Institution: Edinburgh Napier University

Unit of Assessment: 7 - Earth Systems and Environmental Sciences

Title of case study: New Paths to Mangrove Conservation

1. Summary of the impact

The Mikoko Pamoja project uses carbon credits for conservation and development in Africa. It is one outcome of Edinburgh Napier University's (ENU) work on mangrove ecology which has local, national and international impacts. With public and private support, the project has recruited >140 international volunteers, trained 46 African scientists, and funded development including schools and pumps. It is pioneering community control of mangroves using new legal instruments and informing the national management plan. A regional forum founded by the team facilitates international networking. The work has been highlighted by the United Kingdom (UK) Department for International Development as good practice and has generated ACES (Association for Coastal Ecosystem Services), a new charity.

2. Underpinning research

Mangrove ecosystems provide vital services at local, regional and global scales, including nursery grounds for fish, protection of coastlines from erosion and storm damage, filtration of sediments and pollutants and carbon sequestration. Despite this high value they are being rapidly destroyed, at rates exceeding those for terrestrial tropical forest, through coastal development, aquaculture and logging. This case study describes novel research (from 2002-2013) on mangroves and application of this new understanding in practical ways to conserve them. Initial research led by Professor Mark Huxham (ENU, 1995-2013), including PhD students and research assistants at ENU, demonstrated juvenile fish use of Kenyan mangroves using natural chemical tracers retained in adult fish[3.6]. This helped make the case for the importance of mangroves as nursery sites. Research then explored the processes of ecosystem recovery, driven by the need to restore large areas devastated by industrial wood extraction some 30 years previously. Two Kenyan and one Sri Lankan PhD students, registered at ENU, as well as scientists from Kenya (specifically, Dr James Kairo of the Kenya Marine and Fisheries Research Institute), Sri Lanka (Professor Loku Jayatissa) and the UK (especially Dr Martin Skov, Bangor University and Professor Maurizio Mencuccini, Edinburgh University) were heavily involved in this work, which has been supported throughout by the Non-Governmental Organisation (NGO), Earthwatch Institute. Large scale experiments (planting 5872 trees) revealed the key physical and chemical constraints preventing natural regeneration (increased wave impact and salinization), and determined the nursery techniques and target species to be used in active restoration[3.3, 3.4]. In addition to these practical applications, ENU work addressed questions of fundamental interest to ecosystem science, including the role of species richness in ecosystem functions and of positive facilitation in plant growth in harsh environments[3.1]. We demonstrated for the first time how higher species richness and higher density can contribute to survival and ecosystem restoration in mangroves, and how altering planting strategies affects the forests' ability to keep up with sea-level rise by raising the level of their substrates[3.5].

Mangrove forests are amongst the most efficient natural carbon sinks and are of global importance as carbon stores. One strand of ENU work has focused on quantifying carbon flows in the forests, for example by looking at rates of decomposition of below-ground carbon, and at the impacts of cutting trees on greenhouse gas fluxes. We have translated this field scale knowledge to national scale information by using remote sensing to quantify rates of forest loss and areas of high future risk of deforestation in Kenya (work conducted between 2009-2012 with Dr Rob Briers, ENU, 2003-2013)[3.2, 3.4]. We have quantified the stocks and flows of above and below-ground carbon at our field site and elsewhere, in order to allow valuations of this ecosystem service on the voluntary carbon market. In addition, socio-economic and policy research, collaborating with social scientists in Kenya and elsewhere has assessed the use and market values of different mangrove ecosystem goods and services and the policy options available for conserving mangroves through payments

for ecosystem services.

3. References to the research (ENU researchers are in **bold**)

3.1 **Huxham, M., Kumara, M.P**., Jayatissa, L.P., Krauss, K.W., Kairo, J., **Langat, J**., Mencuccini, M., Skov M.W. and **Kirui B**. (2010) Intra and inter-specific facilitation in mangroves may increase resilience to climate change threats. *Philosophical Transactions of the Royal Society* 365, 2127-2135. DOI: 10.1098/rstb.2010.0094. ***This paper was part of a prestigious special edition on biological interactions with climate change.***
3.2 **Kirui, K.B**., Kairo, J.G., Bosire, J., Viergever, K., **Rudra, S**., **Huxham, M**. and **Briers, R.A**. (2012) Mapping of mangrove forest land cover change along the Kenya coastline using Landsat imagery. *Ocean and Coastal Management*, DOI:10.1016/j.ocecoaman.2011.12.004.
3.3 **Kirui B.,** Skov M.W., Kairo, J., Mencuccini, M. and **Huxham, M**. (2012) Effects of species richness, identity and environmental variables on growth in planted mangroves. *Marine Ecology Progress Series* 465, 1-10. DOI: 10.3354/meps09999. ***This paper was selected as the open access 'special featured paper' of this edition.***
3.4 **Rideout, A**., Joshi, N., Viergever, K., **Huxham, M**. and **Briers, R.A**. (2013) Making predictions of mangrove deforestation: a comparison of two methods in Kenya. *Global Change Biology*. DOI: 10.1111/gcb.12176.
3.5 **Kumara, M.P.,** Jayatissa, L.P., Krauss, K.W., Phillips, D.H. and **Huxham, M.** (2010) High mangrove density enhances surface accretion, surface elevation change, and tree survival in coastal areas susceptible to sea-level rise. *Oecologia* 164:545-553. DOI: 10.1007/s00442-010-1705-2. ***This paper was covered in the ecological press and showed how high density mangrove forests can raise the level of their substrates.***
3.6 **Huxham, M.,** Kimani, E., Newton, J. and **Augley, J.** (2007) Stable isotope records from otoliths as tracers of fish migration in a mangrove system. *Journal of Fish Biology* 70, 1554-1567. DOI: 10.1111/j.1095-8649.2007.01443.x.

Selected grants (all peer reviewed by Research Council or similar processes):

- Natural Environment Research Council (NERC)/Department for International Development (DfID)/Economic and Social Research Council (ESRC) (the Ecosystems Services and Poverty Alleviation, ESPA, programme). 2010-2012. Swahili seas. £ 249,855 (awarded to M. Huxham)
- NERC/DfID/ESRC (the ESPA programme). 2009 -2010. Capacity building for mangrove assessment, restoration and valuation. £105,612 (awarded to M. Huxham)
- Climate and Development Knowledge Network (DfID). 2012 - 2014. iCoast. £449,100 (awarded to M. Huxham)
- NERC 2008-2010. The mangrove carbon cycle – understanding below-ground processes and managed cutting. £ 48,891 (awarded to M. Huxham).

4. Details of the impact

Our work has had local (environmental and social improvements), national (policy development and implementation) and international (formation of regional and international practitioner networks) impacts; has informed policy makers and has raised awareness and understanding among the general public in Kenya and the UK.

Coastal communities in Kenya suffer from chronic poverty. They rely heavily on natural resources, particularly fish, and are vulnerable to environmental degradation. The 3,000 people living in the Gazi Bay area of Kenya benefit directly from Mikoko Pamoja, a project designed by the Huxham team (from 2008-2013), based on the research described in section 2, that uses carbon credits to fund forest conservation and community development. Mikoko Pamoja is accredited by the charity Plan Vivo and is managed by a committee of local stakeholders (advised by international experts). Our work was the first to develop a technical specification for the accreditation of mangrove carbon (2011) (using site-specific work described in section 2). It is designed to act as a template for future projects; and has been showcased by the Kenyan government[5.1]. Impacts at other sites in East Africa are facilitated through our networking body, the East African Forum for Payments for

Ecosystem Services (EAFPES) [5.2] and our charity, the Association for Coastal Ecosystem Services. The work has funded development including a new school building (benefitting 600 children), new water pumps (supplying 50 households) and the sponsorship, through primary, secondary and tertiary education, of dozens of local children.

We worked with Government in pioneering new uses for legal instruments for community based conservation. With the Kenya Forest Service (KFS) and the Kenya Marine and Fisheries Research Institute we developed a Community Forest Association (CFA; established 2012), the first for a mangrove forest. Our work contributes to the national plan for the United Nations' Reduced Emissions from Forest Degradation and Deforestation (REDD) programme (it is supported by KFS as a demonstration site for this), the production of a national mangrove management plan, and the identification of areas of high forest quality and high risk. Data from ENU work[3.2] were requested by the Kenyan Government.

In 2009, we established EAFPES for regional and Africa-wide networking on payments for ecosystem services (PES) projects to help with co-ordination of coastal PES projects (particularly those involving 'blue carbon' stored in marine ecosystems). EAFPES is supported by the UK Government Ecosystem Services for Poverty Alleviation (ESPA) programme and WWF Kenya. It has run workshops aimed at East African managers and stakeholders, drawing on the work described in section 2, and showcasing the 'our ecosystem' on-line tool that allows managers to assess the value of, and threats, to their mangrove resource[5.3]. It provides a virtual source of information and networking informed by our research and experience. ACES (charity no. SC043978), established in May 2013, facilitates the flow of funds from international donors, corporations and individuals for coastal development and conservation in Africa.

We were invited to the All Party Parliamentary Group on International Development in February 2012[5.4], receiving a special commendation from Stephen O'Brien MP, Minister for International Development, who wrote: 'I found the Making an Impact series informative, especially noting the innovative engagement with Aviva in the Kenya mangrove project'.

We presented a keynote at the Aquatic Resources of Kenya 2010 national conference attended by the Minister for the Environment, which led to a request for data to inform the national mangrove plan. We organised a special session on REDD readiness, carbon credits and mangroves at the West Indian Ocean Marine Science Association October 2011 conference, attracting 55 delegates including regional decision-makers and NGOs.

We have had coverage in the Kenyan and UK press (e.g. BBC 2010[5.5]), using this to inform and educate but also to help recruit volunteers and raise charitable funding. We collaborated with the ASCUS science and art fund to produce a video drawing on our work on Kenyan experiences and perspectives on climate change seen by more than 300 people, in Edinburgh, in February 2012.

Practical conservation outcomes over the past decade (2004-2013) have included the planting of more than 10,000 mangrove trees and the restoration of ~20 ha of degraded land[5.6, 5.7]. Hundreds of Kenyan school children have visited our site, and > 40 developing country researchers have worked with us. Kenyan scientists, trained to Masters and PhD level through our project, with funding from charities and businesses (Aviva Ltd and Zurich International), have progressed to Kenyan Government and academic positions, vindicating our strategy to strengthen capacity for mangrove conservation and management within Kenya.

5. Sources to corroborate the impact

[5.1] Film produced by the Kenyan Ministry of Environment and Mineral Resources showcasing our work and the Mikoko Pamoja project; our project is featured from 8.05 minutes onwards: http://www.youtube.com/watch?v=xgI_XY37c5E&feature=em-share_video_user.

[5.2] For the East African Forum for Payments for Ecosystem Services, including documents proving legal confirmation of local groups and management plans: http://www.eafpes.org/.

5.3 For the on-line tool for local managers in Kenya to assess the carbon contents and risk status of their mangrove forests: http://icoast.ourecosystem.com/interface/ (to operate this application requires a login that can be provided on request).
5.4 For All Party Parliamentary Group on International Development and the Environment, go to: http://www.appgide.org/meetings and scroll down the page to "Previous meetings". See also: http://www.appgide.org/sites/appg.iiedlist.org/files/pdf/ESPA-APPG-James-Kairo.pdf.
5.5 For an example of journalism/press coverage see BBC: http://news.bbc.co.uk/1/hi/sci/tech/8893767.stm.
5.6 For work with the international NGO Earthwatch Institute, including details of education and the site: http://www.earthwatch.org/exped/huxham.html.
5.7 For an overview of some of the impacts described by ESPA, a key UK government supporter that uses this project as a case study, see: http://www.espa.ac.uk/projects/ne-i003401-1.

Corroborating Organisations: contact information for relevant individuals within the following organisations provided separately.

- Associate Director, Kenya Marine and Fisheries Research Institute – to corroborate all claims about policy and local impacts in Kenya, and importance of the research to Kenyan national policy.
- Associate Director, Earthwatch Institute – to corroborate long-term commitment to local site and people, educational impacts and outreach, and communication impacts.
- Director, Ecosystem Services for Poverty Alleviation Programme – to corroborate work with UK policy makers, corporations and funders.