GENDER DIFFERENTIATED FOOD SECURITY: PRODUCTIVITY TRAPS IN MALAWIAN AGRICULTURE

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ABSTRACT

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After decades of international development efforts aimed at alleviating poverty and hunger, the gender gap in household food security among farming households remains alarming. Many smallholder farmers in Malawi do not have access to material and socio-cultural resources to increase their food production, but women face more barriers due to social gendered norms and practices. Using household level data from Malawi, this study applies a feminist political ecology framework to investigate the factors that inhibit food security in farming households. Results suggest that female-headed households are more likely to be food insecure. However, when variables representing different forms of power were controlled, gender of the household head lost statistical significance. These findings suggest that various forms of gendered rights and responsibilities (e.g., land, labor and capital) in Malawi may be structuring the total effect of food insecurity in farmer households, however more research is needed to confirm this. Women farmers have multiple roles to play as a producer, reproducer and consumer, that differ substantially from men's practice as farmers. Understanding the gendered differences in power, by uncovering the barriers and access to productive resources and knowledge along multiple levels, is critical to creating a gender-equitable food system.

Keywords: Malawi, gender, feminist political ecology, agriculture, food insecurity

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INTRODUCTION

Food insecurity and food insecurity crises are persistent social problems, but the distribution of this peril and resources used to overcome it is susceptible to change and has tangible effects on the environment, the economy and people's livelihoods. Dramatic scientific advancements in modern agricultural technology and economic changes of structural adjustments and globalization have all been strategies used to help address poverty and food insecurity. Despite these changes, hunger remains the world's number one cause of death, killing more than HIV/AIDS, malaria, and tuberculosis combined (WFP 2018). An alarming 98 percent of the world's undernourished people disproportionately live in less developed countries (FAO 2010b). Over six million people (38 percent of the population) in Malawi are deemed "food insecure", meaning they lack sufficient, safe and nutritious food to lead an active and healthy life (USAID 2017; WFP 2017). Food insecurity and hunger-related diseases trap individuals in a vicious cycle of poverty (WFP 2018). Today, approximately one in four people live in extreme poverty in Malawi, meaning they live on less than $1.25 per day (WFP 2017). Many of these individuals live in rural areas, and the majority of those who are undernourished also produce food for subsistence and income (FAO 2015).

Many farmers in less developed countries still do not have access to adequate resources to help improve their agricultural outputs, and women's access is even more limited due to traditional cultural beliefs and social factors (FAO 2010a; Morris and Doss 1999; Ndiritu et al. 2013). These disparities are further complicated by increasing climate variability in drought and floods brought on by climate change; making Malawian smallholder farmers particularly vulnerable to losses in agricultural production and to food insecurity (FAO 2010a). Today, Malawi's average maize yields are less than two tons per hectare, below the average for Sub-

Saharan Africa (FAO 2015). Clearly, these "food security" policies have not helped everyone; instead, they have arguably exacerbated inequities based on hierarchical divisions rooted in class, race, and gender.

Women farmers living in rural areas often get caught in what is called the "gender-differentiated low productivity trap" (Croppenstedt, Goldstein, and Rosas 2013). This concept explains the vicious cycle women farmers living in rural areas often face: Their lower access and control over resources explains their low participation in more profitable commercial agricultural markets, therefore preventing them from accumulating wealth and productive inputs. Malawi is an interesting case, because matrilineal landholding systems (i.e., descent and devolution of land rights) are the traditional norms for the majority of the population, especially where the Chewa culture dominates (Berge, Kambewa, Munthali, and Wiig 2014).[1] Under this matrilineal system, it is assumed that sons will marry women who inherit land. In Malawi, women have the rights to use, own and inherit the land, whereas men are seen as users and borrowers.

Historically, development projects have used a 'one-size-fits-all' approach to tackle food insecurity. These approaches generally focus on enhancing production with the emphasis placed on maximizing efficiency and increasing agricultural yields. The consideration of the cultural context and possible gendered knowledge and practices that are seldom considered, yet exist or arise in the process of trying to eradicate food insecurity challenges. Efforts to reduce food insecurity today place much focus on farming practices like intercropping with nitrogen fixing crops (like legumes) and using organic fertilizer (like livestock manure) (Ortega, Waldman, Richardson, Clay, and Snapps 2016). But such solutions rarely speak to the social organization of gender relations in any real or meaningful way.

[1] The Chewa culture makes up the largest ethnic group in Malawi (32 percent of the national population). They are a matrilocal and matrilineal group, where husbands move to their wife's village after marriage (Berge et al. 2014).

Doss (2014a) argues that the structure and composition of the household and the educational levels of household members is shown to influence the outcomes of decisions regarding agricultural production and consumption. She also argues that in order to fully understand women's role in agriculture, women's primary economic activity and their participation (or lack of) in organizations, can help in understanding the ways to close the gender gap in agriculture. Recommendations for future research by Peterman, Behrman and Quisumbing (2014) suggest that studies should "continue to undertake and validate empirical work on gender issues in agriculture, and explicitly explore alternative design and delivery mechanisms to meet context-specific gender needs."

When local social and cultural norms and values are not considered when implementing certain projects and policies, it can exacerbate gendered inequalities in resources (Rubin and Manfre 2014). In a study using household level data, Kilic et al. (2015) found that on average, female-managed plots in Malawi are 25 percent less productive than their male counterparts. Their conclusions of their research support the view that significant gender disparities in the use of inputs as well as asset ownership are the central factors explaining the gender differences in household level food security (Kilic et al. 2015). Due and Gladwin (1991) found that structural adjustment programs implemented in Malawi were 'gender blind' (i.e., embedded with assumptions that the impacts on women would be the same as men), creating an adverse effect on female-headed households'. Numerous studies from less developed countries, including Malawi, have found that a disproportionate amount of female-headed households suffer from food insecurity (Babatunde et al. 2008; Kassie et al. 2014; Kassie et al. 2015; Mallick and Rafi 2010). With all of this glaring evidence, the modern scientific way of framing food security has

proven itself wrong, unjust and unsustainable. The way we frame and understand issues surrounding food security needs to change.

In this paper, I use a feminist political ecology framework to assess its utility in helping to explain these lingering shortcomings. A feminist political ecology framework draws attention to the political, cultural, and geographical context to reveal how gender norms are integrated in the everyday lives of farmers, imbuing men and women with different socio-environmental experiences. Feminist political ecologists argue that gender is a crucial variable, intersecting with variables of race, class and other dimensions, in constituting knowledge of, access to, and control over natural resources (Rocheleau, Thomas-Slayter, and Wangari 1996). Analyses using feminist political ecology can illuminate and explain the complex lived experiences of rapidly changing livelihoods as a result of climate change and international development interventions. Specifically, I use a feminist political ecology framework to understand differences in household food insecurity among female versus male-headed households in Malawi. Thus, the research question of this paper asks: can differences in household level food security be explained by gendered differences in knowledge, access and/or power over material and socio-cultural resources. In the following section, I review relevant research that undergirds this question.

LITERATURE REVIEW

A number of international development initiatives that have tried to address issues of food insecurity and poverty, such as the Green Revolution, have failed in rural places in Sub-Saharan Africa because they were guided by apolitical ecology ideologies (i.e., ecoscarcity and modernization (Robbins 2012). These ideologies assume that the problem with food security is a Malthusian concern of balancing population and ecological resources. The problem with this approach is that few issues are apolitical, and by ignoring political economic forces, it puts blinders on socio-environmental analyses to only look at the *symptoms* of problems; it neglects their origins or causes. On the other hand, political ecology uses a normative assumption of materiality (i.e., social constructivist approach) that seeks to identify broader systems of influence to discover the *causes* of dire problems like hunger (Robbins 2012). Political ecology connects global and local phenomena to understand the genealogy of narratives and decision-making in regards to the environment; and in doing so explores hierarchies of power (Adger Benjaminsen, Brown, and Svarstad 2001). By looking at changes in human-environment interactions at the household, community and regional levels, political ecologists have expanded our understanding of unintended consequences of international development in less developed countries, particularly the ecological and social harms done in Sub-Saharan Africa as a result of the Green Revolution (Robbins 2012).

Although political ecologists have historically emphasized the importance of considering broader institutional systems to understand issues of inequality and vulnerability, it has primarily focused on the uneven access to power on the basis of race and class (Jarosz 2011). For example, a political ecologist studying sustainable intensification (SI) in Malawi may find that SI is welcome in the country because it helps increase yields and lifts some farmers out of poverty.

However, this analysis does not examine gendered issues such as the potential for increasing the labor burdens for women, or cultural practices that make it harder for women farmers (and female-headed households) to compete with their male counterparts in more profitable agricultural markets (Croppenstedt et al. 2013). Therefore, political ecology may neglect important findings that show resistance to changes in sustainable ecological progress that are not expected from undifferentiated smallholder subsistence farmers, but rather resistance specifically from women (Robbins 2012).

Feminist political ecology brings a feminist perspective to political ecology by drawing from feminist cultural ecology, feminist geography and feminist political economy (Rocheleau, et al. 1996). The 'feminist' perspective in this framework rejects essentialist theories that assume women are biologically closer to nature; and instead understands that human-environment interactions are socially constructed, as such, social relations like patriarchy are necessary to acknowledge in explaining the ways in which women may or may not face food insecurity (Jarosz 2011). Like political ecology, feminist political ecology seeks to understand how material relationships in society shape differences in the distribution and access to power. However, feminist political ecology sets itself apart from political ecology by treating gender as a central social variable that *intersects* with other axes of power (e.g., class, ethnicity and race) in investigating the distribution and control over resources and environmental decision-making (Thomas-Slayter, Wangari, and Rocheleau 2011).

Using a feminist political ecology framework also highlights the ways women's relationship to the land are mediated by gendered knowledge of agriculture, gendered access to productive resources, and gendered forms of political activism (Rocheleau et al. 1996). In other words, because of socially structured gendered expectations and opportunities, men and women

experience and interact with the environment differently, and often have different knowledge of, access to and control over ecological systems. Research using feminist political ecology varies from investigating who is excluded in practicing alternative agriculture, to analyzing women's movements focused on retaining access to resources (Jarosz 2011; Rocheleu et al. 1996).

Generally, there is a limited amount of research that explicitly uses the feminist political ecology framework. Additionally, because an important aspect of feminist political ecology is to understand the pluralities of meanings of material relationships in society, the framework has primarily been applied in qualitative case studies (Hovorka 2006; Thomas-Slayter et al. 2011). However, Elmhist (2011) argues research that focuses on understanding the gender dynamics of power across and within multiple scales of human-environmental sites can be considered research that takes a feminist political ecology approach. Studies that compare agricultural productivity outcomes of female- versus male-headed households and/or managed plots have found persistent and systematic gender differences in Malawi, supporting the feminist political ecology framework (Chirwa 2005; Fisher and Kandiwa 2014; Gilbert, Sakala, and Benson 2002; Kilic, Palacios-Lopez, and Goldstein 2015; Waldman, Ortega, Richardson, Clay, and Snapp 2016; World Bank and Government of Malawi 2007). Therefore, this paper uses a feminist political ecology framework to explain the gender gap in food insecurity among smallholder farmers in Malawi. Understanding what causes the gendered food security gap is crucial for identifying the proper programs and policies that can support farmers in improving their households' food security status (Peterman et al. 2014).

Gendered Knowledge

Feminist political ecology includes three critical themes in its analytical framework including: gendered knowledge (or gendered science), gendered environmental rights and responsibilities,

and gendered environmental politics and grassroots activism (Rocheleau et al. 1996). This is to say that women's relationships to the environment are influenced by gendered knowledge of agriculture (and the environment), gendered access to resources (i.e., capital), and gendered forms of political activism. Gendered knowledge can be regarded as what is considered science and the different ways of practicing agriculture (Rocheleau et al. 1996). Women's skills regarding agricultural production are different than men because they are based on different informal (i.e., local knowledge) and formal knowledge of agricultural processes that might be gleaned through access to extension services (Robbins 2012). Furthermore, women farmers in rural areas have multiple roles to play (i.e., producer, reproducer and consumer) in the household, on the land, and in the community, that differ from men's knowledge and practice as farmers.

Some researchers suggest that the opportunities for expanding legume intercropping, as a way to address issues of food insecurity, are significant (Ortega et al. 2016; Waldman et al. 2016). In their study on Malawian farmers' perceptions of legume intercropping practices, Waldman, Ortega, Richardson, Clay and Snapp (2016) found gender to be a significant determinant of intercropping adoption because of gendered knowledge regarding on-farm decision making and preferences for legume attributes. Malawian women farmers in their study tended to adopt less sustainable practices (like intercropping with legumes) because they perceived these practices to require higher labor requirements. They also found that women in their sample had a higher preference and better access to soybean and pigeonpea (seed) than men.

Smallholder women farmers in rural areas of less developed countries, like Malawi, experience gendered knowledge in multiple ways. Research has found that women are less likely

to adopt newer and more efficient technologies due to low formal education levels; lack of training in production and negotiation with buyers; little to no access to participating in organizations that inform them of market decision-making or agricultural practices (that could help empower them); and because of their multiple roles as women they face time burdens (as they are forced to divide their efforts between housework, care work, and fieldwork) and do not have enough time to grow or market crops efficiently or effectively (Quisumbing and Pandolfelli 2010; Young, O'Connell, Mutone-Smith, Sharma, Foster, Palan, Yeh, and Cekan 2011). Studies conducted in Malawi have pointed out that farmer households headed by females are disadvantaged when it comes to access to extension services (Gilbert et al. 2002; World Bank and Government of Malawi 2007).

Results of a nationwide trial aimed at increasing the productivity of maize-based cropping systems conducted by the Malawian extension service, indicated that extension services were skewed toward 'well-to-do' male farms (i.e., had maize stocks that lasted from year to year, owned livestock, or possessed several changes of clothing) (Gilbert et al. 2002). The researchers point out a common selection bias in extension services: the majority of extension agents chose more male farmers (81 percent) to be part of the trial, despite the fact that the majority (69 percent) of full-time farmers in Malawi are female. A different study suggests that female-headed households were disadvantaged due to their tendency to own smaller farms, compared to male-headed households in Malawi (World Bank and Government of Malawi 2007). Nonetheless, the overall conclusion from numerous studies document the fact that a male bias in extension services exists across countries in Sub-Saharan Africa (Due and Gladwin 1991; Gilbert et al. 2002; Staudt 1982; World Bank and Government of Malawi 2007). Due and Gladwin (1991) explain that women in Malawi who attend extension services unfortunately lose social

status by participating in these farmers' groups. Since married women receive credit indirectly through their husbands participation in these groups, women who are full members are either unmarried or are in a polygamous union (whose husband is giving fertilizer to the other wife). It is thus a social stigma, rather than a privilege, for women to attend these meetings (Due and Gladwin 1991).

Gendered Environmental Rights and Responsibilities

Rights of control and access to natural resources (such as land) are often differentiated by gender, as well as responsibilities to manage various ecological systems for the household and the community (Robbins 2012). These gendered rights and responsibilities may apply to natural resources (i.e., land, water, animals) or to the quality of the environment (Rocheleau et al. 1996). This means that in addition to a gender gap in resources, there is a gendered division of power to restore environments and regulate the actions of others. It is important to note that this theme within feminist political ecology framework highlights that not only is the right to control one's own labor gendered, but so is the ability to control the actions of others (Rocheleu et al. 1996).

Men and women have different barriers to face when trying to overcome poverty and food insecurity, such as legal access to land, culturally defined gender norms, and gendered labor (Young et al. 2011). The central and southern parts of Malawi, including Dedza and Ntcheu regions, are dominated by ethnic groups that have historically practiced matrilineal landholding inherence; which would assumedly be related to improved access to environmental rights for female-headed households (Berge, Kambewa, Munthali, and Wiig 2014). However, even in matrilineal systems, economic problems and conflicts arise among those who have the right to inherit the land (Saidi et al. 1999). The Saidi Commission (1999) found that in some cases, a widow in patrilineal systems is better off than a widower in matrilineal systems. Other research

has indicated that these land ownership patterns are not static and have changed as a result of outside economic and social pressures, specifically from structural adjustment programs (Takane 2009).

There are number of institutional and norm-based constraints that inhibits women's access to productive inputs like fertilizer and seeds, as well as various social norms that prevent women from controlling resources (Croppenstedt et al. 2013). Access, distribution and power over these resources in Malawi have been found to vary based on gender (Chirwa 2005; Fisher and Kandiwa 2014). Using headship as an indicator of gender Chirwa (2005) found that female-headed households are less likely to adopt fertilizer than male-headed households. Another study, conducted by Fisher and Kandiwa (2014), found that the women farmer's probability of adopting modern maize was 12 percent lower for wives in male-headed households, and 11 percent lower for female-headed households, when compared to male farmers. However, further analysis discovered that female-headed household that received a subsidy for both modern maize seeds and fertilizer, had an increased probability of adopting modern maize by 222 percent (Fisher and Kandiwa 2014). These results suggest that sometimes it is not a matter of land rights or gendered knowledge, but a matter of gendered access to natural resources and productive inputs. In the following section, I discuss the data collection process and research methods used to conduct this study.

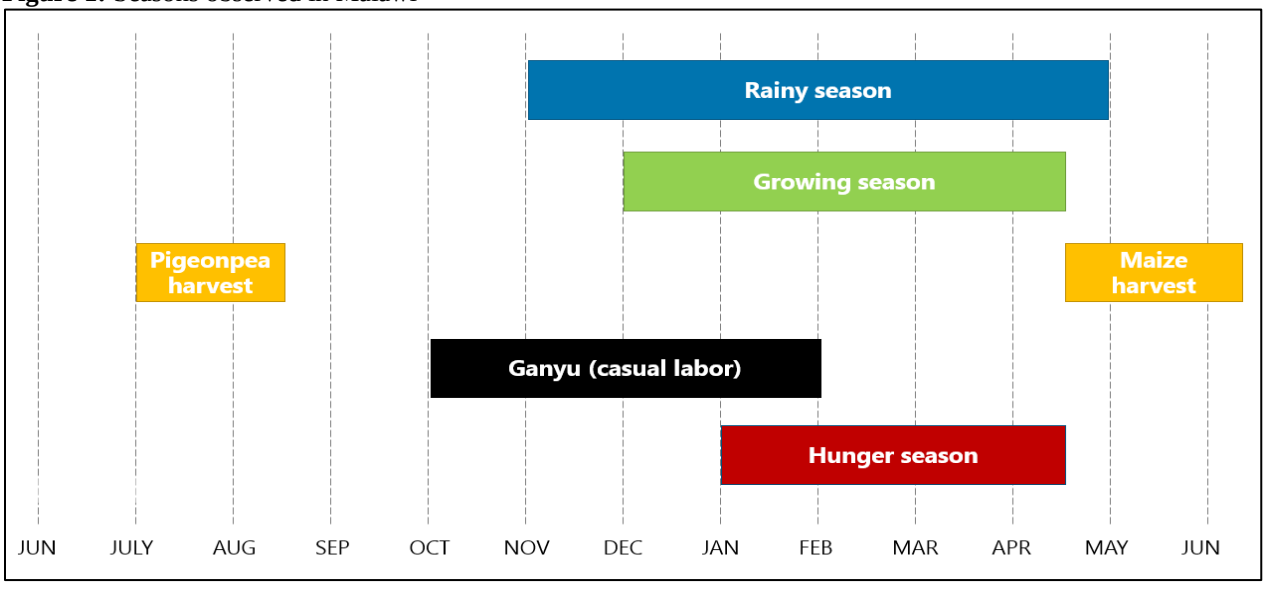
DATA AND METHODS

The data used in this study comes from a baseline survey conducted in 2013 as part of the Africa Research in Sustainable Intensification for the Next Generation (Africa RISING) project in Malawi. Africa RISING is funded by the United States Agency for International Development (USAID) as part of the government's Feed the Future initiative (see https://africa-rising.net/). The questionnaire in the baseline survey asked farming households questions including measures of household assets, food security, farm characteristics, and agricultural production. The baseline household survey was implemented from May to June of 2013 in two regions located in central Malawi: 1) Dadza and 2) Ntcheu. With annual rainfall varying from 800 to 1,000 millimeters, and elevation ranging from 555 to 1,238 meters above sea level, the study area covers several agro-ecological and climatic zones (Hockett and Richardson 2016). Study sites were chosen using a stratified random approach to represent: 1) low agricultural potential (high evapotranspiration, variable rainfall), 2) medium agricultural potential, and 3) high agricultural potential (well-distributed rainfall).

A household was defined as a group of people who live together and share a common kitchen. A total of 324 maize farming households were randomly selected to be surveyed: 163 households in Dedza and 160 households in Ntcheu were sampled. These two districts are known to have high rates of undernutrition and malnutrition due to a diet primarily made up of maize (Hansen 2016; Waldmen et al. 2016). Sorghum was once the dominant stable crop in southern Africa until the early 1990s. Maize was introduced into Africa by colonizers in the 1500s and has grown to be the stable crop in many African countries including Malawi. Today, nearly 53 percent of the total land farmed in Dedza, Malawi produces maize, and 38 percent of total land farmed in Ntcheu, Malawi (Waldman et al. 2016). The remainder of smallholder land is planted

with tobacco, cotton, groundnut, pigeonpea, soya bean, common bean, and other crops. With a unimodal pattern of precipitation, farmers are generally limited to planting one crop per season. The rainy season in Malawi runs from November to April, in parallel with the maize growing season (see Figure 1). Maize and groundnut harvest begins in late April and lasts until mid-June; pigeonpea is harvested several months later in July (Snapp et al. 2002). The period before the maize harvest in Malawi is known as "the hunger season" (Carletto et al. 2012; FAO 2006). The hunger season is a cyclical event that begins in January for some households, and lasts until April (the beginning of the maize harvest). At the end of the harvest season, some farmers are forced to sell their crops immediately in order to pay back loans; creating periodic climatic shocks in the market (FAO 2017). Nyambose and Jumbe (2013) found that farmer households in Malawi practice a wide range of strategies to make sure they have secure access to food (and are resilient to food shortage shocks), with ganyu (i.e., casual rural labor) as the most prevalent strategy devised. Ganyu tends to be seasonal, concentrated between October and February, when the poor are desperate for sources of income and food (Whiteside 1999).

Figure 1: Seasons observed in Malawi



Household level food security in Malawi is commonly equated with the size of their food supply from the grower's field, because poor farmers in Malawi tend to avoid purchasing their food requirements in the market (Me-Nsope and Larkins 2016; Snapp et al. 2002). The dependent measure, household food insecurity, derives from a question on the Africa RISING survey asking households the number of months their food supply (from all rainfed fields) is anticipated to last this season (2012-2013).[2] There were twelve responses given ranging from zero to twelve: responses of zero meant the household had already run out of food, and the highest possible response of twelve reflected that households would have enough food supply to last a year (until May 2013).[3] Furthermore, this measurement is a count of the number of months a household is food secure and the distribution in the sample is highly skewed, so an ordinary least-squares regression is not the appropriate analytic technique (Hoffman 2016).

Given the distribution of the variable, a negative binomial regression model was selected for the analysis. Negative binomial models are an extension of the Poisson regression model, but is more appropriate for over-dispersed dependent variables such as is my case of the months of food supply (Hoffman 2016). In the analysis, I ran a likelihood-ratio test of $\alpha = 0$ to determine if the Poisson's assumption that the conditional variance of the outcome is equal to the conditional mean of the outcome holds. For each of the models, the over-dispersion parameter estimate is statistically significant, indicating that a negative binomial regression should be used instead of Poisson regression because the variance of the dependent variable exceeds the mean. However, because most respondents responded twelve months of food supply and a negative binomial regression is a better model choice, I recoded the variable so the majority of responses would be

[2] Malawi's rural population consists primarily (90 percent) of subsistence farming households who rely on rainfed fields (Hockett and Richardson 2018).
[3] One observation that responded "17" was dropped from the analysis, since it was an obvious outlier (given that it was not an answer on the questionnaire and possibly reflects a recording error).

zero (Figure 2). With a new mean of 3.81 and a variance of 10.29, the dependent variable represented in this paper measures how many months a household will *not* have food supply (from all fields) from May 2012 to May 2013.

Figure 2: Distribution of dependent variable "food insecurity"

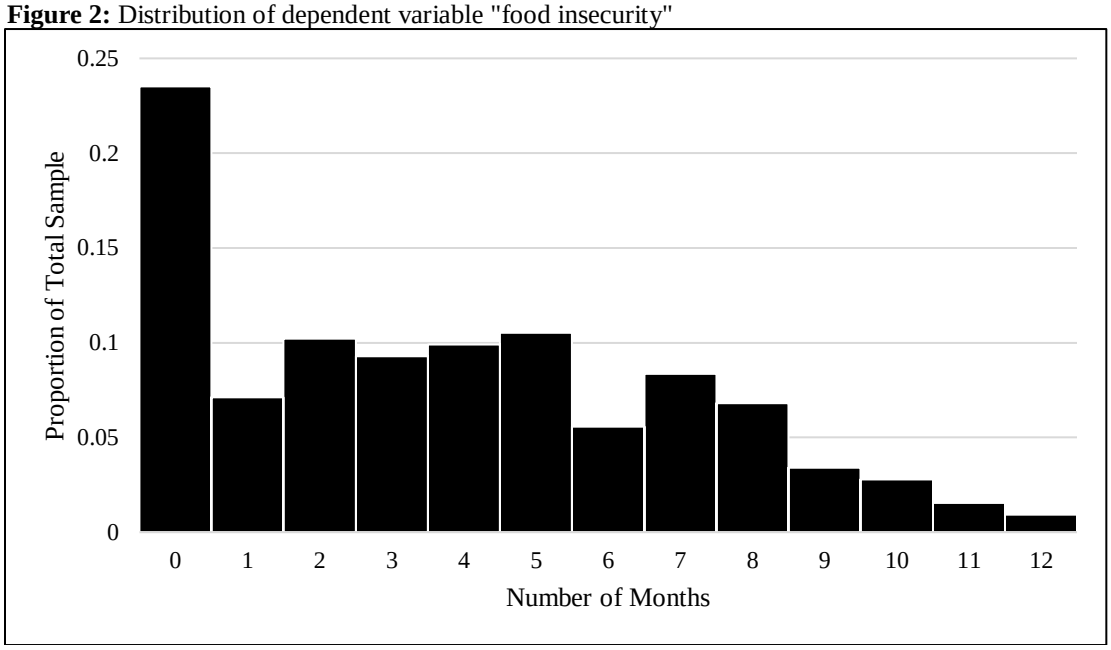
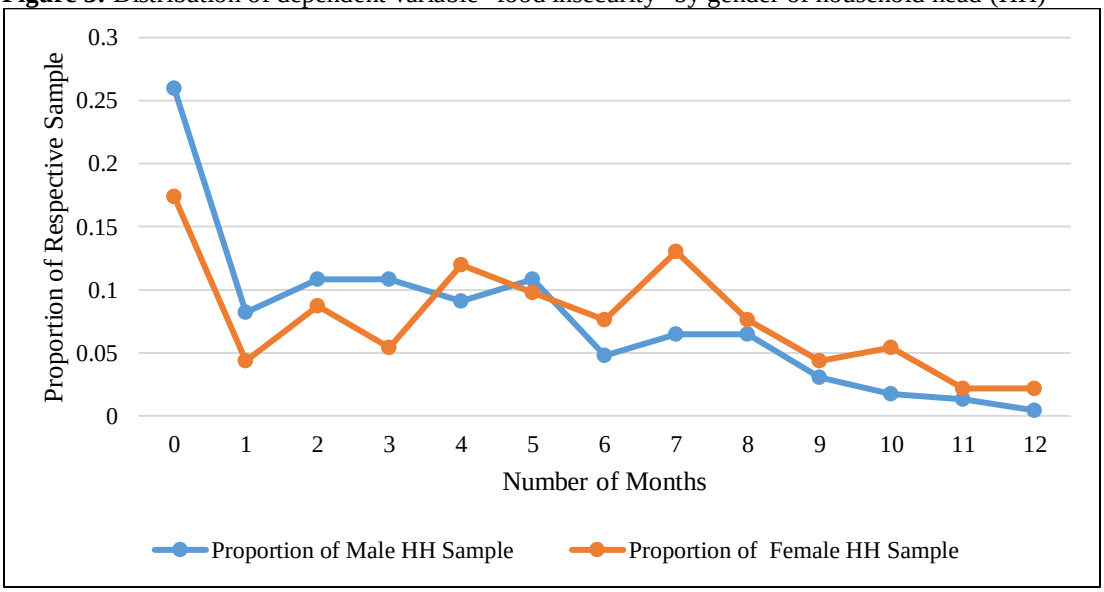


Figure 3: Distribution of dependent variable "food insecurity" by gender of household head (HH)



Independent Variables

Household Demographics. As noted in the literature review, recent research finds that households that struggle the most with food insecurity are those which are female-headed (WFP 2017). In this study, household headship's gender is captured as a dummy variable, with 1=female-headed households, and 0=male-headed households as the reference category in the models. A household was defined as female-headed if a male lived or worked elsewhere and a female made the household and agricultural decisions more than half of the year. On the other hand, if a male was present during the growing season and made most of the agricultural decisions for the household (even if he lived elsewhere before and after the growing season), the household was defined as male-headed. Out of the total 323 respondents included in the model, 231 (71.52 percent) households were headed by males, and 92 (28.28 percent) households were headed by females. The incidence of female-headed households in the survey used in this paper is consistent with what has been reported in other surveys such as the 2012 Demographic and Health Surveys (DHS) that reported 27.8 percent of households in Malawi are headed by females (World Bank 2018). Table 1 displays descriptive statistics by household headship gender, reporting the mean values for continuous variables, and percentages for categorical and binary variables.

Feminist political ecology focuses on gender, but it must engage with other important social variables such as class, ethnicity and nationality (Rocheleau et al. 1996). At the same time, the severity of barriers that farmers must confront to overcome poverty and food insecurity vary between not only gender, but location (Young et al. 2011). For these reasons, the region where farmers live, as well as measurements that capture their ethnicity were coded as dummy variables. Region was included in the models as a binary variable, with 0 = Dedza as the

reference category. The explanatory variable "ethnic group" was planned to be included in the models, but given the interdependence between the Dedza region and the Chewa ethnic group, ethnicity was not included. The Chewa ethnic group makes up the majority of villages in the Dedza region, and the Ngoni ethnic group makes up the majority of villages in the Ntcheu region (Berge, Kambewa, Munthali, and Wiig 2014). In this study's sample, most individuals of the Chewa and Ntcheu regions live in these corresponding regions. Using Paul Allison's personal criterion (Hoffman 2016) for detecting appropriate variance inflation factors (VIF) for the model, issues of collinearity were shown between the Dedza region the Chewa ethnic group (VIF of 2.52 and 2.50, respectively). The explanatory variable representing region was used in the models, rather than ethnicity, due to unproportioned groupings in the categorical variables representing household's ethnicity (see Table 1).

Field Characteristics. In order to gain a clearer understanding of why farmers may be experiencing food insecurity, an integrated model that combines various dimensions of nature-society parameters is needed (Ness, Urbel-Piirsalu, Anderberg and Olsson 2007). Soil fertility is a severe problem in Malawi, that often has limiting yield potential that assists in trapping farmers in a vicious cycle of poverty (Ortega et al. 2016). Soil fertility was measured subjectively by asking farmers to rank their land as either 1) Not fertile, 2) Average fertility, or 3) Very fertile. This variable was coded as categorical, with 0= not fertile as the reference category. Another field characteristic that was included in the models (as a continuous explanatory variable) captured the number of months farmers' maize supply lasted from the previous year (May 2011-May 2012).

Table 1: Descriptive statistics by gender of the household head (HH)

Variable	Range	Total (N=323)	Male HH (71.52%)	Female HH (28.48%)	Sig
Dependent Variable					
Food Insecurity (mean months)	0-12	3.81	3.43	4.76	*
Independent Variables					
Household Demographics					
Region (%)	0-1				
Dedza =0 (Reference)		50.46	50.65	50	
Ntcheu		49.54	49.35	50	
Ethnic group (%)	0-1				*
Chewa =0 (Reference)		35.6	36.36	33.7	
Ngoni		61.3	62.34	58.7	
Tumbuka		0.31	0	1.09	
Sena		0.62	0.43	1.09	
Yao		1.86	0.87	4.35	*
Swahili		0.31	0	1.09	
Field Characteristics					
Maize supply from previous year (mean months)	0-12	7.63	7.81	7.15	*
Land fertility (%)	0-1				
Not fertile =0 (Reference)		35.29	35.5	34.78	
Average fertility		41.8	41.13	43.48	
Very fertile		22.91	23.38	21.74	
Knowledge					
Formal education (%)	0-1				
No education =0 (Reference)		25.53	19.91	32.61	*
Some primary		58.2	58.87	56.52	
Primary		5.88	6.06	5.43	
Some secondary		8.67	10.82	3.26	*
Secondary		3.72	4.33	2.17	*
Access to organizations (mean groups)	0-4	0.99	1.06	0.84	
Intercropping (mean rotating crops)	0-3	0.58	0.59	0.53	
Environmental rights and responsibilities					
Number of fields (mean fields)	1-8	2.23	2.36	1.9	*
Household farm labor (mean persons)	0-8	2.8	2.98	2.34	*
Primary source of income from sales of produce (%)	0-1	67.49	72.73	54.35	*
Household asset index (mean assets)	0-8	1.63	1.89	0.99	*
Agricultural asset index (mean assets)	0-3	0.62	0.67	0.48	*
Used pesticide (%)	0-1	72.45	77.49	59.78	*
Used chemical fertilizer (%)	0-1	84.83	87.45	78.26	*
Used organic fertilizer (%)	0-1	6.5	8.23	2.17	*

Note: Binary and categorical variables are given counts and corresponding percentages for each household gender; numeric/continuous variables are given mean numbers

*Significant at 5% or better in difference of means test between household head genders (and between respondents gender for variables “education” and “access to organizations”)

Gendered Knowledge. There is no 'power' variable in the dataset, however, borrowing from the feminist political ecology framework allowed me to create variables of power, including measures of access and control over various knowledges and physical resources. Based on arguments regarding the ways formal education and access to information is gendered (Doss 2014a; Rocheleau et al. 1996), educational attainment was constructed into four dummy indicators of respondents' formal education: 1) Some primary education (yes = 1, else = 0); 2) Completed primary school (yes = 1, else = 0); 3) Some secondary education (yes = 1, else = 0); and 4) Completed secondary school (yes = 1, else = 0). No formal education is the reference category. An explanatory variable that represented how many groups the respondent participates in was coded as a continuous variable (ranging from zero to four). The four organizations a respondent could participate in included agricultural groups, community groups, savings/credits groups and various support and non-profit groups. This variable represents the ways in which knowledge is gendered, due to access and participation in various 'ways of knowing'. Lastly, to assess whether there are gendered practices in agriculture, intercropping was included as an explanatory variable in the models and coded as a continuous variable: representing how many crops were intercropped with household's maize production in a year (ranging from zero to four crops).

Gendered Environmental Rights and Responsibilities. To measure power within environmental rights and responsibilities, I included a number of variables representing access to and control over various forms of resources and labor. The lineage system in both Ntcheu and Dedza is matrilineal, so a variable that captures the amount of land households have access and control may be a reason to see differences in household food insecurity. To investigate gendered differences in control over land, the number of fields households planted in the 2013-2014

harvest season (ranging from one to eight fields) was included and measured as a continuous variable in the models.

The ability to control one's own labor, as well as to control the actions of others, is argued to be gendered (Rocheleu et al. 1996). Based on these arguments from feminist political ecology, the number of individuals that most frequently provide labor on the household farm was coded as a continuous variable and ranged from zero to eight people. An explanatory variable that represents the households' whose primary source of income comes from selling crops from their farm was also included in the models. Primary source of income was measured as a dummy variable including non-farm labor and sales of produce from one's own farm or dimba/small garden (1= yes; 0 = else).

To account for arguments regarding asset ownership as factors influencing gendered disparities in agricultural production and food security (Kilic et al. 2015; Robbins 2012), I constructed two separate asset indices representing ownership over household assets, and ownership over agricultural resources. As it has been recommended in previous literature (Moser and Felton 2007), I constructed an asset index that characterizes ownership over various household assets. The survey data included eight asset indicators that were given a score of one if a household responded that they owned a particular asset. Household asset index included questions on whether or not they owned: cell phone, bicycle, radio, television, sofa set, improved charcoal/wood burning stove, kerosene/gas stove, motorbike, car/truck, and/or solar panel. These questions were then summed up to analyze the household's total financial wealth (the summated variable ranges from zero to eight). Similarly, I created a separate asset index to analyze household's productive inputs, specifically for their farming operations. The agricultural asset variable was created in the same manner, representing household ownership of five possible

agricultural assets included in the survey: a dimba (small garden), sprayer, treadle pump, ox cart, and/or plow. Despite there being five agricultural assets included in the survey, the values in the sample range from zero to three because no one in the sample owned a plow and no one in the sample owned all four of the remaining agricultural assets.

Three measures capture access to different productive resources as a way of measuring power (Rocheleau et al. 1996). Chemical fertilizer and pesticide use are popular yet environmentally exploitive and unsustainable farming practices conducted in Malawi, and are generally practiced more in male-headed households (Chirwa 2005; Waldman et al. 2016). Both pesticide and chemical fertilizer use were coded as their own individual binary variables (1 = practiced). Organic fertilizer is represented in the model as a binary variable and is coded as one if the household used either manure from compost and/or livestock. In the succeeding two sections, I lay out the results of this study and discuss their implications.

RESULTS

Table 1 shows values for the entire sample, and values for male- and female-headed households, respectively, and significant differences that exist between both types of households. Female-headed households experience more months of food insecurity on average compared to male-headed households, consistent with previous findings in Malawi (Kassie et al. 2015) and other less developed countries (Kassie et al. 2014, Mallick and Rafi 2010).

On average, households reported that their maize supply from last year (2011-2012) lasted 7.63 months; meaning that their supply lasted until the end of December (i.e., right before the hunger season). Male-headed households reported having 7.81 months of maize supply, a statistically significantly higher amount than the average number of months female-headed households reported (7.15 months).

With regard to the gendered division of productive inputs, male-headed households are also significantly more likely to use pesticide, chemical fertilizer and organic fertilizer than female-headed households. In addition, those in male-headed households owned significantly more household (non-agricultural) and agricultural assets, compared to female-headed households. Specifically looking at indicators of household wealth, male-headed households owned an average of 1.89 household assets, which is significantly higher than the 0.99 household assets owned in female-headed households.

Additionally, respondents in male-headed households were significantly more likely to have either some secondary education or have completed secondary education, than respondents in female-headed households. And, while there is no statistical significant difference in primary educational attainment, respondents in female-headed households are significantly more likely to

have no formal education compared to respondents in male-headed households (33 and 20 percent respectively).

Despite being part of a matrilineal landholding system, female-headed households in this sample had, on average, planted significantly fewer fields than their male counterparts (1.9 fields, 2.4 fields, respectively). Female-headed households also showed to have significantly less household labor compared with male-headed households, which could explain why male-headed households were able to plant more fields. Snapp et al. (2002) found that female-headed households in Malawi were more likely to report that lack of labor was a major constraint to expanding their production. Thus, the disparity in fields planted could reflect women's multiple roles as a producer, reproducer of social life, and consumer; and their increased labor burdens as women farmers. This triple burden faced by women could also explain why those in male-headed households were significantly more likely to report that their primary source of income comes from their sales of produce. Although women, men, and children participate in ganyu in Malawi, a closer look at the most important sources of income reported by households' in the survey, female-headed households are much more likely to report that their primary source of income comes from ganyu labor (short-term rural labor) and remittances, compared to male-headed households (see Table 2).

Table 2: Primary source of income for the household by gender of the household head (HH)

Most important source of income	Total (N=323)	% Male HH (N=231)	% Female HH (N=92)	Sig
Sales from produce	218	73%	54%	*
Ganyu labor	36	7%	21%	*
Salary/Wage employment	7	3%	0%	
Remittances	4	0%	4%	*
Small business/Self employment	56	16%	21%	
Other	2	1%	0%	

*Significant at 5% or better in difference of means test between household head genders

Whiteside (1999) found that female-headed households are particularly labor constrained, which limits their earning power; leaving little opportunity for investing in sustainable livelihood development. It is widely recognized that the seasonality of ganyu has negative impacts that conflict with one's own agricultural production (Whiteside 1999). More female-headed households reporting ganyu as their primary source of income, reveals possible concerns about households headed by females being more vulnerable to falling into the hunger trap more frequently because the inconsistent income from ganyu labor is the most important source, rather than income from selling produce from their own production.

Household Food Insecurity

A negative binomial regression was used to model the severity of household food insecurity, given that the dependent variable is a count of the number of months a household does not have food supply from their own harvest. A series of negative binomial regression models were estimated to determine the expected number of months' households would experience food insecurity based on the gender of head of household, field characteristics, and various explanatory variables controlling for different gendered knowledge, environmental rights and responsibilities. The incidence rate ratios for each of the independent variables are presented in each model (Table 3). The first model estimated the total effect of gender, controlling for region. The second model incorporates field characteristics, including how fertile farmer's land is and the number of months of maize supply the household had from the previous year. Models three and four both build off of model two by adding knowledge (science), and environmental rights and responsibilities, respectively. Model five represents the full model, including all of the explanatory variables.

Table 3: Negative binomial models of number of months households experience food insecurity

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Demographics					
Household head (Female)	1.386**	1.325**	1.268*	1.071	1.084
Region (Dedza)	0.775*	0.841	0.824*	0.873	0.858
Field Characteristics					
Months of maize supply (previous year)		0.878***	0.887***	0.912***	0.912***
Land fertility					
Average land fertility		0.620***	0.662***	0.686***	0.696***
Very fertile land		0.558***	0.563***	0.649***	0.636***
Knowledge					
Formal education					
Some Primary			1.013		1.082
Primary			0.808		0.960
Some Secondary			0.801		1.035
Secondary			0.413**		0.504*
Group participation			0.887*		0.956
Rotating crops			0.995		0.978
Environmental rights and responsibilities					
Number of fields				0.900*	0.900*
Household farm labor				1.05	1.045
Primary source of income (From sales of produce)				0.810*	0.839*
Household asset index				0.892***	0.909**
Agricultural assets				1.024	1.049
Pesticide				0.923	0.946
Chemical fertilizer				0.714**	0.701**
Organic fertilizer				0.352***	0.334***
Pseudo R-squared	0.008	0.056	0.067	0.097	0.102
BIC	1591.8	1533.7	1551.7	1514.9	1541.5

Note: Incidence rate ratios (IRRs) are presented, and N=323 (in all models).
* p<0.05, ** p<0.01, *** p<0.001

I used Bayesian information criterion (BIC) and guidelines from Raftery (1995) to determine which model is better fitting. According to these guidelines, there is strong evidence that the addition of knowledge (including formal education, access to organizations, and intercropping) does not improve the fit of model two. At the same time, there is very strong

evidence that model four is a better fitting model than model two. This means that we do better at predicting the average number of months' households experience food insecurity with the addition of environmental rights and responsibilities, and not the addition of knowledge (or science). In the discussion that follows, further analysis of the results from models one, two and four are elaborated.

To check for multicollinearity, I ran variance inflation factor (VIF) tests on the model five. The results returned a mean VIF score of 1.28, and VIF scores under 1.58 for every independent variable in the model. Using Paul Allison's personal criterion (Hoffman 2016), this tells us that all of the independent variables in the model are not correlated to one another, and do not create problems of collinearity.

In model one, the gender variable is significant, indicating that households headed by females tend to have more months of food insecurity than households headed by males. In model two, the effect of gender is reduced slightly when controlling for field characteristics, such as months of maize supply from the previous year and land fertility. At the same time, both field characteristic variables were found to be statistically significant. The effects of field characteristics increased when environmental rights and responsibility variables were included in model four. The incidence rate ratios from model four indicate that for every month a household's maize supply lasted in the year before, it decreased the average number of months of food insecurity the following year. Households that reported either having average soil fertility or very fertile soil were expected to have roughly four (31 and 35 percent, respectively) fewer months of household food insecurity, compared to households that do not have fertile land. The small percent difference seen between average and very fertile land are due to subjective accounts of the variable (since this measures farmers perceptions of their soil, rather than an

objective measurement of soil fertility). However, it is interesting to note that when land fertility is controlled for, the effects of region lost statistical significance (from model two to model four).

Results from model four indicate that the number of fields planted, sales from produce as primary income, household assets, and access and practice of fertilizer (chemical and organic) all help to decrease the number of months households are food insecure. More importantly, the results from model four also shows that the effect of household gender reduced and lost all statistical significance when variables accounting for environmental rights and responsibilities were controlled for. Kilic et al. (2015) has found that when researchers control for observed reasons that contribute to gendered disparities (such as access to and control over resources), the gender gap disappears. One reason household headship gender loses statistical significance may be due to gendered differences in power. I controlled for these various forms informed by feminist political ecology (i.e., gendered knowledge and environmental rights and responsibilities) to discover which variables are tied to power. The best example of this finding is seen in the variable that measures household ownership over non-farm assets. For every increase in one asset the household owns, there is a 11 percent decrease in the average number of months a household is food insecure. The effects of household headship gender may have lost significance because, rather than gender being a direct cause of household food insecurity, the effects of gender is structured into variables of rights and responsibilities (that directly influence household food insecurity). In other words, this would suggest gendered dimensions of power through various environmental rights and responsibilities. On the other hand, diminishing significance in gender may have been due to the fairly small sample size used in this regression; which may discredit this hypothesis.

The incidence rate ratios from model four shows that farmers who used chemical fertilizer on their fields are expected to have fewer months of food insecurity than those who did not use any, holding everything else constant. The same holds true for farmers who used organic fertilizer, which is strongly and positively associated with a decline in the number of months households experience food insecurity. Organic fertilizer is not only deemed to be a more sustainable practice in the long run (Cordell, Drangert, and White 2009), the model indicates that it reduces more months of household food insecurity compared to chemical fertilizer.

Model four also shows that every field planted in a year, leads to 10 percent decrease in the average number of months (roughly one less month) a household is food insecure, holding everything else constant. Finally, households that report sales from produce (from either their farm or dimba/small garden) as their household's most important source of income, are expected to experience roughly two fewer months (19 percent) of food insecurity, compared to households that report non-farm sales as their primary source of income.

DISCUSSION

Rotating crops showed to have no statistical significance in limiting the number of months households experience food insecurity, however having more fields to plant crops did prove to be statistically significant. At the same time, male-headed households had significantly more household labor and planted significantly more fields compared to female-headed households, despite being part of a matrilineal landholding system. These results suggest that labor availability may be more important in explaining the gender gap than having access to land, consistent with findings from Snapp et al. (2002) that found that lack of labor was a major constraint in expanding production in female-headed households. Lower labor availability leads to lower agricultural production, leaving a higher percentage of the household's production for family consumption and a lower percentage available for sale (Due and Gladwin 1999). The significantly higher percentage of male-headed households that report their primary income comes from sales from produce, and the significant and positive effect this has on reducing household food insecurity suggests how important it is to address the gender gap in market participation. Policies that address relieving women of their triple burden and make agricultural production more efficient so they can have enough agricultural output remaining from subsistence to actually market, rather than being forced to turn to ganyu, would help address the gender gap in food insecurity.

Having a higher asset index score showed to decrease the number of months households are food insecure, but it is still unclear as to which of the eight assets are more likely to contribute more than others since all were given equal weight in the model. With a larger sample size and gender desegregated data of ownership status, future research should look more closely

at these assets separately to determine the specific assets that help households reduce their food insecurity.

Households that used either chemical or organic fertilizer were shown to experience less months of household food insecurity than those who did not use any. However, only eight percent of all male-headed households and two percent of all female-headed households in the sample used organic fertilizer. This is an extreme difference in access when compared to households that used chemical fertilizer. An overwhelming 87 percent of all male-headed households and 78 percent of all female-headed households in the sample use chemical fertilizer. These disparities do not represent specifically barriers for women, but rather these results may show the power of Malawi's government in influencing a science-based knowledge, one that values efficient production (e.g., Malawi's Farm Input Subsidy Program) rather than valuing local knowledge or sustainable solutions.

The findings informed by the negative binomial regressions should be taken with caution, because they represent forms of power that are highly gendered. The approach used in this study (feminist political ecology) aimed to capture how gendered knowledge, rights and responsibilities may be structuring the *total* effect of food insecurity; rather than how household gender *directly* effects food insecurity. Although the descriptive analysis revealed that female-headed households are significantly more likely to be food insecure than male-headed households, the negative binomial models show that household headship gender does not matter when one holds constant the proxy for rights and responsibilities in production (e.g., primary source of income from produce sales) and maintaining a healthy biosphere (e.g., chemical and organic fertilizer use). Results from the regression also show that, as expected, having access to productive resources has very significant and positive effects on reducing household food

insecurity. Thus, one hypothesis framed by feminist political ecology is that household head gender has no direct effect on food insecurity, but because female-headed households lack access to productive resources (i.e., rights and responsibilities), they experience more months of food insecurity than male-headed households. However, the small sample size of female-headed households represented in this study may not have been large enough to detect a direct effect of gender. More data and sophisticated statistical models are needed to test this effectively.

CONCLUSION

Women farmers have multiple roles to play (as a producer, reproducer and consumer) in various facets of her life, that differ substantially from men's knowledge and practice as farmers (Rocheleau et al. 1996). Male-headed households may be able to devote more of their time to agricultural production for sales of produce and be able to plant more fields, as well as have greater access to productive resources such as fertilizer and ownership over various household assets. Gendered knowledge and rights and responsibilities identified in this study may lead to not only conflict, but to a collapse of environmental systems managed by women (Robbins 2012). Reaching the goal of household food security should not come at the cost of simultaneously increasing women's labor burden, nor should it create gendered barriers that prevent women from accessing resources. The results in this paper raise questions about women's power over resources and gendered ways of knowing and managing the environment.

The descriptive analysis of the household head gender gap reveals, not surprisingly, that female-headed households have lower levels of environmental rights and responsibilities than male-headed households, causing a food security disparity. At the same time, results from the negative binomial model show that the likelihood of escaping food insecurity is influenced by having access to and power over material resources. These include claiming sales from produce as the primary source of income, having ownership of household assets, and productive inputs in the form of organic fertilizer, chemical fertilizer, and the number of fields planted. From a practitioner's point of view, the significant impact of owning non-agricultural assets (cell phone, bicycle, etc.), field characteristics and access to productive inputs, may suggest that assisting female-headed households in accessing and owning these economic resources may improve their household food security. Furthermore, the significant and positive effect that having sales from

produce be the most important source of income (compared to ganyu labor or anything else) places a great importance of empowering households (especially female-headed households) so they can produce and secure their own food supply and do not have to turn to ganyu labor as a primary source of income.

The descriptive analysis presented in this paper would support the hypothesis that female-headed experience more months of food insecurity than male-headed households because they lack access and power over material resources; and the theory (i.e., feminist political ecology) would support this. However, the negative binomial models show that more research is needed to support this claim. Future studies should consider conducting interviews or collecting longitudinal data to adequately address this study's shortcomings by testing a direct effect of gender; while structural equation modeling could better explore the connection between variables, to determine if there is an indirect effect of gender working through various knowledges and/or environmental rights and responsibilities.

Finally, the survey data used in this study did not include gender disaggregated data beyond identifying the gender of the respondent and household head. Future research should continue to test the relevance of the feminist political ecology framework in informing gender-equitable solutions to food security in Malawi and include gender-specific variables in the questionnaire that relate to decisions of resource allocation, crop production and household consumption.

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