TROPICAL RESOURCES

THE BULLETIN OF THE YALE TROPICAL RESOURCES INSTITUTE
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Transformation of heirloom rice harvest practices
Crisis-inspired urban agriculture in Cuba
Spatial patterns of coral reef grazing
Peanut contamination in Northern Ghana
Reforestation of cattle ranching landscapes

Yale SCHOOL OF FORESTRY & ENVIRONMENTAL STUDIES

TROPICAL RESOURCES

The Bulletin of the Yale Tropical Resources Institute

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The Bulletin

Please access the 2017 Bulletin at http://tri.yale.edu/tropical-resources-bulletin in order to view maps, graphs, photographs, and figures in color.
All figures used in these articles are the authors' own unless otherwise indicated.

About TRI

Mission

The Mission of the Tropical Resources Institute is to support interdisciplinary, problem oriented, and applied research on the most complex challenges confronting the management of tropical resources worldwide. Lasting solutions will be achieved through the integration of social and economic needs with ecological realities, the strengthening of local institutions in collaborative relationships with international networks, the transfer of knowledge and skills among local, national, and international actors, and the training and education of a cadre of future environmental leaders.

The problems surrounding the management of tropical resources are rapidly increasing in complexity, while demands on those resources are expanding exponentially. Emerging structures of global environmental governance and local conflicts over land use require new strategies and leaders who are able to function across a diversity of disciplines and sectors and at multiple scales. The Tropical Resources Institute seeks to train students to be leaders in this new era, leveraging resources, knowledge, and expertise among governments, scientists, NGOs, and communities to provide the information and tools this new generation will require to equitably address the challenges ahead.

TRI News

TRI Program Officer: Devon Parish

We are sad to see Devon leave TRI. She has been a tremendous help for the last two years and are hugely grateful. We wish her the best for her future.

New TRI website!

We are excited to announce the new TRI website and web address (tri.yale.edu). We will gradually populate this new site with previous fellows and other background information.

Publications

We are building a database of all publications resulting from TRI support. If you are a previous TRI Fellow, and published *anything* resulting from your fellowship research (journal article, book, popular press article, webpage, report, …), please let us know at tri@yale.edu.

The Burch Prize 2017

The William R. Burch Prize is named in honor of the influential founding director of TRI. The $1,000 prize, generously funded by TRI alumni, is awarded annually to the paper written by a TRI Fellow published in *Tropical Resources* that best reflects Bill's visionary interdisciplinary leadership of TRI, as well as the mission of TRI: to support interdisciplinary, problem-oriented student research on the most complex challenges confronting the conservation and management of tropical environments and natural resources worldwide.

Abdul Majeed Ibrahim is awarded 2017 Burch Prize

The Yale Tropical Resources Institute is proud to announce that the 2017 Burch Prize is awarded to Abdul Majeed Ibrahim for his paper *Peanuts and aflatoxin contamination in northern Ghana: Women's local knowledge and practices*. His article addresses the important role of contamination of staple foodstuffs in Africa, and how the social aspects of rural life affect the incidence and spread of the fungi responsible. A combination of science and local knowledge to resolve this issue seems clear. The role of F&ES and TRI is to seek solutions to these seemingly intractable problems.

A Word from the Director

In this volume (Vol. 36) of *Tropical Resources*, we present the research of eight TRI Fellows who conducted fieldwork in 2015 or 2016. Fieldwork was conducted in the tropics of the Americas, Africa, and Asia, ranging from marine studies of grazing to urban agriculture.

First, Bart DiFiore (MESc) examines how predators might influence herbivores to change their behavior and graze in different locations, comparing fished and unfished areas of coral reef in Belize.

Second, Samantha Garvin (MESc) documents the conflicts between humans and wildlife in a region of Botswana that has a higher population density of elephants than people. She recommends a more interactive and integrative approach to enable coexistence between large herbivores and various human stakeholders.

Third, Sam Geldin (MESc) examines the stories told by and about conservation and development projects and how they can inhibit cooperation between actors and the establishment of best practice. He recommends more transparent and evidence-based impact assessments, as well as incentives for institutions to collaborate and not compete.

Fourth, Abdul-Majeed (MEM) details the problems of contamination of crops and dissemination of scientific knowledge to help this contamination in rural smallholder farming communities. He documents current practices to deal with fungal contamination of peanuts, and recommends several interventions that would help, as well as how they might be implemented.

Fifth, Tess McNamara (MArch, MEM) investigates urban agriculture in Cuba, where isolation from the U.S. and the collapse of the U.S.S.R. led to the urgent need to feed its' population. Tess highlights unique factors of the Cuban situation, as well as making recommendations that can be applied in other countries.

Sixth, Sarah Sax (MESc) visits a community in the Peruvian Amazon to understand the issues of cultivating oil palm, and how laws, economics, and history collide to contribute to environmental injustice.

Seventh, Adrian Salazar (MEM) describes the transformation of rice-growing communities in the Philippines and how the cultivation of heirloom varieties of rice can be encouraged and developed as a way to conserve culture and the environment.

Finally, Veronica Chang (MEM) reports on an experimental reforestation project in the dry Azuero Peninsula of Panama, finding that some native species may well be suitable candidates for timber plantations and agroforestry systems.

In all these studies, the interactions between humans and humans, and humans and their environment, is key to the success or otherwise of conservation and development, and increasing the sustainability of communities throughout the tropics.

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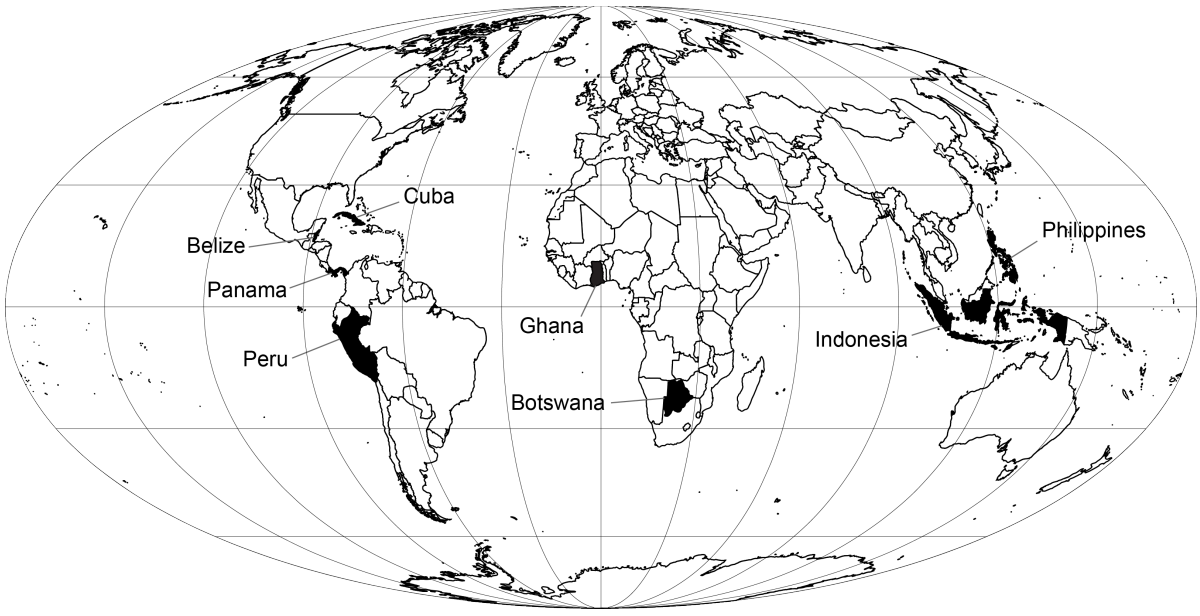
TRI Fellows research sites represented in this issue



Belize: Bart DiFiore

Botswana: Sam Garvin

Panama: Veronica Chang

Indonesia: Sam Geldin

Ghana: Abdul-Majeed Ibrahim

Cuba: Tess McNamara

Philippines: Adrien Salazar

Peru: Sarah Sax

DiFiore, B. 2017. Spatial patterns of grazing near patch reefs in Belize: Satellite and *in situ* metrics. *Tropical Resources* **36**, 1–8.

Spatial patterns of grazing near patch reefs in Belize: Satellite and *in situ* metrics

Bartholomew DiFiore, MESc[*]

Abstract

Grazing halos—barren areas of sand that surround coral patch reefs in otherwise continuous seagrass plains—form due to predator avoidance by herbivorous fish and echinoderms that preferentially graze seagrasses close to the safety of the reef structure. Grazing halos are readily visible from satellite and aerial imagery and halo size may be indicative of local predator abundance. This study analyzed grazing patterns in the South Water Caye Marine Reserve (Belize) using remote sensing techniques and field surveys. Eight patch reefs were analyzed within a no-take conservation zone and fished zones. At each patch reef herbivore behavior was determined using grazing assays deployed along transects from the reef edge, while metrics of grazing halo extent were determined using satellite imagery. Grazing pressure was found to decrease with distance from the reef refuge. Furthermore, grazing was greater in no-take areas and decreased more rapidly with distance from the reef edge when compared to similar fished sites. Grazing in situ was significantly higher inside of grazing halos when compared to outside halos. On average, 92.4±12 % of the grazing that did occur was located inside of the halo boundary. This study provides novel evidence of differences in the spatial pattern of grazing between protected and fished sites. It also provides direct support for the efficacy of using satellite imagery to monitor grazing patterns at patch reefs.

Halos de pastoreo ('grazing halos') son zonas de arenas descubiertas que rodean parches de arrecifes coralinos en medio de praderas de hiervas marinas. Estos halos se forman por la herbívora de peces y equinodermos que usan los arrecifes para refugiarse de los depredadores y se alimentan de las hiervas marinas, cercanas a los arrecifes. Los halos de pastoreo son fáciles de reconocer a partir de imágenes satelitales y fotografías aéreas, y su tamaño puede correlacionarse con la abundancia de depredadores. Este estudio analizó patrones de pastoreo en halos localizados en la Reserva Marina de South Water Caye (Belice) utilizando técnicas de detección remota y verificación en campo. Se estudiaron ocho parches de arrecifes localizados en una zona de conservación que incluye áreas de pesca libre y áreas de pesca restringida. En cada parche se determinó la intensidad de la herbivoría utilizando transectos de pastoreo desde el borde del arrecife, y el tamaño de los halos fue determinado mediante imágenes satelitales. Se encontró que el pastoreo disminuye a medida que la distancia desde el arrecife incrementa. Además, el pastoreo fue mayor en las áreas con pesca restringida y disminuyo más rápidamente con relación a la distancia desde el arrecife, que en sitios sin restricciones de pesca. El pastoreo in situ fue significativamente mayor dentro de los halos que al exterior de estos. En promedio, 92,4±12% del pastoreo se localizo dentro del perímetro de halo. Este estudio proporciona nuevas evidencias sobre los patrones espacial de pastoreo entre sitios de pesca y con pesca restringida en halos de pastoreo. También demuestra la eficacia de imágenes satelitales para estudiar los patrones de pastoreo en los parches de arrecifes.

[*]Bart DiFiore is a second year Master of Environmental Science candidate at the Yale School of Forestry and Environmental Studies. He is from the coastal town of Gloucester, Massachusetts, and holds BA degrees in English and Biology from Middlebury College. His research focuses on the factors that drive the spatial distribution of grazing at coral patch reefs. He will be starting a PhD in marine ecology at the University of California Santa Barbara in 2017.

Introduction

Grazing zones are conspicuous features of the coral reef landscape and can be found throughout the back reef lagoons of coral reefs in Australia, the Caribbean, Indonesia, and the Red Sea. Grazing zones are denuded substrate surrounding patch reefs in shallow waters formed as a result of herbivores foraging close to the protection of the patch reef (Randall 1965, Ogden et al. 1973). Due to their appearance when viewed in areal or satellite imagery (Fig. 1), researchers often call these zones grazing "halos" (Ogden et al. 1973). Despite their ubiquity, the factors that control grazing zone size are largely unknown. Researchers generally accept that grazing halos represent a behavioral response of herbivores to the risk of predation (Valentine et al. 2007, Madin et al. 2011, Downie et al. 2013), but there is little empirical evidence confirming this hypothesis. Theoretically, grazing distance must represent some tradeoff between competition amongst herbivores, the risk of predation, and the quality of the refuge habitat.

Recently, Madin et al. (2011) proposed the use of satellite imagery to indirectly estimate local predator abundances based on the size and extent of grazing halos. If possible, this method would allow managers to remotely monitor predator abundances in hard to access coral reef environments using only satellite metrics. To test such a methodology, however, it is first necessary to confirm the relationship between satellite-derived measures of grazing halo extent and grazing by herbivores in situ.

Herbivory is a critical in maintaining the balance between hard coral and macroalgae substrate in coral reef ecosystems (Adam et al. 2015). Quantifying herbivory has been one of the long-standing aims of coral reef research. Yet very few studies have examined the spatial distribution of grazing in relation to isolated, refuge habitats; the few studies that do often only quantify grazing at a limited number of discrete distances (Valentine et al. 2007, 2008, Downie et al. 2013), and not at higher resolutions closer to the refuge (Ogden et al. 1973, Madin et al. 2011, for exceptions). This study sought to quantify herbivory throughout grazing halos surrounding patch reefs in Belize. Specifically, we attempted to address two questions:

1. How does grazing vary with distance from the reef refuge? Does this relationship change inside and outside of the no-take conservation zone?

2. Can satellite images be used to accurately quantify grazing patterns near patch reefs?

This analysis represents a portion of the author's broader study that examines how fish community structure and refuge quality affects grazing distance.

Methods

Study site

This study was conducted at the Smithsonian Institution's field station, Carrie Bow Caye, Belize (16°48.154' N, 88°4.915' W), a small islet located 20 km southeast of Dangriga, Belize, on the seaward edge of the Meso-American Barrier Reef. The station is situated within the Southwater Caye Marine Reserve that was established in 1996 as a Belize Barrier Reef Reserve System World Heritage Site. In

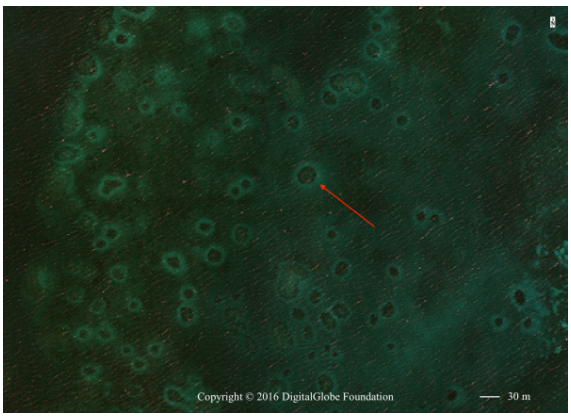


Fig. 1. Image of patch reefs and surrounding grazing halos in the South Water Caye Marine Reserve, Belize. Red arrow points to a grazing halo.

2009 Belizean managers implemented a no-take conservation zone that prohibits commercial fishing over the northwest portion of the Southwater Reserve (Fig. 2). The reserve's lagoon ranges from 1–20 m in depth and consists of sand flats and seagrass plains (predominantly *Thallasia testudinum* Banks ex König [Hydrocharitaceae]), punctuated by numerous patch reefs of various size (>5 m² to <1 km²). The patch reefs vary from low-relief rubble aggregates dominated by gorgonian fan corals, to highly complex reef structures dominated by branching and massive coral types.

We conducted fieldwork on eight patch reefs, two inside of the conservation, no take zone, and six within fished portions of the broader marine reserve. We selected shallow water patch reefs based on the continuity of grazing halos, accessibility, and depth (<7 m). We conducted all fieldwork using mask, snorkel and fins in June, 2017.

Grazing assays

We assessed the distance herbivorous fish and echinoderms grazed from the reef edge using grazing assays similar to those conducted in Hay et al. (1981), Madin et al. (2011), and Valentine et al. (2007). We controlled for variation in seagrass nutritional quality by collecting *T. testudinum* blades from seagrass beds near each patch reef. Each seagrass blade was cut to 7 cm, photographed, clipped to weighted clothespins, and deployed immediately along three randomized transects extending from the reef edge, with two clips placed every 2 m from 0–20 m. We re-photographed each blade after 24 hours and calculated the loss in blade area by comparing blade area before and after deployment using ImageJ software (Schneider et al. 2012).

Satellite-derived metrics of grazing

Using satellite imagery we calculated the halo extent for each grazing zone as the average distance from the patch edge to the edge of the grazing halo. Using ArcGIS, we manually delineated reef edges and halos, converted the shapefiles to densified point clouds, and calculated the average minimum distance from the reef to the halo edge. Grazing halos can appear diffuse or noncontiguous in the satellite imagery. We approximated the outside of the halo as the line of maximum transition from sand to seagrass, connecting between definitive points if the halo was not continuous. We determined halo dimensions for 7 of 8 patches using a high-resolution image captured by the GeoEye-1 sensor in 2015. Clouds obscured the remaining patch and we analyzed the halo using a 2009 World View 2 scene. All imagery was provided by the DigitalGlobe Foundation.

In order to validate the spectral signature of grazing, we took photos of a 0.25 m² quadrat laid on the substrate along transects extending from the patch edge. We analyzed the photos using Coral Point Count software (Kohler and Gill 2006) and determined seagrass percent cover with distance from the patch. The analysis of substrate photographs is ongoing and only one patch reef has been completed.

Data analysis

Prior to analysis of the grazing data we visually inspected each blade for evidence of bites, and we only allowed blades with obvious signs of grazing to present a change in area. Variation in unbitten blade size before and after deployment was low (2–4%), and we attributed it to inaccuracies in the blade image analysis. A pair of blades at each distance along a transect was treated as the sampling unit (n = 252). We calculated the proportion grazed (Y_{graze}) as:

$$Y_{graze} = \frac{(BladeA_0 + BladeB_0) - (BladeA_1 + BladeB_1)}{(BladeA_0 + BladeB_0)}, \quad (1)$$

where $BladeA$ and $BladeB$ are the blade areas, at time$_0$ (before placing out in the transects) and time$_1$ (following collection).

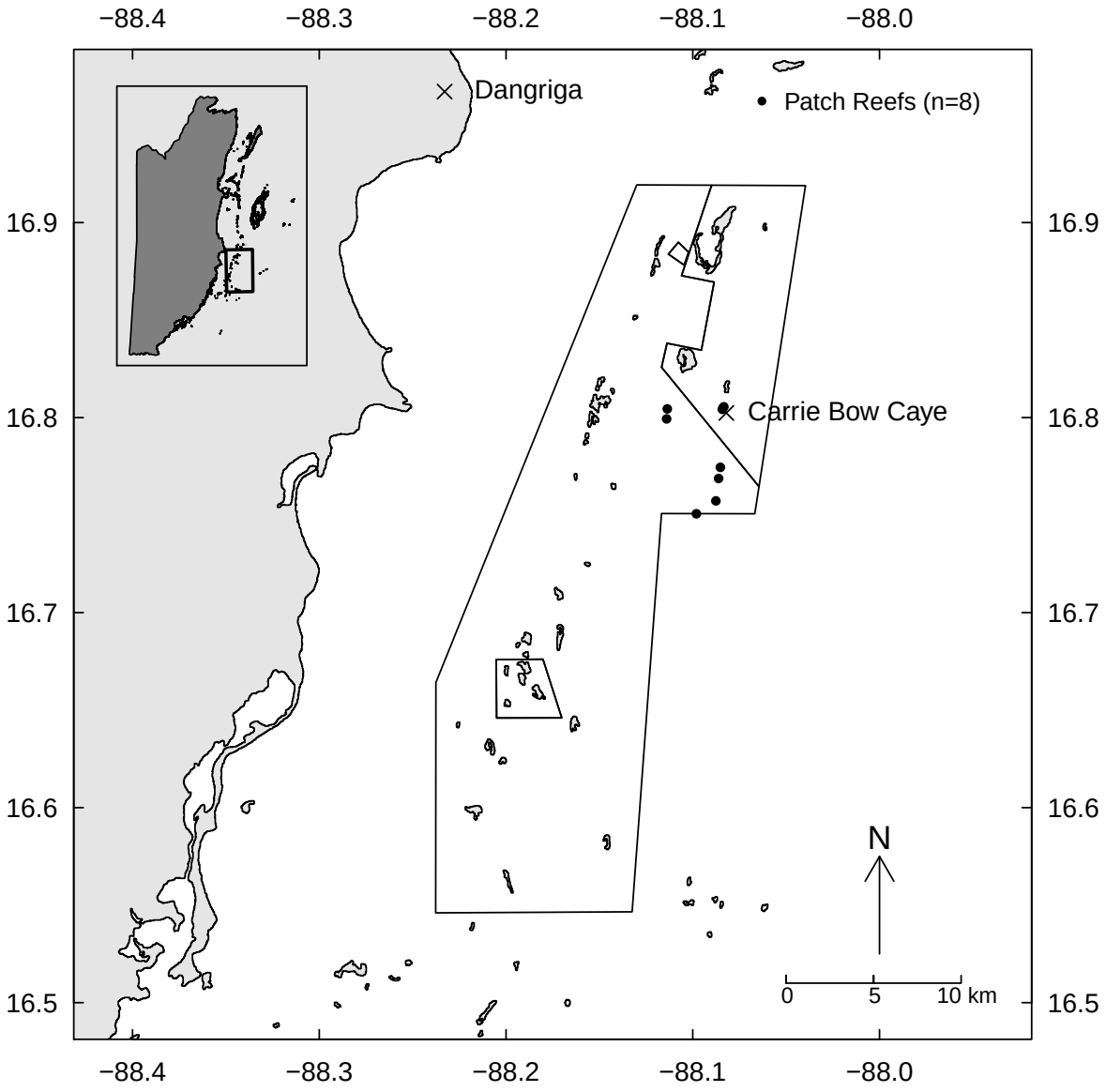


Fig. 2. Map of the South Water Caye Reserve with various protection zones. Red arrow points to Smithsonian Marine Station at Carrie Bow Caye.

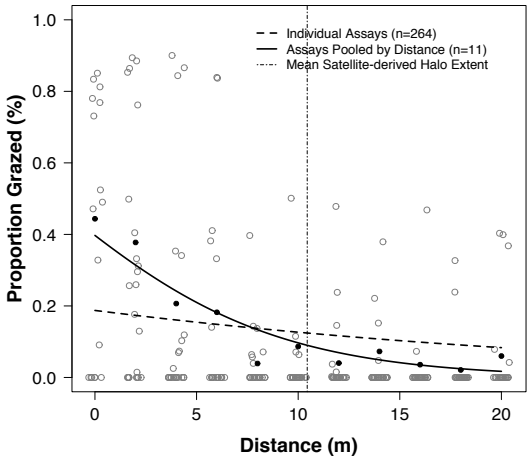


Fig. 3. Changes in grazing pressure with distance from patch reef refuges in the South Water Caye Marine Reserve in Belize. Grazing is represented as the proportional area of seagrass blades consumed during a 24-hour deployment. Pooled data represent the proportion grazed across all transects and patch reefs. Data was modeled using beta regression and all models were significant ($p < 0.01$). The mean satellite derived halo-extent was the averaged estimate of grazing halo width (m) at 7 of 8 patch reefs. One was excluded because the halo was not discernable.

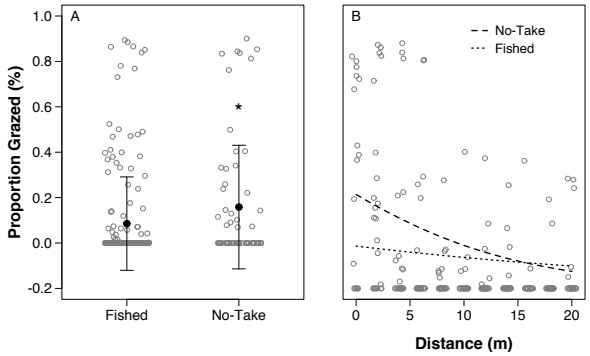


Fig. 4. Differences in the mean grazing proportion for assays in fished and no-take sites (A; Mann-Whitney Test, $W = 6872.5$, $p < 0.05$). B) Differences in the spatial patterns of herbivory at fished and no-take sites modeled using beta regression. The overall amount and pattern in grazing differed significantly with grazing declining faster in no-take areas ($p < 0.001$).

The data were zero-inflated due to the large number of assays that were not grazed. We used both linear regression with logit transformations and logit beta regression to analyze the relationships between grazing, distance, and protection status. Due to the non-normal distribution of the data even with a logit transformation, beta regression of the non-binomial proportion data seemed the best methodology available. We used Mann-Whitney tests to see if there was a difference in the mean grazing proportion between no-take and fished sites. All statistics were computed in R version 3.3.1 (R Development Core Team, 2013).

In order to test the accuracy of using satellite images to monitor grazing patterns, we thresholded the grazing at each patch to the satellite-derived measure of mean halo extent for that patch. Then we calculated the proportion of the change in blade area both inside and outside of the halo boundary. We used Wilcoxon signed rank tests to determine differences in mean in situ grazing in relation to the halo boundary. One patch reef was dropped from the analysis as the halo was indiscernible in satellite imagery. To confirm the efficacy of the satellite images in sensing change in seagrass coverage across the halo zone, we used linear regression to test for differences in satellite reflectance and seagrass cover.

Results

Across all patches, herbivores grazed 10.3±22.5 % (mean±SD) of the area of each deployed assay ($n = 262$) and 31.8% of assays had evidence of grazing. We did find distinct patterns in the spatial distribution of grazing with more than 50% of grazing occurring within 2 m of the reef edge and 85% occurring within 10 m. Using beta regression models, we found that grazing decreased significantly with distance (Fig. 3). The relationship was different depending on if the data were treated as individual assays (pseudo $R^2 = 0.16$, $p < 0.001$) or pooled as

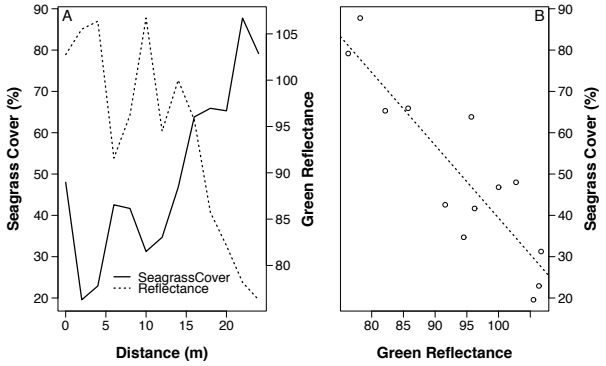


Fig. 5. A) Patterns in seagrass coverage and satellite reflectance in the green band along the same transect extending from the reef edge. B) Reflectance was negatively correlated with seagrass coverage (linear regression, R2 = 0.78, p < 0.001).

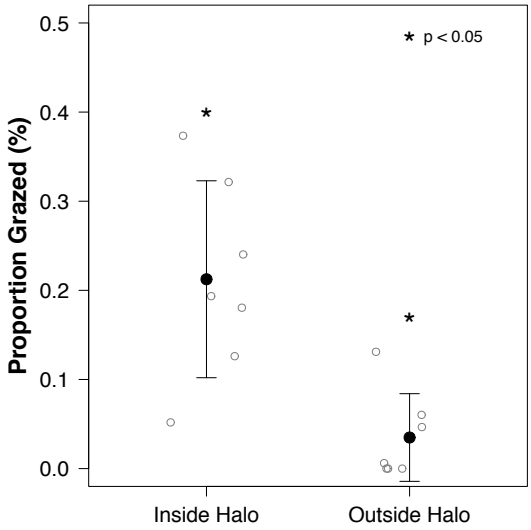


Fig. 6. Differences in the proportion of grazed blade area inside and outside of the satellite-derived measure of grazing halo extent. Grazing was significantly higher within the boundary of each patch's respective halo (paired Wilcoxon signed-rank test, W = 28, p = 0.02). Ninety-five percent of the grazing that did occur happened within the halo boundary as predicted from satellite imagery.

the proportion of grazed blade area at each distance (pseudo R^2 = 0.73, p <0.001). Simple logit regression of the individual assays did not find a significant negative relationship between grazing and distance (p = 0.29), but the logit transformation did not normalize the data's distribution.

Grazing differed significantly between the no-take patches and nearby, similar fished patches (Fig. 4A). Of the area of seagrass deployed, 17.7% was grazed in no-take areas, while 11.6% was grazed in fished zones. Herbivory was more intense closer to the reef edge and declined faster than fished patches (Fig. 4B).

Our initial evaluation of seagrass coverage throughout the grazing halo has revealed that seagrass coverage increases with distance from the reef edge while satellite reflectance values decline along the same transect at one patch reef (Fig. 5a) Seagrass coverage and reflectance were negatively related (Fig. 5b; linear regression, R^2 = 0.78, p < 0.001). When the grazing results at each patch were categorized as either "inside" or "outside" of that patch's respective mean grazing halo width (satellite-derived), we found that the proportion grazed inside (21.2±11%) was significantly greater than the portion grazed outside (3.5±5%) of the halo threshold (Fig. 6). Of the grazing that did occur, on average 92.4 % occurred within the halo boundary, as compared to only 7.6% outside of the boundary.

Discussion

Herbivory is a critical, top-down driver of heterogeneity in biogenic habitats including coral reefs (McClanahan et al. 2011) and seagrasses (Heithaus et al. 2012). Despite its importance, the preponderance of research has focused on herbivory within the reef structure itself, rather than as a function of distance from the reef refuge. Back reef zones host a variety of different habitats in close proximity, including seagrass and/or macroalgae plains, sand flats, coral rubble, and patch reefs. Fish com-

munities in the back reef zones are known to move between these different habitats promoting cross-habitat nutrient subsidies (Valentine et al. 2008). Therefore, it is critical that we understand the spatial distribution of grazing from refuges, as it both directly (via herbivory) and indirectly (via cross-habitat subsidies) influences biogenic habitat.

In this study we found strong evidence that grazing decreases with distance from patch reefs in the South Water Cay marine reserve in Belize. This finding verifies our hypothesis and is consistent with similar studies of grazing zones in Australia (Madin et al. 2011), the U.S. Virgin Islands (Randall et al. 1965, Ogden et al. 1973), and the Florida Keys (Valentine et al. 2008). To date, however, researchers have little understanding of the factors driving the spatial variation in grazing and how this variation may differ between geographically distinct coral reef/seagrass ecosystems. The spatial extent of grazing must represent some trade-off between: 1) resource availability on the reef refuge, 2) competition amongst the local herbivore guild, 3) the risk of predation, 4) the quality of the reef refuge, 5) predation strategy, 6) the herbivore and predator size class distribution, and 7) the nutritional quality of the surrounding substrate. The current analysis is part of a larger study examining the interplay of these factors on the spatial distribution of grazing near patch reefs.

Interesting, this study provides some of the first evidence of differences in herbivory within the grazing zone between no-take protected sites and fished sites. We found that grazing was higher in no-take areas and decreased more rapidly with distance from the reef edge (Fig. 4b). In fished zones grazed was lower on average and decreased slowly in a linear fashion. No-take protected zones in other geographic locations have been shown to increase piscivore and herbivore populations (Valentine et al. 2007), although this pattern is not universal and often contested. A variety of factors may have caused the grazing patterns to differ between fished and unfished areas. Our study was limited to only two patch reefs within the protected zone and may not have captured the true variability in grazing patterns. Ecologically, grazing may have been higher inside of the protected zone due to a greater abundance of large herbivores. Large herbivores, like mature parrotfish, often attain sizes that afford an escape from common reef associated predators (Kramer and Heck 2007). The rapid decline in grazing with distance in no-take sites compared to fished reefs, however, suggests that there may be a greater risk of predation within the protected area. Smithsonian researchers familiar with the site have not seen dramatic increases in predator populations inside the conservation area and say that illegal fishing is a factor (V. Paul, *personal communication*). The effect of differences in fish community structure on grazing patterns remains to be directly tested. Our data does provide initial evidence to support the hypothesis that the risk of predation may be greater inside the protected area.

Our findings confirmed the efficacy of using satellite imagery to monitor grazing surrounding patch reefs. When the satellite-derived measures of halo extent were imposed on the grazing data we found that the majority of grazing occurred within the halo extent. Furthermore, the spectral reflectance in the images was correlated with changes in seagrass coverage as you moved away from the reef edge. Together, these findings suggest that satellite imagery can be used to accurately predict halo width around patch reefs. Such evidence confirms the legitimacy of using satellite imagery to monitor grazing patterns at larger spatial scales.

Acknowledgements

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Beth Decker (Yale), and various research assistants: Audrey Looby (Smithsonian), Trent Hodges, Simon Thomas-Train, Terry Petronzio, and Luke DiFiore

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The jumbo problem of living with elephants: Varying perspectives on human-elephant conflict in Chobe District, Botswana

Samantha Garvin, MESc[*]

Abstract

Although elephants look like gentle giants, living with them is no small task. Elephants can cause injury to people and damage to property. In Chobe District, Botswana, where there are more elephants than people, these interactions occur with great frequency and can erode tolerance of elephants and broader conservation goals over time. Chobe District is undergoing rapid changes; development is putting pressure on wildlife movements throughout townships. With these changes, identifying ways for species to live together will be crucial to maintaining elephant population viability and human safety. This study utilizes semi-structured interviews and discourse analysis techniques to look across a wide variety of sectors at perspectives of the problems with human-elephant coexistence. How the act of living with elephants influences what kinds of solutions are proposed and carried out. Most participants see the problem as biophysical, a consequence of overlapping human and elephant habitat. A large proportion sees the relationships and motives of different actors as influencing the problem. Other participants identified issues with how decisions are made and carried out. This analysis argues for reconstructing a social context and decision-making process to identify common goals and work towards coexistence.

Introduction

In an age of rapid development, the challenge for conservation is to create space for wildlife without negatively impacting local communities. Elephant (*Loxodonta africana* Blumenbach, [Elephantidae]) management is a complex, value-based, policy problem. Since Botswana is home to over a third of the continent's savannah elephants, management decisions here have major consequences on the species as a whole (Chase et al. 2016). In Chobe District, Botswana, where there are more elephants than residents, the two species interact regularly. A low estimate of incidents of elephant damage in northern Botswana is 150 cases annually (Demotts & Hoon 2012). Both elephants and people can die in such encounters. Human development continues to encroach on elephant habitat (Fig. 1.). In farming areas, elephants break down fences and enter fields to eat crops, often leaving the farmer with little for subsistence. In townships, elephants may trample a borehole or raid a garden. When conservation policies try to protect such charismatic yet dangerous species, all wildlife institutions must work together towards the common interest (Clark 2002).

This study identifies how various stakeholders involved in elephant management view human-elephant conflict in the context of wildlife management in Botswana. Management is complicated by several factors: the historical context of conservation (Parry & Campbell 1992), pressures of development (Adams et al. 2016), politics of the trophy hunting industry (Mbaiwa 2017), centralized control of natural resources (Adams 2016), and the present danger of living with elephants. Instit-

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Fig. 1. Slow for elephant crossing! Roads cut across elephant ranges, and elephants must cross to access food and water. Vehicle-elephant accidents occur and can be fatal for both elephants and people. Decisions for development have impacts on the physical environment, but also on how people relate to it, too. (*Credit:* S. Garvin).

utions from the non-profit, public, and private sectors play key roles in driving wildlife policies that affect people's ability to live with wildlife and the wildlife itself. The perspectives across institutions translate into various approaches for wildlife management that can have serious implications for the continued existence of elephants and the success of conservation in Northern Botswana.

Methods

The following methods are based on longstanding ethnographic practices (Longhurst 2003; Schenshul et al. 1999). These practices allow for a context-specific approach to analyzing various perspectives on human-elephant conflict.

Study area

Botswana has over 130,000 elephants (Chase et al. 2016) and 2 million people in a country of 580,000 km^2. Chobe District (22,560 km^2), in northeast Botswana, is made up of 70% protected areas (Adams 2016). Kasane and Kazungula are two townships with the largest human settlement in the district (ibid). Chobe National Park, in northern Botswana is 11,700km^2 and is a prominent tourist attraction for the district (Botswana Tourism Organisation 2013). The park was established in 1968 and has one of the largest concentrations of wildlife in Africa, with 450 bird species and 19 antelope species (ibid). The tourism industry, which currently accounts for 10% of Botswana's GDP (Gupta 2013), attracts people from other parts of Southern Africa to Chobe. These migrants, many of whom have never lived with elephants before, are now interacting with them more frequently, leading to greater incidence of conflict (Mbaiwa 2011). Non-governmental institutions currently address this problem by educating community members on how to protect themselves and their personal property (Adams et al. 2016). The national government has also been involved with implementing mitigation strategies (Gupta 2013) and a compensation scheme to repay individuals for property damage (Sifuna 2009).

Data collection

From June–August 2016, data was collected in Chobe District in northern Botswana and in Gaborone, the nation's capital. A total of 64 semi-structured interviews were conducted. Interviews were guided by questions targeting the participants' experience with wildlife, their views of problems with wildlife management, current status of that problem, underlying causes, future predictions, and suggestions for addressing these problems. All participant information was kept confidential and anonymous. In addition, over the two months of fieldwork, Elephants Without Borders (EWB), a local non-governmental organization, was the focus of participant observation.

The following analysis utilizes the multimethod and contextual approach outlined by Wallace and Clark (2015) to undertake problem orientation. Problem orientation is a form of rationality that helps clarify each institution's goals, the current status of the problem (trends), socio-economic

and political factors (conditions), projected outcomes if no action is taken (projection), and realistic alternatives (Clark & Wallace 2015). It aims to find and address problems with consideration of the local context. This paper focuses on three elements of problem orientation: trends, projections, and alternatives. The interviews with participants in elephant management targeted their personal view and understanding of the challenges facing wildlife management. Problem orientation has been used to identify policy problems and suggest alternatives in cases of human-wildlife conflict, national parks, and several other contexts (Clark et al. 2002).

Fig. 2. Samantha Garvin visiting a captive elephant herd, a tourist activity in Northern Botswana. The tourism industry is a stakeholder in elephant management in Botswana (*Credit:* K. Landen).

Results

Human-elephant conflict is a symptom of problems with wildlife management, changes in the biophysical landscape, and current governance structures. There are many participants involved in or affected by elephant management in northern Botswana. Fifteen government officials were interviewed (23.4%) including employees of the Department of Wildlife and National Parks (DWNP), the Department of Forestry and Range Resources, the Land Board, Parliament, the Department of Environmental Affairs, and local chiefs (termed *Kgosi*). Seventeen tourism professionals were interviewed (26.6%) including wildlife guides, safari operators, employees of Botswana Tourism Organisation, lodge managers, and members of HATAB. Twenty non-governmental institutions were interviewed (31.2%) including independent researchers, research NGOs, development partners, international agreement secretariats, and research funding bodies. Three representatives from community based organizations (4.7%), Seboba Community Trust and Chobe Enclave Community Trust, were included in this study. Nine community members (14.6%), including long-term residents, members of IKOVA, commercial farmers, Peace Corps volunteers, and local news reporters were interviewed as well. For purposes of this analysis, the perspective of the central government of Botswana was derived from interviews with other participants and is a construct rather than a discrete entity.

Human-elephant interactions are a controversial and sensitive topic. All participants identified different methods for addressing conflict as well as accompanying policies. Table 1 highlights examples of different constructions of the problem using quotations from interviews. Whereas many participants focused on the physical problems of human and elephant interactions, many discussed the social dynamics that influence how wildlife is managed. Other participants pointed to the creation and implementation of policies that influence the efficacy of elephant management and conservation more broadly.

Biophysical problem

Many participants identified the issue of humans and elephants sharing overlapping habitat as the primary problem. Participants pointed to shifting elephant ranges, increasing wildlife populations, increasing numbers of residents, and the placement of settlements near to protected areas as key causes of conflict.

Table 1. Participants identified problems with human-wildlife conflict that can be classified into three different types of problems; biophysical, social, and decision-making. The anonymized quotations are from study participants to illustrate such perspectives.

Problem dimensions	What is the problem?	What might happen with status quo?	What should be done?
Biophysical	"There's not enough land for both humans and elephants."	"Eventually human population will kill off animals in the residential area."	"Develop in homestead arrangements."
Social	"People do not feel the wildlife belongs to them."	"[Communities living with wildlife] are just going to give up at some stage. They're just going to take matters into their own hands… I think it's going to be hate killings."	"If we had the rights, not the user rights, but the rights … We will feel ownership."
Decision-making	"We have excellent polices, but they're never implemented."	"The wildlife is using historic movement paths, but new development blocks them and then they become 'problem animals' rather than problematic development."	"[Government officials] need to feel empowered to make decisions so they are motivated to work."

Without changing the status quo, many participants predicted losses of human and elephant lives. These participants typically suggested physical and technical solutions to address this problem. Many suggested reintroducing trophy hunting, introducing elephant culls, fencing townships, moving settlements, or securing wildlife corridors (Fig. 3).

Social context problem

Many participants saw human-elephant conflict as a consequence of interactions between stakeholders. One of the main problems within the social context hinges on the relationships between government and other stakeholders. Since DWNP has the mandate for managing wildlife, the national parks, and community safety with regards to elephants, they are often blamed for the continuous problem of human-elephant conflict. Many non-government participants identified lack of passion or motivation of wildlife officers as a cause of conflict. Many study participants identified close relationships between the tourism industry and decision-makers in government as drivers for tourism centered wildlife management decisions. Some participants pointed to the failure of tourism to share economic benefits with community members as the problem.

Participants with these perspectives typically forecasted growing resentment between stakeholders leading to more illegal natural resource use, poaching, or environmental degradation. In order to avoid this fate, participants suggested changes to address the element of the social context they viewed as most problematic. For instance, if the stakeholder identified problems in benefit transfers

to communities, he or she suggested higher degrees of revenue sharing to communities.

Decision-making problem

Several participants saw human-elephant conflict as a result of poor implementation of policies. Participants from the non-profit and private sectors identified breakdowns in the policy formation and implementation processes as the primary cause of continuous elephant-human interactions. However, they see the shortcomings of the DWNP as signs of larger issues between government and people. Specific policies were often identified as exacerbating tension; the compensation for wildlife damage program creates expectations that the government can fully repay farmers and ranchers for the loss of their crops or cattle (Fig. 3). A formal process exists for consultation from the traditional governance structure of the *kgotla*, a town hall; however, many feel this formal process is largely ornamental. Powerful individuals within central government make decisions. The hunting ban of 2013, enacted by individuals in the highest levels of government, still impacts stakeholders today (Mbaiwa 2017).

The participants who identified decision-making problems projected increased poaching and increased conflict. To address these problems, participants suggested solutions such as increasing communication between central government and district-level wildlife officers. Other participants suggested alternatives to the kgotla as forums for consultation. The solutions proposed were usually addressing the specific elements of the decision process that they saw as flawed.

Discussion

How participants defined the problem of human-elephant conflict led them to suggest similar future scenarios but propose different interventions.

Current trends in elephant populations are influencing people's perception of the problem as biophysical. Elephant populations across Africa are in decline, but in Botswana, the population has remained stable for the past 5 years (Chase 2013). Hunting and poaching pressures from Namibia, Angola, Zimbabwe, and Zambia influence elephant behavior, keeping them close to or within Botswana's borders (Adams 2016). Elephants in Chobe District move regularly between Chobe National Park, the Forest Reserves, and the Chobe River in pursuit of water, shade, and forage. The exact paths elephants follow are learned from their family groups. When elephants encounter new developments in their paths, they can become confused, causing them to wander into residential areas. The solutions proposed by these participants reflect a desire to minimize the risk of elephant encounters. Implementing these solutions may reduce incidences temporarily, but they may not substantially transform conflict.

The underlying causes for the social context problems are not monolithic. Individual stakeholders interact with differing values, expectations, and worldviews. Whether stakeholders seek money for community projects, recognition of authority, safety for themselves, or respect, these values impact how they approach the problems of human-wildlife coexistence. All of these individual values also interact with larger global trends.

These interactions are shaped by large conditioning factors. For instance, the influence of the tourism industry on decision-making can be linked to larger trends of neo-liberalism of nature (Duffy & Moore 2010). The tourism industry transforms human interaction and experience with nature into a marketable product. The economic success of eco-tourism drives government funding and power to the tourism sector. At the same time modernization, or changes from traditional livelihoods to 'new and modern' ways of life (Pi-Sunyer 1989) is happening throughout Botswana. Modernization in northern Botswana is being driven slowly by the tourism industry (Mbaiwa 2011). Traditional lifestyle and culture may be rejected because they can be seen as preventing development and acquisition Western values (ibid). Living with wildlife

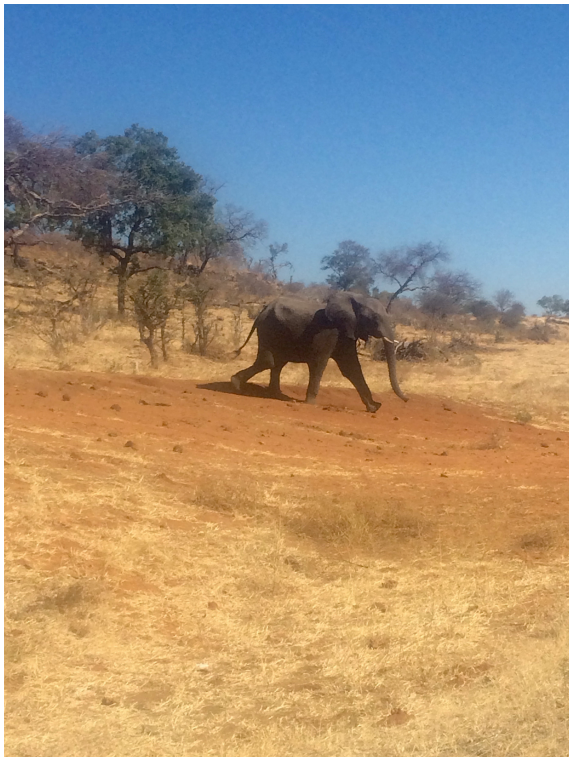

Fig. 3. An elephant uses a corridor to cross from a protected area through a community area to access water. This is one alternative to development that addresses the biophysical elements of the problem (*Credit:* S. Garvin).

in these more rural settings requires cautious behavior; such a lifestyle is not necessary in animal-free urban centers such as Gaberone.

These relationships between stakeholders are influenced by history, as well. Citizens' high expectations of government have been influenced by Botswana's welfare state regime (Gupta 2013). Social safety nets can provide farmers with free seeds to plant, shoats for food security to poor families, a tractor that can be leased for plowing, and elderly pensions. Furthermore, DWNP provides compensation for wildlife caused crop and property damage. Many people see the government as the sole owner and beneficiary of wildlife (Adams 2016), and as a result people expect the government to control the wildlife's behavior. In the 1990s, Community Based Natural Resource Management (CBNRM) policy was designed specifically to distribute economic benefits from natural resources to communities (Mbaiwa 2016). However, for the Chobe Enclave Conservation Trust in Chobe District, the main revenue stream for CBNRM came from the trophy hunting industry, which was abruptly halted during the hunting ban in 2013. With this cut to funds, community works projects have been unable to continue. As a result, some study participants feel that local people no longer benefit from living with wildlife.

The decision-making context is similarly complex. One underlying factor that affects this process is the centralization of authority over wildlife and natural resources. The physical distance between Kasane and Gaborone (over 925km by car) and poor communication infrastructure contribute to the centralized decision-making (Adams 2016). Formal chains for policy formation and implementation are ignored possibly because decision-making is incredibly slow. Many participants similarly stated that the central government does not trust the districts to manage natural resources more directly. However, the decision makers trust the individuals that are closest to them. All of these factors impact the others so that the decision-making process will require serious reform. Furthermore, the effects of this decision process feed into the social relationships.

Recommendations

The following recommendations are aimed at addressing the biophysical, social context, and decision-making problem orientations.

1. Decision-makers and researchers should adopt a problem-oriented approach to management. Clarifying exactly what the problem is will be helpful to fully analyze and understand problems before proposing solutions. In this way, wildlife managers can target specific actions that can have the most impact, and move people towards the com-

mon interest.

2. Appropriate government organizations and participants should integrate land use plans. This is one way to address the biophysical components of elephant management. Many participants identified this alternative, and yet, development is happening haphazardly without control or stakeholder consensus.

3. Policies should be implemented in order to improve upon the tension between various institutions. Capacity to implement policies needs to be built at local district levels of government. This should happen with increased government funding to DWNP, increased numbers of district wildlife officers, and further training on how to manage elephants as well as how to keep Chobe residents safe. Changing officials' placements based on interest may also be beneficial to attract wildlife officers familiar with and passionate about wildlife to work in Chobe District.

These recommendations require a shift in resource allocation, especially when increasing the capacity of district government offices. A concerted effort from all parties to address these problems directly will improve the efficiency of policy implementation in the long run.

Conclusion

This assessment of problem orientation suggests that the problems of human-elephant conflict are a culmination of biophysical, social and decision-making contexts. Currently there is no agreement on exactly what the problem is surrounding human-wildlife conflict. It is evident that this conflict is not happening inside a vacuum. How participants interact with each other impacts how they perceive the problem, and defining a problem involves the social significance of a given situation. The consequences of these actions affect the ability of people and wildlife to coexist. Even though participants identified different problems, most acknowledged the impacts of decisions on wildlife and the environment. By focusing attention on certain issues, participants are declaring what is at stake. The proposed recommendations here address the major aspects of the problem, but will require a concerted effort to make meaningful progress.

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Fig. 4. Cattle illegally roam through a national park, and interact with elephants at a river bank, demonstrating the competing needs of people and wildlife, as well as lack of implementation of park regulations. (*Credit:* S. Garvin).

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Geldin, S. 2017. The evolution of Indonesian waste banks: Two tales, two cities, one reality. *Tropical Resources* **36**, 17–26.

The evolution of Indonesian waste banks: Two tales, two cities, one reality

Sam Geldin, MESc[*]

Abstract

As local governments, NGOs, intergovernmental organizations, research institutes, foreign development agencies, and a host of community actors on-the-ground produce and consume best practices, it quickly becomes easy to lose track of the bigger picture outcomes. This case study uses a digitally documented best practice, the creation of Indonesian waste banks, as an example of how two institutions (specifically, a private sector foundation for corporate social responsibility and an intergovernmental initiative run by a think tank) duplicate and erase each other's role in knowledge creation. Through nearly 40 semi-structured interviews and document analysis, this research explores the consequences of misattribution of institutional knowledge. Evidence suggests that systemic lack of coordination and difficulty of tracing institutional impacts can lead organizations to duplicate efforts and reinforce inefficient flows of knowledge and resources. This study's results, in effect, will help direct practitioner efforts to restructure institutional incentives to cooperate, attribute knowledge, and thus disseminate climate adaptation strategies with greater targeted impact to groups that need them the most.

Dengan banyaknya pemerintah daerah, LSM, organisasi antar pemerintah, lembaga penelitian, lembaga pembangunan asing, dan sejumlah aktor masyarakat daerah menghasilkan dan menggunakan best practices*, menjadi cepat untuk mudahnya kehilangan jejak dari gambaran yang lebih besar terhadap hasil-hasil* best practices *tersebut. Studi kasus ini menggunakan* best practices *yang terdokumentasi secara digital dalam penciptaan bank sampah Indonesia, sebagai contoh bagaimana dua lembaga (khususnya, yayasan swasta dalam melaksanakan tanggung jawab sosial perusahaan dan inisiatif antar-pemerintah yang dipimpin oleh sebuah lembaga* think tank*) menduplikat dan menghapus peran satu sama lain dalam penciptaan pengetahuan. Melalui hampir 40 wawancara semi-terstruktur dan analisis dokumen, penelitian ini mengeksplorasi konsekuensi dari kesalahan pemberian atribut terhadap pengetahuan kelembagaan. Bukti menunjukkan bahwa kelemahan sistemik dalam koordinasi dan keterbatasan melacak dampak kelembagaan dapat membawa organisasi kepada upaya menduplikasi kegiatan organisasi lainnya dan memperburuk ketidakefisienan arus pengetahuan dan sumber daya. Hasil studi ini, pada dasarnya, akan membantu mengarahkan upaya praktisi dalam merestrukturisasi insentif kelembagaan untuk bekerja sama, pemberian atribut untuk pengetahuan, dan dengan demikian menyebarkan strategi adaptasi iklim dengan target dampak yang lebih besar kepada kelompok yang paling membutuhkan.*

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Introduction

While Indonesia has long sought to improve local infrastructure access, its guiding policies in sectors like waste management have changed only recently. New and innovative approaches to develop sustainably were motivated in part by demographic trends between 1990 and 2000, as Indonesia's urban population increased by more than 30 million (UN-Habitat and UN-ESCAP, 2015). In effect, waste disposal sites and other public services simply could not keep up with the increased demand. However, political reforms in the early 2000s, which gave Indonesian municipalities more administrative power, exacerbated challenges to collect and integrate waste regionally. As serious public health concerns became manifest, local governments began recognizing the growing need for improved and diversified solid waste management practices (Damanhuri et al, 2014).

Two events in particular prompted a strategic shift in Indonesia's waste management efforts. In 2001, the overwhelming stench of Surabaya's single brimming landfill prompted public protests and a citywide waste management crisis after its closure (Ramdhani et al, 2010). Similarly, in Indonesia's third-largest city of Bandung, heavy rains and poor operating practices in 2005 triggered the collapse of a major dumpsite onto adjacent villages of *pemulung* (waste-pickers), resulting in nearly 150 deaths and one of the deadliest waste slides ever recorded (Lavigne et al, 2014). Public discontent in the aftermath of this disaster galvanized a sense of urgency to replace open dumps with legally mandated sanitary landfills (Damanhuri et al, 2014). However, limited city budgets and technical capacity, as well as a lack of identified alternatives to stem the expansion of temporary dumping sites, prevented widespread action. In the wave of reactionary provisions that followed Bandung's tragic events and subsequent waste relocation emergency, the national government passed the Solid Waste Management Act of 2008, which prioritized reducing rather than merely collecting waste (Damanhuri et al, 2014). While the law laid the foundation for more comprehensive waste management at the local level, community-based recycling initiatives continue to play a considerable role in meeting waste reduction targets (Meidiana & Gamse, 2010).

One particular practice, collecting recyclables through community waste banks, illustrates not only the power of local governments in customizing sustainable solutions, but also the power of external actors in shaping city-to-city knowledge exchange. Below, I detail the series of events that led to widespread local adoption of waste banks in Indonesian cities, as well as the, at times, conflicting narratives of two major internationally-rooted organizations that disseminated the strategy, the Unilever Peduli Foundation (hereafter UPF) and the Environmentally Sustainable Cities Model Program (supported by the Association of Southeast Asian Nations and hereafter, ASEAN ESC).

My account was produced using a number of sources: academic literature, news articles, interviews with representatives of the two major institutions and other stakeholders, a field visit to a recently established waste bank in Sumatra, and a host of institutional reports and other publicly available web content. While further investigation would provide a more detailed timeline of waste bank dissemination, this summary aims to capture the most critical elements. Ultimately, the two organizations' interconnected but different stories illustrate the ease of erasing an institution's attribution to a best practice,[1] as well as the deeply engrained, often invisible role of institutional competition. The discussion highlights how misattributing knowledge can enable and conceal duplication of efforts, and in effect help explain why resources often never reach the beneficiaries that need them the most.

[1]A best practice can be defined as a replicable action or set of principles or goals meant to reproduce similar outcomes. In practice, however, best practices can only yield "best" results in other locations for certain groups of actors, under certain conditions, and after particular implementation procedures.

Surabaya's Green and Clean program

The first major champion of interest, UPF, acts as Indonesia's corporate social responsibility branch for the eponymous British-Dutch consumer products company. Formed in 2000, the foundation initially intended to improve the water quality of Surabaya's Brantas River near one of UPF's factories.[2] However, UPF traced the river's pollution and tendency to flood directly to local residents, who dumped untreated solid waste directly into the water. As a result, the organization quickly acted upon the need for more comprehensive waste management as the means to enhance watershed management.

Through a multifaceted but targeted approach, the foundation's efforts soon began to reap results. UPF trained 45 local housewives in the Surabaya subdistrict of Jambangan in 2004 as volunteer motivators (known as Environmental Cadres or Agents of Change) to host community meetings and educate roughly a dozen interested households each about recycling and composting practices (Fig. 1) (Ramdhani et al, 2010). In just two years, 90% of households had participated, diverting three-quarters of the community's total waste from the landfill. This prompted UPF to partner with the Jawapos newspaper and the city government to reproduce the model as part of what they called the *Green and Clean Program* (Tahir et al, 2011). Together, they launched biennial competitions in over 100 subdistricts of Surabaya, between 2005 and 2008, to see who could divert the largest volume of trash (Ramdhani et al, 2010). Incentivized by neighborly competition and public prestige, higher performing subdistricts helped institute recycling efforts in lower performing subdistricts and in effect, waste flows in nearly all of the communities began to slow.

The scale and complexity of the Green and Clean Program expanded in concert with its success. It spread to communities in Jakarta in 2006, to Yogyakarta in 2008, and to ten other cities, soon incorporating more than 100,000 Environmental Cadres working in millions of households (Ramdhani et al 2010; Tahir et al, 2011). Civil servants, university students, and teachers began to join cadres of housewives, partly a reflection of the cultural emphasis on neighborly relations, civic service, and patriotic *gotong royong* (or mutual cooperation) (King and Idawati, 2010). In addition, the program began to include other components and local variations. One notable project in 2007 included teaching housewives in Surabaya how to make marketable *trashion* handicrafts, such as handbags and hats, from a portion of the plastic waste collected. The waste for handicrafts would be collected in a 'bank' for storage until ready for assembly and sale, supplementing streams of household and waste bank revenue by as much as 400,000Rp each (Ramdhani et al, 2010; Winarti, 2008). Surabaya's model for waste reduction, income generation, and community empowerment has since won a host of international awards and influenced local initiatives in places like Japan, Nepal, Thailand, and the Philippines (Ramdhani et al, 2010).

Yogyakarta's first waste bank

While UPF's Green and Clean Program likely planted the seed that gave rise to Indonesia's first recognized waste bank, the extent to which UPF influenced the dissemination of waste banks throughout Indonesian cities remains debatable. The whole story begins in the city of Yogyakarta during the time period when Surabaya's Green and Clean Program spread. According to an interview by the national newspaper *Kompas*, a public health lecturer named Bambang Suwerda saw television coverage of communities using a 'waste bank' to store trash and then recycle it into more useful products (Prihtiyani, 2010). The model inspired him to conceive of a waste collecting facility that actually functioned like a conventional bank, where community members could directly exchange recy-

[2]Foundation representative, pers. communication, Aug. 25, 2016, Cirebon Metland Hotel.

Fig. 1. Key visuals disseminated as part of Unilever Peduli and ASEAN ESC's tale of waste bank expansion. *Left:* Cadres of women demonstrate how to collect compost as part of UPF's Green and Clean Program in Surabaya (Ramdhani et al, 2010). *Right:* Bambang Suwerda, recognized by the Ministry of Environment and ASEAN as the founder of Indonesia's first waste bank, inside the Gemah Ripah Waste Bank in the district of Bantul, Yogyakarta (Maeda et al, 2011).

clables for cash. Motivated by his life's work of promoting environmental health in his community, he founded what is now considered Indonesia's original waste bank, *Bank Sampah Gemah Ripah*, in the district of Bantul in 2008 (see Fig. 1) (Prihtiyani, 2010).

To reap the bank's benefits, customers would separate household paper, plastic, and glass into large bags, and bank tellers would itemize and record the total guaranteed price by weight (see Fig. 2) for sale to recycling facilities. After several months of waste savings, customers could access their earnings with a valid receipt (see Fig. 2) and sometimes secure more than half of their monthly living expenses, all while reducing community litter and informal waste picking. Since its inception, the bank diverted more than 1,000 lbs. of inorganic waste each month, retained 15% of collected revenue to cover operating costs, and gained extra revenue by selling finished waste handicrafts (see Fig. 2) (Maeda et al, 2011). Suwerda soon won nationwide notoriety for the success of Gemah Ripah, and the model's flexibility gave it a life of its own outside Yogyakarta.

Around the time of Gemah Ripah's founding, a vast array of actors became involved in waste bank dissemination and many novel innovations soon emerged. Impressed by the model's economic sustainability and incentivized by corporate social responsibility, the Indonesian private sector began partnering with other interested NGOs and communities to invest in more banks (Lubis, 2015). Waste banks promptly spread to dozens of other subdistricts in Yogyakarta—often through study tours—and new banks began to emerge both organically and independently in other cities through networks of businesses, nonprofits, and civil society representatives (Phelps et al, 2014).[3] Communities tailored their waste bank procedures to local needs and desires. For instance: some bank staff got paid and others volunteered; some banks became a learning tool for schoolchildren and others became distribution outlets for handicraft saleswomen;[4] some banks collected business and retail waste in addition to residential waste; and some banks operated strictly as community-based organizations and cooperatives, while others were managed as public-private partnerships (Wijayanti and Suryani, 2014). Individual banks also developed unique service options so that cus-

[3]Program manager, international NGO, pers. communication, Aug. 19, 2016.
[4]Foundation representative, pers. communication, Aug. 26, 2016.

Fig. 2. Waste Bank Inputs and Outputs. *Top left:* Kota Karang Waste Bank in Bandar Lampung, Lampung Province, Sumatra (Geldin, 2016). *Top right:* Trash in coastal waters adjacent to Kota Karang Waste Bank, despite government cleanup efforts, because of solid waste dumped upriver (Geldin, 2016). *Bottom left:* Cadres of women weigh bags of recyclables before tabulating their redeemable price (Geldin, 2016). *Bottom center: Trashion* handbags, made from plastic wrappers, displayed in a distribution outlet in Cirebon (Geldin, 2016). *Bottom right:* A waste recording book and bank deposit card at a waste bank in Bandung (Lubis, 2015).

tomers could exchange their waste savings for over-the-counter transactions. Banks began offering kiosks and mobile apps for customers to use their waste saving credits to pay for food and household supplies,[5] utility bills, health insurance,[6] schooling fees, and property taxes (IGES, 2015; Idrus, 2014; Hajramurni, 2015).

Of course, a waste bank by itself does not necessarily constitute a best practice. Successful outcomes depend on the local context and will not follow if, for example, communities do not express a need or active enthusiasm to participate, if customers lack proper recycling education, if bank staff lack sufficient managerial training, or if price manipulation or oversupply of waste cause the redeemable value of recyclables to dip below profitable levels (Jeffery, 2013).[7] Likewise, informal waste 'mafia' collectors must not feel threatened, as they could cut off service to new banks (Jeffery, 2013). However, the majority of waste banks have overcome such challenges and many ultimately benefited from the financial resources and advisory support of existing community-based waste networks.

As one of the key networks already educating communities about recycling practices, UPF cer-

[5]Local NGO representative, pers. communication, Aug. 20, 2016, Kota Karang Waste Bank, Bandar Lampung.
[6]Foundation representative, pers. communication, Aug. 26, 2016.
[7]Project manager, international NGO, pers. communication, Aug. 12, 2016, Mercy Corps Offices, Jakarta.

tainly became one of the primary means for waste banks to proliferate. In the same year that Suwerda founded Gemah Ripah in Yogyakarta, UPF's Green and Clean Program in the city of Surabaya incorporated waste banks into its competition criteria.[8] When new cities joined the Green and Clean Program, they also inherited the program's institutional resources to mobilize hundreds of waste banks. By 2015, UPF's program alone claimed considerable impact in 17 cities and 12 provinces, supporting 1,258 waste banks, recruiting 55,558 customers, recycling over three tons of inorganic waste, and exchanging more than 3 billion Rp (Unilever, 2016). Yet as shown below, claims of disseminating knowledge of and skills to manage waste banks quickly become difficult to distinguish.

A second, conflicting waste bank narrative

The Association of Southeast Asian Nations' Environmentally Sustainable Cities (ASEAN ESC) Model Program—the second notable institution of interest, an intergovernmental association—complements but also challenges UPF's role disseminating waste bank knowledge. ASEAN member states founded the ASEAN ESC Model Program in order to promote collaboration among the region's environmentally sustainable cities. Administered by the Japanese-based Institute for Global Environmental Strategies (IGES) and funded in part by the Japanese government, ASEAN ESC (like UPF) works to scale up local-level pilot projects and facilitate city-to-city exchanges.

ASEAN ESC's story begins in 2011, three years after waste banks became part of UPF's Green and Clean Program. Indonesia's Ministry of Environment, which wanted to replicate Yogyakarta's waste bank model throughout 250 cities across the nation, partnered with ASEAN ESC to start holding waste bank training workshops in Surabaya (IGES, 2012). Initially, ASEAN ESC and the Surabaya local government claimed that there were only six existing waste banks in the city, all of which operated under a model different than Yogyakarta's (ASEAN ESC, 2011). Yet this assertion directly conflicts with statements made by UPF and independent researchers (Wijayanti and Suryani, 2014).[9] Back in 2008, UPF helped already existing Surabaya waste banks integrate Bambang Suwerda's money-saving concept into their operations.[10] Likewise in 2010, Wijayanti and Suryani (2014) reported fifteen, not six, waste banks in Surabaya. Rather than assume ASEAN ESC and UPF's different accounts intended to mislead observers, such inconsistencies may underscore broader concerns of institutional coordination and evaluation of impact.

Understandably, most government and nongovernment organizations struggle to completely trace the spread of best practices because they lack enough time and documentation. Considering the myriad of interactions between government officials, private sector donors, NGO implementers, and individual community members, there are many obstacles to accurately detail all the exchanges of knowledge related to just one waste bank. Plus, an institution could also undermine its own legitimacy by choosing to document the role of other actors in the first place. Presumably, institutions like ASEAN ESC have no interest in mentioning the perhaps greater knowledge disseminating power of hidden informal middlemen (*pengepul* or *pelapak*) who transfer large volumes of waste from waste-pickers and waste banks to recycling facilities (Tuori, 2012). Such loosely organized informal actors show that they could do much of the information dissemination that ASEAN ESC and other institutions claim to do, for less money and technical support. Yet organizations (both ASEAN ESC and UPF) that do not attempt to trace the cascading influence and context of their actions, let alone acknowledge limits to their own impact, perpetuate

[8] Foundation representative, pers. communication, Aug. 26, 2016.
[9] Foundation representative, pers. communication, Aug. 26, 2016.
[10] Foundation representative, pers. communication, Aug. 26, 2016.

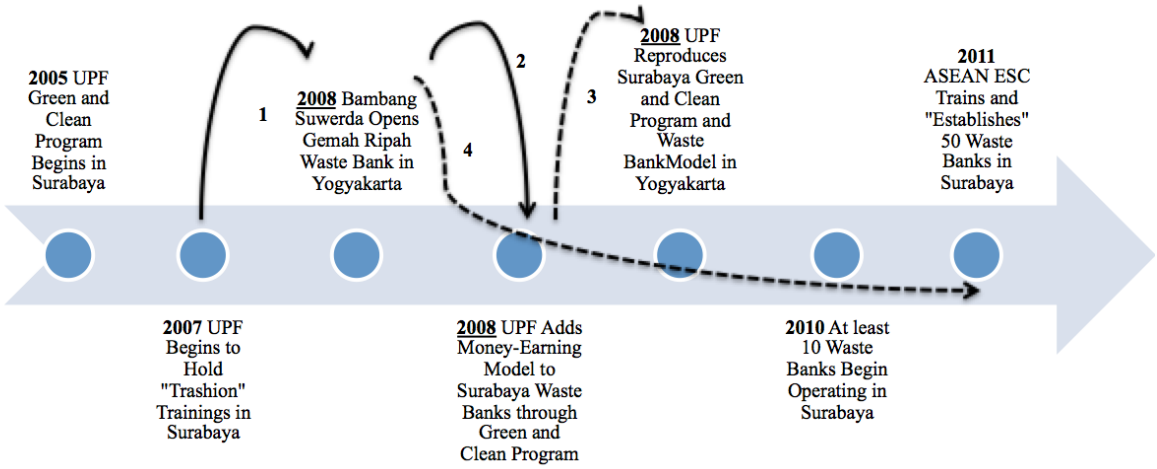

Fig. 3. Timeline of waste bank evolution in two cities. Solid black arrows indicate an event that likely inspired or influenced another listed action. Dashed black arrows connect an influential event with an action that likely repeated earlier actions already documented in the same city. The narrative of UPF's waste bank expansion from Surabaya to Yogyakarta through the Green and Clean Program (3) overlooked the existing presence and influence of the Gemah Ripah Waste Bank, while the narrative of ASEAN ESC's waste bank replication from Yogyakarta to Surabaya (4), claiming to have "established" 50 waste banks in 2011, counts ten existing documented waste banks it did not establish the year before (Wijayanti and Suryani, 2014). Both solid black arrows (1 and 2) were effectively "erased" in the publicized institutional narratives of UPF and ASEAN ESC. While all the arrows are ordered chronologically, the three events that occurred in 2008 are bolded to emphasize that they took place in the same year, a comparatively small window of time that is not equally represented visually in the one or two year periods between other events listed.

the uneven exchange of information resources.

When knowledge leaves no trace

As evidenced by the temporal discrepancies of ASEAN ESC's and UPF's claims, the manner in which both ASEAN ESC and UPF promoted their goals and achievements illustrates two fundamentally different, institutionally-centered accounts of how Indonesian waste banks developed and spread. On the one hand, UPF's main online summary of its environmental achievements, which included launching the Green and Clean Program and dozens of waste banks in Surabaya, erases the city of Yogyakarta's innovative role in developing the model in the first place:

> "Under the name of 'Green and Clean', *we collaborate* … closely together with government, NGOs and community [sic]…The *success of this* [community waste bank] *programme can be seen* from the total unit of waste bank [sic], number of people involved and also the total of waste [sic] that is collected and sold…[T]his concept has been learning and developing [sic] *since 2008. We are sharpening the model* …(Unilever, 2016)." Emphasis added.

While UPF certainly should not be expected to dwell on the origins of the model it promotes, the fact that the organization engaged with many different actors and assumed credit for founding over 1,000 waste banks leaves the impression that UPF's waste banks did not duplicate existing efforts. Yet UPF's 2008 Green and Clean Program replication in Yogyakarta arguably did not need

to found additional waste banks in the same area where Suwerda's waste bank model began and had already spread, acquired resources, and assumed different variations. Knowing the context of Yogyakarta, as the epicenter of Suwerda's waste bank innovation and the likely source of UPF's waste bank model, reframes the otherwise laudable outcomes of Unilever's activities in Yogyakarta (Rosdiana, 2013). Would UPF's same actions in another medium-sized city, far removed from Yogyakarta's established networks, have disseminated more knowledge and generated a greater long-term impact? We do not know.

ASEAN ESC, on the other hand, illustrates how even explicitly giving credit to another institution for its work does not mean its own influence is clear or equal. In the Model Cities initiative's first annual report, ASEAN ESC actually acknowledges UPF's work in Surabaya and asserts that "*Although the waste bank concept was already known among the local community, this programme [ASEAN ESC] provided the catalyst to formally train communities and establish pilot waste banks on a wider scale*" (IGES, 2012: 8). Unlike UPF, ASEAN ESC clarified the observed role of another institution. However because of ASEAN ESC's lack of incentive to actively record UPF's boundaries of influence, it effectively erased other critical pieces of information. For instance, the timing and language of a *Kompas* interview (Prihtiyani, 2010) presents reasonably strong evidence that UPF's Green and Clean *trashion* trainings—widely publicized through its partnership with Jawapos—influenced Bambang Suwerda's idea to establish the first recognized waste bank. This discovery that UPF's activities likely inspired Suwerda's waste bank remains unmentioned in ASEAN ESC's story of waste bank expansion, as it requires effort to uncover and would diminish ASEAN ESC's claim as a catalyst.

That is not to say ASEAN ESC had no influence in supporting the expansion of waste banks. The waste bank management trainings that it conducted for community stakeholders epitomize the crucial transfer of skills, rather than mere transfer of information, necessary to make a long-term impact. However ASEAN ESC's partner, the Ministry of Environment, arguably played a comparatively greater role in waste bank dissemination. The ministry had already identified Bambang Suwerda as the brainchild behind the waste bank concept by 2011, inviting him to train stakeholders in other cities and assist in formulating a 2012 decree that outlined guidelines for waste banks' official recognition (Maeda et al, 2011; Lubis, 2015).[11] ASEAN ESC, meanwhile, almost exclusively disseminated knowledge to environmentally ambitious local governments, who were shortlisted for the ministry's prestigious National Adipura Environmental Award.[12] Surabaya, which received the award in addition to ASEAN ESC's capacity building resources in 2011, already had waste banks operating for years through UPF's Green and Clean Program. While there is certainly some merit to expanding capacity within a model city, denying access to capacity building resources in many smaller cities like Sibolga, which also received recognition for environmental leadership (Harfam, 2012), perpetuates knowledge gaps and reduces the efficiency of knowledge dissemination. By claiming credit for the spread of waste banks in 2011 from Yogyakarta to Surabaya, ASEAN ESC effectively erased UPF's relevant actions and directed knowledge and resources to a city where those assets already existed (see Fig. 3). ASEAN ESC thus demonstrates how selectively represented institutional narratives can delay or prevent distribution of services to the cities in greatest need.

What can we take away?

While tracing the spread of a practice remains difficult, organizations should still take on the challenge. UPF and ASEAN ESC can both claim

[11] Foundation representative, pers. communication, Aug. 25, 2016, Cirebon Metland Hotel.
[12] Program manager, international NGO, pers. communication, Aug. 19, 2016.

they influenced waste bank creation and knowledge dissemination because the evolution of waste banks as a best practice involved multiple back-and-forth innovations. Some Indonesian cities learned about waste banks from study tours to communities with ASEAN ESC-supported waste banks (like Balikpapan), some communities established waste banks as part of UPF's program (like Makassar), some waste banks likely grew out of inspiration from both ASEAN ESC and UPF (Surabaya, Yogyakarta), and still others likely created waste banks independently through networks of informal waste collectors and private companies (Jakarta) (IGES, 2015; Ramdhani et al, 2010).[13] However, written achievements of the two organizations should not conceal crucial context about each other's influence. Institutions must have incentives to coordinate and must be held accountable for making vague or overstated claims of impact without actually attempting to trace a cause-and-effect relationship. Only through widespread adoption of more rigorous, transparent, evidence-based impact evaluations can "needs-led" development truly advance.

Note

The actions of specific organizations I reference in this article should in no way detract one from the overall quality or impact of such institutions' work. My observations, intended to provide insight to the difficulty of tracing impact, merely provide a representative snapshot of the systemic challenges that all institutions face as they share knowledge.

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Peanuts and aflatoxin contamination in northern Ghana: Women's local knowledge and practices

Abdul-Majeed Ibrahim, MEM[*]

Abstract

Peanuts (*Arachis hypogaea*, Fabaceae) are an important rural household crop in Ghana that is produced for consumption and sold to supplement household income, but a significant proportion of each crop is discarded each year, often due to contamination by *Aspergillus* fungi in the form of aflotoxins. In northern Ghana, peanuts are mostly cultivated and processed by women due to the usefulness of the crop in the household. Post-harvest handling of peanuts is a challenge in this region because women mostly rely on their local knowledge and practices. With this in mind, this study sought to identify the different ways women handle post-harvest peanuts to reduce contamination and propose local innovations women can adopt to help them manage post-harvest losses due to contamination. Focus group discussions were organized in twenty-four communities to allow women farmers to engage in a conversation with two goals: establishing and evaluating women's knowledge on aflatoxin contamination, and determining their local knowledge and practices around handling post-harvest peanuts. The initial drying, sorting and storage of peanuts affects the extent of fungal growth that produces aflatoxins. These are crucial yet basic practices that determine the quality of peanuts and whether they are earmarked for sale, used as seeds for replanting, or kept for household consumption. I argue that women farmers use their local knowledge to manage aflatoxin contamination in peanuts; however, this local knowledge has some scientific limitations. For example, while women farmers in northern Ghana have found ways of dealing with contaminated peanuts for reasons of taste and economics, they are typically unfamiliar with the full health risks the contamination can pose.

Introduction

Africa's varied cultures and environments reflect how agriculture is practiced (US Congress, Office of Technology Assessment, 1984). Many households in Africa are smallholder farmers who depend on the subsistence economy, but they can also be significant contributors to state and national economies. Many households consume what they produce on their farm and sell the surplus for income. The effort to meet Africa's food demand is hampered by drought, insect pests, proper storage facilities, market access, farming inputs, and poor rural infrastructure (Alakonya and Monda 2013). One of the most underappreciated public health concerns is the infestation of grains and some legumes by fungal pathogens. Fungal pathogens produce various toxic metabolites called mycotoxins. Aflatoxin is one such toxic mycotoxin, and it is a major health concern in Africa (World Health Organization, 2006). Aflatoxin is the most potent natural carcinogenic substance and has been linked to the prevalence of hepatocellular cancer in Africa (Strosnider et al. 2006). Maize and peanuts are the main sources of human exposure to aflatoxin because these two staples are widely consumed and are susceptible to contamination (Wu et al. 2011).

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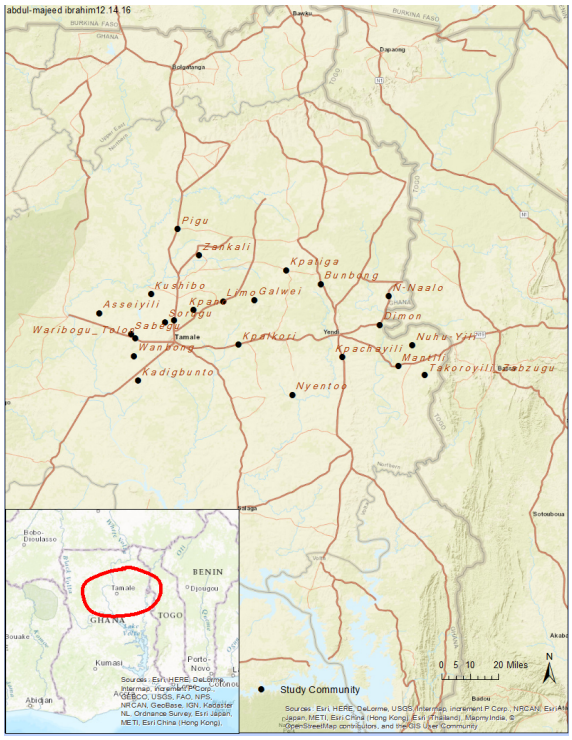

Fig. 1. Location of study communities in northern Ghana.

Aflatoxins are naturally occurring food contaminants produced by two species of fungus (mold): *Aspergillus flavus* and *A. parasiticus*. These fungi colonize a wide array of food including maize, oilseeds, spices, peanuts, tree nuts, milk, and dried fruits (Wu et al. 2011). Aflatoxin contamination can occur in the field or in storage (Williams et al. 2004). Aflatoxin has a negative impact on crop yields, human health, animal productivity, and trade (Nigam et al. 2009). High temperatures and high relative humidity in most parts of Africa make fungal pathogens thrive. Consuming aflatoxin-contaminated food can have both acute and chronic effects on humans (Wu et al. 2011). It also affects animals that consume contaminated feed. When humans consume products such as eggs and milk from infected animals, they can become infected (Wu et al. 2011). Acute toxicity is caused by consuming large amounts of aflatoxin-contaminated food. It can result in decreased liver functioning, abdominal pain, vomiting, and death (Alakonya and Monda 2013). In Kenya, there have been 125 cases of death caused by acute aflatoxin toxicity (Probst et al. 2011). Exposure to small amounts of aflatoxin over a prolonged period cause chronic toxicity—which is carcinogenic (Alakonya and Monda 2013).

Seventy-four percent of all households in northern Ghana report growing peanuts (Quinones and Xinshen, 2011). Peanuts, or groundnuts, (*Arachis hypogaea* L., Fabaceae) are an important rural household crop that is produced for the household's consumption and sold for income. Government regulatory standards in the food system are impossible to enforce because rural households eat what they produce on their own farms (Alakonya and Monda, 2013). Thus, it is difficult to find reliable data on aflatoxin contamination in the food system of Ghana. However, it is clear that the majority of post-harvest peanut losses—both reduced yield and economic losses—are due to aflatoxin contamination (Masters et al. 2013). A study by Awuah and Kpodo (1996) found peanuts sampled from 21 selected markets in the 10 regions of Ghana had high levels of aflatoxin: 31.7% of the damaged nuts and 12.8% of the undamaged nuts examined were infected. An estimated 5–15% of peanuts in Ghana are discarded during sorting (Masters et al. 2013). Ghanaian peanuts continue to be sold mainly on traditional markets in which traders rely on reputation and inspection of nuts. The weakest links for safety and nutrition from peanuts often involves post-harvest handling and marketing (Masters et al. 2013). Therefore, identifying sources and local knowledge about aflatoxin contamination is a vital public health effort.

This study is important because of the role peanuts play in the diets of the rural household. Peanuts are particularly vulnerable to aflatoxin, which recent public health research has shown to be a serious, previously under-appreciated threat to nutrition and health in Africa especially for infants and young children (Masters et al. 2013). Aflatoxin contamination cannot be detected by visual inspec-

tion; hence the lack of awareness of its health and economic impact to households. Malnutrition and stunting in infants and children are high in most parts of northern Ghana (Department for International Development [DFID], 2014). Peanuts are an important source of protein and are used in almost all households to make soup, make snacks (*kuli-kuli* and *Katin* cake), and also as cooking oil. Peanuts are cultivated for household consumption and also sold for income. Unfortunately, farmers consume what has been rejected by aggregators due to their poor quality (DFID, 2014), and this adds to the concern for peanut safety in poor households in particular.

Peanuts provide income to women in poor households (Christie et al. 2014). Women farmers' decisions and practices for the initial drying, sorting, and storage of peanuts heavily influence the extent of fungal growth. Post-harvest activities predispose the harvested products to more infestation. Subsistence level indigenous innovations can substantially reduce the burdens of aflatoxin contamination (Turner et al. 2005). Storage is a major source of infestation: storage bags are not checked for fungal infestation before being re-used, predisposing the nuts to contamination and infestation from previously stored grains or nuts (N'Dede et al. 2013).

Women are emphasized in this discussion because of their dominant role in the post-harvest handling of peanuts. Given their role in the processing of peanuts, they are likely to feed their young infants and children meals containing some form of processed peanuts. Exposure of infants to aflatoxin increases at weaning, and this contributes to stunted growth (Gong et al. 2004). Any real chance of ensuring the safety of peanuts consumed in the household rests on women's awareness of aflatoxin contamination. Women are the primary agents responsible for food preparation, family health care, and other household tasks associated with peanuts (Christie et al. 2014). Women are therefore well positioned to help control aflatoxin contamination in peanuts from the farm to fork.

Women's approach to managing aflatoxin contamination using local knowledge has been successful up to a point. A feasible approach to augmenting peanut farmers' efforts to managing aflatoxin contamination is to complement their indigenous knowledge systems with scientific knowledge of the pathology of the fungus that produces aflatoxins.

This research had the following objectives:

1. Establish and evaluate women farmers' knowledge about aflatoxin contamination
2. Determine women farmers' local knowledge and practices of handling post-harvest peanuts
3. Perform aflatoxin field tests on women farmers' worse and best peanut samples
4. Recommend best practices of handling post-harvest peanuts that minimizes contamination

Methods

Focus group discussions—involving women farmers who grow peanuts—were organized in twelve Disseminating Innovative Resources and Technologies for Smallholder project (DIRTS)[1] districts to establish and evaluate the farmers' understanding of aflatoxin contamination as well as the post-harvest handling practices of peanuts. Each focus group discussion had two sessions separated by an onsite aflatoxin test. For the first session, we evaluated farmer's knowledge on aflatoxin

[1]Disseminating Innovative Resources and Technologies for Smallholder (DIRTS) project is research being done by the Innovation for Poverty Action (IPA), a US-based non-profit organization, to test whether access to improved yield agricultural inputs and extension advice would lead to more intensive land cultivation and increased earnings among farmers in northern Ghana. I selected my research sites based on access to DIRTS projects baseline data, which my academic advisor made available to me. The DIRTS program has established rapport with farmers in these communities since November 2013.

Fig. 2. *Sim bieri*—black, dark colored rotten kernels.

contamination. Second, we proceeded with the rest of the discussion topics, which are summarized in the research objectives (above). The participants were asked to voluntarily bring peanut samples for testing.[2] Two communities in each district were sampled based on the farthest and the nearest from the point of entry into the district and also based on the presence or absence of a community extension agent.[3]

Twelve participants were selected from the group of volunteers in each community but the number was reduced to eight when we got to the tenth community to ensure that all participants contributed actively to the conversation. A focus group discussion lasting at most ninety minutes was organized in each community. Two focus group discussions were organized each day. In a community where we had access to more than twelve participants, participants were selected on a first-come first-serve basis while ensuring that there was an equal proportion of old and young women. Note taking, audio and video recording were used to record the discussion. A video recording was used to help capture non-verbal communications, gestures and behavioral responses. Participants' consent was sought and they were assured of the confidentiality of the recordings. I summarized the discussions immediately after the first focus group. The recordings were transcribed and initial analysis done to aid in moderating subsequent focus group discussions. The research questions were followed as a guide, and relevant themes were coded from all twenty-four transcripts (Nagel and Williams 2013).

Results and analysis: Establishing farmers' local knowledge about aflatoxin

Women are familiar with rotten peanuts and they make hard choices every day about such peanuts.[4] They described their experience with rotten peanuts in a variety of ways but they all pointed to one thing—they were describing signs of aflatoxin-contaminated peanuts at various stages of contamination. For example, some women talked about feeling powder on their fingers when they touch contaminated peanuts; others mentioned that poorly dried peanut kernels stick together when they are stored; some women described molds on their peanuts as "sometimes you see something like cotton on the peanuts". These descriptions are all signs of aflatoxin contamination.

Women deal with peanut contamination all the time, but they may not understand what they are dealing with—or if they do, they understand it in a different way. For example, women know about rotten peanuts or moldy peanuts and how to deal with them, but they do not know that such peanuts are contaminated by aflatoxin[5]—a toxin that is byproduct of molding. Such peanuts are treated like any other food that has gone bad from

[2]We brought our own samples in case participants couldn't provide us with samples. But in all the communities we visited, participants were able to provide samples for testing.

[3]Community extension agents, who are residents of the community, were trained for the DIRTS program.

[4]Due to the lack of a word to use to call aflatoxin, several question were used to establish if the women know about aflatoxin. Questions about women's experience with rotten peanuts generated a lot of discussion in the focus groups. The statement "Experience with rotten peanuts" is used to ask the question because it is in the rotten form that contamination is high.

[5]In a study by N'Dede et al (2013) respondents used physical attributes—black color, white dust, greenish etc.—as a criteria to identify aflatoxin contaminated peanuts. The responders also suspected broken kernels or burrowed kernels by insects to be contaminated by aflatoxin.

microbial growth, such as bacteria and molds, and is not treated as a toxin that is fatal and carcinogenic. For example, it is common for people to cut the part of food that has molded away and consume the part that is not affected. Additionally, some peanuts may look good and not show signs of mold, but an aflatoxin test can reveal high contamination levels. The rural women who do not have the benefits of aflatoxin test kits rely on their sense organs—eyes, nose and tongue—to know if a kernel is rotten or not. The peanuts are unshelled and kernels inspected with the eyes, chewed in the mouth, or smelled. Bruised kernels with dark spots or oily spots are easy to identify with eye inspection as bad nuts. Kernels that taste bitter in the mouth because of rancid taste or odor are also easily identified as bad nuts. Rotten kernels are soft and produce oil when pressed between the fingers as opposed to good kernels that feel hard.

Participants expressed shock when I explained to them that molds leave a poisonous residue on peanuts. Different names are used to refer to bad peanuts: *Sim bieri* (can be identified as black or dark colored rotten kernel, Fig. 2); *sim kpagma* (kernels look fine but a closer inspection shows spot of oil indicating that oil in the kernel has been sucked by an insect identified as the pod sucking bug, Fig. 3)[6]; or *sima din pir'gi* (moldy peanuts, Fig. 4). Other names were mention but further enquiry revealed that they are synonyms. For simplicity, the term "rotten peanuts" will be used to interchangeably refer to these different local names, but specific names will be used to make particular reference when necessary.

The women were able to identify images[7] of aflatoxin-contaminated peanuts but didn't understand the health risks of consuming such peanuts. They found a use for the bad peanuts. For example, some women use rotten peanuts (*sim kpagma* and *sima din pir'gi*) to make *dawadawa*—a food condiment—whereas some use it (*sim bieri*) to start fires for cooking due to the oil content. Some women clean the molds on peanuts (*sima din pir'gi*) and then mix the remainders with good peanuts to cook or make dawadawa.

When asked if they knew about illnesses associated with eating rotten peanuts, the women had different responses. A few women mentioned that they were told at a women's training workshop on how to take care of their children that consuming bad peanuts caused "knee problems and breast

Fig. 3. *Sim kpagma*—kernel has oily patches due to infestation by the pod-sucking bug. *Credit:* https:// commons.wikimedia.org/wiki/File:Peanutjar.jpg

Fig. 4. *Sima din pir'gi*—moldy kernel. *Credit:* http:// www.new-ag.info/en/picture/feature.php?a= 2936.

[6]The Pod-sucking bug *Elasmolomus sordidus* invades peanuts haulms on the field or in storage. They feed on the kernel by perforating peanuts pods with their rostrum and this causes an increase in the free fatty acid content of the oil, thus producing a rancid flavor (Rao and Rameshwar, 2013). This reaction explains the bitter taste when *sim kpagma* is consumed.

[7]Figure two and four were printed and distributed to the participants for identification.

problems.[8] Others too heard on the radio that consuming bad peanuts is not good for human or animal health. Clearly, the women knew a lot about rotten peanuts, but the extent of their understanding of the repercussions of consuming such peanuts was limited. They erroneously assumed that moldy peanuts are safe to consume if you clean the molds away.

Local knowledge and practices

All the farmers who participated harvested, dried, sorted, and stored their peanuts in a similar manner.

Harvesting

Men (mostly the sons or husbands of the women), or the women themselves, pull the peanuts from the ground and pile the haulms while the children or other women pick the nuts from the vines. In the instance where not enough labor is available, peanut haulms can be left on the farm for three or four days until all nuts have been pulled out from the ground. However, leaving the peanut haulms on the farm for three or four days initiates aflatoxin contamination. The peanut haulms are invaded by the pod-sucking bug (*Elasmolomus sordidus*, Insecta, Lygaeidae) which pierces its rostrum into the pods to reach the kernels to feed on. Timely harvest is important, but often limited by labor availability and climatic factors. Harvest too early to take advantage of available labor and you risk getting immature peanuts. Harvest late, and you risk insect infestation and losing the majority of your peanuts to the hard and dry ground. One of the women eloquently narrates the insect problem:

> "When you allow harvested peanuts to stay in the farm for long, some reddish insect [the first instar nymphs have a bright red abdomen (Rao and Rameshwar 2013)] suck the oil of the peanut leaving patchy oily spots on the kernels when you unshell the peanuts.[9] The husk of such peanuts peels off when you unshell it. The insects are a sign that the rainy season is nearing an end and the dry season is about to start. Early cultivation and harvesting reduces the insect problem"

Aside from the insect, the piled peanut haulms are exposed to moisture from rain or dew, which creates a conducive condition for aflatoxin contamination. The women are aware of this, and so tried as much as possible to avoid leaving piled peanuts on the farm. The women rely on their social network to harvest their peanuts and transport it on their heads to the house. They practice communal harvesting by helping each other to harvest their peanuts. Women who do not have enough to harvest and can afford to harvest on their own move to help on other farms in exchange for a third of what they help harvest.[10] Most women do this to help soften the blow of poor harvest on their farms. Plucked peanuts are carried in pans or sacks to the house and drying begins.

Drying

The majority of women dry their peanuts on the floor of their compounds (either concrete or graveled) and rely on the sun to reduce the moisture content to optimum levels. Peanuts are dried in pods under the sun and stirred regularly to allow even exposure to the sun. A few women

[8] In N'Dede et al (2013) study, respondent's demonstrated their limited knowledge of the health effects of consuming aflatoxin contaminated peanuts. They listed diseases such malaria, diarrhea, and coughing as illness associated with consuming large quantities of contaminated peanuts.

[9] The pod-sucking bug does not suck the oil, but feeds on kernel and the resulting patchy oil perhaps explains the increase in fatty acid content that causes the rancid flavor.

[10] Each woman plucks as much peanuts from the vines of the piled haulms. In the end, the quantity of peanuts each woman is able to pluck from the vines is divided into three parts and the owner takes two parts and woman who did the plucking takes one part. This is a livelihood strategy commonly practiced among women in peanut farming.

spread polyethylene on the ground before drying their peanuts and this is mostly done when drying peanut kernels.

Contamination during drying is common and the women are aware of some of their practices that expose peanuts to aflatoxin contamination. Drying peanuts on the bare floor exposes peanuts to aflatoxin contamination. At first, women couldn't understand how peanuts protected in their pods could get contaminated from drying on the floor. But children, goats, sheep, and the person tasked with stirring the peanuts may step on the peanuts and crack the pods, exposing the kernels to sand particles, propagules and other contaminants, increasing the likelihood of aflatoxin contamination. Although what the women mentioned about cracked peanuts causing their peanuts to get rotten is true, they failed to make a connection to how drying on the bare floor caused contamination.

Insufficient space for drying peanuts makes stirring difficult, which causes uneven drying. The peanuts that do not get exposed to the sun begin to mold, and if not detected early enough, the mold spreads to other pods. Rain forces women to gather the peanuts and cover them with rubber or tarpaulin for protection. When the rains stop and the tarpaulin or rubber is not removed, the generated heat and trapped moisture in the piled peanuts triggers mold.[11]

All the women stressed the importance of drying in post-harvest handling of peanuts. Getting the right moisture content is crucial in getting quality and healthy peanuts. There is no simple way of telling whether the optimum moisture content of 6–8% (Page et al. 2002) has been reached except to use a moisture meter. The women who do not have the benefit of this machine use their local knowledge to tell when the optimum moisture content is attained. For too little drying, the peanuts will rot in storage and too much drying makes the peanuts lose their quality—the brown husk peels off leaving the white kernel. Similarly, excessive exposure to the sun can affect groundnut quality (Page et al. 2002). Women had a lot of knowledge to share about how they know peanuts are well dried and ready for storage.

> Dried peanuts are crunchy in the mouth but when they are not dried, it sticks between the teeth when chewed
>
> You hear the kernel shake inside the pod when you shake it
>
> Fetch some for someone to chew to get a second opinion
>
> When you press a kernel between the fingers, it breaks into two and the husk stays on but when the husk peels off, it means the kernel over dried – even with a little press between the fingers, over dried kernel shed its husk easily
>
> Wet kernel is milky when chewed in the mouth but dried kernels feel oily in the mouth
>
> The sand on freshly harvested peanuts pods eventually is removed as the pod dry and no sand will be found on a well dried peanut pod
>
> The oil in over dried kernel stains its pod
>
> The pod of a peanut that is not dried cannot be cracked open with the toe but dried pods can be cracked with the toe.
>
> Dried kernels shake in their pods when it is being stirred during drying under the sun on the floor.

[11] Sometimes there may not be enough sunshine for a day or two after it rains. This is not good for the peanuts and may cause some to mold. Most women who participated do not harvest a lot of peanuts that will make it impossible to dry peanuts in their compound, regardless they struggle with their modest harvest as they rely solely on the sun for drying to the optimum moisture content.

Fig. 5. Left palm contains optimally dried kernels and right palm contains over-dried kernels.

Women pay particular attention to optimum drying because it affects the market quality of their peanuts. Drying affects the color of the peanut when it is taken out of its pod (Fig. 5). Over-dried peanuts become dark brown whereas optimally dried kernels are light brown.[12] Optimally dried kernels fetch higher prices in the market and so farmers pay particular attention to avoid over-drying. Another way kernels become dark brown is if they are dried out-of-pod. The sun-burn makes it dark brown. The women explained that it is just a color change and doesn't affect taste, however, it reduces oil content and such peanuts cannot be stored for long periods.[13] Most of the women dry peanuts with the pods intact to keep their peanuts viable in case they want to use it as seed. When there is high demand for peanuts, aggregators do not mind the color, but they definitely take it into consideration when there is less demand for peanuts. Kernels that have no husk due to over drying are rejected by aggregators and accepted by market traders at a much-reduced prices.

Sorting

Sorting begins at the time of drying. As the women spread the peanuts to expose them to the sun, they pick out peanuts with empty shells, black pods, odd-looking pods, and oily pods. Discarding damaged nuts, discolored nuts or odd-shaped nuts can help reduce levels of aflatoxin contamination. Aflatoxins, before storage, may be found on a few nuts (Whitaker, 2003). Hand-picking dirty and odd-looking nuts can result in a 40–80% reduction in aflatoxin levels (Park, 2002; Fandohan et al. 2005; and Afolabi et al. 2006). Some women reported that it is good practice to sweep away the sand (carried along from the farm) that falls off the peanut shells as they dry.

> …when you bring the peanuts to the house, you pour them at one place and take out the ones with holes in it [peanuts with holes bored by insects] and also remove the weeds in the peanuts, you will realize that the sand in the peanuts will also settle on the ground. To have very good nuts, you have to collect the peanuts from that place leaving the sand…

Women are able to identify undesirable nuts to sort by pressing on the pod. They pick out pods that collapse—meaning it has no kernel in it—or the kernel is rotten. A collapsed pod could also contain immature kernels or shriveled kernels.[14] The peanuts are also winnowed to get rid of weightless pods—implying they have no kernel inside them.[15]

[12] See Fig. 5.

[13] Women who experimented drying freshly harvested peanut kernels out-of-pods claim, when you expose one side of the kernel to the sun without turning the other side, you notice the difference in color on both sides—the side exposed to the sun becomes dark brown and the side hidden form direct sun remains light brown.

[14] See Fig. 6: shriveled kernels doesn't imply the nuts are rotten, but it is sorted and dried separately from the rest. Interestingly, it is sweeter ("sugar sweet") than regular kernels.

[15] What has been described in the paragraph above is done for shelled peanuts. However, for unshelled peanuts, the kernels are sorted differently if it is intended for immediate household consumption. To prepare kernels for cooking, some women described pouring the peanut kernels into hot water so that bad kernels would suspend whereas good kernels sink to the bottom. They explained that cold water can also be used but hot water is preferred because it is able to kill insects that may be hiding somewhere in the kernels.

Kernels may be sorted for different purposes. Broken kernels may be sorted from full kernels or shriveled kernels may be sorted from full kernels (Fig. 6). It all depends on what the peanuts are going to be used for. Broken, dehusked, and shriveled kernels may be sorted when selecting seeds for replanting or when preparing peanut kernels for the market. These sorted kernels may not be rotten, they are not just desirable for the market and they are not viable seeds. Kernels meant for household consumption are not sorted as thoroughly: Broken, dehusked, and shriveled kernels are not removed.

Fig. 6. Shriveled kernels are good peanuts for consumption but can't be used as seeds for replanting.

Storage

A hygienic and well-ventilated store room is the ideal place to store peanuts. Storage rooms used by the women are usually structures built with poor ventilation. The women store their peanuts in polyethylene sacks.[16] A few women use jute sacks, which are commonly used for storing maize and cocoa beans in Ghana. They leave the shells intact for storage—that way the kernels are protected and can be stored for a couple of months. The jute sacks are better than the polyethylene sack in terms of air circulation around the peanuts, but women prefer the polyethylene because it can be used to store a lot more peanuts than the jute sacks. The bagged peanuts are stacked on each other in musky and poorly ventilated store rooms or kitchens.

The women knew and understood the importance of putting wooden pallets on the floor before stacking the bagged peanuts. This is done to protect the peanuts from the cold floor, which can cause enough moisture to generate in the stored peanuts to cause molding. The participants' store rooms are also not sealed from insects and rodents. There are gaps between the ceiling of the rooms and walls, allowing insects, wall geckos, and small rodents access to the stored peanuts. Activities of insect pests increase moisture levels during storage due to their metabolism, thereby changing the microenvironment conditions (Beti et al. 1995). The insects can also transport fungal propagules during movement (Beti et al. 995). Thus, high insect population levels during storage significantly increases the risk of aflatoxin contamination. Another observed practice was the reuse of storage bags from the previous season without disinfection. Some women are able to dry the sacks in the sun to allow the insects to come out; however, this does not get rid of fungal spores or toxin residue from previously stored peanuts.

Aflatoxin contamination

Aflatoxin tests were performed halfway through each focus group discussion using VICAM's AflaCheck.[17] It is a qualitative one-step test kit for the detection of aflatoxin. I used a strip test protocol that detected the presence of aflatoxin at a cutoff level of 10 parts per billion (Waters Corporation, 2013). In each community, we tested the "good" and "bad" peanuts the women provided.[18] I

[16] Polyethylene bags are larger and can be reused several times compared to the jute sack. Because peanuts are mostly stored with pods, which makes it bulky and fills the bag quickly, polyethylene bags are preferred.

[17] AflaCheck is a registered trademark of Waters Corporation, headquartered in Milford, MA, USA. (www.vicam.com)

[18] I differentiated "good" to them as peanuts they trust is free of any sort of contamination and they would not hesitate to consume whereas "bad" peanuts as those they judge as unfit for consumption.

Fig. 7. Test strip showing two red lines implying a negative test (< 10ppb).

Fig. 8. Test strip showing a single red line implying a positive test (> or = 10ppb).

clarified what I meant by "good" and "bad" peanuts because in the first communities we visited, women distinguished "good" and "bad" as peanuts that could be used as seeds for planting and those that could not be used as seeds for planting respectively. In this case, they brought good kernels and provided shriveled peanuts as bad. Their perspective of "good" or "bad" peanuts helped clarify to me their priority when handling post-harvest peanuts. They would be careful to ensure that peanuts set aside for seeds were free of contamination and viable but would not go such lengths to protect peanuts designated for consumption.

The results expected after testing was to see either: (1) see two red lines which meant the sample contained less than 10ppb of aflatoxin (a negative test, Fig. 7) or (2) see a single red line which meant the sample contained greater than or equal to 10ppb of aflatoxin (a positive test, Fig. 8).

The "good" peanuts tested negative (<10ppb of aflatoxin) and the "bad" ones with rotten kernels tested positive (≥10ppb of aflatoxin). Note that the negative test for the "good peanuts" doesn't mean there is no aflatoxin present. Aflatoxin could be present in concentrations >0 but <10ppb.[19] This form of test—although it doesn't tell us exactly how much contamination is in each sample—serves the purpose of explaining to the women that there may be some amount of the toxin in the peanut and that concentration increases with poor handling of peanuts. It was also used to make the claim of why they should not use "bad peanuts" for dawadawa or mix them with good peanuts to make soup. They understood that consuming large quantities of "bad peanuts" meant they were accumulating increased concentration of the toxin in their bodies. Referencing it to the acute and chronic toxicity of aflatoxin, I made a convincing case why they have consumed different kinds of peanuts (bad or good) and may or may not have experienced some form of sickness. Most of the participants nodded in agreement and some argued that they have observed instances where consuming "bad peanuts" have affected them in different ways.

The women were able to identify and explain some pathways to aflatoxin contamination and could tell signs that show that peanuts are going bad or have gone bad.

> …when peanuts gets spoilt you will see white dusty substance. During drying, when some of the shells of the nuts crack and you don't remove them and you store them, after a while you will find that most of the nuts become powdery…
>
> *Yua* [see below] enters peanuts when

[19] The World Health Organization (WHO) has set a maximum level of aflatoxin at 20ppb in human food and 100ppb in animal feed (N'Dede et al, 2013, cited in WHO, 1998). The European Union has a much stricter limit set at 4ppb for any food product meant for human consumption.

it is exposed to too much heat, for example when you stack too many sacks of peanuts on top of each other and there isn't enough air circulation or proper ventilation in the store room. Also if the nuts are not dried well. Such nuts cannot be used for anything no matter how much you wash them.

When there is *yua* in peanuts, some green coloration appear on it. If the peanuts are not well dried before storage or when dried peanuts are placed on the bare ground, the wet peanuts will affect it and some green coloration will appear on the peanuts.

Yua was a term that was mentioned during the discussion and the women had different explanations describing what it means, however, it was clear that they were all referring to the same thing when they used the term. I probed further by asking about practices they have adopted to mitigate yua in their peanuts, and the response I received conforms to recommendations from literature (Turner et al. 2005).

Put wood or blocks and pack sacks on them to prevent sacks from making contact with cool floor. The jute sacks can rot and the peanuts will be exposed to moisture from the bare floor.

Don't allow the bags of peanuts to lean against the walls of the store room

…now we reduce the yua by reducing the way we step on the peanuts during drying and storage.

When you notice your peanuts are spoiling, then you dry them again

Hire more labor to help to pluck the peanuts from the vines after harvest and carry them home on time to avoid rain beating the peanuts on the farm

Fig. 9. Granaries for storing mostly rice and maize cultivated by men.

Early harvest so that you can dry quickly before the rains intensify

When you dry the peanuts properly and winnow away the empty pods before storage, they can't be infested by this yua again.

The women learned this from their own experiences from previous seasons as well as what they were taught by their parents.

My own story is different, when I harvest and wants to store my peanuts and I realise my husband's granary is not full, I seek permission from him and add mine to his and go for it whenever I need it. I realized when I store the peanuts in his granary; I pick it in very good condition. There is a saying that when you trip twice, you become wise. I stored peanuts the first year and when I needed it and opened it, the bad nuts were more than the good ones. The same thing repeated the second year, but I realised my husband's peanuts were always good so I took the initiative to store it in my husband's granary too

Further questioning revealed that this respondent's case was different and was not a common occurrence among the other women. The men build granaries from straws and tree branches in which they mostly store rice (Fig. 9). The women typically do not own granaries because they cannot afford to build them and their husbands are busy with farm work or some other off-farm occupation. The case of this respondent was unique because she was an elderly woman and perhaps the first wife of her husband, so she has greater influence in her compound compared to other participants who were younger and probably junior wives of their husbands. All the participants in the communities I visited agree that storing in the granary is the best way to store peanuts for a long period. But such storage methods are for the men who grow the "important crops" such as rice and maize.

Discussion and conclusion

Local knowledge is intricately tied to rural livelihoods and so local populations possess in-depth information about agriculture, agro-forestry, pest-management, soil fertility, multiple cropping, food preservation and storage, etc. (Agrawal, 1995). Scientific/western knowledge on the other hand is abstract and isolated from the daily lives of people and focuses more on analytical representation of the world (Agrawal, 1995). Local knowledge has been described as low value by western knowledge, and it is no surprise that most local people elevate western knowledge over local knowledge. Agrawal argues that characterizing knowledge based on who possess it is nonsensical since the same knowledge can be high or low prestige depending on who advances it (Agrawal, 1995).

Local knowledge systems are culturally and socially embedded in communities and may differ from one community to another. This was evident in the two tribes — Dagomba and Konkomba — among the communities I visited. The rationale for certain practices differed in each of the two tribes and between communities of the same tribe that are quite far apart from each other. Instead of trying to categorize knowledge as local or scientific, it may be useful to accept differences within these categories and search for similarities between them (Agrawal, 1995). Local people can experiment and innovate with scientific information by combining it with their local knowledge to fill gaps (Chandler, 1991). However, Nadasdy cautions about power relations involved with integrating local knowledge and science (Nadasty, 2004). He argues that science compartmentalizes and distills local knowledge in a way that distorts its values and practices. Science is often used to extend western influence across remote locations rather than to empower local people (Nadasty, 2004).

I believe that knowledge sharing goes both ways, and depending on the direction of flow, information can be readapted to suit the needs of the user. Just as science can take and adapt local knowledge, local knowledge can also take science to adapt for use. However, as rightly noted by Agrawal and Nadasty, western knowledge is too powerful to allow a balanced exchange between the two. Allowing local people to pick what they need from science (by presenting options), rather than prescribing scientific solutions, will better serve to complement local knowledge. For example, consider an instance where a farmer is presented with two options: a prescribed improved peanut variety vs. an option on how to reduce aflatoxin contamination; my guess is that the farmer's priority will be how to maintain kernel quality for long periods in storage and so will choose the option that teaches how to reduce aflatoxin contamination.[20] The farmer will care less about an improved variety if they are struggling with post-harvest handling. Several other reasons will make them not interested in this improved variety: they will not risk trying something new because it is an important

[20] See Gray, L. C., & Morant, P. (2003) where farmer's perceptions about soil fertility reflect concerns that are more important to them and contradict scientist's perceptions of soil fertility.

part of their livelihood and income source; and the women replant seeds they have harvested, so they won't understand why they should purchase new seeds if they can get their own seeds. This is an instance where western knowledge attempts to use local knowledge divorced from its social and cultural context (Nadasty, 2004).

Climate change is an example of one such complex phenomena the women cannot make sense of using their local knowledge. In this instance, climate change renders some of their local knowledge obsolete and defunct. For example, using observations of the pod-sucking bug to determine the start and end of rainfall may become less accurate due to climate change. Women rely on sunshine to dry their peanuts but due to erratic rainfall, their local practice of drying peanuts in the sun with unpredictable rainfall patterns becomes challenging and may require western equipment such as the moisture meter. There are other practices that can be done efficiently using local practices, for example sorting peanuts. Removing rotten peanuts by hand picking is labor-intensive but will result in better quality peanuts than any form of mechanical means of sorting.[21]

With particular reference to this study, it is clear that women know about rotten peanuts and are aware that they are dangerous to consume in large quantities. Women know how to handle their peanuts to the best of their capability and knowledge: they have tried to make sense of observations they have made in post-harvest handling of peanuts and succeeded in understanding some phenomena and failed in others. There are just some things that local knowledge cannot help explain and the same goes for western knowledge.

The women's perception of a peanuts' suitability depends on whether it is going to be used as seed, for sale, or used as food for household consumption. The women cared more about how to keep kernels viable for replanting or of good quality for sale based on what aggregators check before buying peanuts. Little attention is given to peanuts designated for household consumption. In most households, peanuts designated for household consumption are those that fail to make the criteria as 'viable seeds' or meet market standards. The majority of samples (both best and worse peanuts) tested positive except in communities where kernels provided for testing are freshly removed from the pods. Unless there is physical indication that peanuts have gone bad, generally the women did not perceive potentially contaminated peanuts as harmful to their health. Interestingly, not all contaminated peanuts show the physical signs of green coloration. Kernels may look clean and healthy but may test positive for aflatoxin. This was observed in some communities who had both their good and bad peanuts test positive. Although the women did understand that aesthetics alone is not enough to help them decide if peanuts is safe for consumption, the majority of women are used to relying on physical aesthetics to decide whether to consume or not to consume peanuts. For example, *sim kpagma* is aflatoxin contaminated peanuts but looks good physically, however, when you chew a few kernels, it is rancid. Some women disregards the bitterness and go on ahead to process it into butter by adding a few good peanuts to balance the rancidity. Perhaps, the only threat the women perceive from the *sim kpagma* is the bitterness and not the fact that it is contaminated with aflatoxin. There is a chance to educate women to desist from consuming unsafe nuts as they are already aware of and observe most of the good practice that are convenient for them.

Extension agents are lacking in this region[22] and may not even reach women due to religious and cultural reasons (Masters et al. 2013). Extension agents are important for the transmission of scientific knowledge to the women farmers. In this study, one of the two criteria used to sample communities was based on whether there was a commu-

[21] I haven't heard about, or come across in the literature, a mechanical sorting machine that separates bad peanuts from good ones.

[22] On average, there is only one extension agent for every 3,000 farmers (Master et al 2013).

nity extension agent present or absent. I observed that there was no difference in the knowledge exhibited by participants across the communities.[23]

When an adopted practice results in positive outcomes, it could lead to more adoption of related practices. Survey data from the DIRTS project show that some agricultural extension agents (AEA) have less contact with women. This could be due to several reasons: it could be that the visit times of AEA favor men than women. Most of the participants' peanuts farms are 1 acre or a little above and so they spend part of their time engaged in off-farm business for extra income. There may be a lack of disincentive to seek extension advice because they do not make enough financial commitment in their peanut farms. Most women recycle seeds from the previous harvest and do not apply fertilizer.

Recycling seeds for replanting is causing problems for the women. Especially at a time like this when the impact of climate change is manifesting in smallholder agriculture. The variety of peanuts cultivated depends on aggregators' preferences and market demand. Most participants with the exception of a few, grow the *china* peanuts variety. Most participants prefer this variety because of the short maturation time and the aesthetics of the kernel. Unfortunately, they recycle the seeds too many times causing perhaps the reported low yields.

It appears the women do not realize the importance of using certified seeds, and efforts should be made to increase the contact time with extension agents. Education on seed recycling for planting and certified seeds should be emphasized. Perhaps more emphasis should be placed on explaining the rationale behind certain extension messages to help farmers make informed decisions on adoption. For example, when educating farmers about recycling seeds only twice and then buy certified seeds, more efforts should be made to explain the reasoning behind that recommendation. Breaking down messages into understandable bits may be oversimplifying things and not achieving the desired effects.

Participants demonstrated knowledge of good storage practices for peanuts and integrated pest management (IPM) practices. They understand concepts like planting and harvesting on time to minimize pest and disease attack. However, despite acknowledging that drying is a vital stage of post-harvest handling, women seem to struggle to adopt some of the practices from the video on drying. Again, it comes back to certain constraints that cause reluctance in adoption. Labor constraints, financial constraints, being able to innovate using available resources, constraints from nature (rainfall and sunshine) may hamper the adoption of some extension messages. Drying takes a lot of time and it always requires that someone sit close to watch out for animals while it dries. Some practices like buying tarpaulin or polyethylene to spread on the ground before drying is a practice a few participants adopted due to financial constraints. There is little incentive to invest in polyethylene since most women harvest few peanuts. The impression I got from participants was that their harvest is not worth making that extra investment in the post-harvest handling stages. There are some practices that women can adopt by innovating with available resources at their disposal. For example, women are able to get wood to make racks or arrange stones on the floor of storage room before stacking bags of peanuts on top.

I have examined post-harvest interventions women employ to minimize aflatoxin contamination in peanuts. It is clear that the applicability of their local knowledge is limited in certain circumstances, which makes their efforts to minimize contamination counterproductive. Information sharing via extension agents can get women access to scientific knowledge that they can readapt for their use. I found it interesting how the participants are able to determine if peanuts are optimally

[23]Community extension agents (CEAs) of the DIRTS program did not seem to have any effect on difference in knowledge among the participants or perhaps, participants were simply not reached by CEAs. Several other reason could have accounted for this, too. Note that all participants were women whereas DIRTs project deal with both male and female farmers.

dried without using any form of equipment. Post-harvest interventions such as drying, sorting, and storage are important practices women use to reduce aflatoxin contamination in peanuts. Drying seems to be the factor of most concern amongst the challenges women farmers face. Unlike harvesting and sorting where the limiting factor is labor, the limiting factors for drying include climate change and its side effects that they have no control over. For the first time, I have actually appreciated the impact of climate change on crop production and how it affects communities that depend on natural resources for their livelihood. It is unfortunate that local people cannot adapt local knowledge quickly enough to understand the environment better and adjust appropriately to climate change. Participants I spoke to informally told me how the rain falls at a time they do not expect it and are not prepared for it. It affects how they handle their peanuts because rainfall patterns have changed and they are finding it hard to determine when to sow seeds.

Recommendations

Basic sanitation practices are crucial to handling post-harvest peanuts. Observing sanitation practices like sweeping the floor before drying peanuts or disinfecting old sacks before reuse can help reduce aflatoxin contamination. Storing peanuts in pods also protects kernels and helps to reduce aflatoxin contamination. Early cultivation and timely harvest also reduces the chances of pest attacks and subsequent contamination.[24]

There are scientific methods to dealing with aflatoxin, however I hesitate to propose such interventions due to the cost involved and the subsequent side effects of these technological interventions (Ferguson, 1990).[25] Using a moisture meter for drying or using hermetically sealed bags for storage (Masters et al. 2013), and genetic engineering (Alakonya and Monda, 2013) are some scientific methods to control aflatoxin.

Government and other stakeholders should train and deploy more female extension agents to work closely with women farmers. To encourage adoption of practices, extension messages and technologies should be designed in a way that allows farmers the chance to use their already existing or available resources. To achieve this, there should be more innovation in crafting and delivering extension messages. Further research is needed to understand if and how climate change will affect local knowledge and practices.

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[24]This recommendation will be difficult to adhere to due to the effects of climate changes (i.e., erratic rainfall patterns and drought).

[25]See James Ferguson's *The Anti-Politics Machine* where he argues that bureaucratic state power use "poverty as its entry point" to launch an intervention (in this case a project to boost agricultural production) had no effect on poverty but created a new local administration.

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Appendix A. Field Site Selection and Justification

I selected my research sites based on my access to DIRTS project baseline data. DIRTS program has established rapport with farmers in these districts since November 2013. Moreover, I had access to Community Extension Agents (CEA) – select community members purposefully trained by IPA (Innovation for Poverty Action) for the DIRTS (Disseminating Innovative Resources and Technologies for Smallholder) project. The DIRTS project is implemented in 162 communities, consisting of 3240 households in 12 districts of the northern region of Ghana. The project is supported by USAID, ATAI and Yale University. Details of IPA's DIRTS project and methodology can be found at http://www.povertyaction.org/study/disseminating-innovative-resources-and-technologies-smallholder-farmersghana

Appendix B. Questions for Focus Group Discussion

Because aflatoxin cannot be seen with visual inspection and is difficult to describe in the local language, I established farmer knowledge on aflatoxin contamination by asking them about the fungus that deposits aflatoxin on peanuts. Poorly-dried stored peanuts get moldy with green coloration.

Establishing farmers knowledge on aflatoxin

Tell me about your experience with rotten peanuts
How can you tell if it is rotten? (e.g., by tasting or eye inspection)
What makes the peanuts get rotten?
What are some illness associated with eating rotten peanuts?
Are there other names you use in referring to bad peanuts?
What happens if you store peanuts that is not properly dried?
Do your peanuts get moldy in storage?
Are sorted moldy peanuts the same as rotten peanuts?
Are you familiar with green coloration on poorly dried stored peanuts?
What do you do with such peanuts?

[*Perform aflatoxin test on both their best and worst peanuts*]

Tell us about *yua* in peanuts
How did you hear about aflatoxin contamination?
What practices did you adopt to mitigate this *yua* in peanuts?
When did you start adopting new practices to minimize peanuts contamination?

Practices

How do you sort your peanuts?
How do you dry and store your peanuts
How do you know if the peanuts has dried enough and is ready for storage?
What practices have you adopted to ensure you reduce peanuts contamination?

Knowledge

How often do you talk about peanuts farming or any other crop you grow with your friends, neighbors or your relations?

Tell us about other ways that you know people handle post-harvest peanuts in order to reduce aflatoxin contamination.

How are buyer/aggregators able to select the best peanuts?

Tell me about your overall experience in groundnut cultivation.

Amongst your friends, neighbors and other peanuts farmers from nearby communities, do you know someone who is able to reduce the amount of bad peanuts from their harvest?

Do you know what this farmer is doing differently that you are not?

Have you tried reaching out to learn what that farmer does differently that you don't do?

Do you know of harvested peanuts varieties that have less bad nuts from their harvest?

Do you belong to a women's group and how helpful it is?

How often do you meet and to talk about good practices of handling peanuts?

Do buyers/aggregators check farmers' peanuts for quality before they purchase?

What do they check?

Do they offer different prices for different qualities of peanuts, or do they simply reject to purchase peanuts that they think are low-quality?

How would you use peanuts that are rejected by a buyer/aggregator?

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Crisis of urban agriculture: Case studies in Cuba

Tess McNamara, MArch & MEM[*]

Abstract

This project investigates the extensive system of urban agriculture (UA) in Cuba, a network that arose out of nation-wide food crisis in the 1990s, with the purpose of speculating how elements of this system might be applied to other nations also grappling with food instability born from crisis. The study is primarily spatial in nature; it investigates the common characteristics of UA land in Cuba, the aesthetic impact of the farms on their urban context, and how UA produce travels from farm to consumer. After visiting, analyzing, and interviewing farmers on 21 UA sites (predominantly government-run organopónicos) across the cities of Havana, Cienfuegos, Trinidad, and Santiago de Cuba, successful and replicable elements of the Cuban system emerged. The farms are often in the center of areas of high density, on vestigial construction lots, and have on-site marketplaces, resulting in vibrant community spaces and immediate access to fresh vegetables. The system benefits in a number of ways from the strong, centralized government in Cuba, which is highly motivated to support in-country food production due to previous instability and ongoing insecurity. Organopónico regulations ensure quality and 'organic' methods, prices are lower than other options due to government support and minimized transportation costs, and all land used for these farms is owned and 'leased' to farmers by the government. While some elements of the Cuban system are unique to the country's distinct history and political system, I have identified significant spatial attributes with the potential for replication.

History of urban agriculture in Cuba

Cuba's history of food production is indelibly tied to the political systems in power both at home and abroad. Cuba's food instability was solidified in 1972, when Castro signed trade deals with the Soviet Union after the 1962 U.S. embargo. These agreements limited Cuba's agricultural products to nonessential foods like citrus and sugarcane, and established a dependence on trade relationships for critical goods like cereals and oil. (Clouse 2014: 38). By 1988, Cuba was importing 57% of its food supply (Murphy 1999: 1) with staples like cereals, beans, and rice imported at rates of 100%, 90% and 49% respectively. That year the Soviet Union and Soviet Bloc together provided 84.6% of Cuba's imports and received 81.7% of its exports. At this time, Cuba's exports were 75% sugar and sugar derivatives, which were purchased by the Soviet Union at an inflated, favorable price (Rosset and Benjamin 18). Up until 1989, the Cuban agricultural sector was characterized by a dominance of export monocultures, scant at-home crop production, heavy dependence on imported raw materials and food, and a high degree of modernization in farming methods, all buoyed by their agreement with the Soviet Union (Rosset 1994: 18).

Therefore, with the collapse of the Soviet Union in 1989, Cuba lost its supply of wheat, beans, and oil almost overnight (Wright 2009: 3-4). Cuba was forced to develop a way to feed its population

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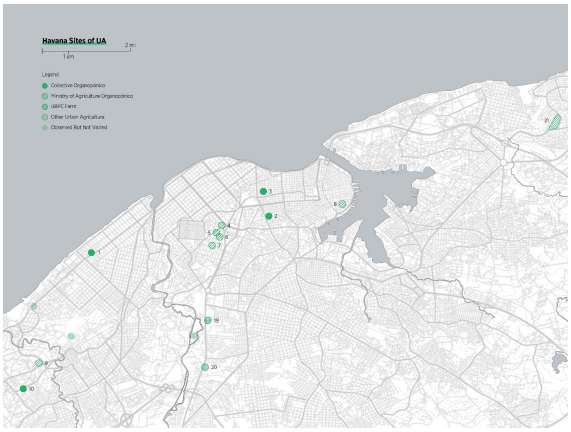

Fig. 1. Map of Havana indicating visited and observes sites of urban agriculture.

of 10.5 million people, 69% of whom lived in cities, without the imports of staple grains and agricultural technology that its entire food system had come to depend on (Rosset 1994: 15). The following decade is defined in Cuba's history as The Special Period in Time of Peace, an austerity program officially mandated in 1991 that today is a standin reference for Cuba's extreme isolationism. Food crisis followed this political and economic turmoil, and it has been estimated that the average Cuban's daily caloric intake was reduced by 30% when compared to 1980s levels (Ibid: 22). In the three years after the collapse of the Soviet Union, this food shortage translated into a loss of thirty pounds for the average Cuban (Clouse 2014: 33).

This period of isolation transformed the country—socially, politically, and spatially. Faced with extreme rations, Cuba's urban population took to vacant urban land in order to produce their own food. The acute food shortages pushed the government to allow individuals to grow food on government-owned urban land, and in 1993 Castro responded to even more severe U.S. sanctions with the Third Agrarian Reform Law, which allowed 70% of Cuba's agricultural land to be transferred to individuals and cooperatives through usufruct rights (Schultz 2012). The agricultural systems developed during this period were devoid of pesticides and fertilizers by necessity, and therefore Cuba's emerging farming practices were organic by default. The Cuban Special Period represents the largest attempted conversion from conventional to alternative, semi-organic, agriculture in the world's history (Rosset 1994: 34). By 2001, food security was under control in Havana, in large part due to government-supported urban farming (Clouse 2014: 44). From guerrilla growers to the state-run organopónicos, urban agriculture in Havana alone converted 35,000 hectares of land into productive space. By the early 2000s, Cuban officials estimated, conservatively, that more than 50% of the fruits and vegetables consumed in Havana were produced within the city (Clouse 2014: 35). A country whose food system was previously reliant on imports became self-sufficient through urban, organic agriculture (Diaz 2005).

The Cuban diet today has improved from its crisis time severity; however the population is still under 'food stress' due to the challenges Cubans face in securing a balanced diet. High protein animal products like butter, cheese, milk, and meat are still in short supply, as Cuba's cattle population has yet to rebound to 1980s levels due to the difficulty of growing feed in a tropical climate (Clouse 2014: 52). The isolation Cuba saw in the early 90s is also no longer a reality. Today, 25% of Cuba's total food and agriculture imports come from the U.S., including poultry, corn, and wheat. Brazil is Cuba's main source of soy products, and other food imports come from the EU and People's Republic of China. (Ibid: 38-39). While Cuba-U.S. relations had shown further signs of thawing in early 2016, at time of writing the inauguration of President Trump casts doubt on future improvements to trade partnerships between the neighboring countries. Although Cuba today has diversified its imports of food, it is still dependent on Venezuela alone for oil, an all too familiar dynamic. The two countries' 15-year oil agreement is unraveling as Venezuela experiences increasing political and economic turmoil. In 2016, Venezuelan exports of

oil to Cuba dropped by 40%, and the Cuban government had to reduce power service daily in state run buildings (Parraga 2016). Cuba's need for low-input, urban agriculture has not yet evaporated.

Methods

This study is motivated by the premise that with rising global instability and increasing urban populations, our petroleum-based food system will come under threat. Cuba's food crisis in the 1990s, and the nation's subsequent use of urban agriculture as an adaptation to this crisis, deserve a fresh look as we enter a time of potential world-wide food insecurity. This is a spatial study that investigates the network of urban agriculture in Cuba in order to speculate if and how elements of the Cuban system might be extended to other nations or cities grappling with food instability in the face of crisis. The study asked four questions of urban agriculture in Cuba: What is the path food takes from growth to consumption? What are the common characteristics of urban land used for food production? What are the spatial and aesthetic impacts of urban farms on the surrounding city fabric? Do urban residents depend on this produce as a food source?

In pursuit of these questions, I conducted field research in urban Cuba during July 2016 (Fig. 1). The cities chosen for in-depth analysis were Havana, Cienfuegos, Trinidad, and Santiago de Cuba, due to both population size and reported significance in previous studies of urban agriculture. While I identified a few sites of UA prior to travel based on information from previous studies, the majority of farms visited were identified while in the field. Once at a site, I mapped the farm, conducted informal interviews, and documented surrounding context. Spatial data was analyzed upon return, and farms were mapped and classified based on the following variables: relationship to Ministry of Agriculture (MINAG), density of surrounding area, and size of lot (Table 1).

Fig. 2. Centro Havana, Cuba

Results and analysis

The 21 sites of urban agriculture that I visited across the four cities displayed three clear spatial trends and common functional significance. Of these 21 sites, 14 were classified as organopónicos: for-profit urban farms run by residents on government land. Of the 14 organopónicos, nine were run by collectives and five by residents working directly for the Ministry of Agriculture. All organopónicos are subject to government regulation, and therefore characteristics such as bed size, vending practices, and types of produce grown are consistent across sites. Two of the 21 sites were larger and run by Basic Units of Cooperative Production (UBPC), four were informal with no point of sale, and one was an old organopónico converted into a medicinal herb garden due to problems with water access.

Table 1. Location and information on study sites in Cuba.

Name	City	Affiliation	Market	Density	Size
INRE 1	Havana	Collective Organopónico	Yes	Medium	1.0 ac
24 de Febrero	Havana	Collective Organopónico	Yes	High	0.4 ac
Raquel Pérez	Havana	Collective Organopónico	Yes	High*	0.4 ac
Oro Verde	Havana	MINAG Organopónico	Yes	Low	0.3 ac
5to Congresso	Havana	MINAG Organopónico	Yes	Low	1.3 ac
Plaza	Havana	MINAG Organopónico	Yes	Low	2.5 ac
La Sazon	Havana	MINAG Organopónico	Yes	High*	1.3 ac
San Isidro	Havana	Other	Yes	High	0.1 ac
Playa	Havana	MINAG Organopónico	Yes	Low	5.4 ac
Las Americas	Havana	Collective Organopónico	Yes	Medium	0.5 ac
La Calzada	Cienfuegos	Collective Organopónico	Yes	Medium	0.6 ac
Grifo Viejo	Cienfuegos	Collective Organopónico	Yes	Medium	0.4 ac
Julio Sotolongo	Trinidad	Collective Organopónico	Yes	Medium	0.6 ac
Belleza Productiva	Trinidad	Collective Organopónico	Yes	High*	1.9 ac
Hospital Garden	Santiago	Other	No	Medium	0.1 ac
Chicharrones 1	Santiago	Other	No	High*	0.2 ac
Chicharrones 2	Santiago	Other	No	High*	0.6 ac
addlinespace La Finca Privato	Santiago	Other	No	Low	1.6 ac
Febrero 24	Havana	UBPC	Yes	Low	5.9 ac
1rd Julio	Havana	UBPC	Yes	Low	5.1 ac
Vivero Alamar	Havana	Collective Organopónico	Yes	High*	27.2 ac

Due to its scale, Havana (Fig. 2) had the most diverse range of UA types, with five Ministry of Agriculture-run organopónicos, five collective organopónicos, and 2 UBPCs. The collective organopónicos are run by worker groups that arrange profit sharing for farmers but are still regulated by, and pay a profit tax to, the Ministry of Agriculture to keep their organopónico status. Generally speaking, these collective farms are newer, less organized, and slightly unkempt when compared to their MINAG counterparts. In both Cienfuegos and Trinidad, I visited two organopónicos each, both run by collectives.

Santiago de Cuba is the outlier of the four cities. During field-work there, I did not witness any organopónicos, and there were no points of sale at any of the observed sites of UA. While some of the spatial trends to be discussed do hold true for the more informal farming that was observed, UA in Santiago was of a different tenor. Compared to the bustling sites of UA in other cities, in Santiago no residents or farmers were present, sites were smaller, and had a forgotten, deserted appearance contradicted only by the presence of growing plants. There are a number of reasons why Santiago might be such an anomaly with respect to the type and quality of UA activities. The climate is considerably hotter and drier than Havana, for example, with average temperatures 3° higher and precipitation 10cm lower than its more eastern counterpart (Climate Data). Additionally, the terrain is steeper and more uneven than the other cities, as much of the urban fabric springs out of severe slopes unsuited to agriculture. While the nature of UA was distinct from other cities, the activity was still present and contributes to the significance of

Fig. 3. Market at 24 de Febrero, Havana, Cuba (*top left*); Market at La Calzada, Cienfuegos, Cuba (*bottom left*); Market and housing at La Sazon, Havana, Cuba (*right*).

an important spatial trend that will be discussed in the following section.

Accepting Santiago de Cuba as an outlier, the UA I observed in the other three cities had significant commonalities, and through my visual observation and farmer interviews, research question one, what is the path food takes from growth to consumption, was immediately answered. The 14 organopónicos were highly regulated and organized—each had an attached market stall to sell produce and were clearly subject to spatial standards. The consistency of market stalls explains how food grown on UA sites reaches consumers, as produce is consistently sold directly from the farm to residents. It is significant to note that none of the farming observed was subsistence farming; all food was produced with the goal of sale for profit at both UBPCs and organopónicos.

Three trends: Markets, housing, and water

Research question two, what are the common characteristics of urban land used for food production, is best discussed through three spatial trends across the witnessed urban agriculture sites: the presence and urban significance of market stalls attached to farms, the confluence of high density housing projects with sites of UA, and the persistent concern of water access for farming activities.

With the exception of Santiago de Cuba, as already noted, all instances of urban farming we ob-

served came with an adjacent market stall, just feet away from the produce production. These markets were consistently within the urban lot of the farm (Fig. 3). Facing the street and typically labeled with the farm name, these market stalls, staffed by farmers, sell the produce from the farm to residents in the surrounding neighborhood. When these stalls are set back from the sidewalk (Fig. 3), as is the case at INRE 1, La Sazon, and Oro Verde, the markets serve as informal community spaces, where residents interact while buying fresh produce for their home, casa guests, or paladar (informal restaurants operated out of residences). In contrast, these market stalls can also be pressed right up against the sidewalk, presenting a welcoming front to the neighborhood. In some cases, like Raquel Perez, 24 de Febrero, and Vivero Alamar, the attached market stall extends the length of the farm, incorporating an entrance and a covered vending area, almost as if trying to blend into the surrounding urban fabric (Fig. 3). In the summer months, the organopónico markets supplement their own produce with vegetables grown in the cooler countryside, an arrangement that maintains their role as bustling hubs of community food access all year round.

The second trend worth noting is the spatial overlap of housing projects and organopónicos. This concurrence was apparent in La Sazon (Figs. 3 and 4) and Raquel Perez in Havana, in Belleza Productiva in Trinidad, and in the farming seen in the Chicharrones neighborhood in Santiago de Cuba. The housing developments at these sites were built in the 1980s Soviet era, the pre-collapse period in which the USSR's influence over Cuba was extreme. The USSR was not only Cuba's main source of imported goods, but also their resource for technology and expertise (Rosset 1994: 30). The time of this construction made these housing projects ripe areas for urban farming in the decade that followed. For example, Organopónico Raquel Perez, founded in the late 1990s, was built on a lot flanked by two 20-story high-rise apartment complexes. This lot was used as a staging area during the 1980s construction, so when the economy collapsed a few years after they were built, the central lot had yet to be put into use and was available for urban farming. This places organopónicos directly amidst areas of high-density residential populations, and means that farms and their markets are within walking distance of a large number of city residents.

The third trend among UA sites in Cuba is the challenge of water access for farming in an urban environment. This was especially evident in Havana, where the government controls residents' supply of water through a network of crumbling infrastructure, often restricting supply in times of drought (Clouse 2014: 45). Water access is therefore a fraught subject in Havana, and farmers at Raquel Perez, INRE 1, Vivero Alamar, and San Isidro confirmed this by mentioning water use as a point of contention between the community and urban farms. Farmers at Raquel Perez, INRE 1, and Alamar boasted their own, on-site well, an essential resource that both ensures consistent irrigation and appeases residents' concern about farmers expending the neighborhood's entire water supply. Access to clean and plentiful water for crop irrigation is a fundamental challenge facing agricultural activity in urban areas (*Ibid*: 54).

Attitudes toward urban agriculture

Research questions three and four, *what are the spatial and aesthetic impacts of urban farms on the surrounding city fabric*, and *do urban residents depend on this produce as a food source*, were both answered by conversations with residents and farmers. The three themes of market accessibility, housing density, and *water use* influence residents' feelings toward organopónicos, with the first two contributing to their popularity. A few residents mentioned that they appreciate the greenery that urban farms bring to the neighborhood, a contrast particularly evident in Habana Vieja and Centro Habana (Fig. 1), where treeless streets are filled with swirling dust and unrelenting sun. The farms of San Isidro, Raquel Perez, and 24 de Febrero emerge

from this dense crumbling fabric like oases—lush, green openings in a densely packed city-scape.

Many urban residents also spoke of how they love the proximity, assurance of quality, and low price of food grown on organopónicos. As a point of comparison, one farmer explained that agromercados, markets that sell produce grown in the countryside, are five times the price of organopónicos, largely due to difference in transportation costs. Considering this price differential in reference to the average Cuban's $40 monthly salary implies that residents rely on the food from urban farms to maintain a complete and balanced diet. Therefore, within the Cuban system of urban agriculture today, land used for farming is government-owned and often near high-density development. These farms provide aesthetic respite from a dusty, decaying urban fabric. Food is sold from market stalls directly on the farm, and residents rely on this relatively inexpensive source of fresh produce.

Conclusions

Conclusions regarding the replicability of the Cuban system can be drawn based on both the results of this study and an understanding of the conditions that contributed to UA's proliferation in Cuba. However, it is first important to discuss the unique elements of the Cuban situation, which complicate a discussion of replicability. It is clear that urban agriculture in Cuba was motivated and enabled by the extreme extent of their food crisis, the enduring U.S. embargo, the strength and power of the centralized government, and both vacancy and low land values in urban settings.

The unique reach of the central government in Cuba cannot be separated from the success of the urban agriculture program. All of the sites of urban agriculture observed were on government land. The legal framework of usufruct rights allowed individuals and groups to use government land for farming initiatives over long-term lease periods for 25-year renewable terms (Schultz 2012: 117-38). MINAG also provides seeds for organopónicos, in

Fig. 4. Housing at La Sazon, Havana, Cuba.

effect shouldering much of the burden of cost. This policy and framework of ownership makes it easy for the government to assign land uses to plots of land, independently from market force. In fact, between 1960 and 2012, there was no real estate market in Cuba—Cubans legally owned their homes but were unable to sell them (Clouse 2014: 56). Therefore, after the food and economic crisis of the '90s, urban land had no real value: state construction had halted and Cubans could not sell or buy property. These unique land-use policies, and the government's ability to control all development, are elements of the Cuban system unlikely to be replicated in other countries.

However, there are other UA practices developed in Cuba that have the potential to be employed elsewhere to improve food security in advance of crisis. The cases explored in this study indicate that government support for urban farming practices is essential for ensuring adequate land access and effective affordability of produce. To this end, governments in other nations could subsidize urban farming practices in the face of food crisis, providing seeds and public land to support the activity. Additionally, the on-site vending so pervasive in the Cuban system demonstrates an effective method of integrating an urban farm into city fabric. This market strategy also ensures that time, cost, and energy used in the transportation of food

to citizen is minimized—an essential feature of the Cuban system that ensures functionality in the face of threats to the nation's food system or economy. Additionally, the model of centering urban farms within dense urban populations, like housing developments, has potential for successful replication. This spatial overlap places affordable, fresh, produce within range of a large number of people, who are generally of low income and therefore sensitive to food insecurity. The water issues presented in the Cuban system, resolved only by the expensive project of digging an on-site well, is a significant impediment to proliferation of UA in other countries, particularly those in dry climates. Adaptations involving appropriate plant species can mitigate some of this challenge, however adequate water access is likely a pre-requisite for a successful UA system.

Haiti and Jamaica would be appropriate starting points for a study that sought to apply the lessons learned from the Cuban example to other specific nations. Though their political climates differ from Cuba's, they are also Caribbean island nations that experience food insecurity in the face of crisis. Both are import dependent and geographically isolated; Haiti still reels from the 2010 earthquake and 2016 Hurricane Matthew; and Jamaica confronts an economic crisis made more severe by the rising cost of imported food (Cave 2005). Overall, the Cuban experience with urban agriculture demonstrates a revolutionary use of urban space that alleviated the impact of widespread food crisis. Elements of this system have the potential to be replicated in other nations, both to prevent a crisis from affecting food supply, and to mitigate the effects of a crisis that is already underway.

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Making the forest productive

Sarah Sax, MESc[*]

Abstract

Large-scale cultivation of oil palm (*Elaeis guineensis*) spread throughout the tropics in the 20th century, with various socio-environmental effects, and is still ongoing. In the Peruvian Amazon, I examined the ways that the expansion of palm oil reaffirms or challenges existing power structures and identities that contribute to the uneven distribution of negative environmental impacts. I conducted over 30 semi-structured interviews with indigenous federations, government officials, NGOs, smallholders, and Shipibo-Konibo indigenous community members as well as conducting ethnographic research in three indigenous and one non-indigenous community. This article attempts to conceptualize the different legal, economic, and historical elements that contribute to one specific case of an oil palm plantation encroaching on the ancestral territory of the Shipibo village of Santa Clara de Uchunya. This case resulted in deforestation of 72–99% of the 6,874 ha of the land acquired, the majority of which falls within the ancestral territory of the Shipibo. Understanding the practices and power structures that contribute to cases of environmental injustice can ultimately help us design strategies for more sustainable and just resource management.

Los cultivos de palma aceitera (Elaeis guineensis) se han extendido en el trópico a lo largo del siglo XX, y su cultivo sigue en expansión, trayendo consigo efectos socioambientales. En la Amazonia Peruana, conduje una investigación para evaluar como la expansión de palma aceitera establece o reafirma las estructuras de poder y las identidades existentes que contribuyen a la distribución desigual de las cargas ambientales negativas. Para ello realice 30 entrevistas semi-estructuradas con federaciones indígenas, oficiales del gobierno peruano, ONG ambientalistas, productores de palma aceitera. También se realizaron investigaciones etnográficas en tres comunidades indígenas y en una comunidad no-indígena. Este articuló conceptualiza los diferentes aspectos legales, económicos e históricos que contribuyen a la expansión de una plantación de palma aceitera en el territorio ancestral de la comunidad Shipibo de Santa Clara de Uchunya. Este caso muestra una deforestación entre 72 y 99% de las 6,874ha de la tierra adquirida por la empresa. La mayoría de esta tierra se ubica sobre el territorio ancestral de los Shipibos. Así, entender las practicas y estructuras de poder que contribuyen en los casos de injusticia ambiental puede ayudar en la búsqueda de estrategias para un manejo de recursos más justos y más sostenible.

Introduction

In April 2015, a conservation organization, Mapping the Andean Amazon Project (MAAP), posted the following image as their 'map of the week', under the title *Image #4: Large-Scale Oil Palm Causes Deforestation of Primary Forest in the Peruvian Amazon* (Fig. 1).

Two blocks of land are clearly demarcated, with different colour codes representing different timescales of deforestation. The rivers, lakes, plantations, and main cities are visible. Numbers show the rate of deforestation in these two areas over a 5-year period. This map, like so many remote sensing maps that depict deforestation, seems to the

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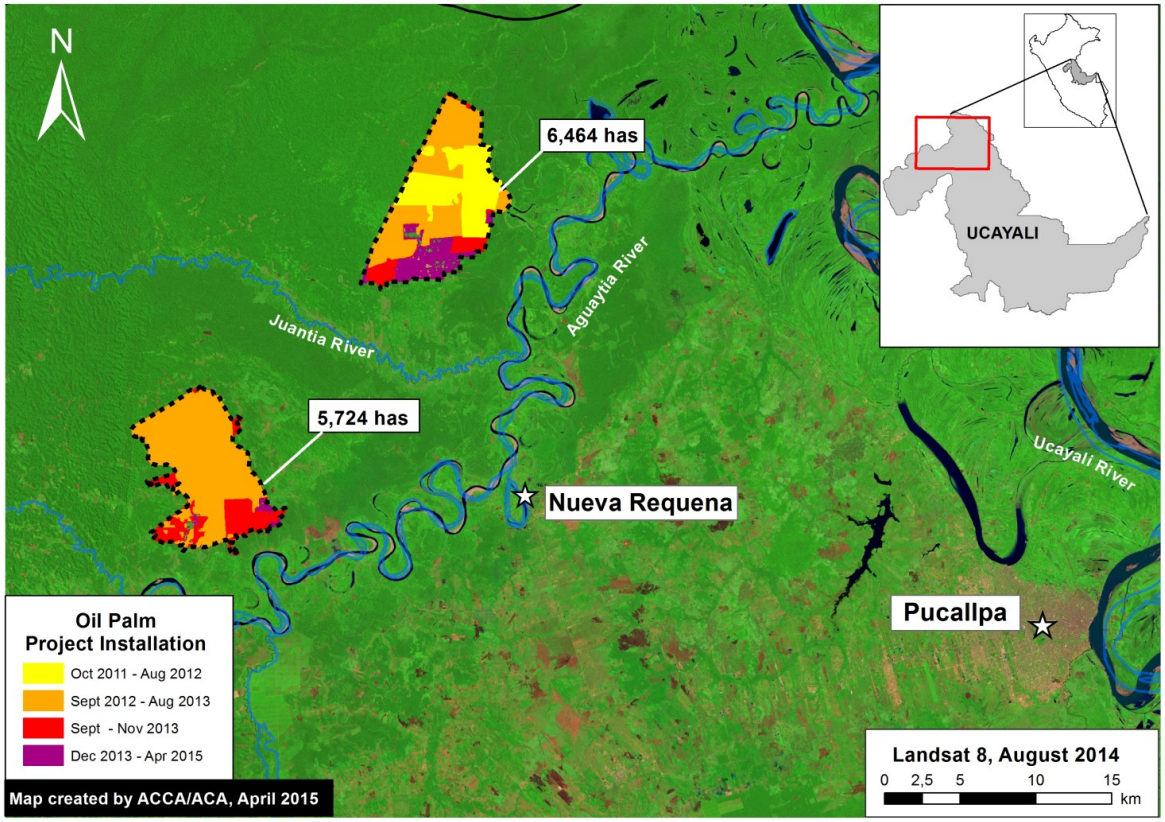

Fig. 1. Mapping the Andean Amazon Project (MAAP) Image #4 showing deforestation due to Plantaciones de Pucallpa SAC and Plantaciones de Ucayali SAC (*Credit:* Finer and Novosa 2015).

uncritical eye like an accurate, apolitical, even objective representation of reality. To the critical eye however, attention turns from what is made visible to what is rendered *invisible* in these maps (Harley 1992): historical inequities, lack of zoning, corruption, discriminatory policies and laws regulating forest use, property rights, and land grabbing. Life under the canopy of the forest is harder to depict via remote sensing than one might think.

The specific case captured by these images begins, according to LANDSAT time series data, in August 2010 when a company called *Plantaciones de Pucallpa SAC* started deforesting primary and secondary rainforest to create a palm oil plantation. Plantaciones de Pucallpa SAC operates as a subsidiary of *United Oils Ltd*, which belongs to the group *United Cacao del Peru Norte*. These companies are all owned or run by Dennis Melka, who owns over 25 such companies in Peru and is known locally as 'the Melka Group'. The companies received their main funding from *United Cacao Limited SEZC*, which raised capital through the AIM (Alternative Investment Market, a sub-market of the London Stock Exchange) and later, the Bolsa de Valores de Lima.

Much of the rain forest in the images falls within the ancestral territory of the Shipibo-Konibo indigenous village of Santa Clara de Uchunya, near Nueva Requena. Between 2011 and 2013, Plantaciones de Pucallpa deforested approximately 6,000 ha of rain forest for the creation of an oil palm plantation, and another 5,000 ha for a

second plantation nearby. In September 2013, they started planting oil palm, allegedly for sale to the European biodiesel market.

Subsequently, the Shipibo-Konibo village was stripped of many communally owned agricultural plots, was denied access to the forest for hunting, collecting and foraging, lost multiple sources of potable water because of contamination, and experienced heavy overfishing of their bay by the workers of the plantation. Santa Clara de Uchunya and several local NGOs protested and documented the ongoing deforestation by Plantaciones de Pucallpa SAC. As a result of the protests, the village of Santa Clara de Uchunya experienced continuous threats of violence by masked gunmen. The plantation cut off access to the village and members of the village were harassed in person and online by members of the press and adjacent villages. Indigenous leaders were forced to flee the city after receiving numerous death threats.

Various stakeholders, including the Roundtable on Sustainable Palm Oil (RSPO), the National Government, the local environmental prosecutors office, and the village of Santa Clara de Uchunya brought cases against the plantation, starting as early as 2013. Despite these legal efforts, deforestation and expansion of the oil palm plantation continued until mid-2016, at which point the plantation was sold to a 'foreign buyer'. The Ucayali plantations put up for auction were acquired by other companies also controlled by Melka: Plantaciones Agrícolas de Pucallpa SAC and Plantaciones Agrícolas de Ucayali SAC, later renamed Ocho Sur P SAC and Ocho Sur U SAC in late August 2016. By then, the damage and deforestation had been done. For the makers of maps such as Fig. 1, this date is where the conflict ends.

Generating the right resolution

How does one conceptualize something as complex as an environmental conflict that connects the most widely grown modern biofuel with 500 years of colonialization centered in a specific locality? What kind of analysis is needed to account for both the very real, local consequences and the larger political-economic circumstances that bring such conflicts into being?

Palm oil is a truly transnational commodity, and as such, any analysis of palm oil expansion would not be possible without attention to its global connections. From its humble beginnings, the oil palm tree (*Elaeis guineensis* Jacq., Arecaceae), originating in West Africa, was prized for the high oil content of its fleshy mesocarp, providing needed calories from the fat as well as being an important seasonal source of betacarotene for the local populations that grew it in diverse agroforestry systems. It was brought in the 19th century by the Dutch to Indonesia and used primarily as oil for steam-powered machines. Adapting to its new environment well, palm oil was eventually seized upon by the Indonesian government during its massive relocation program, the 'estate-transmigration program' or PIR-Trans, which operated from 1986–1994 (McCarthy 2010). It is now the most widely grown oil feed stock, grown for the most part in the humid tropics of Malaysia and Indonesia, financed by transnational companies, and sold around the world as cooking oil in South Asia, for cosmetics in North America, and increasingly as biofuel in Western Europe (Schouten et al 2011; Dauverge and Neville 2010; McCarthy 2010).

An analysis of oil palm is necessarily an analysis of globalization—an analysis of the social relations of an increasingly global production. An analysis of conflicts ensuing from the production of oil palm is not simply the encounter between two opposing stakeholders, although it is often conceptualized that way: *The struggle of the Shipibo community of Santa Clara de Uchunya against the expansion of oil palm* (FPP 2015). Nor is it just a conflict over a single natural resource, as in, *Palm oil firms in Peru plan to clear 23,000 hectares of primary forest* (The Guardian 2015). Such conceptualizations oversimplify and imply linearity, suggesting stable identities of people and places over time and a crossing of two distinct paths with a clear sense of direction-

ality.

Instead, most environmental conflicts have tentacles that reach outwards, spanning across history, economies, knowledge systems, discourses, and space. The environmental conflict between Santa Clara de Uchunya and Plantaciones de Pucallpa this summer is such an example. Expressed largely as a land conflict between a foreign oil palm plantation, and a Peruvian indigenous community, deep in the central Amazon Basin, the roots of the conflict stretch outwards from multiple points that have converged in such a way as to produce a violent, inequitable outcome.

At the heart of environmental conflicts is the contestation of knowledge (Escobar 1996; Foucault 1980; Peet and Watts 1996). From the local to the global scale, a multitude of different people, researchers, organizations, government bodies, international environmental NGOs, companies, politicians, and arguably even commodities compete in creating discourses (Foucault 1982; see also Mintz 1985 and Agrawal 2004). These discourses influence how and why certain types of knowledge predominate and circulate; what ecological, legal, economic, and social outcomes they produce; and who is able to benefit and claim authority over resources. These resources include not only material ones such as land, but also immaterial resources such as truth, authority and power.

If this is the case, how does one research such conflicts with wildly varying geographic localities, identities, structures, and interrelationships? Political ecology offers a framework for analyzing environmental conflicts in a way that allows us to take seriously the local ecological impacts as well as the broader political-economic influences. Political ecologists ask how knowledge about, access to, and control over natural resources is mediated by social hierarchies and relations of difference based on power relations (Robbins 2004; Watts and Peet 2004). Therefore, political ecologists focus critical attention on the spatial entanglements of constructions and practices of knowledge (Tsing 2011). Environmental anthropology, precisely through its adherence to empirical and grounded ethnography, also helps us understand different notions, cultural visions, and situated forms of knowledge about the material world. Both political ecology and environmental anthropology help to show that there is no singular, unique, and universal concept of nature; there are in fact multiple 'natures' that are produced materially through economic, technical, and everyday practices, as well as symbolically and discursively through cultural interpretations, such as science (Goldman and Turner 2011; Görg 2011; Robbins 2013; Fairhead and Leach 2003). Any analysis therefore needs to capture both what is happening in the material, economic realm, as well as the social realm.

Resolution scale 1:10000

From 10,000 feet in the air, the oil palm plantation looks like a surreal cubist painting. Flying over a mosaic of lush shades of all different kinds of green of the forest, suddenly a square appears – neat rows of green dots, interspersed with lines of packed, dry red earth for 3 miles. Then the sea of green encases the square again. The land has been divided up into boxes; small boxes inside larger boxes, neat lines of homogeneity. It seems like a perverse footprint: the branding of capitalist rationality upon the rainforest.

Our ability to see and recognize human impact on land is framed by the names we have for things. When the *conquistadores* came to South America 500 years ago, they were not able to differentiate well between the selva – that wild expanse of virgin rainforest – and indigenous cultivated forest. For the Spanish, land that was not growing wheat or producing meat was not considered productive. The *chacras* and *purmas*[1] of the original

[1]Chacras denote agricultural land cleared and actively managed for a few seasons, especially to produce root staples such as yam and cassava. A purma is a chacra that has become overgrown and is used for other agricultural activities, mainly fruit harvesting and hunting.

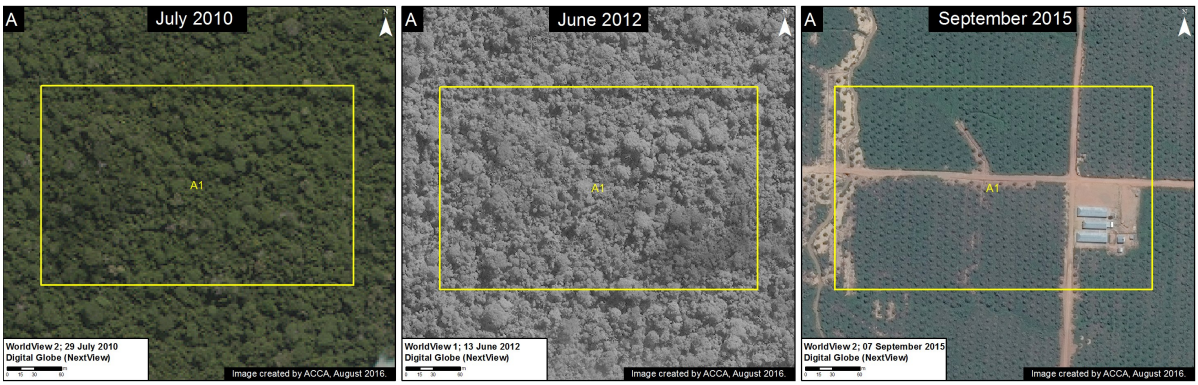

Fig. 2. Map 41c. Image from Digital Globe (Nextview) showing deforestation of the Shipibo ancestral territory (*Credit:* Finer et al. 2016).

inhabitants, their swidden farms and communally managed lands were not seen, because the underlying logic that drove them was unrecognizable to the intruders. Instead, the conquistadores saw the land as unruly, wild land that needed to be domesticated (see Scott 1998) in order to be productive. This differentiation of 'productive' and 'unproductive', conferring the ability to create discrete types of lands and forests, has remained essentially unchanged for over 400 years and shapes understandings of this conflict.

As a perennial tree, the oil palm has an economic life span of around 25 years, which made it the perfect partner for the resettlement schemes, which resettled migrants on "unoccupied" land on Indonesia's outer islands. Not only did this process increase the state's authority over previously unruly territory, it also meant that resettled people were transformed by the state into law-abiding, tax-paying residents (Scott 1998). This logic was similarly adopted by the Peruvian government in 1992: illegal coca growers were transformed, via oil palm, from people functioning outside the formal market, to people now firmly within it. They became "productive" citizens, producing and amassing wealth, status, and control for the government from the forest.

However, the forestry law introduced in 2011 in Peru had sweeping effects, the most relevant of which is the prioritization of the forest as a resource. New forests, previously considered "unoccupied land", were established. Now there are "communal forests", "local forests" on top of already existing types of forests, such as the "forests of permanent production". All in all, six new types of forests were created with defined ownership structures and use limitations. The transformation of the forest into a resource demands the need for defined ownership over that resource; a project for which, via capitalist logic, the state is best equipped (Dasgupta 1990; Vaccaro et al, 2013; De Jong and Ruiz, 2012).

Private property and capitalism, especially in their modern incarnation of neoliberalism, are difficult, or potentially impossible, to untangle from one another. Underlying the logic of neoliberalism is the need for the establishment of private property. For the state, private property is an effective way of socially constructing and politically controlling nature as well as people (Vaccaro et al, 2013). It is the division of land that ultimately creates territory. The use of territorialization strategies is a characteristic of almost all modern states (De Jong and Ruiz, 2012; Vandergeest and Peluso 1995). To have the power to exclude or include people within particular geographic boundaries, to be able to control what people do and their access to natural resources within those boundaries—that is where the power of the state lies (Vandergeest and Peluso 1995).

In 2010, encouraged by the Peruvian government's embrace of neoliberal policies and erasure of many barriers to forest exploitation, the Melka Group moved into Peru and began the transformation of 12,000 ha of forest to highly efficient, highly productive oil palm plantations.

Resolution scale 1:100

To make land "productive" is not an easy job. The forest fights back with a vengeance, ensnaring the machete-wielding colonist farmer with vines and spikes, sending poisonous snakes and stinging ants. The Shipibo, traditionally fishermen who also practice swidden farming and whose ancestors have successfully cultivated the forest for thousands of years, find the type of permanent land-use change favored by the colonists highly unproductive. The topsoil, notoriously thin in the Amazon, loses nutrients quickly, assisted by the torrential downpour of the rainy season that leaches any remaining nutrients from the soil. According to the law, permanent land-use change is *required* for land to be considered "productive". But productive for whom?

In Peru, if a smallholder is able to find 'unoccupied' land to manage 'transparently, productively, and peacefully' (La Ley de Reforma Agraria de Peru N° 17716) for 10 years, they receive the title to that property. Whether or not others already consider that land productive is irrelevant. Between 2010 and 2016, Plantaciones de Pucallpa acquired 233 such land titles from colonist farmers, who had been granted the land by the regional government. Some of that land was in what the Shipibo consider to be their ancestral territory, and many of the titles were later found to have been forged by the Regional Department of Agriculture.

Indigenous communal property management systems, driven by communal values of reciprocity, are often fundamentally at odds with the capitalist logic of productivity and individualism. Titling communal property is difficult in a system where private property is the norm and scant resources—financial, institutional, legal, and otherwise—exist for other types of land titling. Despite the presence of two large internationally-funded land titling projects, the last indigenous communal land title was granted over 15 years ago in Ucayali (AIDESEP 2015). If indigenous groups do receive title to communal lands, often the extension of land to which they gain title is far smaller than their traditional territory. Santa Clara de Uchunya, for example, received 218 ha of communal lands when they first applied for a communal land title in 1989. This is in stark contrast to the 50 ha given to each of the 17 non-indigenous individuals who were granted land titles in 2016, all falling within what the Shipibo consider their ancestral territory.

Although a signatory of the International Labor Organization Convention 169, which obliges the Peruvian government to recognize the "rights of ownership and possession of the peoples concerned over the lands, which they traditionally occupy", Peruvian law institutionalized the definition in 2011, but still has no means by which to demarcate, measure, or title such lands.

The Sami have 108 different words for snow. The Tuareg have 7 different words for sand. Peruvian Law has six different names for forests, and none for ancestral territory; the Shipibo language has no word for private property. The conflict in Santa Clara de Uchunya begs the age-old question: if one has no name for something, can it actually exist?

Resolution scale 1:1

From below the canopy of the palms, the plantation is eerily silent. We reach the edge of the plantation after walking through the secondary forest adjoining the chacra of one of the residents of Santa Clara de Uchunya. Half a mile out, I can already see the edge effect produced by the plantation. Light intensity becomes greater, the humidity decreases, more shade-intolerant species appear, and walking becomes even more difficult as shrubs and vines inhabit the forest floor with greater density. As we reach the edge, I notice an increase in

Cecropia, a notable pioneer species of recently disturbed forests, an ominous sign of destruction and loss. Stepping out onto the plantation after walking three miles through the secondary rain forest deafens me with silence and blinds me with the sudden intensity of the noontime Amazonian sun. The heavy use of pesticides and herbicides around the palm trees kills almost anything that would otherwise live here. Looking through the lines of towering palm trees, their trunks painted white to protect against the ferocious ants and rats. These opportunistic scavengers remind us of lessons we learnt as children to share, to give; they are nature's last line of defense against man's ceaseless need for control and exclusion.

What I see must be so much different from what the men wading through the dense underbrush see. For me, the forest is an overpowering, mysterious green force sustaining life, sustaining our atmosphere. Based on the commentaries the men exchange with me, this forest is their hunting ground, their pharmacy, their market, their playground, and a source of inspiration. The older Shipibo generation remembers more than the younger men. They remember how their grandparents used to live near here in a *yaka* (individual homesteads loosely connected to other homesteads). They remember how they would hunt *ama*, *amen*, and the bigger, more elusive (and more delicious) *sachavaca*[2], the prized game of the forest. They remember the water that would run clear from the many sources, how this area used to provide the best *caoba* for the construction of their houses.

The older men also remember the stories that their grandmothers and great-grandmothers used to tell. Their great-grandmothers tell stories of how they were forced to flee the rubber barons who came for their parents. Rubber, it would seem, developed a taste for death and destruction in the Amazon before becoming a crucial commodity for the wars that would bring demise to thousands more. In the West we grieve the many soldiers lost in those wars that were enabled by the production of rubber, yet never do we mention the thousands of indigenous lives lost, the multitude of families ripped apart, the bodies mutilated, and the forests disfigured that form the basis for our own stories of loss and glory.

Their grandmothers tell stories of fighting with the *papayeros*[3] who, so that Europe could satisfy its newfound taste for tropical fruit, would encroach upon the "free" land for a season, abandoning the papaya groves after they used up all of the soil nitrogen, leaving small piles of sickly fruit rotting in the sandy soil. Excess breeds excess, an alien concept for a culture for whom greed and hording is the biggest sin. Their parents too have stories to tell. The stories are often of illegal loggers, almost always closely followed by illegal coca growers. Two products, entwined both at their site of material production in the Amazon and at their site of social production in the West: a social production of desire. This desire is a desire for speed, a desire for fast money, fast furniture, fast lifestyles that necessarily requires the production of disposable land, disposable forests, disposable people.

Now these men, too, will have a story to tell their children. A story of oil palm, that by its insidious nature permeates every aspect of our lives here in the West: from the oil that fuels the cars we drive, the pastries we consume and the sugary spreads we smear on our bread, as well as the feed we give to chickens and cattle to satisfy our desire for flesh.

Above the crude barbed wire that blocks off what once was a hunting ground, a pharmacy, a market, a source of subsistence and livelihood for the Shipibo community of Santa Clara and is now an oil palm plantation, there hangs a sign that leaves a metallic taste of irony in my mouth: "Private Property – do not enter".

[2]Ama, amen are the Shipibo words for different types of animals commonly hunted that belong to the agouti family. Sachavaca is the Spanish word for Tapir.

[3]Illegal colonist farmers who slash and burn parts of the forest for just a growing season to grow papaya.

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The Heirloom Rice Project: Rural transformation in the rice terrace landscapes of Ifugao and Mountain Province, Philippines

Adrien Salazar, MEM[*]

> While the outward appearance of the agricultural landscape in the broader central valleys has probably retained its general form throughout the historic period, any resemblance to a static and unchanging permanent sculpture or construction is misleading. Only by constant repair, extension, restructuring, and the dynamic recycling of resources has the present landscape been achieved and maintained … all available cultural and environmental evidence indicates that the contemporary form of land use in Ifugao was developed in small increments by the forebears of the present inhabitants, over a period of many centuries, within this and adjacent regions of northern Luzon.
>
> From *Ethnographic Atlas of Ifugao*, 1980. Harold Conklin, April 27, 1926 – February 18, 2016.

Introduction

In landscapes all over the world, communities have developed complex resource management and production systems that have enabled them to sustain livelihoods in their local environments for generations. These systems tend to employ multiple land-uses, a diversity of crop varieties and species, and traditional technologies that have co-evolved with the societies that steward these landscapes and resources. In these socio-ecological systems (SES), communities utilize diverse technologies, knowledge, and management structures to produce food, fodder, and fiber to support their livelihoods, steward ecosystems and local biodiversity.

Many of these production systems are maintained today in rural and frontier landscapes that are undergoing transformation due to various forces. Formerly remote communities are increasingly connected to regional, national, and international markets. Traditional systems and technology compete with industrial food production and resource extraction. Communities seek economic development and diversified sources of income. Yet as some aspects of the human-environment relations that have shaped these systems transform over time, other elements endure.

The rice terraces of the Cordillera Mountains region of the Philippines, developed and managed by dozens of ethno-linguistically distinct indigenous peoples, are such a landscape system constituted by multiple land-uses, diversified crop production, and traditional governance systems (Acabado 2014, Araral 2013, Camacho et al. 2012, Conklin et al. 1980, , Crisologo-Mendoza & Prill-Brett 2009, De Raedt 1987, Eder 1982, Nozawa et al. 2008). Farmers in these communities engage in private and communal forest management, swidden agriculture, and rice production in centuries-old ter-

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race and irrigation systems that take advantage of the mountainous tropical terrain (Acabado 2014, Nozawa et al. 2008, Conklin et al. 1980). The peoples of the region have built and maintained these systems for hundreds of years through intensive management, cultural practices, and labor arrangements that imbue the landscape with spiritual and social meanings (Conklin et al. 1980).

The microclimate of this mountain landscape and farmers' own tastes have resulted in over 500 locally-adapted rice varieties, most of which are grown for subsistence (Nozawa et al. 2008). For many farmers, their native rice is a source of sustenance and serves as a living connection to ancestral practices. This landscape is globally recognized for its cultural, ecological, and architectural value, having been designated a UNESCO World Heritage Cultural Landscape in 1995, the third site to receive designation and the first to receive such as an "organically evolved landscape" (Rössler 2006).

The Cordillera Rice Terraces (CRT), like most rural frontier landscapes around the world, face a host of internal and external pressures reshaping the landscape and the societies that depend on it. The rice terrace socio-ecological system continues to evolve in response to bio-physical and socioeconomic forces of change. Traditional diversified agricultural systems confront pressures to produce more food for growing populations, increased connectivity to markets, urbanization, and development. Such pressures encourage homogenization of land-use in traditionally mosaic landscapes, and use of chemical inputs that degrade agroecosystems (Biodiversity International 2014, Koohafkan & Cruz 2011). In addition to regular risks smallholder farmers face such as pests, crop disease, lack of access to farm capital, and weather variability, farmers also adapt their production and land-use strategies to cope with increasingly degraded terrace infrastructure, extreme weather, and reduced household labor due to migration and increased off-farm income opportunity (Bantayan et al. 2012, Eder 1982, Gomez & Pacardo 2005, Ngidlo 2011, 2013a,b). These forces influence farmers' land-use choices and in turn shape the biophysical face of the landscape.

Development efforts in the region have attempted to help conserve the form and practices of the CRT landscape, repair damaged rice terraces, as well as improve farmer livelihoods. The Heirloom Rice Project (HRP) entered this region as one intervention attempting to conserve traditional heirloom rice and promote economic opportunity for farmers. Launched in 2014, the HRP was an agricultural development project funded by the International Fund for Agriculture and Development and the Philippines Department of Agriculture, implemented by the International Rice Research Institute (IRRI) and the Philippine Rice Research Institute (PhilRice) in collaboration with local government units, universities, and NGOs. The primary aims of the project were to characterize and conserve the diversity of native, or 'heirloom', rice varieties, improve farmer organizational and business capacity, and develop markets for these distinct rice varieties (IRRI 2014, Cruz et al. 2014).[1]

Through a mix of strategies, the project aimed to create favorable market conditions for heirloom rice in order to improve farmer income potential from this rice. The project engaged scientific characterization and development of traditional rice varieties, market research, enhancement of farmer production techniques, and obtaining of geographic indication for locally-sourced rice varieties. These strategies together aimed to create greater incentives for farmers to maintain and develop rice varieties on their lands as a counterweight to forces that threaten the integrity of these landscapes. The project thus proposed conservation of heirloom rice and farmer income opportunities derived from improved heirloom rice production as one solution to conservation of the CRT.

[1]Cruz, C.V., Plant Pathologist (Senior Scientist II) at Plant Breeding, Genetics and Biotechnology (PBGB) Division, IRRI. Interviewed by Adrien Salazar. December 1, 2014.

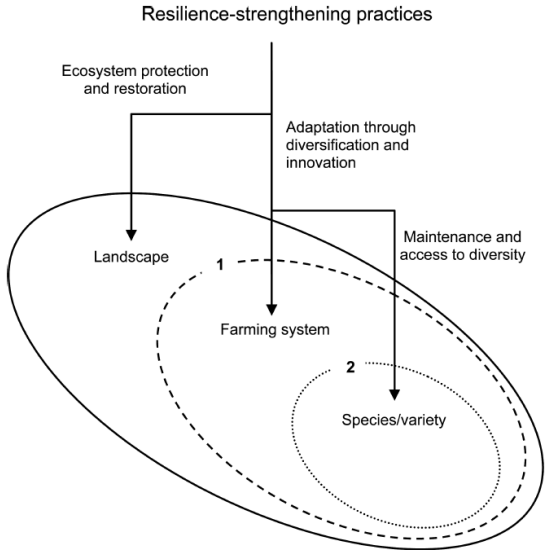

Fig. 1. Linkages for building resilience across scales. From Mijatovic et al. (2013).

Change and vulnerability in the Cordillera Rice Terrace landscape

Biophysical, social, and cultural change in Cordillera Rice Terrace systems are well documented in literature about this landscape (Bantayan et al. 2012, Eder 1982, Gomez & Pacardo 2005, Ngidlo 2013a,b). Assessing farmers' perceptions of change and vulnerability can complement such analyses. Identifying farmers' perceptions of vulnerability can help reveal salient pressures that inform farmer's decisions. This information in turn can inform decisions about the type of interventions farmers desire.

This report summarizes research conducted from June–August 2015, in the second year of the IRRI Heirloom Rice Project, at three project sites: Hapao in Ifugao Province, and Barlig and Kadaclan in Mountain Province. Through analysis of project documents, participant observation, and interviews conducted with project stakeholders, this study characterizes the perceptions of transformation in this landscape.

Characterizing change in this landscape and the way the project intervenes in an ongoing process of rural transformation can provide valuable insight into whether and how agricultural development projects can 1) address vulnerability of farmers and 2) help conserve traditional agricultural systems and landscapes at risk.

Change, vulnerability, and resilience in socio-ecological systems

A substantial body of literature conceptualizes the dynamics of coupled social systems and environmental systems, or social-ecological systems (SES) (Berkes et al. 2000, 2008, Folke 2006, Olsson et al. 2004, Turner et al. 2003, Holmes 2001, Walker et al. 2006). These analyses emphasize the interconnected social and ecological dimensions of natural resource management systems, their ability to withstand change, and to transform (Folke et al. 2005).

Characterizing change and resilience in SES can be a daunting task as these landscapes take diverse forms all over the world (Walker et al. 2004). Attempts to develop measures of resilience for agro-ecological systems and traditional landscapes have focused on identifying bundles of ecological, agricultural, cultural, and socio-economic indicators that contribute to functions of the system (Bergamini et al. 2013, Biodiversity International 2014, Mijatovic et al. 1993). Recognizing multiple scales – crop species and variety scale, field and farm scale, and landscape scales – of productive systems surfaces dynamics between individual farmer crop and land-use choices, social networks, and agro-ecosystems (Mijatovic et al. 2010) (Fig. 1).

Past descriptions of the Cordillera Rice Terraces have drawn from the rich ethnographic body of study of Cordillera communities and their resource management systems, and studies documenting the biophysical dynamics of the rice terrace agro-ecological systems (Conklin et al. 1980, Kwiatkowski 2013, Nozawa et al. 2008). However few studies of the CRT have analyzed rural change within a framework of vulnerability and resilience of farmers and landscapes. This study de-

scribes perceptions of vulnerability and change at three HRP project sites. The analysis draws from interviews and observations describing farmer perceptions of their own vulnerabilities and needs. Understanding processes of change, vulnerability, and resilience in the CRT landscape is useful to accurately identify social, economic, and biophysical factors that can be leveraged to promote conservation of the wealth of cultural heritage, knowledge, and agro-ecological functions of these systems.

Characterizing rural transformation and change

Over the last several decades scholars of multiple disciplines have described rural transformation as a process of transition from subsistence to commercial agriculture, of mechanization, commoditization, and out-migration (Gibson et al. 2010, Mertz et al. 2005, Pingali 1987). Scholars have documented landscape change in the form of degradation, land-use change, and the persistence of traditional management strategies (Mertz et al. 2005). Markets are a strong force of change, but are not the only factor in rural transformation.

Gibson et al (2010) have suggested that this discourse has had a 'performative effect' on how agricultural development practitioners characterize rural change and the types of interventions they engage (Gibson et al. 2010). While some rural economies have undergone transitions driven by processes of industrialization and globalization, this linear model of change is limited in its capacity to describe transformation in rural societies.

Changing ecological, demographic, and sociopolitical conditions in agricultural economies, have resulted in transformations in state power, connectivity to global processes, and changes in livelihood and income sources for farming communities (Mertz et al. 2005). Farmers engage various responses to political and economic change, such as adoption of new production practices, cash crops, intensification or dis-intensification of land-uses, engagement with markets, expansion of livelihood strategies, or maintenance of traditional practices (Mertz et al. 2005). Farmers do not necessarily resist development, and in many cases also continue to maintain traditional practices not only for livelihood benefits, but at times because these practices are central to cultural identity and social structures (Cramb et al. 2009).

The representation of rural change as unidirectional transformation towards intensification, mechanization, and urbanization—in effect, de-ruralization—fails to capture the range of strategies farmers engage in response to social, economic, and political change. Gibson et al (2010) argue that this discourse naturalizes the classic economic development pathway of capitalist modernization, neglecting the diversity of economic practices farmers engage, the presence of the non-agricultural in the rural context, and global connections that do not necessarily produce de-ruralizing consequences. This produces a "guiding dynamic" of capitalist development, obscuring variation and heterogeneity of rural transformation (Koppel et al. 1994).

Alternative models of rural transformation have attempted to capture the breadth of forces influencing change in rural landscapes. The sustainable livelihoods framework (SLF) expanded notions of livelihood practices of rural households beyond farm and land-focused definitions of rurality (Chambers & Conway 1992, Ellis 1998, Scoones 1998). SLF scholars "took up the task of developing a new language of the rural, drawing upon ecological representations of diversity, complexity, sustainability, resilience and vulnerability" (Gibson et al. 2010). Scholars drew on the ecological resilience literature and applied them to socio-economic contexts, emphasizing for example the significance of complexity and diversity in livelihood strategies in enhancing resilience (Adger2000, Chambers & Conway 1992, Scoones 1998).

This discourse shifted development strategies towards livelihood diversification, with an emphasis on understanding vulnerability in rural contexts in terms of five capitals—natural, physical, financial, human, and social. However, in practice, diversification strategies have moved towards eco-

nomic outputs as measures of development, returning to a representation of rural transformation as an inescapable march towards economic development.

Alternatively, Jacobs (2000) has suggested rural socio-economic systems exhibit complex dynamics of natural ecosystems, for example habitat maintenance, diversity, resilience, interdependence of developments, and co-developments. Analyses such as these create wider space for representing rural dynamics in ways that embody the diversity of processes that constitute complex SES. An analysis of complex dynamics and simultaneous transformative effects occurring concurrently at different scales and timeframes can illuminate farmers' production decisions and livelihood strategies, and inform the aims of development interventions like the HRP a in an evolving landscape.

Methods

This study attempts to characterize the rice terrace landscape in three sites of the HRP. The study utilizes a diversity of methods to assess perceptions of change and farmer priorities for intervention outcomes. I conducted a review of the literature on the CRT to assess how previous scholarship has characterized vulnerability and change in the landscape. I reviewed project documents including official project reports to identify the HRP intervention logical framework. I conducted participant observation during HRP activities, semi-structured and unstructured interviews with 36 project implementers, partners, and farmer-beneficiaries.

Through analysis of literature, participant observation, and interviews, I identified processes of transformation in the rice terrace landscapes of Hapao and Barlig, salient for HRP actors. I analyzed the causal linkages between perceived social, economic, cultural, environmental, and historical changes to theorize processes of transformation occurring in these communities. I also identified threats and vulnerabilities that farmers expressed as their greatest concerns in the maintenance of their livelihoods and culture.

I conducted farmer interviews at two project sites: Barangay Hapao, Hungduan, Ifugao and Barangay Barlig Centro, Barlig, Mountain Province (Fig. 2). I developed a list of 49 indicators based on the views expressed by farmers I had interviewed and implemented an indicator scoring workshop among farmer organization members in two sites: Barangays Kadaclan and Barlig Centro in Barlig, Mountain Province. The results of the indicator assessment are not presented in this paper.

Site description

The Heirloom Rice Project has fifteen sites across four provinces of the Cordillera region—Ifugao, Mountain Province, Kalinga, and Benguet. The objectives of the project are to conserve heirloom rice varieties, improve farm productivity, enhance capacity for farm enterprise, and identify market opportunities for heirloom rice. The project engaged farmer associations and cooperatives, local government units such as municipal departments of agriculture, and local universities and colleges. HRP activities included needs assessment, visioning activities, rice identification, varietal trial plots, disease tests, and extension workshops.

Hapao, Ifugao.—Hapao, a *barangay* (submunicipal or village government unit) is part of the municipality of Hungduan, in Ifugao Province (Fig. 2). Hapao has a population of 2,138, or 21% of the total population of Hungduan as of 2015 (National Statistical Coordination Board, Philippines). The land area of Hungduan is 23,131 ha, of which the municipality classifies 11,403 ha (48%) as forest, 6,876 ha (30%) as grassland, and 705 ha (3%) as agricultural. Rice terraces in the municipality are classified as part of the World Heritage Site cluster of rice terraces in Ifugao Province. Hapao is 1,677 ha and municipal figures designate 160 ha as rice terraces, however community-based mapping has identified 555 ha of rice terrace area in the barangay (Bantayan et al. 2012).

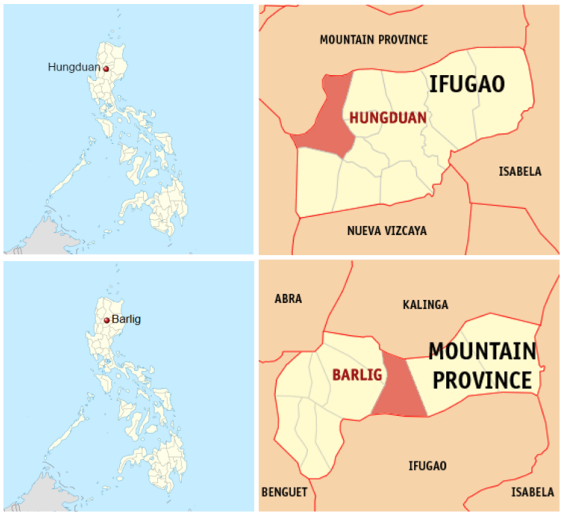

Fig. 2. Study location (Wikimedia Creative Commons, 2015)

I conducted semi-structured interviews with members of the Hapao Farmers Association (HFA), the HRP farmer-beneficiary group of Hapao. This association was established in 2006 as one of the initial members of a regional cooperative, the Rice Terraces Farmers Cooperative, based in Banaue, Ifugao. The HFA has 62 member farmers of which 58 (93%) are women. Farming is the primary source of livelihood for residents of Hapao. They grow a number of rice varieties. Some varieties identified by the HRP include *tinawon*, *minaangan*, *uklan*, and *umbuukan*. The rice production calendar begins in October or November with harvest taking place from June-August. Interviews were collected in July 2015 during the peak of the harvest season, which posed some selection bias for farmers who had flexibility to participate in the study during this demanding period. Interviews were conducted in English, with translation support in Ifugao provided by an assistant who was a resident of Hapao.

Barlig, Mountain Province.—In Barlig, two groups were consulted: the Barlig Heirloom Rice Organization (HRO) and the Kadaclan Heirloom Rice Organization. Both groups are located in the municipality of Barlig in Mountain Province, Philippines, but each encompasses a distinct ethno-linguistic peoples and geographic areas—the Barlig and the Kadaclan clusters of barangays in Barlig municipality, respectively (Figs. 2 and 3). Barlig municipality covers a range of 1000-2862 m above sea level and is characterized by pine and oak forest, rice fields, and swamps, with approximately 73% (26281 ha) of the total land area in forest and 5.33% (1921 ha) in agriculture (Municipal Planning and Development Office, Barlig, 2002). Of 1425.7 ha in crop production in 2002, 1118 ha were in rice production (Municipal Planning and Development Office, Barlig, 2002). The total population of the municipality was 5838 in 2010 (Municipal Planning and Development Office, Barlig, 2015), constituted mostly by three ethno-linguistic groups—the I-Kachakran, I-Lias, and I-Fiallig peoples. Interviews and workshop activities were conducted in late July and early August, during the harvest season. Interviews were conducted in English by the author with translation support from Municipal Agriculturalist Office staff.

The Kadaclan HRO was founded in 2008 via the support of the NGO RICE Inc., and has 71 members covering the barangays of Chupac, Lunas, Kaleo, and Ogo-og. This farmer group specializes primarily in the production of the *ominio* rice variety for subsistence and for export, but farmers grow a number of other varieties for subsistence consumption. The Barlig HRO began in 2013 via the support of RICE Inc. and the Office of the Municipal Agriculturalist (OMAg). Barlig HRO covers the most populous cluster of barangays of Barlig, with members from Barangays Gawana and Latang. Barlig HRO currently has 30 members producing a number of rice varieties for market including *chananay*, *kulii*, *engoppor*, and *chorchor-os* varieties. The formal involvement of these organizations in the IRRI HRP has included engagement in planning processes with project partners including OMAg, the Department of Agriculture regional office, and local universities. The farmers groups have also participated in a number of extension trainings facilitated by OMAg and PhilRice for the HRP.

Results

Farmers vulnerabilities in the face of change in the Rice Terraces

Review of project documentation, interviews with project implementers, and participant observation reveals that Heirloom Rice Project implementers framed the project around perceived vulnerabilities at the crop variety and farmer household scale. The project was framed around two objectives: conservation of genetic resources and economic development. The project identified market and product development as a means to encourage farmers to grow heirloom varieties, some of which may be "threatened genetic resources". Productivity improvements, business capacity, and market linkages were causally suggested to help conserve rice varieties while increasing income for farmers. Program proponents suggested that increasing conservation of rice varieties and improving income from heirloom rice would promote the long-term conservation of traditional rice production in the CRT landscape.

The HRP identified sites as "resource poor areas rich in agrobiodiversity" where a number of productive limitations and limited market access reduced farmers' ability to generate income from their traditional rice. Project documentation also referred to conservation of "climate resilient rice varieties" and the ability of genetic diversity to provide farmers capacity to cope with climate change. Project implementers also suggested that the project would help protect and conserve the culture of the indigenous communities who manage the rice terraces. Thus the project aimed to address key vulnerabilities of: 1) lack of productive capital for rice production, 2) limited income opportunity, 3) risk of loss of genetic diversity, 4) risk of cultural loss, and 5) climate change risks.

The economic development and agrobiodiversity conservation focus of the project influenced the way activities with farmers were framed. Activities were oriented towards scientific identification of varieties and production-enhancement.

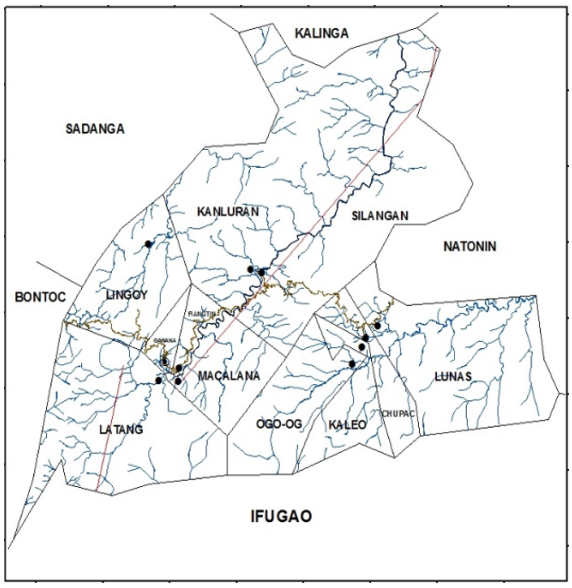

Fig. 3. Barlig Municipality (Barlig Comprehensive Land Use Plan, 2015)

In a participatory needs-assessment conducted for three Ifugao Province sites including Hapao, farmers identified problems and areas of need. Nearly all of these were production-oriented challenges. The HRP-facilitated needs-assessment identified the main areas for improving rice production as: 1) increasing yield, 2) improving postharvest/processing and marketing, 3) provision of farmer implements and inputs, 4) capacity building, 5) infrastructure development, and 6) multipurpose environment conservation strategy. Likewise the Barlig HRO and Kadaclan HRO participatory needs-assessments were framed around issues faced in production, post-harvest, and marketing with a number of similar challenges and opportunities identified in these areas.

Interviews with farmers echoed these productive needs but revealed other areas of vulnerability. While many farmers expressed a need and desire for increased cash income and increased yields, farmers in Hapao also emphasized their concern for food security. Farmers expressed the primacy of produc-

ing rice for their household before selling any rice in the market. During interviews farmers repeatedly demonstrated that at least half of rice they grew was for their own household consumption, revealing that most heirloom rice production is subsistence-oriented. Participants generally produce sufficient amounts of rice for consumption, however some respondents suggested that other farmers are only able to produce enough rice for 4-5 months of consumption.

Farmers also expressed a number of production vulnerabilities. These include challenges in the maintenance and repair of damaged terraces, terrace abandonment, insufficient irrigation, climate risks such as typhoons and flooding, prevalence of crop pests, lack of capital and equipment, and labor limitations due to migration. These challenges are viewed as intertwined. Climate impacts such as typhoons, for example, are of primary concern for farmers in Hapao because they can result in damages to terrace infrastructure. This damage can lead to long-term reductions in yields, threatening food security. Farmers in Barlig expressed concern for threats that impact rice production including climate-based impacts on rice quality and the prevalence of pests—namely rats and earth worms—that reduce yields.

Change and robustness in the Rice Terraces Landscape

Changes observed by farmers are manifold: environmental change, agricultural change, socio-economic change, cultural change, and socio-demographic change. Certain practices and conditions have also persisted and demonstrate the robustness of some elements of the rice terrace landscape systems.

Some of the most salient changes for farmers are those agricultural changes that have transformed traditional production. Some respondents in Hapao noted that the planting calendar has shifted later in the year for many farmers. Most farmers in Hapao expressed a specific change in the variety of rice produced from the *tinawon* variety to the *mina-angan* variety within a generation due to evidenced improved yields from *mina-angan* rice.

In contrast, Barlig farmers tended to produce a mix of varieties in their fields. They expressed more flexibility in trading rice varieties with one another and experimenting to select rice varieties for various characteristics including yield and flavor. No specific time-scale in rice varietal changes was identified by Barlig farmers suggesting that the dynamic movement of rice varieties among Barlig farmers is an ongoing historical practice.

Hapao farmers also expressed pride in maintenance of traditional production methods, avoiding herbicide and pesticide use, while also mentioning that some technology has introduced mechanization to certain elements of production. Many Hapao farmers expressed concern for the disregard of some traditional practices including terrace restoration and irrigation maintenance. In contrast some Barlig farmers mentioned they had experimented with various technologies including chemical fertilizers, herbicide, and mechanized equipment to aid in maintenance of their fields.

Key observed changes in the rural economy include monetization (entry into cash economies), development of infrastructure, and increased connectivity to regional and global economies. The communities in Ifugao have historically organized their economies around rice production for subsistence. However increased integration into national and international markets has introduced the necessity for cash income and diversified sources of livelihood. Local development of roads, electricity, and other infrastructure have improved connectivity of the region, and tourism has brought in some development.

Some traditional labor arrangements have been influenced by economic transformations as well. The traditional communal irrigation management of Hapao has declined as farmers observe that irrigation repair is increasingly viewed as a responsibility of the state. Volunteer labor or labor in exchange for rice has been replaced by labor for cash. However *ubbu*, or communal harvesting, continues to

persist in Hapao. Many families also have members who have migrated to cities or outside the country, who work and send remittances to their families.

Farmers also observed transformations on the physical landscape due to coupled environmental and social forces. Hapao farmers note degraded infrastructure and damage to rice terraces, the presence of pests and disease, and the impacts of climate as key forces. Farmers in both Hapao and Barlig perceive a greater prevalence of damage to terrace infrastructure, which generally is linked to flooding from weather events. However farmers expressed that they do not perceive weather events as any worse or more intense as in the past. Rather the prevalence of terrace damage is perceived as a result of "abandonment" due to labor constraints on repairs. Barlig farmers expressed concern over abandonment of rice fields as well as over the conversion of rice fields to vegetable production—viewed as a departure from the appropriate use of the terraces. Farmers who convert some portion of their fields for vegetable production did so as an alternative use of damaged terraces, to produce additional food for home consumption or for sale.

Cultural transformation is an ongoing process in the region. Rice production is historically highly ritualized. In Ifugao province this has meant production involved the engagement of *mumbaki*, spiritual knowledge-holders who facilitate ritual at various stages of rice production. Hapao farmers suggested that fewer and fewer people practice the traditional rituals because there are fewer *mumbaki* remaining, and many farmers have converted to Christianity. In Barlig, none of the farmers interviewed practiced traditional rituals associated with production. Elder farmers interviewed recalled practices from their youth but mentioned that these practices diminished by the time they were adults, as traditional practitioners passed. The vast majority (84.1%) of residents of Barlig identify as some Christian denomination.

Farmers are also concerned about conservation of their culture in a general sense, as young people are sent out for education and work, not returning to farm work. This movement of people out of the region was cited frequently by farmers as a labor constraint. Fewer people remained to manage the terraces and help in rice production. This also disrupted traditional practices of inheritance. In Ifugao province, rules of inheritance have traditionally prevented rice terrace land from being divided among children (Araral 2013). Eldest children typically inherited entirety of rice terraces. However, today this practice is inconsistent and those who tend the terraces are the family members who choose to remain in the countryside.

Discussion

This research project combines a mix of methodologies in order to describe the perceived vulnerabilities farmers and to characterize the nature of rural transformation in two HRP project sites. The following sections summarize the context of change at the sites and highlight some of ways the HRP aligns with or misses some of the areas of concern revealed by the analysis.

Rural transformation in the Cordillera Rice Terrace landscape

For a project like the HRP, understanding the dynamics of ongoing transformation, vulnerability, and resilience is key for developing interventions that address threats to the integrity of landscapes while meeting the needs of community members who steward them. This study revealed that the farmer communities of Hapao and Barlig not only face numerous rice production constraints and a desire for greater economic opportunity, but that these constraints arise out of processes of socio-economic and cultural transformation occurring in these communities at multiple scales.

For farming communities in Barlig and Hapao, a number of push and pull factors influence farmer production choices. This study demonstrates that the desire for improved production is a salient concern among farmers. For many, however the first imperative for improved production is food

security rather than income from their heirloom rice. Farmers are also concerned about infrastructural integrity of their terraces and lack of upkeep across the landscape leading to terrace abandonment. Conservation of traditional cultural value systems is also a key concern for these communities.

Farmer and landscape vulnerability that arises from these issues occurs at multiple scales. For example farmers make seed and variety choices at the field and farm household scale, but issues such as cultural loss, labor constraints, and outmigration are processes that occur at the community, regional, and even international scales. Some of these processes may also appear at odds with one another—for some farmers the desire to maintain traditional cultural practices may conflict with the desire for increased productivity. However this tension demonstrates that farmers in the CRT are able to engage a diversity of practices and strategies in response to the change and vulnerability they face. For the HRP, which focuses on farmer households and farmer self-help groups as the scalar unit, this means a holistic consideration of these dynamic processes (Fig. 4) and integration of other strategies at multiple scales, perhaps engaged by other partners, can help address some of these salient concerns beyond farm productivity. While agricultural development projects may be limited in their scope by necessity, this project highlights the challenges of a linear-development-driven understanding of rural transformation. While agricultural development projects may be limited in their scope by necessity, this project highlights the challenges of a linear-development-driven understanding of rural transformation.

The rice terrace landscapes of Hapao and Barlig are being transformed by a host of processes of change. Agricultural production transformations such as shifts in rice varieties and transitions away from traditional production processes are shaped by farmers' preferences for improving yields with appropriate technologies. Farmers face the biophysical forces, like climate change, which map onto the landscape in the form of damaged and degraded terrace infrastructure. Cultural transformations such as declining practice of traditional labor arrangements and demographic shifts due to migration limit the labor capacity of farmer households to maintain their terraces, as socio-economic integration transforms farmers' relationships to cash economies. As Christianization and cultural norms influence farmer's choices to engage in traditional rituals, traditional knowledge and practices are at risk of disappearing from the landscape.

Additionally while some elements of the SES undergo transformation, certain elements persist, disrupting the narrative of linear unidirectional development. What persists and what transforms can vary from one community to another. For example, varietal choices can change rapidly in an environment where farmers grow multiple varieties in the same field, as in Barlig, however in Hapao, farmers have grown primarily the same varieties due to consistent yields.

A model of change that is more representative of interactions between processes and across scales would account for these multiple transformations. What farmers want and need from agricultural and development interventions is thus shaped by a complex matrix of factors including desire to conserve a landscape and culture, desire for increased economic opportunity, desire for food security and subsistence, and desire for cash income. An intervention like the HRP attempts to impress upon a changing SES a certain kind of transformation, in a certain direction, what Koppel and colleagues call a "guiding force" of capitalist development (Koppel et al. 1994).

This linear model of change obscures the diversity of transformations actually taking place in rural landscapes. The success of such interventions will remain limited at best, and may even have unforeseen negative consequences such as increasing risk of cultural loss, if the logical frameworks fail to recognize feedbacks, scalar processes, and interdependence.

A different model of change that accounts for

complexity, diversity, and interdependence, across scales, may enable such development projects to more accurately assess the forms of rural transformation taking place in key areas at risk. Alternative frameworks for understanding transformation, such as an ecological understanding of interdependent developments and diversity of livelihoods proposed by Jacobs (2000) can be useful for more accurately assessing where interventions are or are not addressing key SES vulnerabilities (Jacobs 2010). In the case of the HRP such an analysis reveals that while the project acknowledges key processes in agricultural and socio-economic transformations, it may fail to adequately address environmental, socio-cultural, and demographic transformations that are intertwined and complicating the former.

Ultimately this analysis of rural transformation can help create a richer picture that can inform how interventions like the HRP position their activities in relation to processes of change already occurring in these communities, with sensitivity to those changes of greatest concern to the target population.

Conclusion

The Heirloom Rice Project represents an articulation of agricultural development that links agro-biodiversity conservation with farmer business and organization capacity development in the Cordillera Rice Terraces. The project aimed to address key vulnerabilities including income opportunities for farmers, limited access to productive capital, risk of biodiversity loss, and climate change.

In a landscape that faces a myriad of transformative forces the HRP suggested development of heirloom rice and markets would increase farmer incomes and thereby promote agrobiodiversity conservation, economic development, and ultimately conservation of "at risk" rice varieties and the terrace landscape broadly. However multiple processes at various scales beyond the field and farmer households shape the needs and vulnerabilities farmers face. Farmers expressed a range of perceived risks and vulnerabilities, some of which were addressed by the project. They expressed repeatedly the desire to maintain food security, exhibited by a lack of willingness to sell rice if it meant that they would not have enough of their own preferred varieties to feed their families. Farmers clearly expressed a desire for increased yields and income, and for productive enhancements such as pest management solutions and farm capital—all of which were major components of the project. Farmers also expressed key concerns about the maintenance of terrace infrastructure. These included fear of abandonment of rice terraces, attributed to loss of labor capacity due to outmigration, and erosion and damage due to weather impacts, which remained unrepaired due to the labor requirements of infrastructure repairs. Conservation of traditional cultural practices and values were also salient concerns that farmers connected directly to the maintenance of traditional rice production.

Additionally, farmer's environmental concerns related to climate change did not necessarily align with the project strategy of agrobiodiversity conservation. While the project couched agrobiodiversity conservation within the language of building resilience to climate change, there were no project activities that addressed the climate vulnerabilities of greatest concern for farmers—infrastructural damage due to storms and flooding. The project also does not engage some of the socio-economic push-pull factors that have shaped farmer constraints on labor capacity, such as migration. Finally while the project indirectly suggested that conservation of heirloom rice would help conserve the socio-cultural systems of the SES, the project engaged no explicit cultural conservation activities such as cultural education or documentation of traditional knowledge.

The project did produce some material benefits to farmers, some of which were immediate, such as access to equipment and extension services, but the HRP was limited in its capacity to address pervasive vulnerabilities in the social-ecological sys-

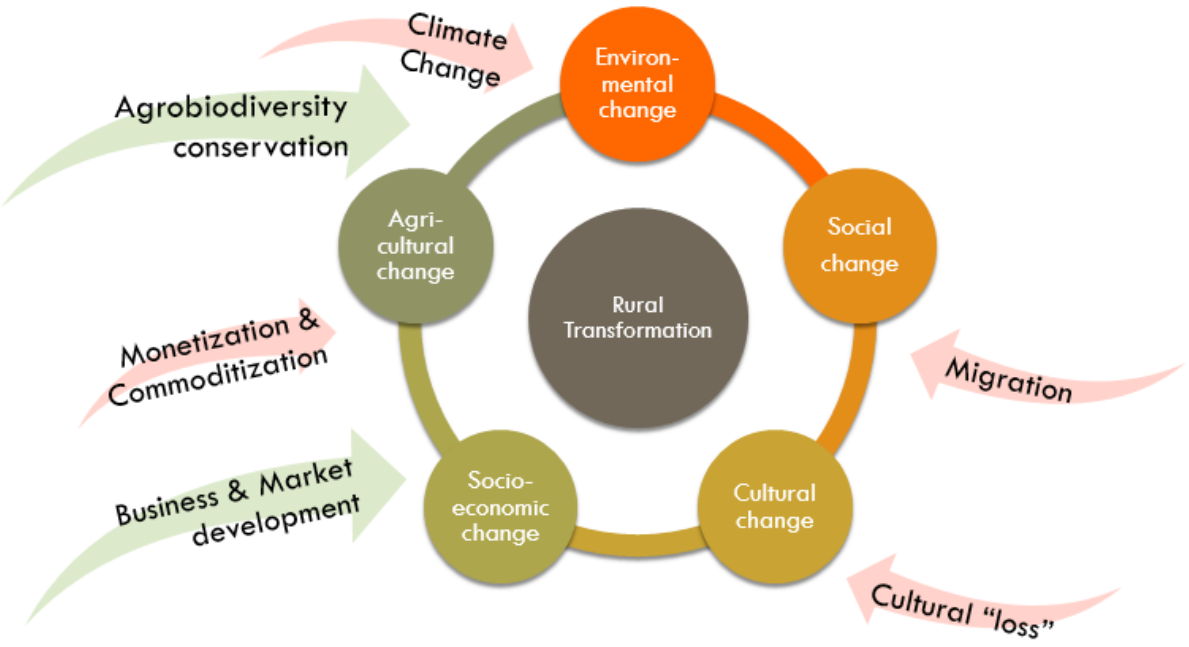

Fig. 4. Model of rural transformation in the Cordillera Rice Terraces SES. Rural transformation does not occur in a unilinear direction. Transformation consists of multiple inter-connected and inter-dependent developments—such as environmental, social, cultural, agricultural, and socio-economic developments—the interplay of which shape the trajectory of transformation in rural societies. Upon these developments forces and processes creating internal and external pressure (Red Arrows) guide transformation. Interventions such as the HRP attempt to intervene on rural transformation by introducing additional forces and pressures (Green Arrows) to guide transformation, attempting to serve as countervailing forces to existing pressures.

tem. The key challenges of a time and budget-constrained development project like the HRP in addressing a complex arrangement of forces are accurately recognizing the complexity of transformative processes in a rural landscape and delineating the scope of the project to address priority vulnerabilities in the SES. The HRP scale of interventions was the crop varietal and farmer household levels. However processes influencing crop choices and farmer livelihood strategies extended beyond these scales. Tools like the SEPLS Resilience Toolkit—which enable communities to identify bundles of indicators of landscape resilience—expand the scale of analysis and could enable a broader understanding of change in the CRT landscape (Biodiversity International 2014).

The specter of linear development in rural transformation posits that rural landscapes like the CRT are undergoing a transformation from subsistence to commercial crop production. However a complexity of forces allow both subsistence livelihoods and elements of traditional agricultural production to persist, all while farmers increasingly engage in economic networks from the local to the global scale that influence labor and land-use choices. These dynamics demonstrate a more nuanced version of rural transformation taking place in the rice terraces. The HRP assumed that biodiversity conservation and economic development could mitigate a number of risks to the SES and conserve the landscape. However given the diversity of forces, some of which are not within the scope of

the project, the capacity of the project to conserve cultural systems and mitigate climate change risks appears limited. The project may be able to conserve specific rice varieties and improve incomes, a staple expertise of the International Rice Research Institute, but this may not be sufficient to protect and conserve these landscapes.

Incorporating a broader systems analysis that acknowledges the breadth of interconnected processes of transformation and change in the landscape can provide a more accurate and causally-driven analysis of vulnerability in the rice terrace landscape. Models that include feedbacks between these processes and scalar considerations can provide insight into what factors influence farmers' land-use decisions and livelihood practices. Defining what resilience means in this landscape by using existing tools and measures of landscape resilience can help identify the suite of variables that interventions like the HRP ought to engage to: encourage conservation of cultural knowledge and traditional systems, integrate new technologies and livelihood strategies appropriately to meet farmer needs, and conserve elements that have allowed these landscapes to endure for centuries.

This study suggests that: 1) expanding the problem definition of rural development projects to address multiple processes influencing rural transformation, 2) considering multiple scales, and 3) including farmers' perceptions of their own vulnerabilities can allow interventions like the Heirloom Rice Project to engage economic development, agro-biodiversity conservation, cultural conservation, and landscape conservation with an integrated strategy and more effective participation of stakeholders.

Heirloom rice production, like many traditional agricultural practices around the world, is often not viewed by farmers as simply an economic activity but also socio-cultural and ecological. As such, economically-driven agricultural interventions should also integrate these factors to conserve the knowledge and practices that maintain the resilience of social-ecological systems. Doing so addresses the nature of rural transformation as a complex dynamic process—a process of processes. Integrating multiple strategies and working with diverse partners to this end could prove to be an effective means to improving the livelihood of farmers and securing the integrity of these changing landscapes for generations.

Recommendations for agricultural development and landscape conservation

1. Future interventions in this region and similar interventions around the world can conduct vulnerability and threats assessments as part of participatory needs and opportunity assessment, to identify causal pathways that lead to farmer and landscape vulnerability

This study has addressed farmer vulnerability explicitly as a key motivation for agricultural and rural development. However vulnerability analysis is often not included as part of interventions, as in the case of the HRP. The analysis in this study has revealed multiple processes that produce various vulnerabilities for farmers and the landscape. Conducting a broader vulnerability assessment that identifies key threats beyond economic livelihood and agrobiodiversity threats—for example, food insecurity, cultural loss, and landscape change—and that identifies the causal pathways of these threats can reveal a more accurate picture of farmer needs and severity of threats. This can inform decisions about activities that intervene at key intersections of change and can help identify opportunities to integrate strategies that offer co-benefits.

2. Expand the project scope and scale beyond the farmer household and farmer self-help group

Assess landscape-scale dynamics and regional, national, and international scale processes and identify feasible points of intervention. The scale of challenges faced by the communities of Hapao and Barlig reveal processes extending beyond the household or barangay. Processes of increasing regional connectivity and migration influence income opportunity and migration, and shape la-

bor constraints for rice production. While one project may not be able to address all threats at all scales, development actors can consider the influence of large-scale processes on farmer household choices in identifying scale-appropriate interventions. Farmer trainings can be supplemented with community development activities at the municipal level, or policy and management at the regional scale, for example. Integration of strategies at multiple scales, with the engagement of partner NGOs and agencies that have capacity to address some processes outside the scope of any given project, can address some of the larger push-pull factors that influence farmer decisions.

3. Activities should be developed, with the HRP or in collaboration with knowledgeable and well-capacitated partners, to explicitly address landscape infrastructure, conservation goals, and cultural conservation

Terrace damage due to storms and flooding and limited farmer capacity for repair were threats that surfaced across sites and across the multiple methodologies of this study. Cultural loss was also a significant concern for communities in which rice production is embedded in traditional social arrangements and ritual practices. While the HRP suggests heirloom rice conservation can conserve rice terraces and the culture of these communities, the project does not explicitly engage in infrastructure improvements or cultural conservation activities. These areas must be addressed to maintain the long-term integrity of the social-ecological landscapes of the rice terraces. Development actors can consider integration of diverse activities across issue areas, or develop partnerships with institutions that hold different expertise and capacity, to integrate agricultural development, biodiversity conservation, and education into a broader strategy for landscape and cultural conservation.

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Chang, V. 2017. Establishment success of 19 native tropical dry forest tree species under reforested cattle ranching landscapes in the Azuero Peninsula, Panama. *Tropical Resources* **36**, 80–87.

Establishment success of 19 native tropical dry forest tree species under reforested cattle ranching landscapes in the Azuero Peninsula, Panama

Veronica Chang, MEM[*]

Abstract

Comprehensive evaluation of reforestation success can assist reforestation project planning and support rural communities in developing countries to alleviate poverty and improve their quality of life. The Azuero Peninsula is one of the most endangered and severely deforested territories of Panama. Anthropogenic drivers have exposed this tropical dry forest region to continuous degradation and loss of biodiversity and ecosystem services. Conventional cattle ranching practices have dominated this region, decreasing on-farm productivity. The Association of Livestock and Agro-Silvopastoral Producers of Pedasi (APASPE) has become a leader in implementing sustainable cattle ranching and forest restoration projects. The objective of this study was to evaluate the success of tropical dry forest reforestation with 19 native species, after 4 years of plantation through survival, growth, crown area, and biomass. Results of this study showed that agroforestry plantations performed better than conventional plantings. Mean survival was 33.25% greater in agroforestry than conventional plots. *Anacardium excelsum* showed high survival rates among plots, followed by *Tabebuia rosae* and *Swietenia macrophylla*. These findings illustrate the performance of native species in timber plantations and agroforestry systems, allowing for initial site-specific recommendations of potentially valuable species for restoration and other uses.

La evaluación completa del éxito de una reforestación puede favorecer la planificación de proyectos de reforestación y ayudar a las comunidades rurales de los países en desarrollo en la lucha por aliviar la pobreza y mejorar su calidad de vida. La Península de Azuero es uno de los territorios más amenazados y severamente deforestados de Panamá. Factores antropogénicos han expuesto a esta región de bosque seco tropical a la continua degradación y pérdida de la biodiversidad y servicios ambientales. Las prácticas convencionales de ganadería han dominado a esta región por décadas, disminuyendo la productividad de las fincas agropecuarias. La Asociación de Productores Pecuario y Agro-silvopastoriles de Pedasí (APASPE) se ha convertido en líder en la implementación de proyectos de restauración forestal y ganadería sostenibles. El objetivo de este estudio fue evaluar el éxito de la reforestación de bosque seco tropical con 19 especies nativas, después de 4 años de plantación, a través del índice de supervivencia de las especies forestales. Los resultados de este estudio mostraron que, las plantaciones agroforestales obtuvieron mejores resultados que las plantaciones convencionales. La supervivencia media fue 33,25% mayor en las parcelas agroforestales que en las convencionales. Anacardium excelsum *mostró altas tasas de supervivencia promedio entre todas las parcelas, seguida de* Pachira quinata *y* Tabebuia rosea. *Estos hallazgos ilustran el desempeño de especies nativas en plantaciones forestales convencionales y sistemas agroforestales, permitiendo dar recomendaciones iniciales específicas al sitio acerca de especies potencialmente valiosas para la restauración y otros usos.*

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Introduction

Dry forests in Latin America have experienced a 12% loss of habitat and forested area between 1980 and 2000 (Miles et al., 2006), becoming one of the most endangered ecosystems in the Neotropics, with only 1.7% of the original cover remaining in Central America (Calvo-Alvarado, McLennan, Sanchez-Azofeifa, & Garvin, 2009). Anthropogenic disturbances, such as deforestation and use of fire to convert forest to agriculture or pasture systems have exposed this biome to continuous degradation with the resulting loss of unique biodiversity and weakening of ecosystem service integrity. Panama's Azuero Peninsula, which comprises predominantly of tropical dry forests, has a long history of cultivation, cattle ranching, and urban expansion. The Azuero Peninsula is also one of the most endangered and severely deforested territories of Panama (Metzel & Montagnini, 2014). The most prevalent land-use in Azuero is conventional cattle pastures. Within the Province of Los Santos, where this study took place, 62% of land area is in pasture (Trejos Castillo, 2004). Conventional pastures entail removing and burning forests, applying herbicides and planting exotic pasture grasses, which are often overgrazed, decreasing on-farm productivity. Among other pathways, degraded cattle pastures may be abandoned, or rehabilitated to support diversity and quality and quantity of ecosystem services (Griscom, Ashton, & Berlyn, 2005).

In Mesoamerica, environmental, economic and livelihood benefits offered by trees have increased the interest of small landholders in utilizing a diversity of native species for restoration purposes (Garen et al., 2011; Garen et al., 2009; Montagnini, Gonzalez, Porras, & Rheingans, 1995). Recent work in Panama has assessed survival and initial growth of native tree species optimal growth over a broad precipitation and soil fertility gradients (Hall et al., 2011; Van Breugel et al., 2011; Wishnie et al., 2007). However, information is lacking on the potential for reforestation under regimes that are more influenced by humans in such heavily agricultural landscape, for example on abandoned cattle pastures.

The Environmental Leadership & Training Initiative (ELTI), an initiative of Yale University's School of Forestry and Environmental Studies (F&ES) in collaboration with the Smithsonian Tropical Research Institute (STRI), seeks to empower people to enhance biodiversity, ecosystem services and livelihoods in tropical forest landscapes by developing local capacity to protect and restore native tree and forest in agricultural landscapes. The Association of Livestock and Agro-Silvopastoral Producers of Pedasi (APASPE), a group of landowners that participate in ELTI's Training and Leadership Programs in Azuero, is comprised of approximately 38 landholders who have become leaders in implementing sustainable cattle ranching practices and forest restoration. APASPE members have implemented two large forest restoration and sustainable ranching projects funded by the Global Environment Facility's (GEF) Small Grants Programme (SGP) that focus on recuperating riparian forests, native species reforestation and silvopastoral systems (SPS).

To assess reforestation success, based on the physical and socio-economic objectives of reforestation projects, performance measures should be evaluated during the main stages of the restoration (Le, Smith, Herbohn, & Harrison, 2012). The evaluation of performance of the APASPE on-farm reforestation plantings in riparian areas is important in terms of illustrating the success or failure of native species when established in cattle ranching landscapes. This can be challenging due to the variety of biophysical and social variables that can affect successful tree establishment. Comparing tree growth with different management strategies (conventional plantation versus agroforestry systems) is also relevant for helping farmers design methods to potentially improve performance and decrease cost, which are incentives that are increasingly important due to the high costs and lack of incentive policies for forest restoration.

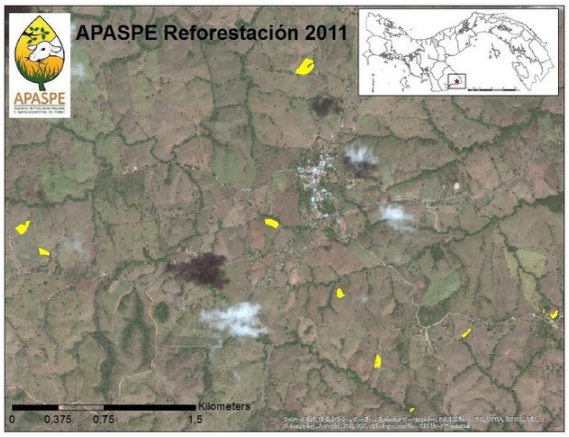

Fig. 1. The areas where reforestation plots (agroforestry and conventional) were established (marked in yellow). *Map:* Veronica Chang & Jonas Lechner.

In this paper, we evaluate the establishment success of tropical dry forest riparian reforestation with 19 native species after 4 years of plantation (Le et al., 2012), following survival from 2011 to 2016. In particular, I asked the following questions:

1. Do trees differ in establishment success in agroforestry versus conventional reforestation systems?
2. Do species differ in their overall establishment success?
3. Do species differ in establishment success between agroforestry versus conventional systems?

Results from these studies will illustrate the performance of native species and potential economic benefits from timber species plantations and agroforestry systems. Additionally, the results will be utilized to develop a restoration strategy case study and other training materials for local stakeholders.

Methods

Study site

The study was conducted in the town of Los Asientos (Fig. 1) in the province of Los Santos, Panama (7°31'N, 80°8'W). Los Asientos is a small rural town with a population of approximately 755 people. The landscape around Los Asientos is constituted mostly of agricultural and cattle ranching lands with fragments of secondary tropical dry forest rich in biodiversity. The climate of Los Santos is tropical savanna (Koppen classification) presenting two predominant seasons (wet and dry) with temperatures oscillating from 28°C and average precipitation of approximately 1100 mm per year. According the Holdridge classification, the area of Los Asientos belong to the life zone of Tropical Dry Forest (INEC, n.d.).

Reforestation plots

In 2011, as part of their first-phase sustainable ranching and riparian restoration project, APASPE established 12 mixed species reforestation plots (with ranges of 0.1 and 1.2 hectares) that consist of a total of 3691 individuals, including 3590 native fruit and timber species, covering approximately a total of 3.07 hectares (Fig.1). Although all plots are located in the same region and near the population of Los Asientos, they differ in aspects of area of reforestation, landform (lower, mid and upper slope), land use (conventional and agroforestry plantation), distance to riparian zone (from 140 to 1140 m), and disturbances to the site (grazing animals, insects and drought).

The following native tree species were available to plant by landholders, from which they voluntarily selected the preferable species to be planted, *Albizia saman*, *Anacardium excelsum*, *Anacardium occidentale*, *Annona muricata*, *Calycophyllum candidissimum*, *Cedrela odorata*, *Chrysophyllum cainito*, *Cordia alliodora*, *Dalbergia retusa*, *Diphysa americana*, *Enterlobium cyclocarpum*, *Gliricidia sepium*, *Inga* spp, *Myrospermum frutescens*, *Pachira quinata*, *Psidium guajava*, *Swietenia macrophylla*, *Tabebuia guayacan* and *Tabebuia rosea*.

The plantation spacing for all the sites (conventional and agroforestry plantations) was 3 x 3 m, as it is considered the most appropriate for optimal

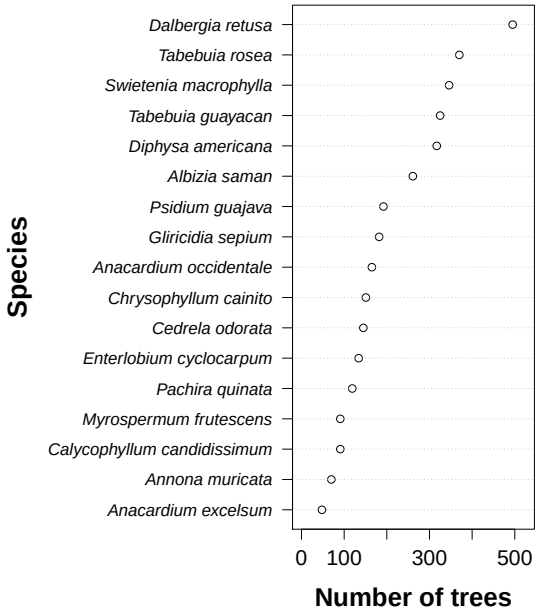

Fig. 2. Species composition (number of trees) over all APASPE 2011 forest restoration plots, recorded during the 2016 measurements.

growth for tropical tree species (Grant, Nichols, Pelletier, Glencross, & Bell, 2006). In four of the 12 plots, farmers utilized agroforestry planting techniques following a Taungya system in which, annual, perennial, and forage crops were planted among forest plantations during the first years after establishment, with the purpose of use the available space and provide food and income to the landowners and their families who own these farms (Escalante 2015). These crops included pigeon pea, cassava, maize, beans, plantains, and Mexican sunflower. The other eight plantations were established without any type of intercropping. All trees were planted in riparian areas (with average distance to the riparian zone of 0.32 km) in order to provide a large buffer zone for important watershed areas.

Baseline information was recorded for each plot on the number of individuals by species. ELTI's Panama Coordinator, Jacob L. Slusser measured all plots for the first time in June 2015. Sapling survival (1756 native tree seedlings) was tallied and basal diameter (50mm above ground level) was recorded for all species. To assess reforestation success, in 2016 we measured various indicators of establishment success (survival rate of trees), growth success (tree growth), vegetation structure (crown area), and biomass (Le et al. 2012). In particular, for this study we examined the survival of planted trees from 2011 to 2016.

Data analysis

Two species (*Cordia alliodora* and *Inga* spp.) were removed from this analysis, since both were initially established only in conventional plots.

To compare tree survival in conventional versus agroforestry plots (Q1), I evaluated the number of dead and alive trees in 2016 with a proportion test. To compare survival rates among species (Q2), I applied a χ^2 test, comparing the proportion of alive trees of each species. To compare survival rates of species in conventional versus agroforestry systems (Q3), I utilized a generalized linear model (GLM) to test the effect of species and plantation systems on the proportion of alive trees in 2016. All analyses were performed using R Studio (Version 1.0.136).

Results

In the 12 APASPE restoration plots in 2016, we identified 1,756 individuals (not including non-native species and individuals that were naturally regenerated or replanted), representing 19 native tree species, 17 genera, and 11 families. The most common species were *Tabebuia rosea*, *Dalbergia retusa* and *Swietenia macrophylla*, comprising 46% of all individuals (16.7%, 15.7%, and 13.7%, respectively; Fig. 2).

Survival of trees in conventional vs. agroforestry systems

A total of 3,590 native trees were planted in 2011: 2,582 in conventional and 1,008 in agroforestry plots. Of these, a total of 1,756 survived to 2016: 945 in conventional plots and 811 in agroforestry

plots. Overall survival was greater in agroforestry plots (2-sample test for equality of proportions: χ^2 = 566.71, df = 1, P < 0.001).

At the plot level, survival varied from 22% to 89%. Mean survival rate in the eight conventional plots was 35.8±22.2% (range = 4.9–87.0%), whereas mean survival rate in the four agroforestry plots was 69.1±24.1% (0.0–97.8%). (Fig. 3).

Survival rates of species

Overall mean survival of species was 52.4±16.9% (range = 0% *Myrospermum frutescens* in agroforestry sites to 97.8% *Swietenia macrophylla* in agroforestry sites) and varied significantly among species (χ^2 = 469.89, df = 16, p < 0.0001, Fig. 4). The species with the highest overall survival were *Anacardium excelsum*, *Tabebuia rosae* and *Swietenia macrophylla*, while the species with the lowest average survival rate was *Myrospermum frutescens* (Fig. 4).

Survival rates of species and reforestation system

Over all species, survival in conventional plantations was significantly lower than in agroforestry plantations (GLM, z = -21.49, p < 0.0001).

Differences in survival rates between agroforestry and conventional systems ranged from -0.85 to 0.45 (mean = -0.33). The species with the biggest difference were *Calycophyllum candidissimum*, *Pachira quinata*, *Swietenia macrophylla*, and *Dalbergia retusa*, with higher survival in agroforestry. However, all but two species (*Anacardium excelsum* and *Myrospermum frutescens*) had higher survival under the agroforestry system, and there was a significant interaction between species and reforestation system (χ^2 test: deviance = 190.42, p < 0.0001, Fig. 4).

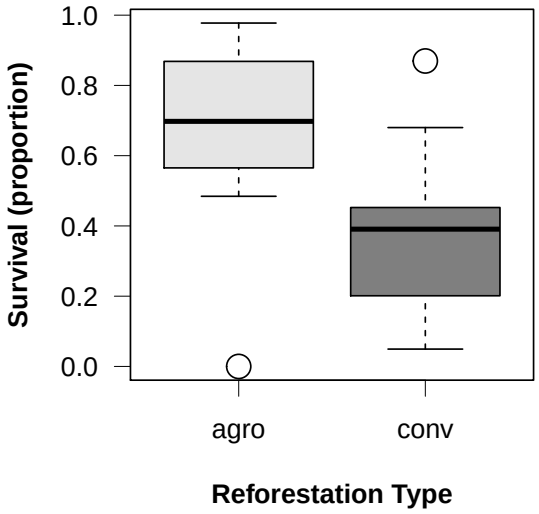

Fig. 4. Survivorship of all trees in the 2011 APASPE reforestation plots. Boxplots show survival of 17 native species established in 8 conventional versus 4 agroforestry plantations. Data collected during summer of 2016.

Conclusion

The tropical dry forest in the Azuero peninsula has supported the local rural communities for their livelihoods and ecosystem services for centuries. However, conventional cattle ranching has dominated this region for decades, degrading the land and decreasing farm productivity. The performance of the APASPE on-farm reforestation plantings in riparian areas is important in terms of recuperating the ecosystem services of the dry forest. By using short-term establishment indicators, we can illustrate the success or failure of the plantations under agroforestry and conventional systems, allowing to make initial site-specific recommendations of potentially valuable species for restoration and other uses.

In this study, we analyzed data across on-farm reforestation plots in Los Asientos, Panama to evaluate restoration success of forest communities under agroforestry and conventional restoration models. Our study used 12 sites. We measured and quantified restoration success through the use of potential indicators and analyzed the differences in survival between sites that share similar production schemes. Variability in these indicators has been observed among plots, where trees planted un-

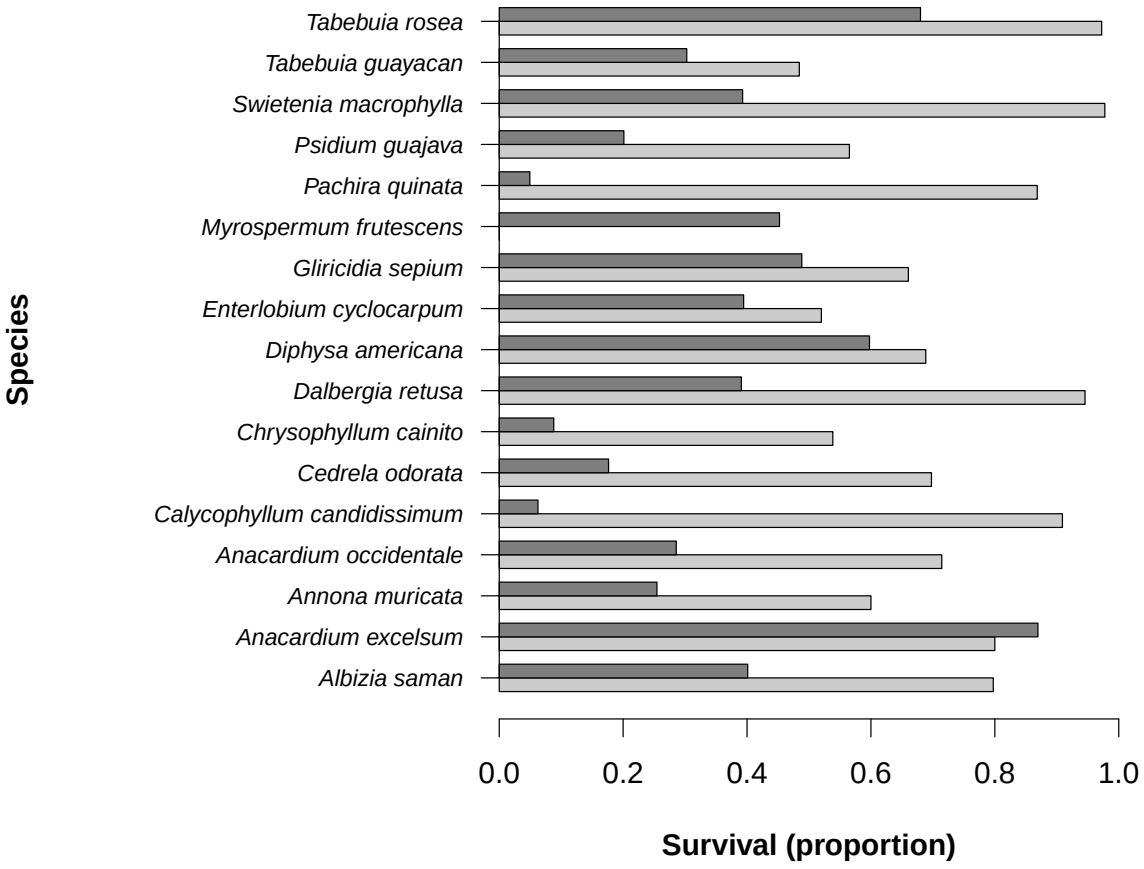

Fig. 3. Species-specific survival rates from 2011 to 2016 in the APASPE 2011 forest restoration plots.

der agroforestry systems showed a greater survival rate than tress in conventional plantings, suggesting distinctions in farm management and/or specific conditions at each site. Mean survival rate was 33.25% greater in agroforestry than conventional plots. Overall Anacardium excelsum exhibited high average survival rate (83.48%) with low variability for both conventional and agroforestry sites, and showed the greatest survivorship among species at conventional plantations. On the other hand, survivorship of *Calycophyllum candidissimum* and *Pachira quinata* was markedly higher (above 80%) in the agroforestry as compared to the conventional plots (Fig. 4).

This information could consequently help in setting long-term goals for future restoration project planning, as diverse native timber and fruit species can be established in hostile ranching landscapes with more success via agroforestry systems, as the data illustrates, which is an important restoration strategy for these types of productive landscapes.

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