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REPORT

Vulnerability of coastal livelihoods to shrimp farming: Insights from Mozambique

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Abstract Millions of people around the world depend on shrimp aquaculture for their livelihoods. Yet, the phenomenal growth of shrimp farming has often given rise to considerable environmental and social damage. This article examines the impacts of commercial, export-oriented shrimp aquaculture on local livelihood vulnerability by comparing the exposure, sensitivity, and adaptive capacity of shrimp farm employees with non-farm employees in rural Mozambique. Exposure to stressors was similar between the two groups. Shrimp farm employees had higher assets and higher adaptive capacity than non-farm employees. However, because their income is heavily dependent on a single commodity, shrimp farm employees were highly susceptible to the boom crop nature of intensive shrimp farming. The implications for aquaculture policy and vulnerability research are discussed. The article argues that coastal vulnerability is dynamic, variable, and influenced by multiple processes operating at multiple scales.

Keywords Vulnerability · Livelihood · Shrimp farming · Mozambique · Africa

INTRODUCTION

Penaeid shrimp (*Penaeus monodon* and *Litopenaeus vannamei*) have emerged as one of the most valuable globally traded seafood products. Between 2001 and 2010, global shrimp aquaculture production tripled from 1.3 to 3.8 million tonnes (FAO 2012). National governments, private investors, and international development agencies have been promoting shrimp aquaculture as a pathway for raising rural incomes, improving local food security, and bolstering foreign exchange in tropical developing countries (World Bank 2013). Consequently, millions of people now depend on shrimp farming for their livelihoods. While Asia currently accounts for the majority of global shrimp production, favorable market forecasts have generated increased interest in introducing shrimp farming into new production areas. Many analysts view countries in Africa as the new frontier for the expansion of shrimp farming (Brummett et al. 2008).

While there is considerable potential for the development of shrimp farming in many African nations, the debate over its prospective social benefits continues owing to the industry's chequered past. Production has often followed a roller coaster trajectory of rapid growth followed by abrupt collapse as a result of market fluctuations, disease outbreaks, and pollution (Hall 2011). The variable nature of farming success is apparent in both countries where the industry is dominated by thousands of small-scale farmers such as in Thailand and Vietnam (Lebel et al. 2010), as well as in countries where the industry is characterized by large commercial farms such as Ecuador (Veuthey and Gerber 2012). In both farming contexts, the non-linear, 'boom crop' nature of shrimp production has often contributed to increasing levels of social and ecological vulnerability (Primavera 2006; Paul and Vogl 2011).

Increasingly, aquaculture systems are being conceptualized as complex social-ecological systems, which are characterized by nonlinear feedbacks and interactions across spatial and temporal scales (Lebel et al. 2010; Blythe 2013). The impacts of commercial shrimp farming, however, are often studied in isolation from other key system features and therefore overlook the outcomes created by exposure to multiple, interacting relationships. This article explores how exposure to multiple stressors interacts to affect the vulnerability of people living in coastal

areas and, in particular, how changes introduced by shrimp aquaculture interact with other key system attributes to shape local landscapes of vulnerability. Drawing on comparative, place-based research in central Mozambique, we investigate three specific questions: (i) what stressors and shocks are being experienced by households along Mozambique's central coast, (ii) how are households responding, and (iii) how do these processes affect local livelihood vulnerability?

SHRIMP AQUACULTURE IN MOZAMBIQUE

> Shrimp for Mozambique are something like gold or diamonds
> —Ministry of Fisheries employee, August 2009

Shrimp have been fished by local people along the Mozambican coast for centuries. Yet, shrimp did not capture colonial interest until the early 1960s when the Portuguese began to recognize the export earning potential of a shrimp fishery. By the early 1980s, wild caught shrimp became Mozambique's second largest export earner following cashews (FAO 2011). The contribution of shrimp to foreign exchange peaked at 28.8 % during the mid-1980s and subsequently began to decline (FAO 2011). The government responded by investigating the potential for a commercial shrimp aquaculture industry. In 1988, it established a 10-hectare pilot farm near Maputo, which marked the beginning of commercial aquaculture in Mozambique (Omar and Hecht 2011).

Mozambique's environment is considered ideal for shrimp aquaculture: black tiger shrimp (*Penaeus monodon*) are a native species and the tropical temperatures permit year round production. In 2008, the government established the National Institute for Aquaculture Development (INAQUA) and prepared their Aquaculture Development Strategy (2008–2017) with the objective of substantially increasing both small-scale and commercial aquaculture. Aquaculture has been identified as a high priority activity not only for its capacity to generate export earnings, but for its potential for helping to alleviate rural poverty, improve local food security, and meet the population's nutritional needs. The Ministry of Fisheries has recently identified 30 000 hectares of land as suitable for commercial shrimp farming, meaning free of land use conflict or risk to protected ecosystems (Omar and Hecht 2011).

Despite the favorable environment and high priority status, the shrimp farming industry in Mozambique is currently small. The first industrial farm was built in 1994. By 2004, there were three large farms, though only two farms are currently operating with a total production area of 534 ha (RAF 2013). The industry employs an estimated 600 people in an economically active population of 11.3 million (FAO 2006; World Bank 2011). Small-scale aquaculture is virtually non-existent. Mozambique's nascent shrimp farming industry has also been affected by shrimp disease. The white spot syndrome virus (WSSV), which is one of the most contagious viral diseases of penaeid shrimp (Lightner et al. 2012), appeared in Mozambique for the first time in 2011. The outbreak led to mass mortality among shrimp at the farm for this case study within a matter of days. Ponds were drained, production was suspended for over a year, and the contracts of several hundred employees were terminated (FAO 2013).

ANALYTICAL FRAMEWORK

A number of theoretical and empirical frameworks for conducting vulnerability assessments have been developed in recent years, reflecting different perspectives and schools of thought ranging from natural hazards to rural livelihoods and poverty, and most recently climate change research (Füssel and Klein 2006). Broadly, the various perspectives can be classified into two interpretations: outcome vulnerability and contextual vulnerability (O'Brien et al. 2007). Outcome vulnerability is considered a result of the impacts of climate change on a particular exposure unit, which is offset by adaptation measures. Firm boundaries are drawn between 'nature' and 'society', where society is understood as a fixed unit that both drives the process of vulnerability and experiences the consequences of a biophysical stressor, commonly climate change (Scott et al. 2012). Contextual vulnerability approaches, on the other hand, emphasize the situated nature of vulnerability (O'Brien et al. 2007). Researchers explore the characteristics of individuals, households, communities, or regions in order to understand differential capacities to respond to changing conditions (Cinner et al. 2012; Bennett et al. 2014). Vulnerability is considered a characteristic of linked social-ecological systems; one that is shaped by multi-scalar interactions between social, political, economic, and ecological structures and processes (Adger 2006). Contextual conditions are understood to influence the exposure, as well as responses, of a particular group or place.

In order to understand the differential vulnerability of households to multiple stressors in central Mozambique, we draw on Turner et al.'s (2003) framework which takes a contextual approach to understanding vulnerability within linked social-ecological systems. The term social-ecological is used to emphasize that the two components are equally important, that they function as a coupled, interdependent, and interactive system and to stress that the delineation between subsystems is artificial (Berkes et al. 2003). Since vulnerability analyses that consider the

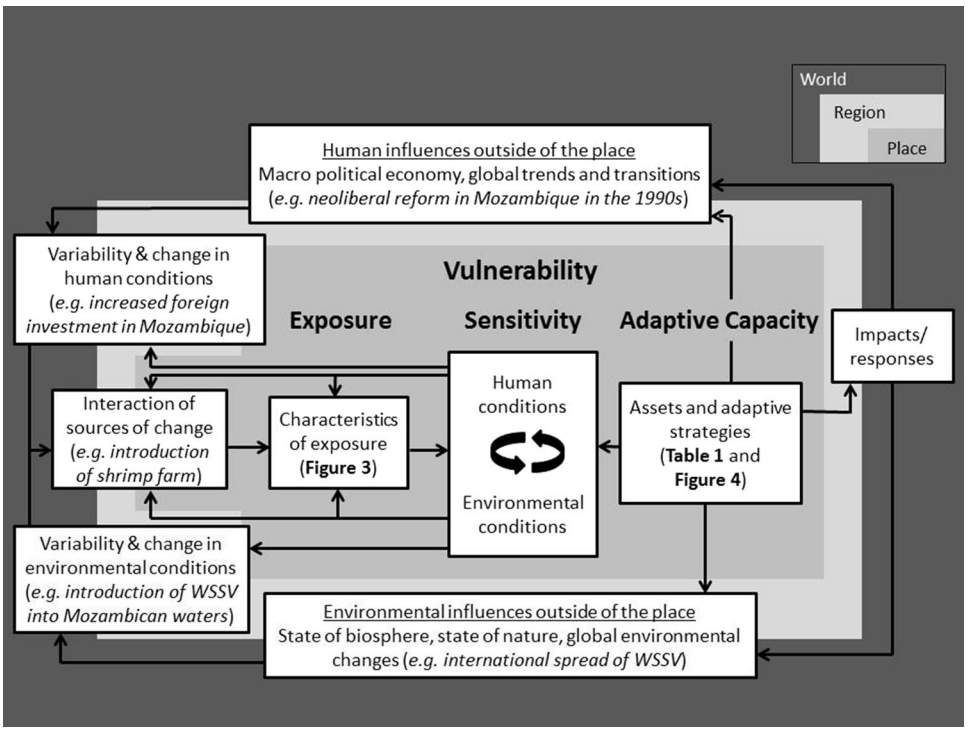

Fig. 1 Vulnerability framework (adapted from Turner et al. 2003)

totality of complex social-ecological systems are unrealistic, Turner et al. (2003) developed a heuristic to help guide empirical vulnerability research (Fig. 1). Their framework illustrates how the components of vulnerability (exposure, sensitivity and adaptive capacity) at a particular scale (called 'place' in the heuristic) interact with social and environmental conditions within and across scales. The framework helps us situate our analysis within the context of nested scales of social-ecological change in Mozambique: ranging from national macroeconomic reform to the local introduction of a commercial shrimp farm (Fig. 1).

While definitions and approaches vary, vulnerability is most often characterized as being a function of exposure, sensitivity and adaptive capacity (Parry et al. 2007, Marshall et al. 2010). *Exposure* is defined as the nature and degree to which a system experiences environmental or social stressors or shocks (Adger 2006). Stressors are characterized as continuously or slowly increasing pressure (e.g., chronic poverty), whereas shocks are understood as acute spikes in pressure beyond the normal range of variability (e.g., rapid disease outbreak) (Turner et al. 2003). *Sensitivity* is the degree to which a system is affected by stressors or shocks (Adger 2006). While vaguely defined in the literature, the sensitivity of a household may depend on livelihood characteristics and the nature of the stressors (Cinner et al. 2012). *Adaptive capacity* describes the ability of a system to anticipate and respond to stressors and shocks (Gallopín 2006). In this article, we propose that adaptive capacity can be aptly characterised as a function of two components of livelihood: household assets and adaptive strategies. A livelihood is defined as the assets, activities, and access to these (as mediated by institutions and social relations) that determine the living gained by individuals or households (Ellis 2000). Assets are conceived of comprising five main categories: physical capital (infrastructure, producer goods); natural capital (land, trees, fish stocks); human capital (education, health); financial capital (savings, credit); and social capital (kinship, social networks, associations) (Allison and Ellis 2001). We posit that households will draw on a combination of assets and adaptive strategies to cope with stressors and are thus important explanatory variables in analyses of livelihood vulnerability.

MATERIALS AND METHODS

Research community

Mozambique is one of the poorest countries in the world. The United Nations Development Programme ranks it as 185th out of 187 countries on the human development index (UNDP 2013). In 2009, over half of the population was living below the national poverty line of 18 meticais or US$0.50 a day (GoM 2011).

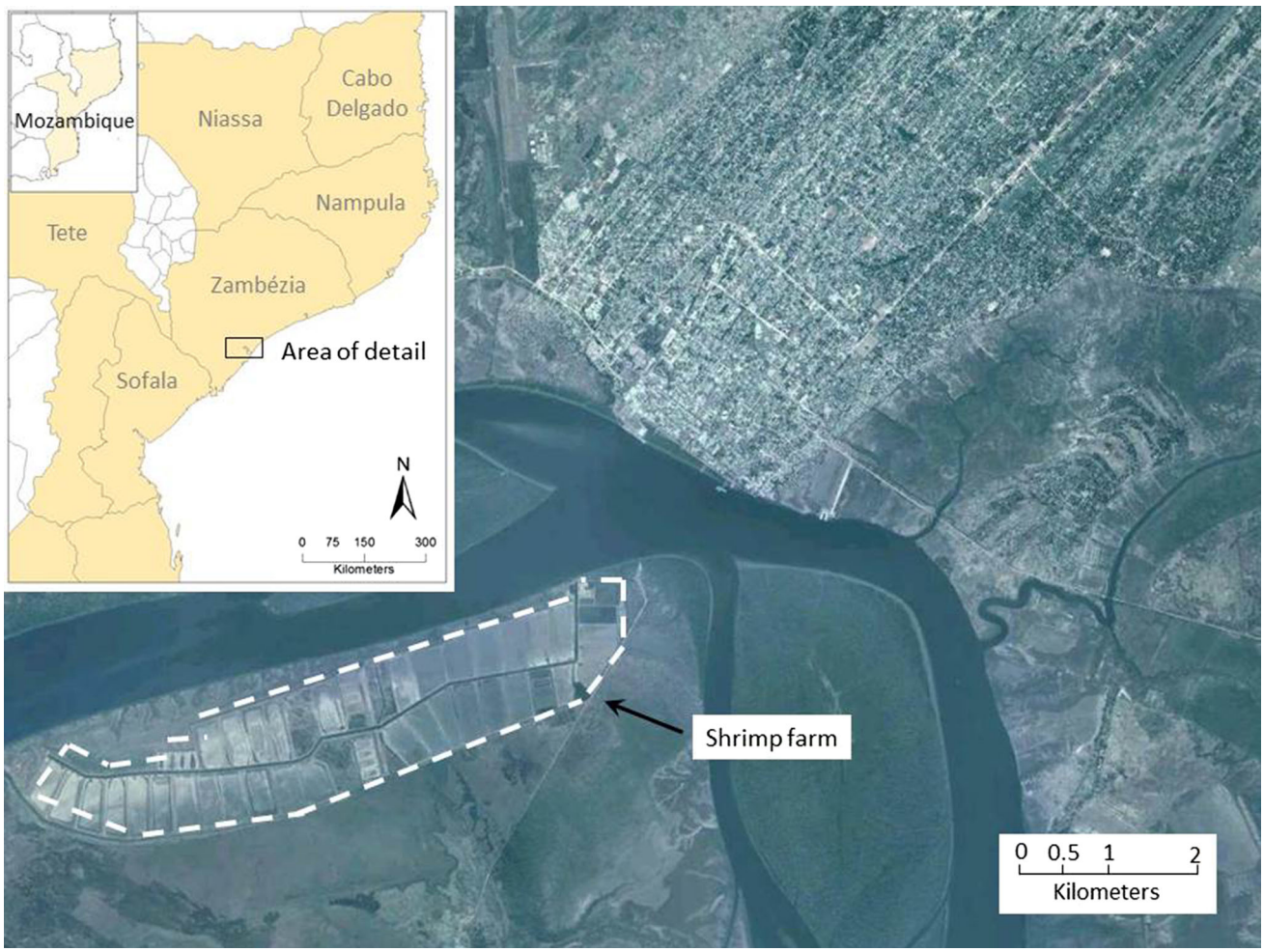

Fig. 2 Satellite image of the shrimp farm (inside the *white dashed line*) in central Mozambique (Google Earth 2013)

Located on the southern coast of Zambezia, one of Mozambique's poorest provinces, Inhanssunge is known for its mangrove-lined estuaries and high temperatures. Wage work is extremely limited; therefore, subsistence agriculture and fishing form the basis of livelihoods for the majority of the population. Inhanssunge is the site of the country's largest shrimp farm (Fig. 2).

Study farm site

The shrimp farm in Inhanssunge is a commercial, export-oriented farm. Following a pilot project in 1994, production for export began in 2000. In 2009, the farm consisted of 340 ha of ponds (Galli, personal communication). The farm produces black tiger shrimp (*Penaeus monodon*) in a semi-intensive environment with flow-through water systems (no aeration). The farm exports its shrimp to high-end European markets and has successfully developed an identity for their shrimp as an environmentally sustainable, organic product that meets the standards of the French AB-Bio label and EU regulation 710-2009. None of the shrimp produced are consumed locally. In 2010, the farm employed approximately 400 full time workers, the majority of whom live in Inhanssunge, which lies 20 km south of the farm.

Surveys and interviews

To investigate livelihood vulnerability, household surveys were conducted between September and December 2010 with members of the two livelihood groups: ninety shrimp farm employees (mean age = 35, SD 10.8) and forty-three non-farm employees (mean age = 31, SD 11.5). Surveys were conducted at the farm or in Inhanssunge. Every third employee, and in the community every third household, was asked to participate in the research. Surveys focused on: (i) stressors and shocks that people had experienced in the previous year, (ii) household assets and (iii) adaptive strategies. Each category consisted of a closed set of questions (developed based on focus groups conducted

during a scoping trip in 2009) followed by an open-ended section so that respondents could add items that were not included in the initial list. Descriptive statistics (mean age, confidence intervals) were calculated using Microsoft Excel 2010.

To complement the quantitative data, qualitative semi-structured interviews were conducted with shrimp farm employees ($n = 14$) and non-farm employees ($n = 12$). Respondents were identified by the farm manager or the community chief, respectively, and subsequently via snowball sampling. Interviews permitted respondents to expand on how they experience and cope with stressors and shocks. Interviews were coded using qualitative software NVivo 9.

RESULTS

Exposure

Our analysis begins by exploring the exposure of households in Inhanssunge to stressors and shocks (Fig. 3).

Two important points emerge. First, the data demonstrate that livelihood stressors and shocks arise from multiple sources, including social, ecological and economic disturbances. Over 80 % of households were struggling with diseases. Lack of food was reported by 80 % of households. Drought and crop disease, such as the Lethal Yellowing Disease in palms, reduced agricultural production. Half of all households had lost a family member in the previous year. Respondents explained that lack of jobs and poor roads challenge their ability to earn a living. Clean water and electricity are limited. Finally, Inhanssunge residents explained that before the shrimp farm was established, the land was used by community members for making salt, for fishing and as pasture for livestock, livelihood strategies that had become physically blocked by the presence of the shrimp farm.

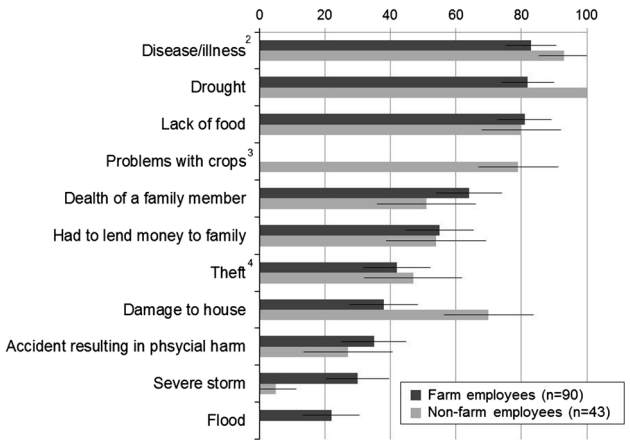

Fig. 3 Summary of exposure to stressors and shocks in two livelihood groups in Mozambique. *Bars* indicate percentage of total survey respondents (±95 % CI) that experienced each stressor or shock in previous 12 months (*1*). (*1*) No respondents identified the WSSV as a stressor because the surveys were conducted in 2010 and the WSSV appeared for the first time in Mozambique in 2011. (*2*) Diseases included cholera, HIV/AIDS, malaria, tuberculosis, and asthma. (*3*) Problems with crops included lack of rain, reduced production, and damage from pests and disease. (*4*) Stolen materials included food (rice, potatoes, and chickens) and household materials (bicycles, radios, clothing, fishing nets, and cell phones)

Second, the exposure data demonstrate that sources of stress are complex and interactive, sometimes across scales. For example, national economic liberalization enabled the establishment of the foreign owned shrimp farm, which has blocked local access to previously common land. Likewise, interview respondents explained that drought has reduced agricultural production, which in turn led to food shortages. They also indicated that: i) lack of jobs leads to increased incidence of theft and ii) lack of clean drinking water contributes to higher incidence of disease. Thus, stressors in the natural environment interact with social stressors, and vice versa, within and across scales.

Sensitivity

In our analytical framework (Fig. 1), sensitivity is composed of human and environmental conditions. In this study, we use primary livelihood activity as a proxy for human condition and as a determinant of sensitivity. While multiple livelihoods generally contribute to household income, invariably households would identify their primary source of support as either shrimp farm or non-shrimp farm income. Other substantive determinants of sensitivity, notably environmental conditions, are factored out of the comparison as they remain constant for both farm employee and non-employee groups.

The impact of stressors and shocks varies between the two livelihood groups. Crop diseases that reduce agricultural yields have had a major impact on households who depend on agriculture with relatively lower impact on households with shrimp farm employees (Fig. 3). Similarly, while drought had a major impact on both livelihood groups, this was universal for those dependent on agriculture whereas shrimp farm employees were less affected.

Conversely, shrimp farm employees are highly sensitive to disturbances that affect farm production. The WSSV suspended farm production in Inhanssunge for approximately one year. While impacts of the disease outbreak are not captured in our data as the study concluded prior to the outbreak, the FAO (2013, p. 11) reported that "[t]he impact on employment was felt severely due to the absence of any economic activity or other livelihood alternative in those areas; the direct result was migration of people or small

Table 1 Summary of assets among two livelihood groups in Mozambique. Values indicate the percentage of total respondents in each group who positively identified ownership of or access to each asset in household surveys

Asset	Respondents by livelihood group percentage of *n*	
	Shrimp farm employees ($n = 90$)	Non-farm employees ($n = 43$)
Financial capital		
Savings	54	20
Human capital		
Access to a doctor	96	88
Access to a school for your children	91	91
Literacy	90	76
Secondary education	37	12
Natural capital		
Livestock/poultry	60	67
Machamba[a]	97	95
Physical capital		
Access to a well	67	56
Bicycle	86	56
Cell phone	30	40
House	96	93
Steel roof	45	23
Grass roof	55	77
Social capital		
Family members in the community	93	90
Spouse	81	84

[a] Local term for subsistence garden

temporary activities which disorganized the main area activities".

Adaptive capacity

We evaluated adaptive capacity through two components: household assets (Table 1) and adaptive strategies (Fig. 4).

The *financial capital* of farm employees was higher than non-farm employees. At the farm, employees earned an average of 2530 MZN per month (equivalent to $84 US), which is the minimum wage defined by the Government of Mozambique for the public sector (Jose, personal communication). Monthly income data from non-farm employees was not collected. However, it is reasonable to assume that the cash income of farm employees was higher than non-farm employees because subsistence farming livelihoods are largely derived from non-monetary sources, such as agricultural production for household consumption. Moreover, half of farm employees reported financial savings, while only 20 % of non-farm employees had savings.

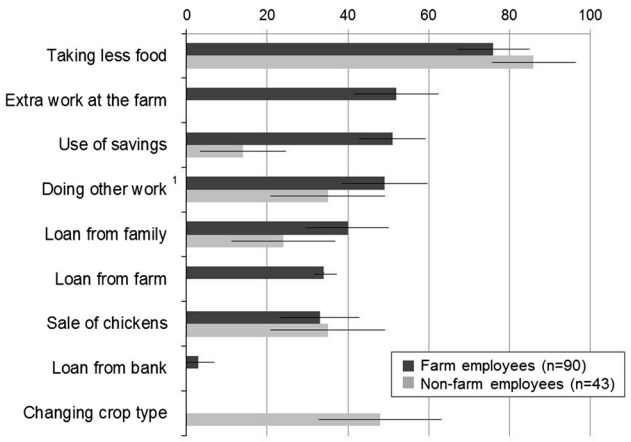

Fig. 4 Summary of adaptive strategies used in response to stressors and shocks by two livelihood groups in Mozambique. *Bars* indicate percentage of total respondents in each group (±95 % CI) who made use of each strategy during the previous 12 months. (*1*) Other work for farm employees included: carpenter ($n = 6$), farming ($n = 4$), masonry ($n = 3$), small business ($n = 2$), tailor ($n = 2$), fisher ($n = 1$), bicycle taxi ($n = 1$), hiring out a wooden cart ($n = 1$), and making salt ($n = 1$). Other work for non-farm employees included: farming ($n = 9$), fishing ($n = 2$), making bricks ($n = 1$), selling chickens ($n = 1$), security guard ($n = 1$), radio mechanic ($n = 1$), small business ($n = 1$), and wage labor ($n = 1$)

Access to doctors, literacy rates and formal education (elements of *human capital*) were higher among farm employees. The administrative director of the farm indicated that being literate and having completed formal schooling could increase an individuals' chance of being hired at the farm. Therefore, literacy and education are likely precursors to employment at the shrimp farm as opposed to outcomes. However, in 2009 the farm was developing literacy and math programs for farm employees and working on a certificate for on the job training (Massinga, personal communication). The farm had partnered with an NGO to conduct quarterly HIV testing, counseling and antiretroviral programs with employees. In addition, the farm was sponsoring three undergraduate students from the Universidade Edaurdo Mondlane—Escola Superior de Ciências Marinhas e Costeiras (UEM-ESCMC), by covering their tuition and providing internship opportunities for the students at the farm. Consequently, we argue that employment at the shrimp farm has the potential to increase the *human capital* of farm employees and the community more broadly.

Shrimp farm employees reported higher access to clean drinking water and houses made with higher quality roofing material (steel as opposed to grass). In addition, the shrimp farm loans bicycles to their employees, thus contributing to employees' *physical capital*. In Inhanssunge, the shrimp farm has also contributed to physical capital for all community members. In 2006, the farm installed electricity and the infrastructure developed to deliver electricity to the

farm was used to deliver electricity to the Inhanssunge district (Galli, personal communication).

Natural and *social capitals* were similar between the two livelihood groups (Table 1). Livestock ownership and subsistence gardens, which play a vital role in the livelihoods of rural communities in Mozambique, were comparable for farm employees and non-farm employees. Likewise, the majority of respondents in both groups were married and had extended family in the community.

Adaptive strategies being employed by households were explored as the second component of adaptive capacity (Fig. 4).

Reducing food consumption was the most commonly used adaptive strategy in both groups. This finding presents an important empirical counter to the narrative surrounding the positive impacts of shrimp farming on food security (FAO 2006; World Bank 2013). Employment at the shrimp farm gave farm employees access to several adaptive strategies that were not available to non-farm employees. Half of farm employees took extra shifts and a third took a loan from the farm to cope with stressors. While both groups took loans from family, more farm employees made use of this strategy than non-farm employees. Only farm employees took loans from a bank. Interview respondents indicated that in order to take a loan from a bank, a deposit was required meaning that people without savings were unable to access bank loans. Therefore, farm employees had more access to credit, both via formal and informal social arrangements, than non-farm employees.

Interview data built on household survey results and suggested that working at the shrimp farm helped employees respond to livelihood stressors. For example, a 54-year-old farm employee noted that "before we would work in the garden and wouldn't have enough money to cover our basic expenses. Now, that's possible." A 32-year-old respondent said that "a job helps in times of difficulty, like when there's disease in your house. When a farm employee is sick, they have direct access to a doctor." Respondents explained that working at the farm has helped them purchase food and school materials for their children. In addition, during periods of food insecurity, when a household member was sick, or when their houses needed repair, farm employees took loans from the farm to help pay for unexpected costs. When asked if there was anything else he would like to add at the end of an interview, a 21-year-old respondent said "they should open farms in other districts and provinces, so there would be paid jobs."

However, eleven of fourteen interview respondents highlighted that an increase in salary would increase their ability to respond to livelihood stress. They explained that they engage in physically demanding labor over long hours yet their salaries do not cover their monthly household expenses.

Synthesis

Table 2 synthesizes the three components of vulnerability (exposure, sensitivity, and adaptive capacity).

Irrespective of primary livelihood activity, households in this study were exposed to multiple chronic stressors, such as disease and drought. However, only shrimp farm employees were exposed to the rapid outbreak of the WSSV. This suggests that while both groups are vulnerable to chronic stressors, employment at the shrimp farm can expose employees to additional shocks related to shrimp production.

Next, we propose that sensitivity is dependent on primary livelihood activity and the type of stressor or shock experienced. At the time household surveys were conducted, many of the most prominent stressors identified by households (e.g., drought, problems with crops) tended to have a greater impact on households dependent on agriculture (non-farm employees) than those dependent on shrimp farm income.

Finally, shrimp farm employees had higher assets than non-farm employees. Moreover, while both groups engage in diversified livelihood activities, working at the farm gave employees access to adaptive strategies, such as access to credit, which were not available to non-farm employees. Therefore, we consider the adaptive capacity of farm employees as higher than that of non-farm employees.

Table 2 Synthesis of livelihood vulnerability analysis in Mozambique

	Shrimp farm employees	Non-farm employees
Exposure		
Stressors (continuous)	✔	✔
Shocks (acute)[a]	✔	✕
Sensitivity		
Occupation	Variable depending on the stressor (e.g., ↑ sensitivity to WSSV)	Variable depending on the stressor (e.g., ↓ sensitivity to WSSV)
Adaptive capacity		
Assets		
Financial capital	⬆	⬇
Human capital	⬆	⬇
Physical capital	⬆	⬇
Natural capital	=	=
Social capital	=	=
Adaptive strategies		
Diversification	✔	✔
No. of adaptive strategies	⬆	⬇

'✔' Indicates presence and '✕' indicates absence of a particular factor in the vulnerability analysis; '⬆' indicates higher, '⬇' indicates lower, and '=' indicates equal value of a factor for one livelihood group *in relation* to the other livelihood group

[a] During our research, the only shock experienced by respondents was the outbreak of the WSSV. Therefore, shocks in this table refer to the WSSV

Overall, the data suggest that due to relatively lower sensitivity and higher adaptive capacity, shrimp farm employees are less vulnerable than non-farm employees to continuous stressors identified by households in Inhanssunge. However, because their income is heavily dependent on a single commodity, which globally has a history of catastrophic collapse due to disease (e.g., WSSV and more recently 'early mortality syndrome'), they are highly susceptible to the boom crop nature of intensive shrimp farming.

DISCUSSION

The introduction of commercial shrimp aquaculture in developing countries is usually valued positively in terms of enhanced livelihoods due to increased income opportunities (World Bank 2013). However, our analysis suggests that the development of commercial shrimp farming in Mozambique has had differential impacts on the vulnerability of local people. Through the shrimp farm, employment opportunities have provided important income sources for some households increasing their ability to cover basic expenses, such as school fees, and to cope with chronic stressors including disease. Electricity infrastructure became available to the entire community after the development of the shrimp farm. At the same time, the volatile nature of export-oriented shrimp farming exposed employees to production related risks. The outbreak of the WSSV in 2011 led to the termination of several hundred employees' contracts (FAO 2013). Moreover, the shrimp farm physically blocked access to communal land that had previously been used by community members for subsistence livelihood activities. Therefore, we argue that vulnerability is not a linear outcome of a discrete number of factors. Rather, it is a multi-faceted, context specific phenomena that affects groups differentially.

In terms of aquaculture policy implications, we argue that interventions in two areas may have the potential to lessen the negative impacts of shrimp farming on livelihood vulnerability in Mozambique: (i) disease risk management and (ii) investment in human capital. First, while the timing of disease outbreaks may be surprising, they are not unforeseeable, particularly in monocultures. Effective management and regulatory practices must then account for disease outbreaks. We propose building on the Responsible Aquaculture Foundation's (2013) policy recommendations for disease risk reduction in Mozambique by developing social insurance programs, funded perhaps by a tax on exported shrimp, which support employees during disease induced layoffs. The WSSV is now present in wild shrimp populations in Mozambique making the risk of future outbreaks more likely. Second, strong human capital, including formal education and training, is a critical component of successful aquaculture because it increases capacity for adaptation and innovation (Lebel et al. 2010). We recommend that in addition to the training being provided by the private sector (e.g., programs for employees and undergraduate students at the farm), investment in public sector personnel would strengthening the shrimp aquaculture industry in Mozambique. At a broader scale, we argue that the negative impacts of shrimp farming could be minimized by drawing on the combined strengths of governments, the private sector, organizations such as the Aquaculture Stewardship Council (ASC) and, critically, local communities to inform grounded aquaculture regulations (Vandergeest 2007; Bush et al. 2013; Diana et al. 2013).

Our research contributes to vulnerability analyses that broaden single stressor approaches and create urgency for understanding the nuances of livelihood vulnerability in the context of multiple shocks and transformations (Bennett et al. 2014). In Mozambique, shrimp farming is just one component of a suite of exposures and adaptive capacities that influence livelihood vulnerability. Like Mills et al. (2011) we find that irrespective of primary livelihood, exposure to chronic non-sectoral stressors, including poverty, food insecurity, and disease, is a critical driver of coastal vulnerability. Policy interventions aimed at reducing livelihood vulnerability will be more effective when they are developed in the context of the complexities of subsistence livelihoods. In addition, vulnerability assessments must account for the connected, interactive nature of exposures in social-ecological systems. In Mozambique, national economic liberalization resulted in international investment in commercial shrimp farming, which introduced wage work for some and blocked access to common land for others. We argue that assessments and policies aimed at reducing local vulnerability need to be nuanced and designed to capture the multiple exposures, sensitivities and adaptive capacities that create differential vulnerability in specific places or for specific groups.

Finally, the article explored livelihood vulnerability over a relatively brief period of time (12 months). An emerging body of literature on poverty traps suggests that while wealthier households may have more to lose due to shocks and stressors; they may have greater capacity to recover in the long-term (Carter et al. 2007). This may be the case in Mozambique. By drawing on their financial assets (e.g., savings or credit), farm employees may have better capacity to withstand and recover from stressors in the long run. Moreover, many non-farm employees sold assets to cope with stressors, which may reduce their ability to cope with future or recurrent stressors. Understanding how households cope with repeated shocks over a longer period of time will be an important area for future vulnerability research.

CONCLUSION

This research examined the impacts of export-oriented shrimp aquaculture on livelihood vulnerability in coastal Mozambique within the context of broader political, institutional, economic, and social change. Our study showed that employment at a commercial shrimp farm both increased livelihood vulnerability (e.g., by increasing employees' exposure to production related risks) and decreased livelihood vulnerability (e.g., by strengthening employees' adaptive capacity). Our data also demonstrate that commercial shrimp farming can create both positive (e.g., by increasing community physical capital) and negative (e.g., by blocking access to previously common land) impacts on the livelihood vulnerability of the surrounding community not directly involved in the farm. We argue that a focus on disease risk management and building human capital in the public sector could make contributions toward minimizing the negative impacts of shrimp farming on coastal communities. Furthermore, we suggest that future vulnerability research needs to be sensitive to multiple, interacting stressors and the differential capacity of individuals or households to respond. Ultimately, these issues are critical if shrimp aquaculture is going to make positive contributing local livelihoods as it continues to expand along Africa's coastal zones.

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