

Institution: Edinburgh Napier University		
Unit of Assessment: UoA 7 – Earth Systems and Environmental Sciences		
Title of case study: Pioneering coastal carbon credits for conservation, development and health benefits		
Period when the underpinning research was undertaken: 2014-2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s): Professor Mark Huxham Dr Robert Briers	Role(s) (e.g. job title): Professor Associate Professor	Period(s) employed by submitting HEI: 1995- ongoing 1998- ongoing
Period when the claimed impact occurred: August 2014- August 2020		
Is this case study continued from a case study submitted in 2014? N		
1. Summary of the impact (indicative maximum 100 words) Research by Edinburgh Napier established the world's first community-based mangrove and seagrass conservation projects funded by carbon credits. These help 14,000 of Kenya's poorest people, improving health and employment, conserving ecosystems and fighting climate change. Mikoko Pamoja (the first project) provides fresh water for 73% of the local population, 9 jobs and educational facilities for 900 children. With Vanga Blue Forest (the 2nd project), these initiatives protect 550 ha of mangroves and 200 ha seagrass, sequester over 9,000 tonnes CO2/year and raise over USD40,000/year for conservation and livelihoods. They pioneered the sale of mangrove and seagrass carbon credits, received the United Nations Equator prize and influenced national and international policy. 2. Underpinning research (indicative maximum 500 words) Facing rapid climate change, the critical importance of carbon capture and storage in natural ecosystems is clear. Identifying, protecting and expanding key ecosystems are urgent priorities. Mangroves and seagrass meadows (which, with saltmarsh, are called 'blue carbon' habitats) may have more than 10 times the carbon density of terrestrial forests. An approximate USD1 Billion/year market for carbon credits (bought by individuals and corporations to offset emissions) funds terrestrial forest conservation but technical and regulatory barriers made it inaccessible for marine habitats before this work. Interdisciplinary research was needed to establish how vulnerable the ecosystems and their stored carbon were, whether protection and restoration were possible, how national and international policy could support this and how carbon credits could be sold for conservation and development benefit. Professor Mark Huxham (Edinburgh Napier University (ENU) 1995-present) was PI for all the research described here with ENU as lead institution. Dr Rob Briers (Assoc. Prof, ENU 1998-ongoing) and 4 PhD students collaborated. Dr James Kairo of Kenya Marine and Fisheries Research Institute (KMFRI) was the lead Kenyan scientist. Collaborators from other HEIs are indicated below. Enabling the accreditation and sale of mangrove and seagrass carbon credits required new research in five interdisciplinary areas: <i>i. How vulnerable are mangrove forests and seagrass beds in Kenya and what are the effects of their loss?</i> In 2011, Huxham, Briers and KMFRI produced the first accurate map of mangroves in Kenya, using satellite images, and calculated rates of loss (0.7%/year). Building on this in 2013,		

Huxham and Briers, working with Professor Fiona Nunan (Birmingham University co-I) Professor Loku Jayatissa (Ruhuna University Sri Lanka, Co-I) and Lesley King (LTS International Ltd, Co-I) modelled forest losses under business-as-usual scenarios [O1] during the iCOAST project [P1]. Hence this strand of work shows rates and drivers of forest loss and likely future trajectories. In 2015, Briers, Huxham and social scientists from the International Union for the Conservation of Nature (IUCN) and Kenya identified the costs to society and local people of this ecological damage. In 2018, the ENU team published the first estimate of seagrass loss for an African country ($\leq 21\%$ over 30 years), allowing incorporation of seagrass into the mangrove carbon projects [O2, P2].

ii. *How much carbon is there in mangrove forests and seagrass beds?*

Equations developed by ENU and Edinburgh University scientists in 2012 allowed predictions of above-ground carbon in Kenyan forests. But most carbon in mangroves and seagrass beds occurs below-ground; it must be extracted and analysed using techniques from sedimentology. In 2016, the ENU team, with KMFRI colleagues, reported an average of $\sim 1500 \text{ t C ha}^{-1}$, 8 to 10 times that for terrestrial forests. We mapped stores of belowground carbon across Kenya's mangroves to identify the most carbon-dense areas for conservation and the development of payments for ecosystem services projects [O3, P3]. In 2019 ENU and KMFRI estimated stocks and vulnerability of carbon in seagrass beds [O4, P2]. Hence, we know the total carbon stocks at the mangrove and seagrass sites at which we work and can advise project developers and the Kenyan Government on stocks at other sites.

iii. *How vulnerable is buried carbon if the habitat is destroyed?*

ENU led the first experimental test in mangroves of the effects of tree removal on soil carbon and found that it was surprisingly vulnerable [O5, P4]. This allowed the modelling of carbon losses under different scenarios during the accreditation of Mikoko Pamoja. In 2019, similar work in seagrass also showed rapid loss of carbon and facilitated seagrass inclusion, for the first time globally, into a payments-for-ecosystem-services (PES) project [O4, P2].

iv. *Is it possible to restore grossly degraded areas of the shore?*

Around the world, mangrove removal has left thousands of km² as waste-lands. Between 2005 and 2013, the ENU and KMFRI teams explored why such sites often failed to recover and developed new ways to restore them. Salinization and wave impacts were revealed as key factors making former forest areas inhospitable to seedlings. Targeted planting with nurse species and mixing species to boost productivity led to forest recovery.

v. *How can state institutions, national and international policies work better to help local people protect ecosystems?*

The ENU and KMFRI teams, with Professor Caroline Upton (Leicester University) and Professor Fiona Nunan (Birmingham University), worked with government agencies in Kenya and Tanzania to understand their practices and help them support communities, identifying institutional factors – including poor communication and understanding of powers - hindering this work, and helping them incorporate research findings into local action [O6, P4]. New projects with IUCN and Dr Dan Friess (Singapore University) are linking local lessons to national and international climate policy under the Paris Agreement [P5, P6].

3. References to the research (indicative maximum of six references)

- [O1] Rideout, A. J. R., Joshi, N. P., Viergever, K. M., Huxham, M., & Briers, R. A. (2013). Making predictions of mangrove deforestation: a comparison of two methods in Kenya. *Global Change Biology*, 19, 3493-3501. [doi:10.1111/gcb.12176](https://doi.org/10.1111/gcb.12176)
- [O2] Harcourt, W., Briers, R., & Huxham, M. (2018). The thin(ning) green line? Investigating changes in Kenya's seagrass coverage. *Biological Letters*, 14(11), 20180227. [doi:10.1098/rsbl.2018.0227](https://doi.org/10.1098/rsbl.2018.0227)
- [O3] Gress, S. K., Huxham, M., Kairo, J. G., Mugi, L. M., & Briers, R. A. (2016). Evaluating, predicting and mapping belowground carbon stores in Kenyan mangroves. *Global Change Biology*, 23(1), 224-234. [doi:10.1111/gcb.13438](https://doi.org/10.1111/gcb.13438) **Listed in REF2**

[O4] Githaiga, M. N., Frouws, A., Kairo, J.G. & Huxham, M. (2019) Seagrass removal leads to rapid changes in fauna and loss of carbon. *Frontiers in Ecology and Evolution*, 7, pp. 1–12. [doi: 10.3389/fevo.2019.00062](https://doi.org/10.3389/fevo.2019.00062). **Listed in REF2**

[O5] Lang'at, J. K. S., Kairo, J. G., Mencuccini, M., Bouillon, S., Skov, M. W., ...Huxham, M. (2014). Rapid Losses of Surface Elevation following Tree Girdling and Cutting in Tropical Mangroves. *PLoS ONE*, 9, e107868. [doi:10.1371/journal.pone.0107868](https://doi.org/10.1371/journal.pone.0107868) **Listed in REF2**

[O6] Kairu, A., Upton, C., Huxham, M., Kotut, K., Mbeche, R., & Kairo, J. (2018). From shiny shoes to muddy reality: understanding how meso-state actors negotiate the implementation gap in participatory forest management. *Society and Natural Resources*, 31(1), (74-88). [doi:10.1080/08941920.2017.1382628](https://doi.org/10.1080/08941920.2017.1382628). ISSN 0894-1920

O1 – O6 are all journal articles which have been through a rigorous peer-review process prior to publication.

Projects:

[P1] iCOAST: understanding the policy and fiscal mechanisms for achieving climate compatible development in the coastal zone. £333,000 awarded to ENU, by the Climate Development Knowledge Network, funded by UK DfID. May 2012- June 2014.

[P2] Punguza Hewa Kaa. £90,000 awarded to ENU. British Council Newton Fund. April 2017- March 2018.

[P3] CESEA; £312,000 awarded to ENU. ESPA (NERC, ESRC and DfID). October 2013-March 2016

[P4] Incorporating seagrass conservation and restoration into community-based PES. USD62,502 / £47,000 awarded to ENU. United Nations Environment Programme. September 2020-April 2021.

[P5] From local roots to global branches: making NDCs work at three different levels. £155,000 awarded to ENU. NERC November 2019-May 2021.

[P6] A thousand flowers will bloom: Ensuring local initiatives inform national and international climate commitments. £126,000 awarded to ENU. International Development Research Centre (Canadian Government) February 2020 – July 2021.

4. Details of the impact (indicative maximum 750 words)

ENU research led to the development, implementation and on-going success of the Mikoko Pamoja (MP, launched 2013) and Vanga Blue Forest (VBF, launched 2019) projects. These support the health and well-being of 14,000 people, improve the local environment, enhance environmental education in Kenya and beyond and influence national and international policy on climate change and coastal conservation. In particular, this work has led to:

Improving lives

Since 2013, MP has sold 11,757 credits raising more than USD130,000 for conservation and development. Most project work – including marketing, administration, technical advice, monitoring and community liaison – is done by Kenyan and international volunteers, so 92% of income goes direct to Kenya. Money is allocated to a community fund, governed by local people and spent on priorities decided through an inclusive and democratic process **[C1]**. Water is a major focus; from 2015 more than 3,500 people have received water from project investments, saving approximately 170,000 hours/year in water collection time (a job done overwhelmingly by girls and women). Rates of diarrhoea have halved since installation of water points. Educational investments are also prominent. New school buildings, furniture and hundreds of textbooks have been purchased, with measurable improvements in achievement in an area with traditionally very low educational outcomes. Dispensaries and schools now have potable water; without the project children had to go the whole school day without a drink **[C2]**. 33 improved cook stoves have been installed into homes, reducing wood use and indoor pollution. One site frequently floods, causing loss of life and livelihoods; a new footbridge will provide safe access to fields. Free sanitary pads are distributed to 300 girls to help address period poverty **[C12]**. The projects provide direct employment for 14 people and approximately 50% of the local population have directly participated in project activities including tree planting, forest patrolling and coastal clean-ups. In addition to strategic investments, MP and VBF respond to emergency need; in May

2020, 1107 people received food following the Covid-19 lockdown. Surveys confirm overwhelming local support. Independent scrutiny by social scientists in 2017 concluded MP was a 'unique, care-based project' [C3].

Environmental and climate benefits

MP and VBF have sequestered more than 24,000 t CO₂ since 2014 and will capture more than 150,000 t CO₂ during their 20 year accreditation (approximately 10% of yearly emissions of Mombasa city or approximately 395,000 London-Edinburgh return flights). Since 2013, more than 20,000 trees have been planted, restoring degraded land, stabilising shorelines and supporting fish, molluscs, crustaceans and other fauna [C4, linked with O4,O5].

Education and public engagement

Since 2015, more than 3,000 Kenyan students (primary, secondary and tertiary) have received on-site education on climate change, sustainability and mangroves [C1]. The work has recruited over 280 international volunteers, including early career scientists, teachers and African environmentalists, who receive training; many now work in related fields. MP has produced curricula materials used in local schools and developed a network of 13 secondary school mangrove champions. Project work helped establish a bursary for local girls and arrange long-term sponsorship for 27 local children, allowing them to complete secondary and, for some, tertiary education. 33 Kenyan postgraduate research students have been supported through MP and VBF; some now hold senior positions in Kenyan universities and ministries. For example, Dr Joseph Lang'at says *"I was mentored and trained as an ecologist under the Mikoko Pamoja programme with Professor Huxham as my Director of Studies. After graduating with my PhD I worked as a senior advisor on environmental management in the County Government of Bomet and can personally attest to the influence of Mikoko Pamoja on my own opportunities and on national policy"*. Since 2014, MP has hosted 7 visits by community groups and international delegations wishing to learn from its experience as part of deliberate efforts to share knowledge within East Africa and beyond. Since 2014 it has appeared in multiple media outlets including the BBC, The Guardian, The Scotsman, The Sun, The Economist, The Mail and New Scientist.

Changes in national and international policy and understanding around the importance of mangroves and blue carbon

As the first mangrove PES project MP pioneered the use of local laws and institutions to allow co-management of forests for community benefit; it is explicitly designed to impact policy and practice elsewhere. Within Kenya, it shaped the development of the 2016 national Mangrove Ecosystem Management Policy, governing over 60,000 ha Kenyan forests [C5, linked with O6]. It informed the 2018 National Climate Change Adaptation Plan. As part of the current 'local roots and global branches' project, the team is working the Kenyan government to help incorporate Blue Carbon and the lessons from MP into the Kenyan Nationally Determined Contributions under the Paris Agreement. Submitted on 28th December 2020, the latest NDC explicitly includes a commitment to harness the potential for coastal carbon PES (p8), and to invest in five Priority Adaptation Programmes (Table 2, programmes 11-15) dealing with protection of blue carbon. These important national commitments were all suggested by the research team and link directly to our work. They represent notional investments of up to USD0.88 billion for adaptation and USD1.6 billion for mitigation between 2020 and 2030 (based on proportional contribution to listed items) [C11]. MP was explicitly cited by President Uhuru Kenyatta in 2020 as an inspiration for the Kenya 2030 Vision strategy. In recognition of this national impact MP was awarded the President's prize at the 2017 Mombasa Show. In 2019 it was the first project globally to incorporate seagrass conservation into blue carbon PES and is used by the United Nations as an exemplar and case study for other seagrass conservation projects [C6], linked with [O2,O4]; hence the projects are sustainable and expanding.

Extensive outreach and press coverage includes a 2019 'Ocean Protectors' documentary by The Economist viewed by over 103,000 people. This outreach resulted in technical assistance being provided for free by the team to another 4 international conservation projects aiming to develop blue carbon PES (in Mozambique, Tanzania, Indonesia and Vanuata) [C7].

A new charity (the Association for Coastal Ecosystem Services – ACES – charity no. SC043978) was registered in 2013 to provide fundraising, marketing and technical support to MP, VBF and similar projects globally. Since 2017 it has supported the Sankandi Youth Association in the Gambia to plant 20,000 mangroves and establish 80 beehives, with impacts for 3,000 people. MP has been showcased at COP 22 (2016) and 23 (2017), used by the International Union for the Conservation of Nature and UNEP as a conservation exemplar and cited in a report used for a Resolution accepted by the United Nations Environment Assembly in 2019. Results informed a Global Environment Forum project worth USD4.5 million [C8]. In 2017 MP won the United Nations Equator prize as an outstanding example of grassroots action against climate change. [C9][C10]

5. Sources to corroborate the impact (indicative maximum of 10 references)

[C1] Mikoko Pamoja Annual report. An example of the reports submitted each year to the accrediting body, showing the range of conservation and development achievements created by the project that year

[C2] Coverage of water provision to village

[C3] Independent report from the University of Sussex on the social governance of Mikoko Pamoja, concluding it is a 'unique care-based project'.

[C4] Project Design Document for Vanga Blue Forest, showing technical, governance and social details needed for accreditation by Plan Vivo Standard

[C5] Letter from Kenyan government endorsing contribution of project work to national policy

[C6] Coverage of incorporation of seagrass conservation UNEP (2020) Protecting Seagrass Through Payments for Ecosystem Services: A Community Guide. Available at: <https://wedocs.unep.org/handle/20.500.11822/32277>

[C7] the Economist screenshot of Ocean Protectors documentary, with more than 103,000 views in December 2020

[C8] A letter from United Nations Environment Programme confirming national and international policy importance of coastal conservation work

[C9] Screen shot of equator prize website

[C10] UN declaration cites a M Huxham report

Sustainable Management for Global Health of Mangroves, March 2019

[C11] Copy of Kenya's Nationally Determined Contributions submission with relevant policy inclusions highlighted on pp 8 and 15.

[C12] Girls receiving help for period poverty in November 2019