Valuing the Arc Programme

Progress report to Leverhulme Trust

Overview and objectives

Valuing the Arc is an interdisciplinary programme with two broad parts.

The first part aims to develop and publish a broad conceptual model for undertaking and 'ecosystem services approach' to conservation. This aims to be generic and applicable globally.

The second part aims to test the conceptual model in a developing country field situation – across a system that is important for biodiversity conservation and ecosystem service delivery. This part will be undertaken across the Eastern Arc Mountains of Tanzania.

The programme will produce high level scientific papers, workshops and seminars, a web site, and technical materials that will feed into the policy process in Tanzania. The programme will also help build capacity on ecosystem service conceptualization, mapping and valuation in five British and two Tanzanian Universities and within the WWF network. Ideas developed will also be promoted among other key collaborators in the USA-based Natural Capital Project.

Administrative progress

Contracts with Valuing the Arc partners

During 2007 Cambridge University prepared and signed sub-contracts with East Anglia, Leeds, York and Cranfield Universities in the UK, and with Sokoine University of Agriculture, the University of Dar es Salaam and the WWF Tanzania Programme Office (WWF TPO) in Tanzania. Funds were provided to all partners who started their project work during the year. At the end of 2007 a change of the responsibility in the eco-tourism module necessitated a contract revision with University of East Anglia and Sokoine University of Agriculture.

Staffing

All staff outlined in the Valuing the Arc proposal to the Leverhulme Trust have now been employed (6 Post Docs in the UK – Dr Brendan Fisher, Dr Sian Morse-Jones, Dr Mathieu Rouget, Dr Neil Burgess, Dr Andrew Marshall, Dr Celina Smith). One of the employed staff (Dr Mathieu Rouget in Cambridge University) resigned due to family

reasons in December 2007 and returned to South Africa, where he continued to work as a consultant for the programme. Cambridge has re-advertised his position and expects to have a new person in place by 1st April 2008. In addition, WWF US provided 5,000 UKP to fund a project assistant for 5 months at Cambridge University, and also funded the staff time for Dr Taylor Ricketts, Dr Robin Naidoo and Mr Nasser Olwero to participate in the programme's work.

PhD students

The programme is funding a PhD on carbon in the UK (advertised), and part of the costs of three PhDs in Tanzania (two on hydrology and one on valuation).

Linked funding is being sought for a PhD in the UK on biodiversity planning and conservation costs (proposal stage).

A related ongoing PhD is also being supported technically at York University (plant biodiversity and forest structure linked to carbon and non-timber forest product values)

Masters and bachelors students

The programme is supporting 8 Tanzanian masters projects (2 on governance, 2 on carbon, 1 on timber, 1 on non-timber, 2 on ecotourism). One masters student linked to the programme in the UK (York) is also working on non-timber forest products.

In 2007 five Cambridge undergraduate students also completed pieces of work of relevance to the programme's objectives.

MOUs with related projects

Due to the collaborative nature of the project, and the strong interest of others to collaborate with Valuing the Arc, we have prepared and signed two MOUs with other related projects during the year.

KITE. This is a project based at the University of York that is looking at past, present and future vegetation patterns in the Eastern Arc Mountains, including under climate change scenarios. An MOU over collaboration was signed in December 2007 that formalizes working relations between Valuing the Arc and KITE. The KITE programme will address issues of climate change and botanical biodiversity pattern that are not funded by Valuing the Arc.

Natural Capital Project. This is a project based out of Stanford University, WWF-US Conservation Science Program and The Nature Conservancy in the USA. It aims to develop computer modeling software for mapping and modeling and valuing ecosystem services. We have agreed that Valuing the Arc will collaborate over the development of computer tools based in ArcGIS for mapping ecosystem services and will field test them in the Eastern Arc Mountains, and that we will collaborate to measure the 'existence

values' of biodiversity. We have also agreed that Valuing the Arc will work together with the Natural Capital Project on issues related to policy and sustainable funding mechanisms – which is where we see the results of Valuing the Arc being used in Tanzania. The Natural Capital project is contributing additional US staff time and funds to the development of the GIS mapping tool being field tested in Tanzania, and to the work on policy and payments for environmental services that are being led by the WWF TPO.

Meetings and workshops

The programme held a series of coordination and planning workshops that defined the work to be done in the UK and in Tanzania. These meetings resulted in agreed workplans and budgets, which are now being implemented.

Meetings in Tanzania

Start up meeting, Dar es Salaam, November 2006. Attended by all programme collaborators in Tanzania, and key UK and USA scientists. Defined how the programme would work.

Planning meetings. Morogoro and Dar es Salaam, February 2007. The programme coordinator from the UK worked to develop the workplans and budgets for all the modules in Tanzania, which were used in the finalization of the relevant contracts.

Land cover meeting, Dar es Salaam, August 2007. Agreed on the relevant land cover data to use in the project, and a way to update it through ground truthing, by working with 30 Tanzanian experts and field practitioners.

Scenarios meeting, Dar es Salaam, September 2007. Developed draft scenarios for use by the project in collaboration with Tanzanian experts and stakeholders.

Project Advisory Committee, Dar es Salaam, September 2007. Set up this advisory body to link to the science of the programme to relevant parts of government and the policy process in Tanzania.

Meetings in the UK

Start up meeting, Norwich, October 2006. A planning meeting between the core UK partners to define the details of the contracts and initiate collaboration.

Start up planning meeting, York, January 2007. Brought together the UK collaborators and defined how they would work together.

Planning and scenarios meeting, Cambridge, May 2007. Agreed the work plans and budgets and defined how UK and Tanzanian partners would work together.

Hydrology module meeting, Cranfield, June 2007. Programme coordinator and GIS analyst coordinated work with Cranfield University staff.

Carbon coordination meeting, Leeds, June 2007. Coordinated the approach to the programme's work on carbon.

KITE - GIS and data sharing meeting, York, February 2007. Shared GIS resources and defined a basis for continuing that work into the future.

Forest governance meeting, Norwich, September 2007. Defined the way that the programme would address the issue of forest governance.

Valuation meeting, Norwich, December 2007. Defined the programme's approach to valuing ecosystem services.

Water governance meeting, Cranfield, January 2008. Hydrological and governance module team members tackled how they would address the issue of water governance.

Progress with Valuing the Arc

Theoretical review

The review is being led Prof Kerry Turner and Dr Brendan Fisher at the University of East Anglia, but with input from most of the Valuing the Arc team especially Prof Andrew Balmford, Dr Neil Burgess and Dr Mathieu Rouget. This module has made significant headway into how research integrating ecological process and human welfare can be robustly undertaken, culminating in one commissioned article (peer-reviewed) and two accepted peer-reviewed articles. The review of the literature shows that there is currently no systematic approach to ecosystem service research that incorporates current economic valuation approaches. This work is an attempt to fill that gap. In addition to the papers (see below) this module will produce a monograph regarding the Valuing the Arc approach.

Eastern Arc case study

The Eastern Arc case study has a number of modules. Progress with each of these is outlined below:

Mapping and GIS. Dr Mathieu Rouget and Dr Neil Burgess at Cambridge and Dr Boniface Mbilinyi and Mr Simon Mwansasu in Tanzania (working together with MOU partners in KITE and the Nat Cap project) have pulled together available GIS data on the study region, and started to develop new GIS products for each of the programme modules (see below). A new GIS road layer for the region is being prepared by the team in Tanzania. A new land cover map for the region has also been developed using a combination of previously existing GIS layers.

Biodiversity. Prof Kim Howell and his team at the University of Dar es Salaam have started to organize species-by-sites data for birds, amphibians (both done), mammals and reptiles (both in progress) for all Eastern Arc sites. Dr Mathieu Rouget and Dr Neil Burgess, working together with NGO and academic collaborators, have synthesized available GIS and site-based biodiversity data sets for the Eastern Arc study area that covers about 25% of the land area of Tanzania. These data will be reviewed at a meeting funded by the UK Royal Society (UKP 9,800) and the Natural Capital Project (UKP 10,000) in Tanzania in February 2008. A PhD Student (Jonathan Green) is expected to be funded through Cambridge University to analyse these data. Summary biodiversity data have also been shared with the Natural Capital Project for incorporation into their ecosystem services mapping tool. Valuation studies for Eastern Arc biodiversity are being designed by Dr Sian Morse-Jones and Dr Andreas Kontoleon in the UK, Dr Robin Naidoo in USA and Dr Kassim Kulindwa in Tanzania; surveys will be implemented in the UK, US and Tanzania during 2008.

Carbon. Dr Andrew Marshall and a team of field researchers, with scientific input from Prof Panteleo Munishi in Tanzania, Dr Simon Lewis at Leeds University and Dr Jon Lovett at York University, have set up a network of detailed forest plots during 2007. Eight 1 ha plots have been established in the Udzungwa Mountains and three in the West Usambara Mountains. These provide a very detailed estimate of carbon storage. A Tanzanian masters and a UK PhD student will continue the work in 2008-2010 – aiming to estimate sequestration rates in these forests. At the same time,Valuing the Arc has assisted KITE to georeference 3,807 forest plots and disturbance transects that will also be used to estimate carbon storage across the region. Estimated carbon data have also been provided to the Natural Capital Project for incorporation into their ecosystem services modeling tool. Carbon values will be obtained from the existing carbon trading mechanisms.

Hydrology. Prof Sue White and Dr Celina Smith in Cranfield have been working with Prof Felix Mtalo and his students, and staff of the Water Basin Authorities, Ministry of Water and Meteorology Department in Tanzania to pull together all available data necessary to run the Soil and Water Assessment Tool (SWAT) hydrological model in the Eastern Arc Mountains. Data from 55 rainfall stations and 20 river gauging stations have been assembled, together with land cover data and a detailed Digital Elevation Model (DEM) for the area. Considerable input has also been made into the development of the Natural Capital projects hydrological module. Valuation in this module will focus on drinking water, water for irrigation and water for hydroelectric power. Techniques will follow the FAO valuation framework for water which was developed in part by Prof Kerry Turner of Valuing the Arc. Meeting with experts on water has begun (Prof Bruce Langford, UEA). Valuation work will be undertaken by Dr Sian Morse-Jones, Dr Kassim Kulindwa and a PhD student from University of Dar es Salaam; studies will commence in 2008.

Timber. Dr Mathieu Rouget and Dr Neil Burgess have been working together with Prof Rogers Malimbwi and Prof Panteleo Munishi in Tanzania, and with the assistance of Mr Jonathan Green in the UK, to organize and put into GIS the existing timber inventory

data for 14 Districts in Tanzania. This will be used for the work of a Masters student in Tanzania, and will also be worked on further in Cambridge. Valuation studies of timber forest products will also be undertaken in 2008 by Dr Brendan Fisher and Dr Sian Morse-Jones from University of East Anglia and Dr Kassim Kulindwa and a PhD student from the University of Dar es Salaam

Non-timber. Dr Neil Burgess in the UK and Prof Seif Madoffe in Tanzania have worked to compile an inventory of the available non-timber forest product data for the Eastern Arc. This will be used as the basis of a masters student project in Tanzania, and as the basis of a bachelors project in Cambridge and a masters project at York University. Valuation studies of non-timber forest products will also be undertaken in 2008 by Dr Brendan Fisher and Dr Sian Morse-Jones from University of East Anglia and Dr Kassim Kulindwa and a PhD student from the University of Dar es Salaam. A method for valuing non-timber products has been identified and is currently being refined to suit the local context.

Ecotourism. Dr Doug Yu and Mr Chris Kirkby in the UK are working with Dr Jafari Kidegesho in Tanzania to design a survey of ecotourism numbers and their values to within the Eastern Arc Region. Field assistants are being recruited and are likely to comprise a masters student from the UK and two masters students from Tanzania. Field work will be undertaken in June-August 2008.

Governance. A map of governance regimes has been compiled for the study area by Dr Mathieu Rouget and Dr Neil Burgess. Dr Jouni Paavola in Leeds has provided advice on forest governance issues and Dr Richard Franceys at Cranfield has advised on water governance issues. Two masters projects are starting up in Tanzania and they will address issues of forest governance in the Udzungwa Mountains.

Pollination. An intern at WWF US, supported by Dr Taylor Ricketts and Dr Neil Burgess, worked on crops of the Eastern Arc Mountains and their pollinators. A report was produced and indicative values of the pollination service were calculated. A further investment will be made by WWF US to support another student working on this issue in Tanzania, supervised by Prof Panteleo Munishi and Dr Taylor Ricketts.

Timetable – progress in 2007

Item	**2006**	**Jan-Mar07**	**Apr-Jun07**	**Jul-Sep07**	**Oct-Dec07**
Start up meeting TZ					
Start up meeting UK					
Contracts signed (UK)					
Contacts signed (TZ)					
MOU with KITE					
MOU with Nat Cap					
Programme coordinator (Cambridge)					
Programme GIS analyst (Cambridge)					
TZ Coordinator (WWFTZ)					
Theoretical Review					

Staff employed					
Case studies for book					
Conceptual paper					
Definitions paper					
Eastern Arc Case Study					
Biodiversity module started (UK)					
Biodiversity module (TZ)					
Biodiversity existence values staffing (UK)					
Carbon staffing (UK and TZ)					
Carbon field work (TZ)					
Carbon plots database (UK)					
Hydrology staffing (UK)					
Hydrology database (UK)					
Hydrology PhD students (TZ)					
Timber database (UK)					
Timber masters (TZ)					
Non-timber database (UK)					
Non-timber masters (TZ)					
Ecotourism database (UK)					
Ecotourism Masters (TZ)					
Governance mapping (UK)					
Governance Masters (TZ)					
Valuation staffing (UK)					
Valuation PhD (TZ)					
Overall Eastern Arc GIS database (UK)					
Landcover map prepared for region (UK and TZ)					
Draft scenarios developed for region (TZ and UK)					

As the above table shows, most of the work in 2007 has been staffing the programme, starting up collaboration with Tanzania, and initiating the work on the conceptual review and the Eastern Arc case study. All programme elements are now in place and running.

Plans for 2008

The programme will continue with the work it has started in the UK and Tanzania. Detailed workplans have been developed and in broad terms these are as follows:

Overall goals. We will conclude our data gathering phase, and will put all data into Arc GIS programme. Work will then focus on building modeling tools that can generalize the results of individual modules across the entire Eastern Arc region, on tools that can synthesise the results of different modules, and on ways to incorporate economic values and future scenarios into the programme. By the end of the year we expect to have fully operational GIS models for all services, and ways to both synthesise models across services, and incorporate values and scenarios.

Cambridge – Zoology Department. A new GIS staff member will be appointed and will continue synthesizing all available data and developing the models for bringing all the various programme data together for analysis. A PhD on biodiversity data will start in the autumn (funding permitting). Staff in Cambridge will compile available data on timber and non-timber values and biodiversity patterns and process. Simple models of biodiversity, timber and non-timber will be developed in collaboration with the Natural Capital Project and Dr Mathieu Rouget in South Africa. Input will be provided to all other parts of the programme in the UK and Tanzania, and to the existing collaborations with KITE in York and the Natural Capital Project in the USA. Two draft papers will be finished and submitted to Journals.

Cambridge – Land Economy Department. Work on designing the biodiversity existence value survey and implementing it will continue.

Cranfield. Will continue to input data and will make first runs of the SWAT model for three hydrological basins. Two Tanzanian PhDs will visit the UK. The simpler hydrological model for the entire Eastern Arc region will be finished in collaboration with the Natural Capital Project.

University of East Anglia. The theoretical review will continue and the draft papers will be finished and accepted by Journals. Work will move on to the large monograph on this issue. The tourism module will start up with a masters student going to Tanzania and working in the field for 2 months to gather relevant tourism data. The biodiversity existence values surveys will be designed and then undertaken in the USA, UK and Tanzania. The methods for gathering economic values of water, timber, non-timber forest products will be defined and field work will start in Tanzania. Detailed scenarios will be completed for the Eastern Arc region and coded for input into the GIS models for the region.

York. Field work to establish carbon plots will be completed. A PhD will be advertised and will be recruited by the end of the year. Collaboration with the KITE project will continue with a database of forest plots and transects being completed and analysed – allowing better maps of forest carbon, forest timber, non-timber and 'disturbance' to be developed. Collaborative papers with Cambridge - Zoology will be drafted.

Leeds. Field work to establish carbon plots will be completed. A PhD will be advertised and will be recruited by the end of the year.

University of Dar es Salaam. Three PhDs will continue their work, two on hydrology and one on valuation. The roads layer will be finishsed. The work on species-by-sites in the Eastern Arc for reptiles and mammals will be concluded. Input of senior staff to the model development and papers will continue.

Sokoine University of Agriculture. Eight masters will continue their work. The landcover maps will be updated and finished. Input of senior staff to the model development and papers will continue.

WWF Tanzania Programme Office. Work on linking programme results to the policy process will continue.

KITE programme. We will continue to implement the MOU with KITE, supporting the work of 2 PhD students and benefiting from the work that they are doing on plant biodiversity patterns and the impacts of climate change.

Natural Caiptal Programme. We will continue to implement the MOU with Nat Cap, working with them to complete 'Tier 1' models of ecosystem services in the Eastern Arc Mountains and to customize their mapping tool for further use in East Africa. Collaborative papers will also be produced and joint presentations will be made to International Meetings.

Papers and other publications

Blomley, T., Pfliegner, K, Isango, J., Zahabu, E., Ahrends, A. and Burgess, N.D. (in press). Seeing the Wood for the Trees: Towards an objective assessment of the impact of Participatory Forest Management on forest condition in Tanzania. *Oryx*

Fisher, B. (2007). Valuing the Arc: applying environmental decision making methodology in Tanzania's Eastern Arc Mountains. *Britain In 2008*: 14.

Fisher, B., Turner, R.K., Costanza, R. and Morling, P. (in press). Defining and Classifying Ecosystem Services for Decision Making. *Ecological Economics*.

Fisher, B. and Turner, R.K. (submitted). Yet another conceptual paper on ecosystem services: working towards something operational. *Biological Conservation*

Fisher, B., Turner, K., Balmford, A., Brouwer, R., Costanza, R., de Groot, R., Farber, S., Ferraro, P., Green, R., Hadley, D., Harlow, J., Jefferiss, P., Kirby, C., Morling, P., Mowatt, S., Naidoo, R., Paavola, J., Strassburg, B., Yu, D. and Zylstra, M. (in press). Integrating Ecosystem Services and Economic Theory: what can we do, what should we do, and what has been done? *Ecological Applications*

Fisher, B., Turner, R.K., Balmford, A., Burgess, N.D., Green, R., Kajembe, G., Kulindwa, K., Lewis, S., Marchant, R., Morse-Jones, S., Naidoo, R., Paavola, J., Ricketts, T. and Rouget, M. (submitted). Valuing the Arc: An ecosystem services approach for integrating natural systems and human welfare in the Eastern Arc Mountains of Tanzania. *Frontiers in Ecology and Conservation*

Fisher, B., Balmford, A., Green, R.E., Trevelyan, R. (submitted). Conservation Science Training: the need for an extra dimension. *Conservation Biology*

Naidoo, R., Balmford, A., Costanza, R., Fisher, B., Green, R.E., Lehner, B., Malcolm, T. R., and Ricketts, T.H. (in press). Global Mapping of Ecosystem Services and Conservation Priorities. *PNAS*

A Valuing the Arc website has been set up: www.valuingthearc.org. The website will be further developed in 2008 to support wider communication of the project's work and dissemination of findings.

Input has been made to the Natural Capital Project's website.
www.naturalcapitalproject.org/tanzania

Seminars where Valuing the Arc papers have been presented

Fuller Science Symposium, Washington DC, November 2006. Prof Andrew Balmford and Dr Neil Burgess attended this meeting and presented the Valuing the Arc programme to an audience of over 200 US scientists and NGO staff

International Society of Ecological Economics, Delhi, December 2006. Dr Brendan Fisher presented the conceptual approach to Valuing the Arc at this meeting.

Cambridge Geography symposium, Cambridge, June 2007. Dr Brendan Fisher presented the Valuing the Arc Programme at this meeting.

S*ociety for Conservation Biology Meeting, Port Elizabeth, July 2007*. Prof Andrew Balmford presented the Valuing the Arc programme to an audience of c.250 conservation scientists from around the world.

NERC / ESRC Ecosystem Services meeting, Nottingham, October 2007. Dr Brendan Fisher presented the Valuing the Arc program to this meeting.

Earth Life Systems Alliance (ELSA) Innaugural Meeting, Norwich, October 2007. Professor Kerry Turner presented the Valuing the Arc programme at this meeting.

CSERGE Research Symposium, Norwich, June 2007. Dr Brendan Fisher presented the Valuing the Arc program to this meeting.

NERC / ESRC Ecosystem Services meeting, Cambridge, January 2008. Dr Neil Burgess and Dr Brendan Fisher presented the Valuing the Arc programme to this meeting. Prof R. Kerry Turner presented part of the Theoretical Review at this meeting.

Money raised

During 2007 we have raised the following co-funding for the programme.

1) Royal Society networking grant for a meeting in Tanzania. 9,800 UKP
2) WWF US Fuller Science Postdoctoral assistant. 5,000 UKP
3) Natural Capital Project – support for policy linkage, Tanzania workshop, development of GIS mapping interface, and biodiversity existence values work. 50,000 UKP