ADAPTATION AND RESILIENCE TO CLIMATE CHANGE (ARCC)

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Introduction and overview

The issue of adaptation and resilience to climate change remains hotly debated due to complexities and challenges inherent in the understanding of our relationship with the environment and changes in climate systems, the contributions human activities make to ecological processes, and over what constitutes resilience, to what and by whom in different settings. The growing incidences of extreme events (floods and droughts) due to a changing climate are increasingly seen as a major risk affecting economy, food security, health, ecosystems, biodiversity and people's livelihoods. Faced with human-caused rapid change in climate, the ensuing policy, behavioural and livelihood changes, and the trade-offs being made between socio-economic development goals and environmental sustainability targets (as stipulated by the UN's SDGs), countries such as Tanzania require new frameworks for envisioning and planning desired futures. This project aims to contribute to these by addressing five key research questions:

- How has the biodiversity of the region been generated, how is it maintained and how does this impact on livelihoods?
- How have the ecosystems responded to past climate change and how will it respond to climate change in the future?
- What have been the socioecological systems in the study area over the past 300 years?
- How have human populations shaped and been shaped by the Eastern Arc forest vegetation?
- How will socioecological systems respond under future climate change and social scenarios?

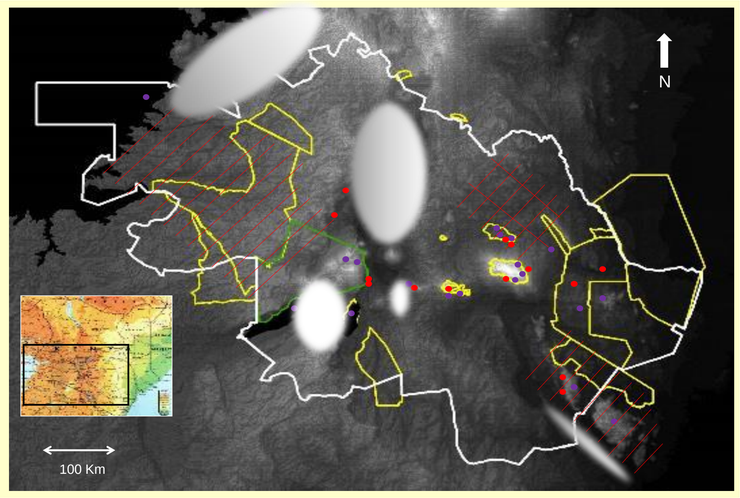


Fig. 1. Location of the main focus of the ARCC research project indicating the position of pollen coring sites, the archaeological survey and the National Park boundaries

Palaeoecology

The palaeoecological component of ARCC will analyse a range of palaeoenvironmental proxies including pollen (Fig 2), charcoal, geochemistry, fungal spores, macrofossils, phytoliths and testate amoebae from a series of sediment cores from the Serengeti region to document past environmental changes with high spatial and temporal resolution. A number of cores derived from the area (Fig. 2) are already under analysis, with preliminary results indicating significant change throughout the past 1,000 years (Fig. 4).

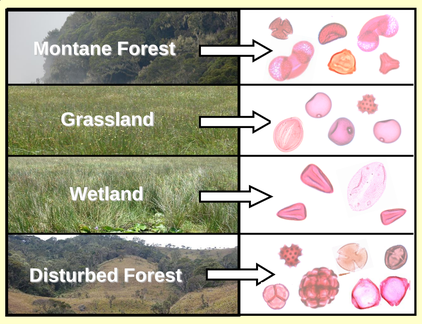
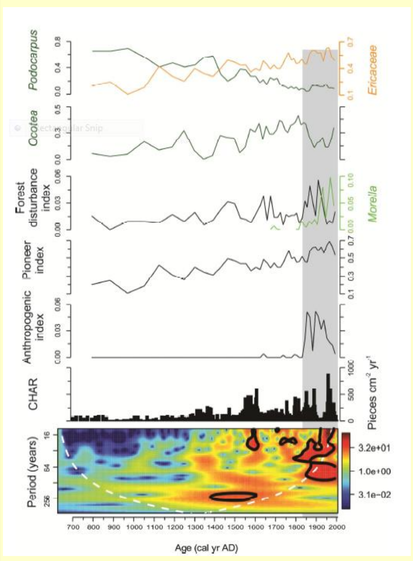


Fig. 2. Conceptual diagram indicating the direct relationship between plant communities and the pollen grains they produce.



While the focus is on pollen analysis, other proxies such as charcoal provide important additional information. For example, regarding local fire regimes in the area of interest. Charcoal results from the Pare Mountains show that fire has been important in creating and maintaining open high altitude forest throughout the past ~700 years.

Fig. 3. Pollen diagram from Dama Swamp on the western extent of the Eastern Arc.

Interpretation of past/present vegetation

Historical Ecology

The analysis of biogeographical patterns combined with archaeological and historical data and the palaeoecology, will provide an overview or broader landscape change across the ARCC study region (Fig. 4),

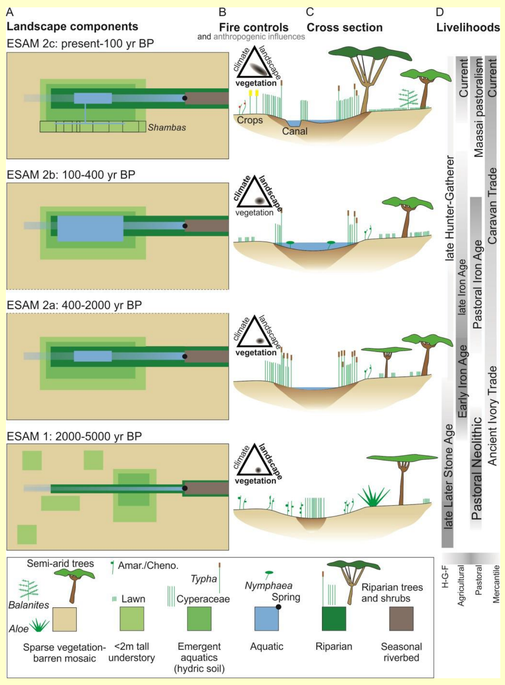
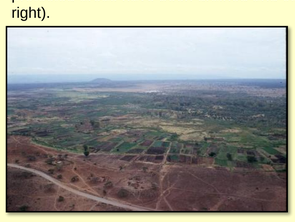


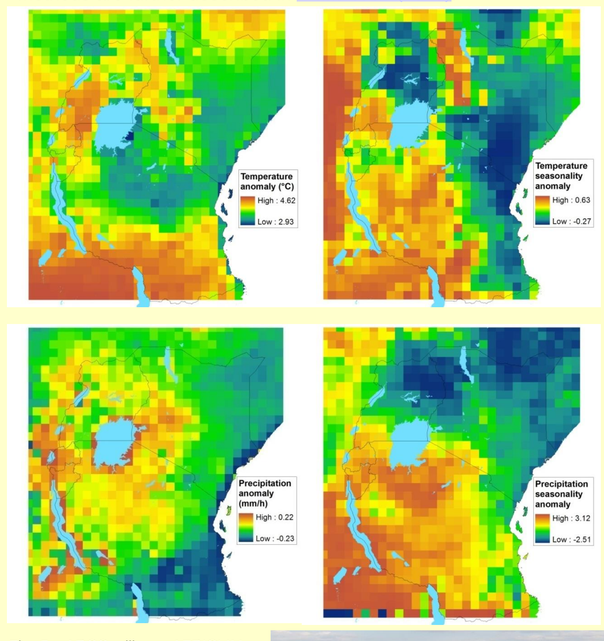
Fig. 4. The whole-scale removal of elephants from the East African landscape, particularly over the past four centuries, will have had a transformative impact on savanna structure and composition. Current land use transformations are similarly having a large impact on swamps (below left). Inside protected areas, these provide a key grazing resource, particularly vital during dry seasons that are becoming increasingly severe and prolonged. In stark contrast, wetlands just outside the protected areas have been drained and converted to agricultural production (below right).



Comparing biogeographical patterns across ecological scales

Modelling Future Climates

ARCC will use the AFRICLIM high-resolution ensemble climate projections for Africa. The database spans ten general circulation models (GCMs), downscaled using five regional climate models (RCMs) and four contemporary baselines, under two representative concentration pathways of the IPCC-AR5 (RCP4.5 and RCP8.5). Methods are further described in Platts et al. (2015).



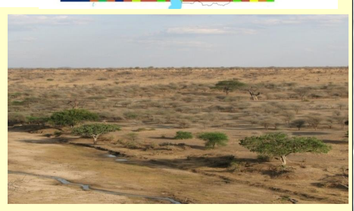


Fig. 5. ARCC will use AFRICLIM climate forecasts based on the REMO ECHAM5 model. Anomalies were calculated for the control and RCP 4.5 emission scenario and the time periods 1981-2000 and 2081-2100, respectively. The spatial database includes monthly grids of temperature and rainfall, and derived bioclimatic summary variables such as moisture indices and dry season length. Changes in the dry season are predicted to be most acute in the future and indeed it is dry season length and intensity that are key factors in the ARCC study areas as shown for Tarangire National Park (Dry season) Tarangire National Park (Wet season right)

Hind casting: the palaeoecolgical work will provide information on past ecosystem character, yielding a tool for understanding past social climatic interactions

Archaeological and historical data will be used to understand the spatial relationships between people, policy, animals, and the ecosystems: a foundation for social scenario building

Climate modelling work will provide future forecasts that will feed into social scenario building

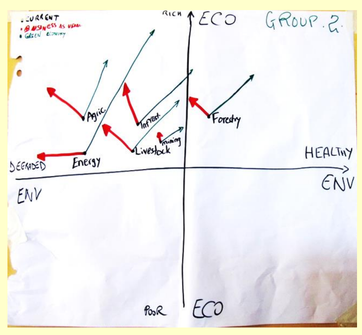


Fig. 6. Participatory scenario planning is a demanding activity, but it provides additional benefits to change the traditional modelling approach by enhancing ownership of the process and output by local stakeholders, and also its legitimacy and relevance by incorporating indigenous knowledge concerning interactions between ecological systems and communities, and by integrating different perspectives from the different stakeholder groups and cultures (e.g. farmers, pastoralists, foragers, conservation groups).

Social Scenario development

Along with population growth and agricultural development, adaptation to climate change is one of the great challenges impacting on livelihoods across East Africa. Scenario approaches are useful in planning future adaptation strategies as they offer the opportunity to consider combinations of change, such as how projected climate change impacts, socio-economic trends, and local production and governance systems interact. As they explore multiple alternatives, scenarios can also account for uncertainty around the future events and the impact of different development pathways. We will apply participatory scenario modelling framework (Fig. 6) to explore potential adaptation strategies to projected climate change in ARCC's study area and their consequences on the landscape and carbon storage (Fig. 7). Local stakeholders drawn from a cross section of society will be engaged in developing scenarios representing how their landscape would look like by mid-21st century if climates change, following AFRICLIM projections (Fig. 5).

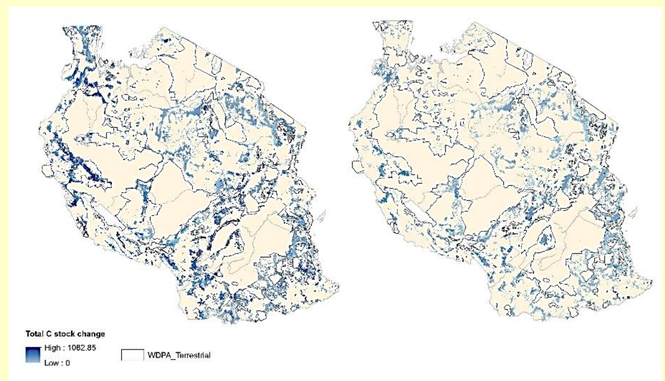


Fig. 7. Predicted changes in Carbon storage across the Tanzanian landscape under a Business as Usual (left) and Green economy (right) future.

Summary The Adaptation & Resilience to Climate Change project will use past societal and ecological trends to examine the use and relationships between people and ecosystem services through time and under different landscape management regimes, to better predict how human-environment-societal-wildlife relationships may respond to future climate change, management interventions and societal use. Focusing in the semi-arid landscapes of the north-western Tanzania we will present a ~300 year environmental history derived from a synthesis of radiocarbon-dated sediment cores from swamps and lakes. Changes in vegetation and charcoal counts are associated with climatic changes, fire activity and anthropogenic activity, much of this associated with the increasing population, partly tied into the caravan trade of the 19th century. Sedentary agriculture has intensified dramatically since the colonial period, a transition accelerated during post-colonial administration. Under the most recent expansion, this has increasingly been focused around the boundaries of protected areas, severely challenging the adaptive capacity of plants, wildlife and the rural communities depending on them. Information from long-term data and diverse perspectives is crucial to facilitating the policy processes and adaptation actions and building resilience and sustainable management of the ecosystems under current and projected future climate change (Fig 8).

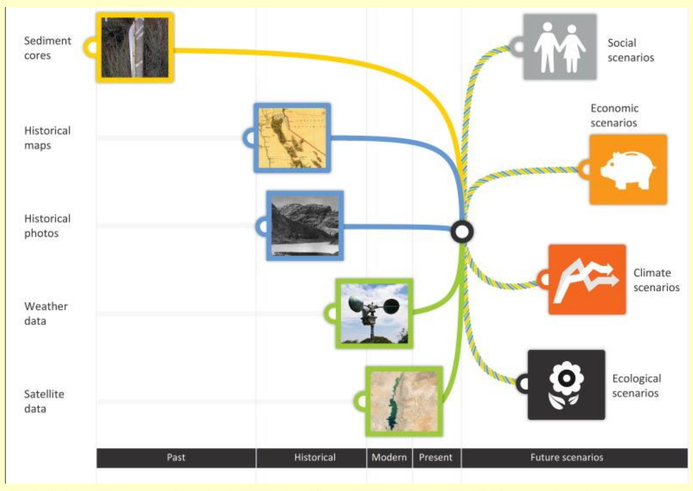


Fig 8. Linkages and areas of overlap between the different components of the ARCC research project

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