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Enhancing resilience in forest ecosystems and adjacent communities in the Eastern Arc Mountains: developing a new social-ecological network model

Network analysis has emerged as a powerful tool for understanding complex social-ecological systems linking humans and natural resources. To date, analyses have quantified either ecological networks people depend on, or social networks that impact ecosystems; neither captures the integrated system. This research aims to fill this methodological gap by developing a multi-layer network model, making the complexity tractable to analysis. The model will be based on the case study of 20 forest-adjacent communities surrounding Amani Nature Reserve, Tanzania - protected water catchment and biodiversity hotspot. Provisioning ecosystem services and knowledge connections will be examined at both the macro- and micro-scale.

Water is a vital provisioning ecosystem service for people in the East Usambara mountain catchment and downstream towns. Currently, funding associated with this PhD limits the level of detail of assessment of ecosystem services to timber and non-timber forest products. This funding would add value to the research by providing additional field time to incorporate water as a network link between people and Amani Nature Reserve. Although recognised as a priority within the reserve management plan, how people use water is given little consideration. This funding would provide data to improve water catchment management and enhance the social-ecological network model.

This project aims to develop empirical insights in relation to current and future abilities of social-ecological systems in the Eastern Arc Mountains of Tanzania to remain resilient.

The current research methodology involves gathering data for 3 types of network analyses, as shown in the below objectives:

1. Using Ecological Network Analysis construct and analyse a network that links species used as forest provisioning ecosystem goods and services and species of high conservation value.
2. Using Social Network Analysis construct and analyse a multi-level network at two levels (individual and group) and in relation to two aspects (resource use and knowledge/learning).
3. Using Multilayer Network Analysis construct and analyse the Social-Ecological Network.
4. Explore qualitatively network structures and context to understand how knowledge/learning and access to ecosystem goods and services link self-organising processes that can lead to resilience.

This funding will pay for additional field time to extend the above network analyses to include water as a provisioning ecosystem service alongside those derived directly from the forest. With respect to objective 1, specific wetlands, watercourses and water-dependent species will be included as network nodes through ecological survey. This is particularly important as it will cover 15 species of endemic amphibians. In relation to objective 2, groups with specific water-resource interest will be included as nodes in the socio-centric macro-level social network. This would be of value in terms of catchment forest protection stakeholders since the 1980s and current hydropower and water resource stakeholders today. The funding will enhance objective 3 by allowing mapping of the network links between people and the water sources and water-dependent species, through inclusion in household-level questionnaires. The questionnaires/semi-structured interviews will be extended to include consideration of how knowledge/learning and access to water has shaped the development of network structures, enhancing objective 4.

This project represents a major innovation in the quantitative assessment of resilience in complex social-ecological systems. There have been numerous calls for multi-level and multi-scale analysis in conceptual frameworks (e.g. Cash et al., 2006; Liu et al., 2007; Ostrom, 2009). The tools to do this have been notably lacking. However multilayer network analysis, a new frontier in complex network theory (e.g. Boccaletti et al., 2014; Kivelä et al., 2014), offers a new methodology that can fill this gap. Local ecosystem management impacts lie in improved biodiversity, environmental justice, communication and social-ecological resilience due to new data on the connections between nature and people.