Resilient Landscapes and Livelihoods Through Better Conservation Planning

Proposal for Boise State Hazard and Climate Resilience Institute Research Grant

Matt Clark

2021-03-01

Executive Summary

Biodiversity buffers ecosystems and human communities against the worsening impacts of climate change. Despite decades of effort into conservation, global biodiversity loss is still a critical problem. Interventions that work in one place are abandoned in others, or worse, harm local communities. This project will combine empirical data collection with simulation modeling to study how feedbacks between the natural and social systems impact conservation.

This work will advance the HCRI Natural Environment and Economy & Society pillars by providing a roadmap for conservation planning in complex social-ecological landscapes while considering the local economic viability of intervention strategies. The aim of this project is to produce land use simulations demonstrating the viability of two conservation paradigms in our study system, Pemba Island, Tanzania. Pemba Island serves as an ideal place to study the factors driving conservation success due to the biological variation across the island and its history of both international and community-based conservation interventions. Simulations will be informed using interviews with local community members and insights from conservation social science.

To apply project insights locally, we are collaborating with Community Forests Pemba, a nonprofit organization focused on climate resilience through sustainable agroforestry. We will produce an interactive dashboard which will visualize how alternative conservation scenarios will impact the environment and local communities. Following completion of this dashboard, we will host a workshop with Community Forests Pemba to demonstrate how simulation results can directly inform future conservation planning.

This scholarly work will build upon ongoing research in Pemba by the Max Planck Institute for Evolutionary Anthropology. Thus, funding this project will support international and cross-disciplinary collaboration, produce an interactive, public-facing dashboard, improve the conservation capacity of Community Forests Pemba, and support the published dissertation work of one Ecology, Evolution, & Behavior PhD student at Boise State University.

Project Team

Matt Clark, doctoral student - Boise State University, Human-Environment Systems

This project is a major component of Matt's dissertation work. As such, he will be involved with all stages of the project. Matt will travel to Pemba and work with Mbarouk M. Omar and Dr. Jeff Andrews to interview community members involved in conservation projects. Matt will code the land use model and build the web dashboard displaying simulation results. Matt, with the help of Mbarouk M. Omar, will co-lead the workshop presenting the project outcomes.

Vicken Hillis PhD, assistant professor - Boise State University, Human-Environment Systems

Dr. Vicken Hillis will supervise Matt Clark at all stages of this project. Dr. Hillis will oversee the development of the land use model and the publication of the scholarly work. Dr. Hillis is also actively involved with securing additional funding for this project.

Jeff Andrews PhD, postdoctoral researcher - Max Planck Institute for Evolutionary Anthropology

Dr. Jeff Andrews has worked in Pemba since 2017 and will help coordinate on-the-ground logistics for this project. Dr. Andrews will also help with data collection and serve as a co-author on all published work.

Monique Borgerhoff-Mulder PhD, professor - University of California Davis, Anthropology

Dr. Monique Borgerhoff-Mulder has worked in international conservation research for multiple decades. Dr. Borgerhoff-Mulder will advise the production of all scholarly work and ensure that it advances conservation social science. Dr. Borgerhoff-Mulder is also involved with securing additional financial support for this project, and leads our team research visa with Tanzania's Department of Forestry and Nonrenewable Natural Resources.

Mbarouk Mussa Omar, executive director - Community Forests Pemba

Mbarouk Mussa Omar will give logistical support to this project in Pemba. This will include arranging interviews with community members, assigning an employee of Community Forests Pemba to work as a translator, and coordinating help with language study for Matt Clark. Mbarouk Mussa Omar will co-lead the workshop where Matt Clark will present the results of this project to Community Forests Pemba and will make use of the insights for real-world application of our research findings.

Project Narrative

Background and Rationale

Diverse and intact natural landscapes are unequivocally our best insurance policy against the worsening impacts of climate change (1–5). In response, $24 billion is spent on conservation interventions annually (6, 7). These interventions are fundamentally about shaping people's behavior through institutional incentives. Interventions commonly achieve this by directly paying local communities to forgo resources (payments for ecosystem services), or by legally protecting a portion of the landscape (protected areas) (8, 9).

Conservation interventions, while well intentioned, frequently fail to meet both ecological and community development goals (10, 11). Economic and ecological processes are inherently interwoven, creating complex interactions that make conservation outcomes difficult to predict. One area in particular, the Coastal Forests of Eastern Africa biodiversity hotspot, has seen considerable foreign and community-based investment in conservation, yet deforestation and biodiversity loss in the area continue to worsen (12, 13).

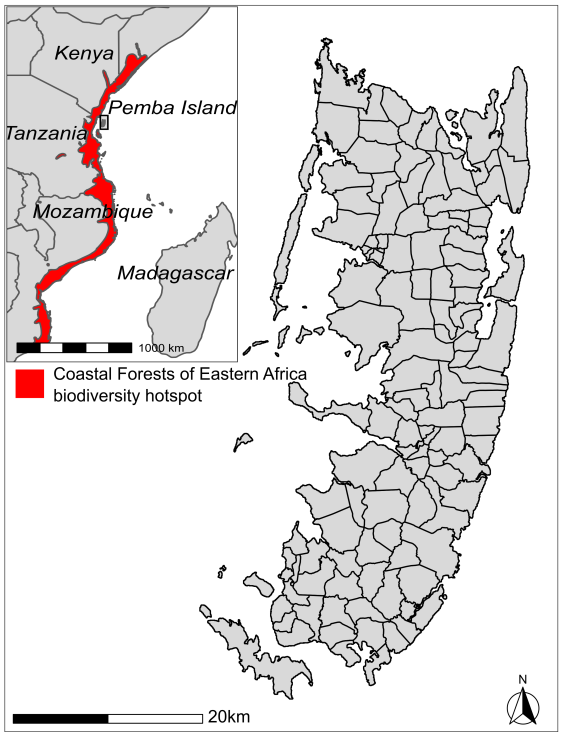

Figure 1: Pemba Island, Tanzania. Black lines show geographic boundaries for 121 distinct communities on the island. Subfigure shows East Africa with the Coastal Forests of Eastern Africa biodiversity hotspot highlighted in red.

This study focuses on Pemba Island, Tanzania, located in the Coastal Forests of Eastern Africa biodiversity hotspot (Figure 1). Deforestation is a perennial issue in Pemba, as the yearly deforestation rate is nearly 2%, and 90% of households rely exclusively on forest products (fuelwood and charcoal) to meet their daily cooking needs (14, 15). As such, Pemba has been subject to a stream of foreign conservation initiatives since the mid 20th century, yet deforestation remains apace. Unfortunately, anecdotal evidence suggests that resentment is mounting amongst residents towards the train of conservation projects that have failed to deliver any sustained economic compensation or ecological benefits. Our collaborative effort will build land use simulations that integrate ecology and economics to demonstrate why conservation and development initiatives have continued to fall short in Pemba, and how we can do better in the future.

This project is in collaboration with the Max Planck Institute for Evolutionary Anthropology, and Community Forests Pemba, a Pemban nonprofit organization established in 2009 with

a mission to conserve and restore Pemba's forests while supporting livelihood development on the island. The organization specifically seeks to build a resilient Pemba, ecologically and economically, with respect to climate change. This effort is mutually beneficial as Community Forests Pemba will facilitate data collection and provide on-the-ground logistical support, while resulting land use simulations will inform future conservation efforts by the organization.

If funded, the project will establish a formal collaboration between the Hazards and Climate Resilience Institute, the Max Planck Institute for Evolutionary Anthropology, Community Forests Pemba, and Boise State Human-Environment Systems. This funding will specifically support the published dissertation work of one Ecology, Evolution, & Behavior PhD student at Boise State, Matt Clark, and will yield an interactive web dashboard displaying all land use simulations described below.

Aims and Objectives

Our project will generate predictions for ecological and economic viability of two common conservation interventions: protected areas and payments for ecosystem services (Table 1).

We will produce two specific deliverables to immediately inform conservation efforts in Pemba.

1. We will create and host an interactive web dashboard to let individuals run our simulations and visualize alternative scenarios to better predict conservation outcomes. This web tool will accompany the scholarly publication of this work to better communicate findings to a broad audience.

2. We will hold a community information and training session with Community Forests Pemba to communicate the findings and implications of this project and to give a live demonstration of the web dashboard described above. This session will be designed to immediately inform ongoing conservation efforts.

Research Methods

Data Collection

All empirical data collection for this project will be in the form of qualitative interviews with local community members. Community Forests Pemba will identify community members who have been subject to a variety of different conservation interventions and rely on each of the four forest types on the island: high tropical rainforest, mangroves, coral rag forest, and agroforestry scrub matrix. Only community members who actively rely on harvesting fuelwood for household needs will be interviewed. Respondents will be compensated for their time (see budget).

With the help of a local translator arranged by Community Forests Pemba, Matt Clark and Dr. Jeff Andrews will conduct structured interviews with each of these community

members. Interviews will consist of a series of scenarios where the respondent is asked how they would modify their fuelwood harvesting strategy based on the environmental and economic conditions of interest. These data will inform how individuals make fuelwood harvesting decisions in our land use simulations in response to changes in the social-ecological landscape.

Modeling

Dr. Vicken Hillis and Dr. Monique Borgerhoff-Mulder will oversee the modeling portion of this project. All model coding will be done by Matt Clark. Simulations, in the form of an agent-based model, will vary features of the natural and social environment, impose three different conservation intervention scenarios on the landscape, and observe how they impact the environment and community access to resources. All variable features are listed in Table 1.

Within this backdrop, simulated individuals will make harvesting decisions about where (protected or not) and how much fuelwood to harvest. Individuals will learn and adjust harvest strategies in response to their environment. Overall, we're interested in how environmental conditions determine the economic impact of interventions, how individuals respond to these impacts, and how community response further shapes their environment.

All simulations will be displayed visually on an interactive dashboard created using the Flexdashboard and R Shiny functionality in the R statistical programming language (16–18). The dashboard will allow users to test all three intervention scenarios and their variations against all described social and ecological starting conditions.

Table 1: Three conservation intervention scenarios to be tested with the proposed land use model.

Intervention	**Scheme**	**Intervention features**	**Environmental features**
No intervention	Baseline comparison. Individuals harvest renewable resources at a rate which matches their household need, regardless of the location on the landscape or harvest rate compared to resource regeneration rate.	N/A	Regrowth rate, Starting degradation
Protected areas	Some portion of the landscape is designated for conservation and resources inside are socially unacceptable to harvest. Resources produced inside the conservation area may spillover to adjacent landscapes. Some individuals may steal resources from the conservation area.	Protected area size	Seed dispersal distance, Regrowth rate, Starting degradation
Payments for ecosystem services	Individuals are incentivised to forgo harvesting resources in return for economic payments. Payments may offset resource collection when individuals previously sold harvested resources, but may fail to change incentive structures when individuals directly depend on resources harvested.	Market value for fuelwood, Payment amount	Market substitutability, Regrowth rate, Starting degradation

Key Implications

Intellectual Merit

Predicting if and how conservation initiatives will evolve has proven to be a major challenge for conservation scientists and practitioners (19). Widely applicable theory around the long-term social viability of conservation projects is sparse (20). Conservation is a complex mix of individual behaviors, informal group-level institutions, and formal interventions. These social features exist on top of underlying variation in the natural environment. Theories from cultural evolution, a field of anthropology, examine the evolution of behaviors generally and may be applicable to conservation (21). Existing cultural evolution theory is highly abstract, offering insights only about nonspecific cooperative behaviors (22, 23). This is problematic as conservation behaviors have behavior-environment feedbacks which are fundamentally different from generic cooperative behaviors. They operate under the sink/source dynamics of renewable, mobile resources as well as variable resource regeneration rates. Specific resources may also be substitutable for other goods on the market or communities may rely on them directly. As such, cultural evolutionary theory must be extended to include these dynamics in order to be effectively applied to conservation.

Broader Impacts

The broader impacts of this research will advance the overall mission of HCRI to build resilient communities by providing methodology and tools to better plan conservation projects for nature and communities as an integrated system, both in Pemba and elsewhere. The project also closely aligns with both the Natural Environment and Economy & Society HRCI pillars in the following ways:

- *Natural Environment* - The work here will provide immediately actionable insights for conservation in Pemba Island and Zanzibar overall. Our community partner, among others, will be provided with the tools to make use of these insights as part of ongoing conservation and community development efforts. More generally, conservation is in need of unifying theory about which kinds of interventions succeed or fail as a result of underlying ecological and social conditions. This research will serve as a foundational building block for conservation science to consider complete social-ecological landscapes moving forward.

- *Economy & Society* - Fuelwood and charcoal are the primary source of energy to 40% of the world's rural poor, producing more renewable energy than solar, wind, and hydroelectric sources combined (24). Conservation may be the key to ensuring continued access to vital resources for communities in an uncertain climatic future, but it may also backfire and disenfranchise communities of much needed resources, especially as the world's most biodiverse areas greatly overlap with the world's poorest communities (9, 25–27). Similar to the pillar above, the work described here will be immediately relevant to better designing conservation projects in our study system, but the implications of the scholarly work are far-reaching. Our simulations will explicitly consider the access to resources by local communities both as an outcome and as a driver of conservation efficacy.

Dissemination Plan

Scholarly results from this project that advance conservation science broadly will be published in a peer-reviewed academic journal. Currently we are targeting *Environmental Modeling and Software*. All model code will be posted on a public GitHub repository and linked to the publication. Before publication we will contribute to open, reproducible science by making our pre-print manuscripts available online using the preprint science repository arXiv.org.

Pemba specific results and the interactive dashboard which will accompany this project will be presented at a workshop with Community Forests Pemba described earlier in this proposal. This workshop is currently planned as an online, remote workshop given budget restrictions and the COVID-19 pandemic. If possible, we would like to host this workshop in-person if conditions change.

Timeline

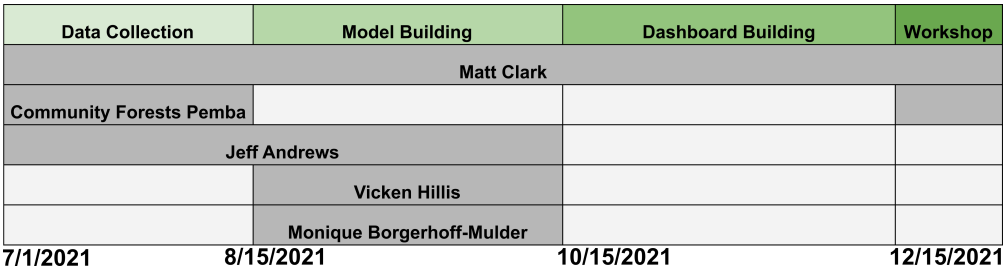

Figure 2: Timeline of proposed research activities and team members involved.

Future Directions

We view the work proposed here as the first step toward a long-term, cross disciplinary collaboration between HCRI, the Max Planck Institute for Evolutionary Anthropology, Community Forests Pemba, and Human-Environment Systems. We hope to establish a research program in Pemba that will create lasting impacts for community members and produce significant scholarly contribution. Future research will seek to collect quantitative data in our system to validate the outcomes of our land use simulations. These data will include biodiversity and land cover data from Pemban forests, as well as community metrics on exposure to conservation interventions and willingness to participate in future interventions. This study system is well positioned to investigate questions from conservation social science and community resilience to climate change. All research will be co-produced with Community Forests Pemba to ensure broader impacts and real-world applicability.

Budget

Table 2: Project budget and justification.

Item	**Amount (USD)**	**Details**
Airfare to Zanzibar	2,500	Air travel round trip for Matt Clark from Boise to Abeid Amani Karume International Airport as of 2/15/2021
Airfare to Pemba	200	Air travel round trip Abeid Amani Karume International Airport to Pemba Airport as of 2/15/2021
Lodging	650	Lodging for Matt Clark at Hill View Guest House, Wete Town, Pemba Island for 50 days @ 13/day.
Field interpreter wage	500	Payment for interpreter to assist with community interviews. Interpreter will be hired from Community Forests Pemba staff.
Swahili tutoring	300	Language tutoring for Matt Clark. Tutor will be coordinated by Community Forests Pemba.
Interview compensation	200	Compensation for community members who participate in qualitative interviews.
Land transportation	300	Transportation in Pemba including gasoline for motorbike and various taxi travel.
TOTAL	4,650	

ABBREVIATED CURRICULUM VITAE

Last updated February 2021

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EDUCATION

Boise State University, Boise, Idaho
Ph.D. in Ecology, Evolution, & Behavior: Human-Environment Systems
Expected graduation: May 2023
GPA 4.0

Boise State University, Boise, Idaho
M.Sc. in Biology: Human-Environment Systems, June 2019
Thesis: *Methodological Advances for Understanding Social Connectivity and Environmental Implications in Multi-Use Landscapes*
GPA 3.8

California State University Chico, Chico, California
B.S. in Ecological, Evolutionary, and Organismal Biology, December 2016
GPA 3.5

PEER REVIEWED PUBLICATIONS

Clark, M., Wilkins, E. J., Dagan, D. T., Powell, R., Sharp, R. L., & Hillis, V. (2019). *Bringing forecasting into the future: Using Google to predict visitation in U.S. national parks*. Journal of Environmental Management, 243, 88–94. https://doi.org/10.1016/j.jenvman.2019.05.006

Clark, M., Hillis, V.. *Network Governance of Natural Resources: Making collaboration count*. (In prep. Manuscript available upon request)

OTHER PUBLICATIONS

Skinner, A., **Clark, M**., Lobo, R., Mahajan, S., De Nardo, M. (2019). *Social Outcomes of the CARE-WWF Alliance in Mozambique: Research Findings from a Decade of Integrated Conservation and Development Programming.* Impact assessment for the CARE-WWF Alliance and the Alliance for Conservation Evidence. *Full report and impact brief available upon request.

Dagan, D., Wheeler, I., Beck, L, Benedetti, A., Blacketer, M., **Clark, M**., McHugh, K., Noss, C., Sizek, J., Wilkins, E., Powell, R., & Sharp, R. *2018 Park break report: Developing a visitation forecasting tool and management recommendations for the Mojave Desert Region NPS Units*. Research report to the National Park Service. *Full report available upon request.

OPEN-SOURCE WEB APPLICATIONS

Clark, M. (2018). National Park Service Visitation Forecast Explorer. http://hillislab.boisestate.edu/GoogleTrendsForecasting/

RECENT CONFERENCE PRESENTATIONS

Clark, M. Computation for Communities and Conservation. Finalist - Boise State Three Minute Thesis Competition 2020. Boise State University. Boise, Idaho.

Clark, M., Hillis, V. Network Governance of Natural Resources: Making collaboration count. 2019. Annual meeting American Association of Geographers. Washington, D.C.

Clark, M., Wilkins, E., Dagan, D., Powell, R., Sharp, R., & Hillis, V.. "Bringing forecasting into the future: Using Google to predict visitation in U.S. National Parks. 2019. Research Computing Days, Boise State University. Boise, Idaho. *2nd place poster, student poster competition.

SELECTED TEACHING EXPERIENCE

Laboratory Instructor **2019 - Present**
Introduction to the Diversity of Life. BIOL 192 - Two sections- Boise State University, ID

Data Carpentry Instructor & Workshop Leader **2019**
R for Social Scientists - Two day workshop - Midwest Big Data Hub, OH

Software Carpentry Instructor & Workshop Leader **2019**
R for Reproducible Scientific Analysis - Two day workshop - New York Academy of Sciences, NY

Software Carpentry Instructor & Workshop Leader **2018**
R for Reproducible Scientific Analysis - Two day workshop - University of Minneapolis, MN

SELECTED PROFESSIONAL EXPERIENCE

World Wildlife Fund **2019**
Quantitative Social Science Intern
Top candidate selected from a nationwide search (U.S.). Responsible for harmonizing and analyzing data from a ten year, flagship CARE-WWF Alliance project in Mozambique. Key research objectives are to explore the food security and wealth impacts of community-managed fisheries, forests and mangrove interventions, using time-series quantitative household surveys.

Boise State R User's Group **2017 - Present**
Founder and Manager
I founded the Boise State R User's Group to bring together statistical computing expertise at Boise State and create a collaborative environment for undergraduates, graduate students, and faculty to further develop the necessary skills to succeed in the scientific arena. Brought in over $800 of outside funding. Created an online open-source repository for others to access R tutorials. Brought in outside speakers on a bi-weekly basis to provide tutorials on novel content

George Wright Society & National Park Service Park Break **2018**
Graduate Student Participant
One of 10 graduate students selected nationwide to travel to Joshua Tree National Park on behalf of the George Wright Society to help manage and forecast increased visitor use. Primary quantitative researcher on the team. Developed a Bayesian forecasting model to predict park visitation. Developed an interactive web application to assist park managers in park planning

Forest Restoration Research Unit, Chiang Mai University **2016**
Forest Restoration Intern
Worked with local Hmong villages to build community support for non-timber forest products and local reforestation projects. Developed educational workshops for up to 50 visiting students. Primary team statistician, analyzed and presented data using R software. Organized collaborative reforestation site maintenance with local peoples and university researchers.

MENTORSHIP EXPERIENCE

Graduate Student Mentor - Boise State Vertically Integrated Projects **2020**
Financial Impacts of Wildfire Smoke on the National Park Service

Graduate Student Mentor - Boise State Vertically Integrated Projects **2020**
Assessing Fuel Efficiency of Improved Cookstoves in Rural Tanzania

Community Forests Pemba (CFP)
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P.O. Box 177, Wete, Pemba
Zanzibar – Tanzania
Tel/Fax: +255 777 427450
E-mail: cfp@forestsinternational.org
Website: www.forestspemba.org
Facebook: Community Forests Pemba (CFP)

CFP/COMM/VOL.2/6/2/2021

26th February, 2021

To whom it may concern,

RE: RECOMMENDATION LETTER FOR MATTEW CLACK PHD STUDENTS

Community Forests Pemba (CFP) is local registered Organization in Zanzibar

CFP is working to support Zanzibar community on Environmental issues and fighting against Climate Change (CC)

If the project Resilient Landscapes and LivelihoodsThrough Better Conservation Planning led by Matthew Clark is funded by the Hazards and ClimateResilience Institute at Boise State University, we agree to participate as described in the proposal text.

We believe that the results of this project will provide valuable insight for conservation planning in Pemba and ask that you please strongly consider this research for funding.

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Mbarouk Mussa Omar
Executive Director
Community Forests Pemba (CFP)
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skype: mbaroukmussa

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References

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2. M. Loreau*et al.*, Biodiversity and ecosystem functioning: Current knowledge and future challenges. *science* **294**, 804–808 (2001).

3. T. H. Oliver*et al.*, Biodiversity and resilience of ecosystem functions. *Trends in ecology & evolution* **30**, 673–684 (2015).

4. F. Lloret, A. Escudero, J. M. Iriondo, J. Martinez-Vilalta, F. Valladares, Extreme climatic events and vegetation: The role of stabilizing processes. *Global Change Biology* **18**, 797–805 (2012).

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6. A. Waldron*et al.*, Protecting 30% of the planet for nature: Costs, benefits and economic implications (2020).

7. A. Waldron*et al.*, Reductions in global biodiversity loss predicted from conservation spending. *Nature* **551**, 364–367 (2017).

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