ruvu catchment, favouring accuracy in dry season flow at the expense of some over-prediction (still within the observed range) during the wet season. Annual flow at Morogoro Bridge was estimated at 1.7-1.9 × 10^9 cubic metres per year (mean observed, 1995-2004: 1.6 × 10^9 cubic metres per year). Independent testing in the Sigi catchment found that the same model parameters again estimated annual flows reasonably well (1.6-1.7 × 10^8 cubic metres per year), but that seasonal flow was more uncertain.

The role of forest and woodland

The Ruvu catchment covers an area of 14,000 km^2, of which 2-3% is forest and 32% is open or closed woodland (miombo). To determine the role of these woody habitats in the regulation of hydrological flow, we modelled the response of Ruvu river flow at Morogoro Bridge (1H8) to scenarios of uncontrolled agricultural expansion, whereby forests and/or woodlands were converted entirely to cropland (maize and beans). Uluguru Nature Reserve, which contains the majority of forests in the catchment, has recently been established and governance is strong. In the absence of this protected area, uncontrolled encroachment may well have occurred; forests outside reserve boundaries have already been cleared. As elsewhere in the EAM, woodland habitats are largely unprotected; we estimate that 43% were lost between 1975 and 2000.

Forest ecosystems have high transpiration rates compared with maize or bean fields. Consequently, conversion to cropland was predicted to result in a 6% (SWAT) or 5% (WatR) increase in total annual flow volumes towards Dar es Salaam. Both modelling approaches predict that the much of this additional water would be discharged rapidly after falling as rain, mainly in the wet season, and so reach the main river channel within a matter of days (SWAT; <1 month, WatR). Conversely, during the dry season when there are fewer rainfall events and water shortages are most acute, both models predict that forest removal would result in a reduction in flow (Figures 2 and 3).

This is because interception of rainfall is higher in forests than in cropland (less water reaches the ground), and because more water infiltrates forest top soils due to

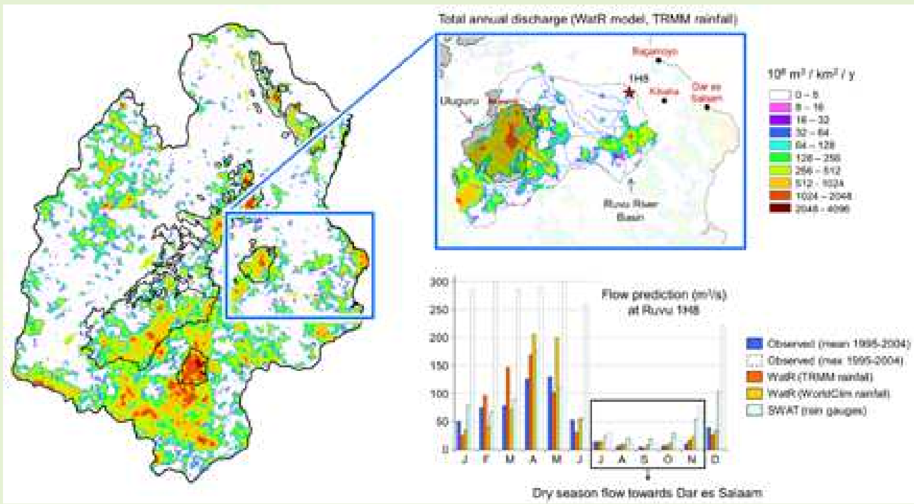


Figure 1. Broad-scale model (WatR) predictions for total annual in the Ruvu catchment (left) and the wider Valuing the Arc study region (right). Bar chart compares WatR results (rainfall from TRMM or WorldClim climatologies) against observed flow at Morogoro Bridge (gauge 1H8), as well as against the more detailed SWAT results (aggregated from daily to monthly values).

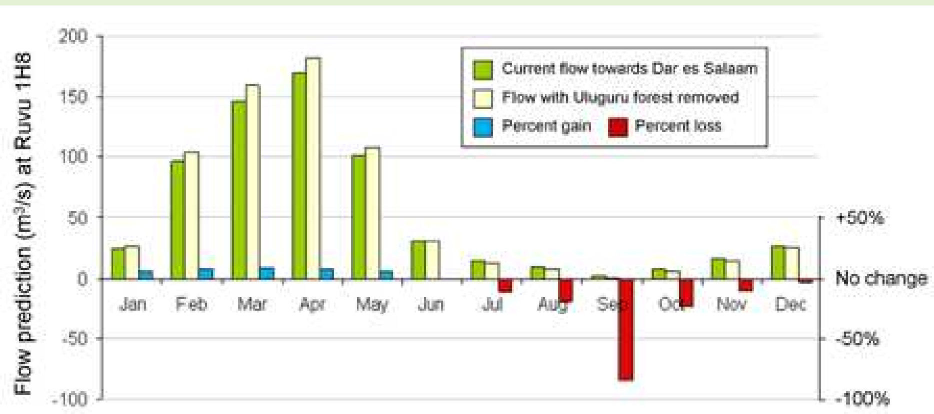


Figure 2. Broad-scale model (WatR) predicts that conversion of forest to cropland in Uluguru would result in reduced Ruvu River flow towards Dar es Salaam during the driest months of the year potentially leading to water shortages, whilst increasing peak flow during the wet season potentially leading to erosion and flooding

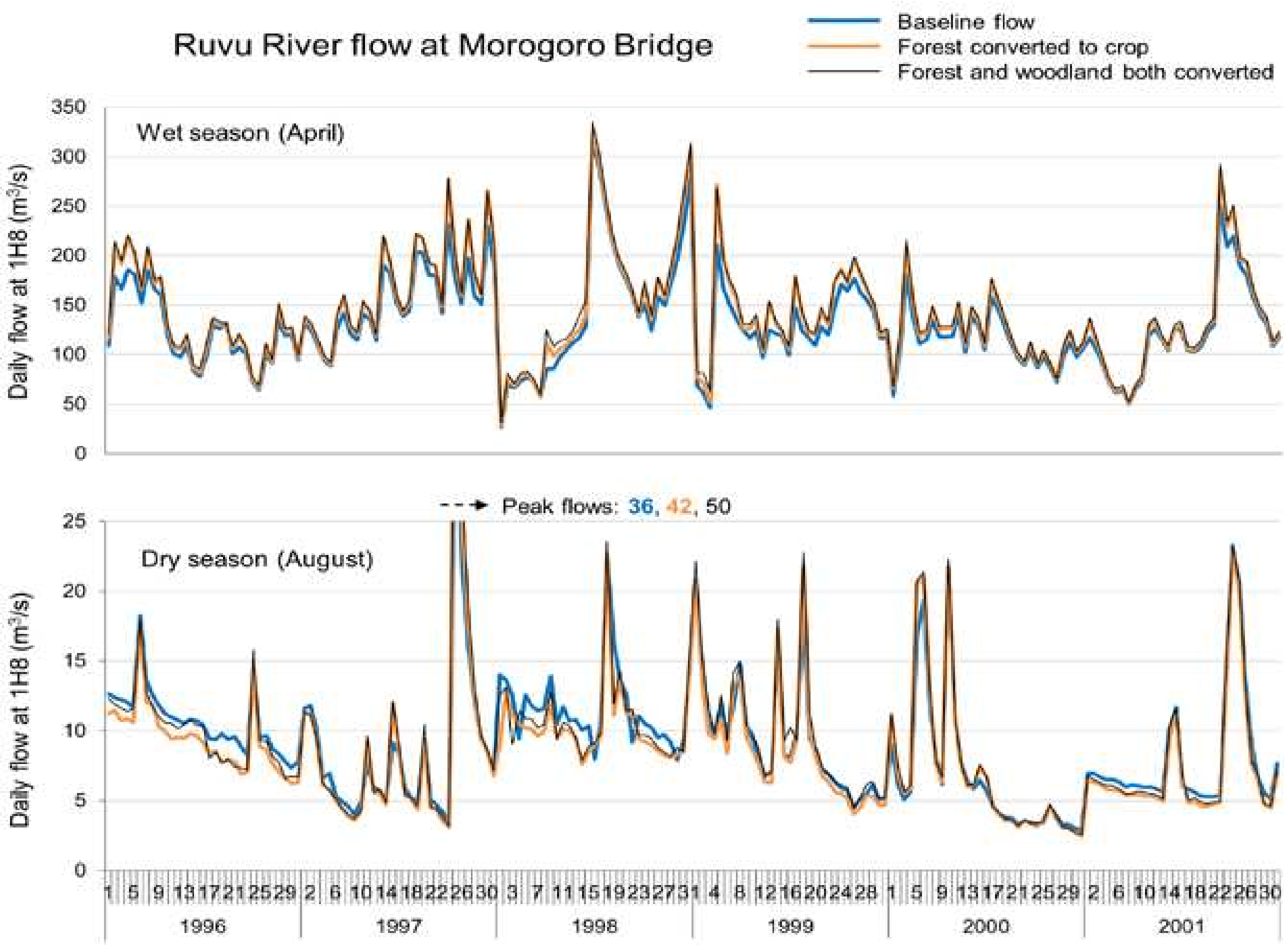


Figure 3. Daily SWAT model prediction of Ruvu River flow towards Dar es Salaam for two representative months in the wet (upper) and dry (lower) seasons. Forest and/or woodland clearance results in higher peak flow during the rainy season and lower flow during dry season.

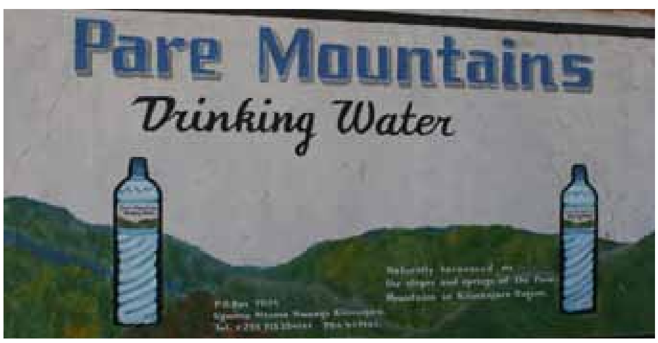
their higher porosity, combined with lower evaporation rates from the soil surface compared with cropland. Thus, without forest vegetation, less water infiltrates the soil to recharge ground water, reducing baseflow throughout the year. The amount of water reaching the ground water is, however, limited in forest ecosystems by higher transpiration rates and the fact that subsoil can be accessed by the deep-rooted trees.

A qualitatively similar phenomenon was observed in the case of woodland conversion (Figure 3). The removal of woodlands, however, had a slightly lesser impact on dry season flow, despite the large difference in land area involved (~4500 km^2 for woodland versus just ~300 km^2 for forest), highlighting the importance of mountain forests in the regulation of hydrological flow.

Conclusions

The complexities outlined above show that the role of forests and woodlands in hydrology is not straight forward, and that understanding this relationship is heavily reliant on detailed and site-specific datasets. Nonetheless, both our broad-scale water model and SWAT suggest that, on balance, the loss of woodland and, especially forest, results in more extreme flow patterns. The people most acutely affected are communities immediately downstream of the conversion, but changes in flow would also be felt in more distant towns and cities.

During periods of increased peak flow, as a result of forest or woodland loss, potential impacts include flooding, top soil erosion, loss of soil fertility, declines in fish populations, increased sedimentation in rivers and reservoirs, and power cuts due to reduced hydroelectric power generation. Impacts during the dry season(s), when already scarce water resources are further reduced, are clear: less potable water from both taps and streams, reduced crop yield (less water



for irrigation) and increased pressure to abstract from deep aquifers using bore-holes, compromising the long-term sustainability of the water resource.

These findings corroborate a widely held belief in Tanzania that deforestation, combined with increased abstraction by agriculture and people, has contributed significantly to reduced dry season flows toward Dar es Salaam. Furthermore, the cloud forests of the Uluguru and elsewhere in the EAM are known to intercept mist and fog, adding more water to the local system, which then infiltrates the soil for slow discharge through the soil and rocks. Since this process is poorly represented in the models described above, the forests of the EAM are likely to play an even greater role in enriching and regulating water resources than shown here.

Sanje falls, Uzungwa, Kilombero catchment

Uluguru, Ruvu catchment

Uluguru, Mgeta River, Ruvu catchment

Uluguru Mountain near Mgeta

Small vegetable farm near Kilombero: lettuce growing in raised beds under irrigation (above); water abstraction using a pump from the nearby river (below)

Further information about this research can be found in Philip Platt's PhD thesis on 'Spatial Modelling, Phytogeography and Conservation in the Eastern Arc Mountains of Tanzania and Kenya.'

There are also costs of Conservation

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While the bulk of Valuing the Arc's work focused on the benefits of conservation, it is also essential to consider the associated costs. Gathering information on these costs is important for helping us consider efficiency, equity and effectiveness: where is it cheapest to conserve, how much will it cost, who will bear that cost and should certain individuals or communities be incentivised or compensated?

MANAGEMENT COSTS

We focussed on three cost types: management costs of protected areas (PAs), damage costs by wild animals, and opportunity costs – the benefits that are forgone when land is set aside for conservation.

In 2010, interviews were held with district forest officers, district catchment managers and nature reserve conservators across the 22 districts of the EAM. Information gathered related to administering, or assisting with administering the management of 482 PAs out of an estimated 500 within the EAM districts (including Village Forest Reserves).

The median amount spent on conservation management across all sites in the EAM was 2.3 USD per hectare per year - less than one third of the 8.3 USD per hectare per year that PA managers say is needed if they are to meet all of their management objectives. This "necessary spend" reported for the EAM is similar to the 7.7 USD per hectare per year that is spent in Tanzanian National Parks (NPs) nationally. Local authority forest reserves received just 10% of the funds needed, whilst national (catchment) Forest Reserves and Nature Reserves (both funded directly by central government) received around one third.

With these data in hand, we also investigated the relationship between management costs and socio-economic and geographic variables in the EAM. We developed a model of the conservation costs of managing protected areas, which showed that areas in areas of higher population density generally have greater management costs.

DAMAGE COSTS

Less obvious but also important are the costs incurred by local communities due to wildlife damage, especially of crops. We interviewed local farmers and found that the most damaging species were monkeys, baboons and bushpigs. Other studies in East Africa suggest that farms that lie within 200 metres of a PA can expect to lose 4-9% of their yield to wildlife. Although this is expected to be less in total than the other cost types we estimated, damage costs in the EAM are borne by local farmers in general and probably the most marginalised farmers in particular – those for whom a lack of wealth or power means that they must farm less desirable land.

OPPORTUNITY COSTS

Lastly, we estimated opportunity costs of conservation: what are the potential benefits from charcoal production and agriculture (the most common proximate causes of forest conversion) that are forgone when PAs are established? We found that the median net value of charcoal production was USD 416 per hectare and the median net present value for agriculture (accounting for expected future profits as well) was USD 942 per hectare. If forest conversion is prevented (and these benefits are forgone), then there will either be leakage, in which people convert forest elsewhere to meet their demand, or there will be diminished household welfare, as locals no longer have access to the land's resources.

Alternatively we can look at the costs of implementing policy changes that increase agricultural yields and decrease charcoal use through the use of fuel-efficient stoves. By taking these steps, the supply of agricultural produce can be increased to meet demand on existing agricultural land, and the demand for charcoal can be decreased to levels that can be supplied sustainably. The implementation costs of such policies were well below the value of the carbon that would be conserved if a carbon payments programme were adopted. Such interventions may be a useful complement to current conservation activities that will also help meet development objectives.

SUMMARY

Recognising who currently bears the costs of conservation is central to improving the equitability of conservation. Many of the benefits of conservation accrue at national and global scales. However, we find that many of the costs of conservation accrue locally (opportunity and damage costs) and are substantial. It is critical then that in developing conservation plans we carefully consider who is paying the costs of conservation and that we seek to develop interventions that address asymmetries in the spread of costs and benefits.

Further detail on the conservation costs in the EAM can be found in the PhD thesis by Jonathan Green

Valuing the Arc's publications

These studies are part of the Valuing the Arc research programme, which has generated more than 60 peer-reviewed publications, one book, six PhDs and eight Masters theses. For details see http://valuingthearc.org/.

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TFCG News

Charcoal producers from Kilosa who have been trained in more sustainable harvesting and production techniques.

MJUMITA Community Forest Project reduces emissions of greenhouse gases from deforestation in Lindi

Since 2009, TFCG has been working in partnership with MJUMITA to implement the 'Making REDD work for communities and forest conservation' project. In May 2014, MJUMITA initiated the validation and verification process for its first community REDD project. The project involves ten communities in Lindi who have successfully reduced emissions of greenhouse gases from deforestation and forest degradation relative to the without-project scenario. The project has been financed by the Government of Norway. MJUMITA is now seeking a buyer for voluntary carbon units from the project. More information about the project is available at: http://www.tfcg.org/makingReddWork.html and on the CCB Project Standards website: www.climate-standards.org

Sustainable Charcoal Project

With a view to generating financial incentives for communities to manage their forests sustainably, TFCG has been piloting the integration of sustainable charcoal production into community-based forest management in woodlands in Kilosa District. Over the last six months, the project has worked with stakeholders along the charcoal value chain to improve the ecological sustainability of the process; and to channel more of the revenue to the forest-owning communities. To find out more, please visit: http://www.tfcg.org/sustainablecharcoal.html The project is financed by the Swiss Agency for Development Cooperation.

The Vital Signs Project in Tanzania

TFCG has recently entered into a partnership with Conservation International to support the implementation of the Vital Signs project in Tanzania. Vital Signs is an integrated monitoring system for ecosystem services in agricultural landscapes. The project is centred around the concept that 'Sustainability cannot be an afterthought'. Looking specifically at agricultural programmes such as SAGCOT, Grow Africa and the New Alliance for Food Security and Nutrition, the project seeks to measure and monitor the success of agricultural development from a systems perspective, by providing an integrated set of metrics and indicators that reflect the interconnectedness of food security, water security, climate security, ecosystem health and human well-being.

Vital signs team members, Mr Joseph Mwalugelo crossing the Ruaha River to access one of the biophysical survey plots.

Vital Signs was developed with funding from the Bill & Melinda Gates Foundation. In Tanzania, since early 2014, the Vital Signs team have been collecting socio-economic and biophysical data from the Ihemi SAGCOT cluster. The project has also developed an atlas of the SAGCOT Corridor available online at: www.vitalsignstanzania.org/atlas

Community level governance monitoring results now available at the TFCG website

As part of the Forest Justice in Tanzania project, a partnership project between TFCG and MJUMITA, surveys were conducted in over 300 villages in 30 districts to assess community-level governance. Surveys were first conducted in 2011 with a follow up survey carried out in 2013. As part of returning the survey results to the participating communities, MJUMITA supported the communities to address governance shortfalls through training and by raising awareness on roles and responsibilities. The 2013 results showed a modest improvement in community-level governance. The results of the surveys are available at: http://www.tfcg.org/forestJusticeTanzania.html

Assessing changes in knowledge, attitudes and practices towards forest conservation in the Eastern Arc Mountains

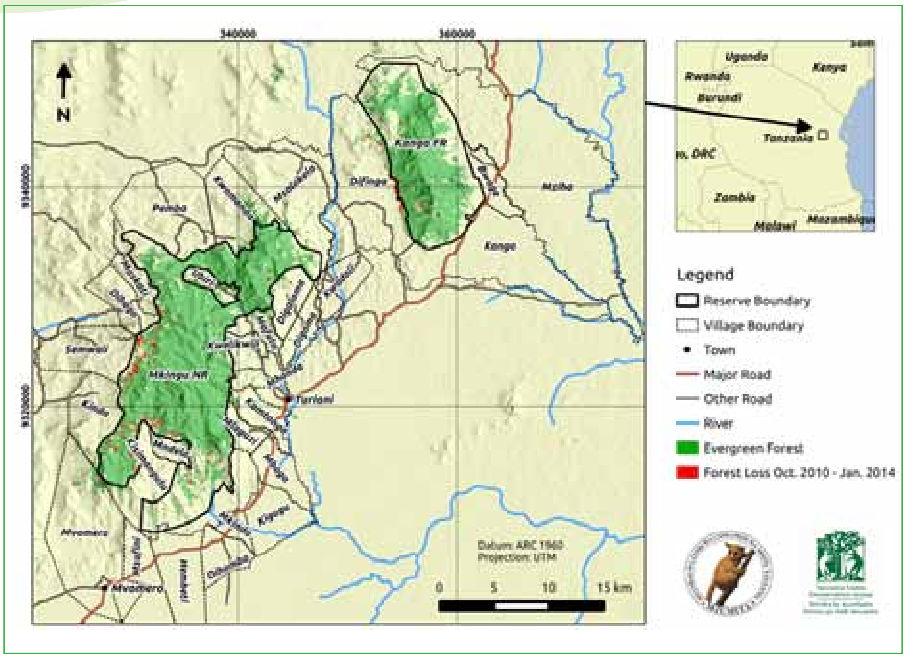
In 2004, TFCG conducted a survey of knowledge, attitudes and practices towards forest conservation in the Eastern Arc Mountains. Ten years later, TFCG returned to the same villages to find out whether there was any change in people's knowledge and attitudes towards the forests. The survey found that people are more familiar with the concept of the Eastern Arc Mountains; are more aware of the linkages between forest and water supply; and that primary schools are providing more environmental education than in 2004. The survey report is due to be published in July 2014 at http://www.tfcg.org/publications.html. The survey was conducted as part of the Bridging the Knowledge Gap, a project financed by the Critical Ecosystem Partnership Fund.

Eastern Arc website

Working closely with the Eastern Arc Mountains Conservation Endowment Fund, TFCG has recently completed an update to the Eastern Arc website including uploading over 150 new reports. See www.easternarc.or.tz.

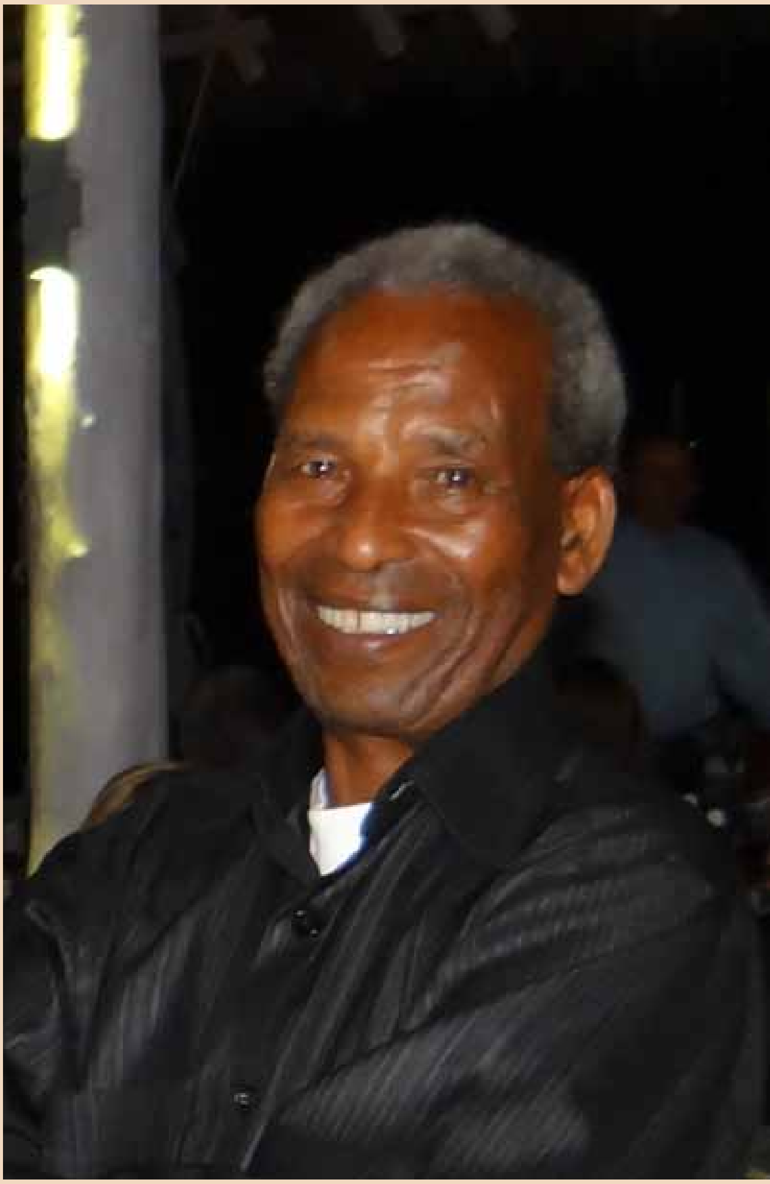
Adding Value to the Arc: forests and livelihoods in the South Nguru Mountain

In the South Nguru Mountains, TFCG has been working with Mvomero District Council and the Tanzania Forest Service to strengthen participatory forest management and sustainable economic development around the South Nguru Mountains through the Adding Value to the Arc project. The 5 year project is funded by the European Union. Since its inception in early 2013, the project has assisted three communities to establish village forest reserves extending over 2,334 ha of forest and woodland. These three communities have also developed village land use plans which are now being implemented. Pressure on Mkingu Nature Reserve is high and our remote sensing analysis has recorded an annual deforestation rate of 0.81 % within Mkingu Nature Reserve between 2010 and 2014. In order to reduce deforestation, the project has initiated joint forest management planning between the government and the communities for Mkingu Nature Reserve in order to promote greater cooperation between local stakeholders in safeguarding the forest and its ecosystem services.



Deforestation in Mkingu NR. The project's analyses show an annual deforestation rate of 0.81 % within Mkingu NR. J. Gwegime

Obituary
Patrick Qorro



Patrick Qorro served as the Chair of the Tanzania Forest Conservation Group between 1994 and 2012.

During his 18 year leadership, the Tanzania Forest Conservation Group expanded from working with just a handful of communities in Muheza, Lushoto and Mufindi to serving 175 villages across 13 Districts. Under his leadership, TFCG helped communities to establish village forest reserves covering over 160,000 ha of woodland and forest. Mr Qorro was instrumental in achieving these results.

Patrick Qorro was born on 17th March 1942 in Kwermusl Village in Mbulu District. He joined the University of Dar es Salaam in 1967 and graduated with a BA in 1970 when he was employed as a lecturer at the Moshi Cooperatives College. In that same year he campaigned for election as MP for Mbulu. He was elected and served in parliament for over 30 years. From there he was quickly promoted to being a Deputy Minister for Agriculture and Cooperatives, and then rose to Junior Minister in the Prime Minister's Office. Patrick served on many boards including as Chair of the influential Tanu Youth league and Chair of Tanzania Breweries. It was in his role as Board Member of TANAPA that he met Alan Rodgers, one of the founders of TFCG. The two worked together in calling for the establishment of the Udzungwa Mountains National Park. Impressed by Patrick's commitment to conservation, Alan invited Patrick to join TFCG where he was elected as Chair.

Mr Qorro was an early supporter of Tanzanian civil society. He sought to build bridges between Civil Society and politicians so that both could better serve the ordinary people of Tanzania. As Chair of the Tanzania Forest Conservation Group, Patrick volunteered his time to meet with political leaders, local government and ordinary farmers in order to encourage more action to conserve Tanzania's forests. He presented the Arc Journal to President Mkapa and to politicians, government officials and others whom he thought could act on its messages about forest conservation. Mr Qorro was constantly urging the TFCG team to expand to new areas and to support more communities across the country.

Patrick was a loyal and entertaining friend to many. He had an international outlook; and had friends across Africa, Europe, America and Cuba. He had a passion for Congolese music and football. He loved to keep abreast of politics and was an avid reader of the Daily News and the Nation. He had a great sense of humour; and a remarkable memory for names and faces.

Patrick Qorro died in Dar es Salaam on 8th February 2014 leaving his beloved wife, Martha; and their five children and five grandchildren.

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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
Editorial Team: Neil Burgess, Andrew Balmford, Philip Platts, Marije Schaafsma and Nike Doggart

This edition of the Arc Journal was financed by the Natural Capital Project and the WWF Coastal East African initiative

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

In memoriam

This edition of the Arc Journal is dedicated to:

Amani Mahundu who was a dedicated field worker on the carbon part of the work

Professor Sue White who led the hydrological work at Cranfield University in the UK.