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Women control over income, agricultural commercialization and dietary diversity: Analysis of rural households in Zambia

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Women empowerment and its positive effect on household welfare is well acknowledged in literature. However, empirical evidence on the effect of women empowerment in agriculture on household food security and how this pathway is influenced by household agricultural commercialization remains scarce. This article attempts to close this gap by examining the impact of women control over agricultural income on household dietary diversity taking into account the household level of agriculture commercialization in rural Zambia. Applying ordered probit regression model, results show that women control over agricultural income has positive and significant impact on household dietary diversity for households that consume relatively more diversified diets compared to those that consume less. However, agricultural commercialization tends to subvert women control over income resulting in positive but less significant impact on household dietary diversity.

Keywords: Household Dietary Diversity, Women Control over Agricultural Income, Primary Decision Maker, Agricultural Commercialization, Ordered Probit, Zambia

Introduction

Women empowerment in agriculture and implications for general household welfare is well acknowledged in literature (see for example: Kassie et al. 2015; Eswaran 2014; Sraboni et al. 2014; Quinsumbing and Maluccio 2003; Hoddinott and Haddad 1995 and Kennedy and Peters 1992). There is growing evidence showing that increasing women's bargaining power in terms of control over income use, their control over assets, and their decision-making powers in respect to crop production and consumption have significant positive impacts on household food security and human capital investment in children (Sraboni et al. 2014; Eswaran 2014; Quinsumbing and Maluccio 2003).

This study goes beyond understanding the influencing factors driving gender control over agriculture income and production decision to examining the impact of Women Control over Agriculture Income (WCAI) on household food security measured by household dietary diversity score (HDDS) as a key component of food security. The study further analyses joint differential impact of WCAI and household agricultural commercialization on HDDS. The HDDS, developed by Food and Nutrition Technical Assistance (FANTA) 2008, which measures different food groups consumed over a given reference period by a household has become a useful tool in assessing household food security. The use of HDDS as a measure of household's access to diverse nutritious food has increased in the last two decades. Given its nature of focus on the food groups consumed over a specific period, HDDS serves as a useful measure of households' access to a diverse range of foods (FANTA 2008; Swindale and Bilinsky 2006), one of the four essential variables (availability, access, utilization and stability) to the attainment of food security (Hoddinott and Yisehac 2002).

The aim of this study is to examine differential impact of women empowerment in the control of agricultural income on household dietary diversity. The specific objectives of the study are twofold:

i. Estimate the impact of women empowerment on different levels of household dietary diversity
ii. Assess joint effects of women control over agricultural income and agricultural commercialization on different levels of household diversity

Overview of agriculture production, gender roles and dietary diversity in Zambia

In Zambia, agriculture remains an important engine of the economy contributing 8.5 percent to the national GDP and national food security. The sector is very linked to food security in that it provides food and nutrients in addition to being a source of income to the majority of the population, in particular the rural women who are mainly subsistence farmers. As shown in Figure 1, maize is the most predominant crop cultivated among the rural households in Zambia. Other important crops are cassava, groundnuts and mixed beans. There has been gradual shift into cash crops such as soy beans and cotton and also into livestock sub-sectors such as goats, poultry and dairy cattle.

Women play a critical role in agricultural production in Zambia. According to the Labour Force Survey (2014), women constitute 60 percent of the population employed in the sector. However, most of these women come from poor households and earn less income compared to men. There are also more gender biases in most rural households in Zambia with regards to asset ownership, agricultural inputs and more important the decision to sell and control income from sale of most agricultural produce. For example, only about 35 percent of women who grew groundnuts in male headed households, made the decision to sell and control income (CSO/MoA/IAPRI 2015).

Despite women in Zambia making significant contribution to the agricultural sector throughout its value chain, providing approximately 52 percent of the total labor force in the sector, the country continues to perform poorly in terms of gender equity and women empowerment. Zambia is currently ranked 29th in Africa in terms of gender equality and that this inequality limits women access and control of productive assets, resulting in them disproportionately bearing the effect of poverty (Zambia Country Analysis 2015). The recent Zambian Demographic Health Survey (ZDHS) reveals that, in comparison to men, women in Zambia have less education, lower literacy levels, and less exposure to technology and mass media, which directly affects their position in their households as well as society (CSO 2015).

During the last decade, Zambia has made stable progress in the production of most food crops yet the country's food security status has declined tremendously. FAO et al. (2017) estimates that 46 percent of Zambia's total population is now food insecure, an increase from 33 percent in 1990. Inadequate consumption of a variety of nutrients is widespread with diets predominantly maize-based and low in both animal and plant protein. Specifically, dietary patterns among the rural households are highly inadequate for vitamin A, vitamin B-12, folate, iron, zinc, and calcium, based on the dietary profile, which shows low levels of consumption of milk, meat, fish, and dairy products (Alaofe et al. 2014). On average, households in rural Zambia consume seven out of a maximum of 16 food groups (CSO/MoA/IAPRI 2015).

The typical rural Zambian diet is mainly composed of maize, starchy roots (e.g. cassava) and, to a lesser extent, fruit and vegetables. Cereals provide almost two-thirds of the dietary energy supply. The heavy dependence on maize tends to raise vulnerability to climatic shocks and food insecurity. According to FAO, IFAD, and WFP (2014), the dietary energy supply is not sufficient to meet population energy requirements, with the prevalence of undernourishment which increased to 48 percent in 2013–2014 from 45 percent in 2003–2005. Food supplies also lack diversity and are poor in essential micronutrients.

Studies indicate that majority of the population in Zambia, especially in rural areas, survive on diets that are deficient in a variety of micronutrients. The Zambia Food Consumption and Micronutrients Survey (2014) conducted in Northern and Luapula Provinces revealed that the prevalence of inadequate intake of the various vitamins and minerals can vary widely, as do the prevalence among provinces. For the two provinces, the dietary

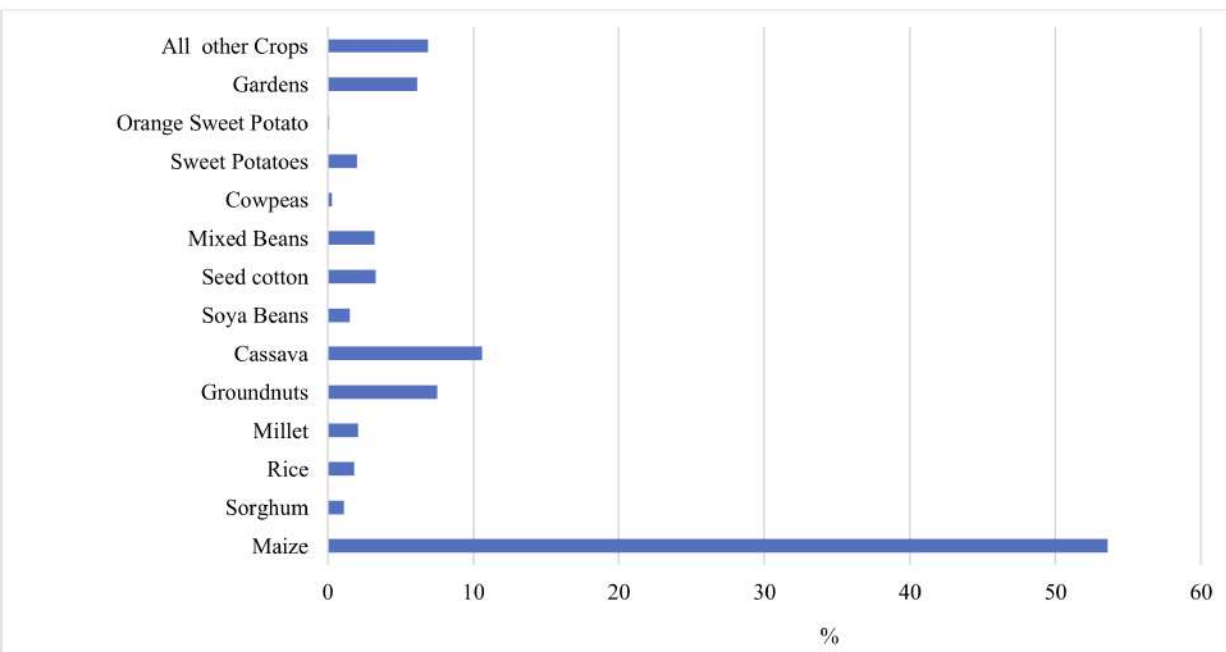

Figure 1 Proportion of cultivated area of each crop. (*Source: CSO/MoA/IAPRI, 2015*)

patterns were generally found to be highly inadequate for vitamin A, vitamin B-12, folate, iron, zinc, and calcium. The dietary profile also featured low levels of consumption of milk, meat, fish, and dairy products. Almost all the children were deficient in vitamin B12, with many others also being deficient in Folate. Almost 60 percent of the children were classified as anemic – a condition that, as is the case for most African countries, is believed to be primarily caused by nutrition, malaria and intestinal worms (Shaw and Friedman 2011 and Zambia Food Consumption and Micronutrients Survey, 2014).

The Zambia Demographic and Health Survey (ZDHS) 2013–14 (CSO 2014) shows that 40 percent of children under age 5 are stunted, with 17 percent being severely stunted. The age group most susceptible to stunting is that between 18–23 months old (54 percent) and the least is that below 6 months (14 percent). It is also probably important to mention that the likelihood of stunting reduces with increase in previous birth interval, in child birth weight, and also in education level and nutritional status of the mother.

Conceptual Framework

The study is guided by the concept of women empowerment in agriculture on one hand and the pathways from food production to dietary diversity and nutrition on the other hand.

Women empowerment in agriculture concept

The focus on women empowerment has become popular since the 1990s among development intervention following wide evidence of its positive impact on a wide range of human welfare indicators. The United Nations has identified five key components of women empowerment: women's sense of self-worth, their right to have and to determine choices, their right to have access to opportunities and resources, their right to have the power to control their own lives, both within and outside the home, and their ability to influence the direction of social change to create a more just social and economic order, nationally and internationally. [1] Empowerment of women, is therefore, a multi-dimensional concept guiding the process of uplifting the economic, social and political status of the underprivileged women in the society (Dandona 2015).

In agriculture, women empowerment is best understood based on the Women Empowerment in Agriculture Index (WEAI) framework, which was recently developed by the US Governments Feed the Future (FTF) program to measure the level of women empowerment in Agriculture. The framework has become popular because of its broader applicability as a diagnostic tool for policymakers, development organizations, and academics seeking to inform efforts to increase womens empowerment (Sraboni et al. 2014). The WEAI is discussed in detail by Alkire et al. 2013, Malapit et al. 2014 and Malapit and Quisumbing 2015. According to Malapit et al. 2014, the WEAI has five domains (5DE) measuring women empowerment:

i. Womens input over productive decisions and autonomy;
ii. Resources relating to womens ownership of productive assets;
iii. Womens control of household income use;
iv. Womens leisure time and workload; and
v. Womens membership in groups and community leadership.

This paper focuses on the third domain and its implications for household food security. Ideally, all domains of the WEAI should be taken into account when measuring women empowerment in agriculture. However, according to Malapit et al. (2014), resource requirement and some cultural sensitivity in collecting some information (e.g. autonomy in production and speaking in public), may limit the collection of data on all domains. For this reason, it may be necessary, depending on the cultural context of the project area, to only use parts of the instruments that will get responses on gender and income (Mofya-Mukuka and Kabisa 2015).

Gender control over agricultural income and food security framework

Generally, income is regarded as one of the most critical determinants to enhancing household food consumption and its dietary diversity (Wright 2014; Sraboni et al. 2014; and Taruvinga et al. 2013). However, most of these notions that link income and household food demand are founded on the traditional neo-classical 'unitary' household model and the consumer economic principles,[2] which stipulate that when a household's real income increases, its demand for normal goods such as food also increases (Haddad 1997).

However, the "unilateral" household decision making model ignores intra-household dynamics that play a key role in determining the allocation of resources in a household. Where gender inequality is predominant and women have a lowered bargaining status, increased demand for basic food and dietary diversity are not necessarily conditioned by the household's level of income rather who has control over income (Wiro 1999; Sraboni et al. 2014 and Amugsi et al. 2016). Considerable evidence shows that increasing women's bargaining power is key in increasing the allocation of income to food budgets and other household's needs (Hoddinott and Haddad 1995; Duflo and Udry 2004 and Malapit et al. 2014).

A study done by the International Food Policy Research Institute (IFPRI) in Rural Bangladesh using data from the Bangladesh Integrated Household Survey (BIHS), validates and enforces these claims by showing that the Ordinary Least Squares (OLS) coefficient estimate of HDDS is positively correlated

[1] UN Secretariat, Inter-agency Task Force on the Implementation of the International Conference on Population and Developments Programme of Action, Guidelines on Womens Empowerment [www.un.org/popin/unfpa/taskforce/guide/iatfwemp.gdl.html].

[2] Random utility theory by Becker, 1965 is a classic example of neoclassical models.

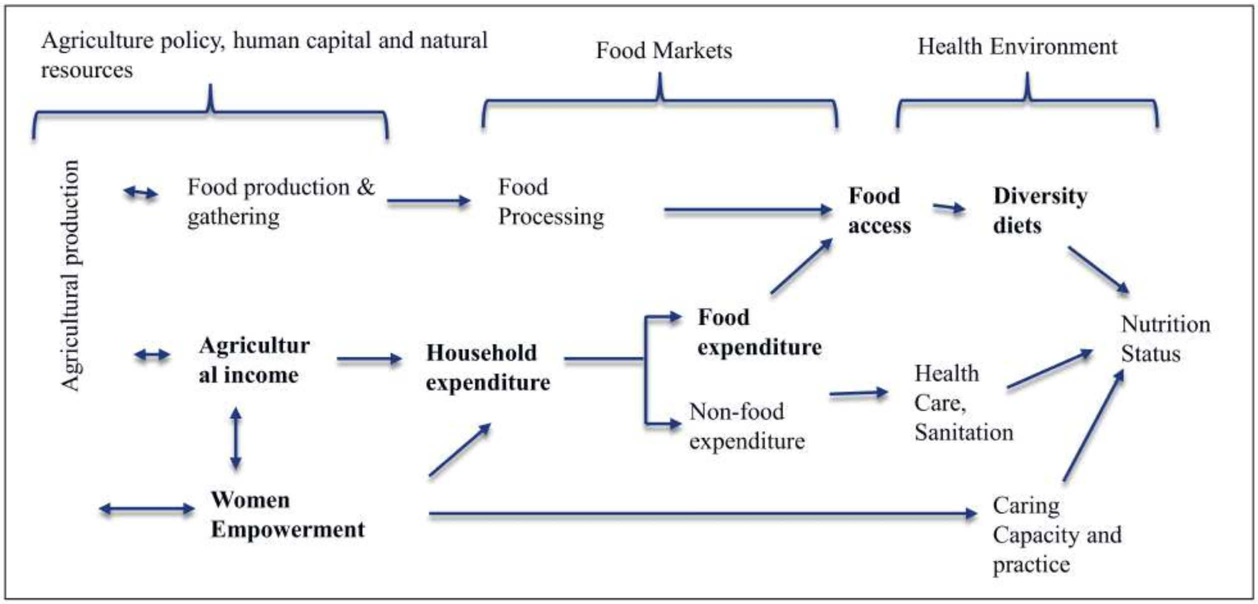

Figure 2 Pathways from agricultural production and women empowerment to dietary diversity and nutrition status. (*Source: Adapted from Herforth and Harris 2014*)

with female empowerment scores (Sraboni et al. 2014). Even after instrumenting for the potentially endogenous empowerment variable, the obtained results remained consistent with the IV projections.

According to Malapit et al. (2014), the pathway from women's empowerment to improved nutrition and food security is influenced by a number of factors, including social norms, knowledge, skills, and how decision-making power is shared within households. Figure 2 shows the pathway from women empowerment in agriculture to consumption of diverse diets.

Data and Methods

Data sources

The study utilizes one wave of nationally representative data on Rural Agricultural Livelihoods carried out in 2015 by the Indaba Agricultural Policy Research Institute (IAPRI) in collaboration with the Central Statistical Office and the Ministry of Agriculture. The 2015 RALS included 7,934 households covering the 2013/14 agricultural season. In total, 442 Standard Enumeration Areas (SEAs) were enumerated [3] targeting 20 randomly selected households per SEA. Due to the challenges of matching household level variables to those of the decision maker, the analysis was done at field/plot or livestock level with total sample size of 18,750. Crop sales data, and livestock files were stacked and later merged with other household level explanatory variables. This means that household variables, including household dietary diversity remained constant across the different fields/crops or livestock of the same household.

Variables used in the model

The selection of the variables to include in the model were guided by the conceptual pathways to household food security and nutrition, as discussed. A correlations matrix of the variables was run and the following variables were found to be highly correlated and therefore dropped from the model:

Variable dropped	*Variable Kept*	*Correlation level*
Age of the decision maker Squared	Age of the PDM	0.9857
Gender of household head	Gender of PDM	0.5844
Maximum education level of any member of the household	Education level of PDM	0.5629
Value of productive assets	Land cultivated	0.3778
Value of productive assets	Total livestock unit	0.4966

Table 1 Variable matric correlation.

i. Outcome variable: HDDS

HDDS was observed at household level and merged to the decision maker variable at field/crop or livestock level. As proxy for household access to diverse foods which is a key component of

[3] SEAs are the lowest geographical sampling units used by CSO and were the primary sampling units. A SEA typically contains 100–200 households.

food security, HDDS was used as the outcome variable. According to FANTA (2008), HDDS is calculated based on different numbers of food groups consumed by the household on a 24-hour recall period. We categorize HDDS into four as follows:

Category	HDDS Level
1	0 to 5
2	6 to 8
3	9 to 10
4	10 to 12

Table 2 HDDS categories.

The categories are based on the distribution of HDDS shown in Figure 3.

The mean HDDS among smallholder households in Zambia is six food groups. Cereals were the most commonly consumed food group by 97.5 percent of the households, followed by dark green leafy vegetables (72.8 percent), other vegetables (71.1 percent), roots and tubers (55 percent) fats and oils (66.5 percent), legumes (52 percent). Meat and meat products and vitamin A fruits were the least consumed food groups.

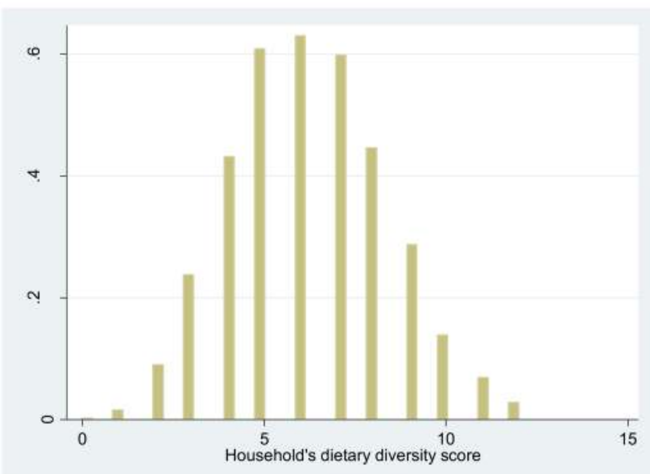

Figure 3 Distribution of HDDS.

ii. Independent variables

Women control over income from agriculture

Based on the UNICEF conceptual framework pathways from agriculture to food security and nutrition, women empowerment is one of the key factors that influence household dietary diversity. Guided by the WEAI, the gender of the Primary Decision Maker (PDM) in the control of income from sales of individual crops or livestock is used as proxy for women empowerment. Gender of the PDM is a dummy variable which is one if it is a woman. The RALS data collects information at field level on the gender of the primary decision maker on what to plant in a particular field, whether or not to sell the harvest from that field, and how the income is used (if they decide to sell). The study focuses on five widely produced crops in Zambia i.e. maize, mixed beans, groundnuts and fruits and vegetables, and livestock (cattle, goats, pigs and village chickens). For crops, the PDM was observed at field levels adding up to 18,750 observations from 7934 households. Similarly, the PDM for each type of livestock was assessed from the observed households. Table 3 shows the percentage of women control over income for each crop.

Crop commercialization

Household dietary diversity as well as decision making over control of income from agriculture can be highly dependent on the level of commercialization of the crop. Previous studies express concern that increasing agriculture commercialization weakens the role of women in decision making and control over agriculture resources and income (Quisumbing and Maizen-Dick, 2001 and Fisher and Qain, 2012). The model therefore included commercialization index variables for each of the crops and livestock. Figure 4 shows the level of commercialization for each enterprise.

Socio-economic factors

In addition to gender of the decision maker in the control of income from agriculture as well as technology adoption, dietary diversity is likely to be influenced by several socio-economic factors (Sraboni et al. 2014). We therefore control for land holding size, access to markets and membership to economic groupings. Land holding size is the total land owned by the household excluding what they may have borrowed or rented in. For access to markets, we use the distance from the homestead to the nearest tarmac road. Households located nearer to the tarmac road are more likely to incur lower transaction costs and have more access to diverse foods and services (Babu et al. 2014 and Kassie et al. 2015).

Rural institutions, such as farmer groups and women groups play a critical role in ensuring household food security. These institutions provide farmers with access to the markets, food, information, credit and productive assets. A dummy variable is included in the model, namely membership to economic groupings to serve as a proxy for local institutions.

Technology adoption can influence production efficiency and improve food production and ultimately household dietary consumption. This study controlled for household adoption of crop rotation, crop diversification and minimum tillage. In Zambia, there are several programs promoting minimum tillage through providing inputs and extension services among other promotion activities.

Agro-ecological factors

Due to climatic variations which could influence food production, availability and access across the country, the study controlled for

		Maize	Groundnuts	Mixed beans	Fruits and vegetables	Livestock
Gender of decision maker	Male % (N)	77.9 (3624)	52.1 (1256)	67 (612)	56.4 (3888)	61.1 (2046)
	Female % (N)	22.4 (1047)	47.9 (1154)	33 (301)	43.6 (3003)	38.9 (1303)
Total		100 (4671)	100 (2410)	100 (913)	100 (6891)	100 (3349)

Table 3 Percentage of gender control over income from individual crops and livestock. (*Source: CSO/MoA/IAPRI, 2015 and Author's own calculations*)

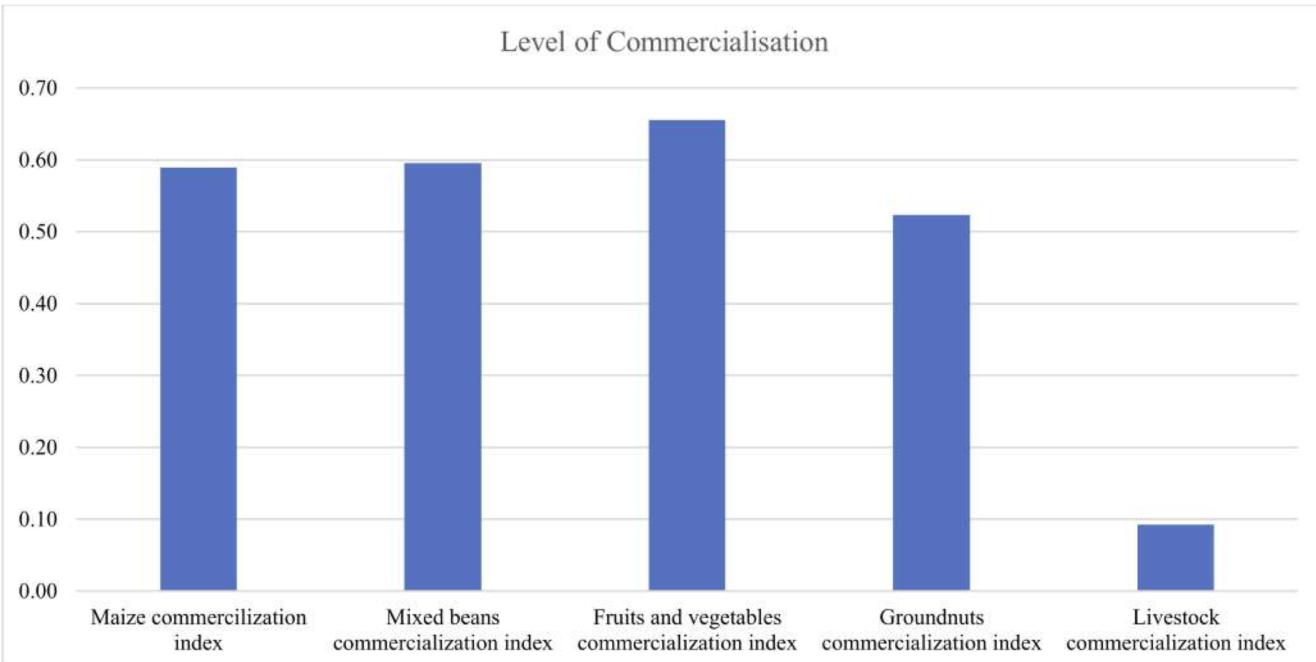

Figure 4 Level of commercialization for each crop livestock. (*Source: Authors calculation using RALS Data 2015.*)

agro-ecological conditions represented by the four agro-ecological zones. The Northern parts of the country, which is a higher-rainfall area fall under Zone III, with rainfall of 1,000–1,500 mm/yr. Zone II covers most of the eastern, central and western regions of the country. It is the medium rainfall area (800–1,000 mm/yr and divided into two: Zone IIa which covers the north-eastern parts of the country and Zone IIb covering the central-western parts. Zone I covers most parts of the southern and western provinces. It is a drought-prone area characterized by low rainfall (< 800 mm/yr) and a short, hot growing season. Table 4 describes the variables used in the model.

Empirical analytical framework

This study applies the ordered probit model to examine the relationship between food security and women empowerment and other social demographic characteristics. The ordered probit model is a generalization of the probit model to a case of more than two categorical outcomes[4] of an ordinal dependent variable (see Green 2012). In this study, we categorize HDDS into four namely: one to five, six to seven, eight to nine and ten to twelve.[5] The Ordinary Least Squares (OLS) estimates for this model produces biased and inconsistent results. Therefore, we adopt the maximum likelihood of the ordered probit which will produce unbiased and consistent estimates of the relationship between womens characteristics to take control over revenue from agricultural products (crops and livestock) and food security levels. Unlike previous studies that have examined the effect of women empowerment on households dietary diversity without taking into account HDDS category levels (e.g. Scrobin et al. 2014), the applications of ordered probit in this study has

[4] In our case, four categories from HDDS.

[5] Since food security measured by HDDS is inherently broad, we move away from the orthodox approach of categorizing access to food security as being food secure and food insecure. The approach adopted in this study allows using the ordinary probit model.

Variable	Observations	Mean	Std. Dev.	Min	Max
Household Dietary Diversity Score	20,094	6.22	2.12	0.00	12.00
=1 if Primary Decision Maker (PDM) is Female	18,729	0.34	0.47	0.00	1.00
Age of decision maker in (Years)	18,729	46.73	13.81	9.00	105.00
Highest level of formal education completed by PDM	18,729	6.31	3.70	0.00	19.00
=1 if PDM is married	18,726	2.66	1.08	1.00	7.00
Full time Adult Equivalent	17,603	3.38	3.14	0.02	42.00
Household Commercialization Index	18,729	0.53	0.24	0.00	2.00
Livestock Commercialization Index	18,729	0.02	0.12	0.00	1.67
=1 if Household practiced conservation agriculture	17,603	0.16	0.37	0.00	1.00
Tropical Livestock Unit	17,603	5.49	12.89	0.00	250.00
= 1 if head/spouse related to the village authorities	16,387	0.48	0.50	0.00	1.00
= 1 if any household member is involved in a farmer association/coop/group/women's group	17,588	0.70	0.46	0.00	1.00
= 1 household head is considered local	16,373	0.10	0.30	0.30	1.00
Distance to nearest tarred road in Km	17,586	25.14	30.99	0.00	300.00
Simpson index of crop diversification	17,603	0.48	0.20	0.00	0.80
Acres cultivated	17,603	4.05	3.80	0.06	67.50
Zone = IIA	20,096	0.47	0.50	0.00	1.00
Zone = IIB	20,096	0.04	0.19	0.00	1.00
Zone = III	20,096	0.40	0.49	0.00	1.00

Table 4 Description of variables. (*Source: CSO/MoA/IAPRI, 2015*)

allowed for observation of the impact at different levels of household dietary diversity. Suppose the underlying relationship in the context of OLS is given by the following equation:

$$y_i = \mathbf{X}_i\beta + \varepsilon_i \qquad (1)$$

where, y_i is the exact but unobserved dependent food security variable, $\mathbf{X}_i$ is a vector of independent variables including our main variable of interest, gender of the decision maker, β is the vector of regression coefficients to be estimated and ε_i is the error term which is identically and independently distributed (iid) as $N(0;1)$. Furthermore, suppose that we cannot observe y^*, we can however, observe only the categories of the responses:

$$y = \begin{cases} 0 & \text{if } y^* \leq 0, \\ 1 & \text{if } 0 < y^* \leq \mu_1 \\ 2 & \text{if } \mu_1 < y^* \leq \mu_2 \\ 3 & \text{if } \mu_2 < y^* \leq \mu_3 \end{cases} \qquad (2)$$

The ordered probit technique will use the observations on y, a form of censored data on y^*, to fit the parameter vector $\boldsymbol{\beta}$. Here, the latent variable y^* is determined by $y^* = x\beta + e, e \mid \mathbf{x} \sim$ Normal (0,1) and $\mu_1 < \mu_2 < ... < \mu_J$ are unknown cut points or threshold parameters (Wooldridge 2006).

Equation (2) was estimated using the maximum likelihood methods (Wooldridge 2006; Greene 2012). Heteroskedasticity was, however, significant in our plot-level data as indicated by a Breusch-Pagan/Cook-Weisberg test ($\chi_1^2 = 26.87$, p-value< 0.0000). To correct this problem and, thus, improve the efficiency of our estimates, we used robust standard errors. Additionally, the Ramsey RESET test, showed no indication of omitted variables (F (3, 16335) = 0.29, p-value< 0.8322)).

Given that the ordered probit model is inherently nonlinear in its coefficients, its estimated parameters do not by themselves represent the marginal effects of the explanatory variables on the dependent variable. Instead, the marginal effects are functions of both the parameters and the data. If we skip all the algebraic details, it has been shown that the marginal effect of a variable x_J on the dependent variable y when $J = 3$ for the category-specific marginal (partial) effects, can be computed as (Wooldridge, 2006; Greene, 2012):

$$\frac{\vartheta \text{Prob}(y = 0 \mid \mathbf{x})}{\vartheta \mathbf{x}} = -\phi(\mathbf{x'}\boldsymbol{\beta})\boldsymbol{\beta},$$

$$\frac{\vartheta \text{Prob}(y = 1 \mid \mathbf{x})}{\vartheta \mathbf{x}} = [\phi(\text{-}\mathbf{x'}\boldsymbol{\beta}) - \phi(\mu - \mathbf{x'}\boldsymbol{\beta})], \tag{3}$$

$$\frac{\vartheta \text{Prob}(y = 2 \mid \mathbf{x})}{\vartheta \mathbf{x}} = [\phi(\mu - \mathbf{x'}\boldsymbol{\beta})\boldsymbol{\beta}.$$

where, ϕ is the standard normal cumulative distribution function. The marginal effects of women empowerment on food security, shows the percentage points of reporting a given category of HDDS, since only one category can be reported at a time.

Results and Discussion

Demographic characteristics of the decision maker

Table 5 presents demographic characteristics of the decision maker comparing the characteristics of the male decision maker to the female decision maker. The data shows that decision making in the use of income from agriculture is dominated by men. Surprisingly, even in female headed households which constitute 17 percent of the sample, only 34 percent of the primary decision makers are women while 66 percent are male. These statistics imply male dominance in decision making regardless of the gender of the household head. As discussed in section one, gender of the decision maker has implications for the kind of foods that the household purchases and ultimately consumes.

Given the endogeneity of the gender decision maker variable in the model, we used instrumental variables to control for it. Following Scrobin et al. (2014) differences in age of the primary male and female decision makers were used as instruments. This variable is strongly correlated with gender of the decision maker but less correlated with the error term.

Regression results

Gender of the PDM and agriculture commercialization

To examine impact of WCAI on different levels of HDDS, we estimate two ordered probit models with HDDS as the categorical outcome variable. The first model estimates the impact of WCAI on HDDS and controls for household crop and livestock commercialization as well as other demographic and socio-economic factors that are likely to influence HDDS. The model estimation results are presented in Table 6. In the second model, we introduce interaction terms of WCAI and crop commercialization index applying the same for livestock commercialization index. This is in order to assess the differential impact of WCAI and household crop and livestock commercialization jointly on HDDS. In this model interaction terms of WCAI and other decision maker demographic characteristics such as age, marital status and education level are also introduced. Table 7 presents results from the second model. Further, we compare results from the two models with results of regression model to ascertain the superiority of the ordered probit model. Similarly, the first OLS model excludes interaction terms while the second model includes the interaction terms and the results are included in Tables 6 and 7 respectively.

Results from the ordered probit model without interaction terms show significantly positive impact of WCAI on HDDS for categories two, three and four compared to men having control over income. WCAI is likely to increase HDDS by 0.9, 2.8 and 0.4 percentage points for categories two, three and four of HDDS respectively. For these categories of the HDDS, the results are consistent with findings of Sraboni et al. (2014) on the role of women empowerment on food security in Bangladesh which found positive and significant impact of women empowerment. The OLS model estimation also indicates positive and significant impact of WCAI on HDDS. However, at lower HDDS level (<5), results indicated a 4.2 percentage point decline in the effect of WCAI on HDDS. These findings suggest that empowering women in the control of resources from agriculture has greater impact on households dietary diversity higher than five.

For the model with interaction terms, presented in Table 6, results show differential impact on HDDS when gender of the PDM is interacted with household crop commercialization index. The results show that the interaction of gender of PDM and commercialization is positive but less strongly associated to HDDS compared to the independent effect of WCAI on HDDS. The interaction of WCAI and household crop commercialization index is likely to increase HDDS by 2.8, 7.9 and 1.2 percentage points for HDDS categories two, three and four respectively. These results imply that, with increased crop commercialization level, the impact of WCAI on HDDS is positive but less significant compared to the impact of WCAI without taking into account household crop commercialization. These results support the concerns raised in previous studies that increasing agriculture commercialization weaken the role of women in decision making and control over agriculture resources and income (Quisumbing and Maizen-Dick, 2001 and Fisher and Qain, 2012). Further analysis of the impact of WCAI jointly with livestock commer-

		Sub-sample		
Variable description *a*	Full sample	Male decision maker	Female decision maker	
Age of the primary decision maker in (Years)	46.73	46.52	47.14	***
Highest level of formal education completed by the primary decision maker (Years)	6.31	6.79	5.36	***
Female headed household (%)	17%	66%	34%	***
Age of household head (Years)	48.27	46.94	50.96	***
Level of education of the household head (Years)	6.39	6.61	5.93	***
Maximum education level by any adult in the prime age in (Years)	8.51	8.48	8.58	*

Table 5 HDDS and demographic characteristics of the primary decision makers *(Source: Authors computations with data from CSO/MoA/IAPRI, 2015)*

	HDDS			
Variable description	0 to 5	6 to 7	8 to 9	10 to 12
=1 if PDM is Female	-0.042***	0.009***	0.028***	0.004***
Age of decision maker in (Years)	0.000	0.000	0.000	0.000
Highest level of formal education completed by PDM	-0.020***	0.005***	0.014***	0.002***
= 1 if PDM is married	-0.018	0.004	0.012	0.002
=1 if HH participated in off-farm activities	-0.080***	0.022***	0.051***	0.007***
Full time equivalent	-0.007***	0.002***	0.004***	0.001***
Tropical Livestock Units	-0.005***	0.001***	0.003***	0.000***
Household Crop Commercialization Index	-0.174***	0.041***	0.116***	0.018***
Livestock commercialization index	0.040	-0.009	-0.027	-0.004
=1 if any household member is belongs to a farmer association/coop/group/women's group	-0.047***	0.012***	0.031***	0.005***
= 1 if head/spouse is related to the village authorities	-0.013	0.003	0.009	0.001
=1 if the HH head is considered local or non-local	-0.005	0.001	0.004	0.001
Area Cultivated	-0.024	0.005*	0.016	0.003
Landholding size (all cultivated land plus fallow)	-0.007***	0.002***	0.005***	0.001***
=1 if HH used minimum tillage	-0.048***	0.010***	0.033***	0.006***
Simpson Index of Crop Diversification	0.095***	-0.022***	-0.063***	-0.010***
Distance to nearest tarred road in Km	0.001***	0.000***	-0.001***	0.000***
zone==IIA	-0.169***	0.036***	0.114***	0.019***
zone==IIB	0.019	-0.005	-0.012	-0.002
zone==III	-0.102***	0.023***	0.068***	0.011***
Constant				
Observations				
R-Squared				

Table 6 Results from model without interactions. (*Source: Authors*)

Independent Variables	*HDDS*				
	OLS	0 to 5	6 to 7	8 to 10	10 to 12
=1 if PDM is Female	-0.8024***	0.193***	-0.055**	-0.121***	-0.017***
Age of decision maker (Years)	-0.0007	0.001**	0.000**	-0.001**	0.000**
Highest level of formal education completed by PDM	0.0820***	-0.021***	0.005***	0.014***	0.002***
= 2 if PDM is female	-0.0827	0.014	-0.003	-0.010	-0.001
=1 if HH participated in off-farm activities	0.4429***	-0.082***	0.023***	0.052***	0.007***
Full time equivalent	0.0365***	-0.007***	0.002***	0.005***	0.001***
Tropical Livestock Units	0.0122***	-0.005***	0.001***	0.003***	0.000***
Household Commercialization Index	0.9837***	-0.128***	0.030***	0.085***	0.013***
Livestock commercialization index	-0.1991	0.060	-0.014	-0.040	-0.006
=1 if any household member is belongs to a farmer association/coop/group/women's group	0.2599***	-0.049***	0.012***	0.032***	0.005***
head/spouse related to the village authorities	-0.0458	-0.012	0.003	0.008	0.001
=1 if the HH head is considered local or non-local	0.0745	-0.006	0.001	0.004	0.001
Area cultivated	0.1081***	-0.024	0.005	0.016	0.002
Landholding size (all cultivated land plus fallow)	0.0497***	-0.007***	0.002***	0.005***	0.001***
=1 if hh used minimum tillage	0.2334***	-0.062***	0.012***	0.043***	0.007***
Simpson Index of Crop Diversification	-0.4189***	0.098***	-0.023***	-0.065***	-0.010***
Distance to nearest tarred road in Km	-0.0057***	0.001***	0.000***	-0.001***	0.000***
zone==IIA	0.6663***	-0.170***	0.037***	0.114***	0.019***
zone==IIB	-0.3442***	0.015	-0.004	-0.010	-0.001
zone==III	0.3710***	-0.103***	0.024***	0.069***	0.011***
*Education level of PDM*Gender of PDM*	0.0123	0.002	0.000	-0.001	0.000
Marital Status Gender of PDM*	0.3683***	-0.076**	0.014***	0.053**	0.009**
HCI Gender PDM*	0.2935**	-0.119**	0.028**	0.079**	0.012*
*Livestock commercialization Index*GenderCI PDM*	0.0444	-0.086	0.020	0.057	0.009
*Conservation agriculture *PDM*	-0.0814	0.046	-0.013	-0.029	-0.004
Constant	4.1455***				
Observations	15,866				
R-squared	0.1443				

Table 7 Results from model with interaction terms. (*Source: Authors*)

cialization index show insignificant results. This is plausible given that livestock is the least commercialized farm enterprise and ownership, especially for large livestock such as cattle, which is primarily controlled by men.

Characteristics of the decision maker

Formal education level of the PDM is likely to improve HDDS for households that consume more diverse foods. However, differential impact is observed when the gender of the PDM is interacted with education level of the PDM, the age of the PDM and marital status of the PDM. While the age of the PDM has no significant impact on HDDS, when the age is interacted with gender of the PDM the results show significant positive but marginal increase in HDDS for categories two, three and four. Similarly, when female PDM is married, the likelihood of increasing HDDS for categories two, three, and four is positive and significant. However, formal education completed by PDM has no significant impact when interacted with gender of the PDM. The results suggest that while formal education level of the PDM is important for improving HDDS, its interaction with gender of the PDM is not significant.

Socio-economic factors

Other socio-economic factors such as participation in off-farm income, membership to economic organizations, for example, farmers cooperatives or women groups, the size of land owned by the household and whether the household practiced minimum tillage are likely to increase HDDS in categories, two, three and four. For HDDS lower than 5, results show declining effect of these variables on the HDDS, similar to the effect of WCIA. The results imply that socio-economic interventions to promote HDDS are likely to yield positive and significant results at HDDS of at least 6, otherwise such households perhaps first require other basic socio-economic interventions in place. Further, the results showed that crop diversification index has declining likelihood of increasing HDDS implying that commercialization (related to more specialized agricultural production) is critical for improving households food access (HDDS). These results support earlier findings that too high household crop diversification becomes inefficient and has negative impact on child nutrition (Mofya-Mukuka and Kuhgatz 2015).

Agro-climatic factors

The results show that agro-ecological conditions significantly impact households dietary diversity. Taking Zone I as the base, there is probability of HDDS increasing when a household is located to Zone IIa which receives relatively more annual rainfall. Zone IIa covers most parts of Eastern and Lusaka provinces. Similarly, households located in higher rainfall areas of Zone III, covering Central, Luapula, Muchinga, Northern and Northwestern provinces are more likely to have higher HDDS. The results imply that diverse food consumption is highly dependent on high rainfall.

Conclusion and Policy Recommendations

In conclusion, our findings suggest that improving HDDS can be achieved by empowering women with more control over use of revenue from agriculture compared to men. Crop commercialization is also important for achieving household food security through increased revenue which enables households to easily purchase diverse foods. However, the findings have shown that increased household crop commercialization subverted women control over agricultural income leading to less strong impact on HDDS. The findings indicate that, for all the crops observed in this study, men took more control of income from agriculture which could explain current low levels of diversified food consumption among the rural households in Zambia. These findings, therefore, suggest the need for interventions to address intra-household gender dynamics to effectively address HDDS.

Furthermore, to attain the benefits of women control over income on household diversity, other socio-economic and environmental factors should effectively be addressed, providing a holistic approach to policy and program interventions. Inasmuch as increasing agriculture production and diversification can potentially increase diverse food availability, it does not directly translate into household food access. For a long time now, policies in Zambia have been directed towards improving production and diversification, and less focus on increasing access, which could explain persistently high levels of hunger and malnutrition amidst increased production of many crops and livestock.

Efforts to improve household dietary diversity should hence focus on enhancing policy factors that increase household income and improve access to markets augmented by more women control over the income.

Therefore, understanding the gendered control of resource gap is crucial for identifying the right policies and programs that can empower women farmers and support them in their efforts to increase food production and improve their households food security status. Ultimately, closing the gender gap is likely to not only achieve agricultural outcomes but augment household food security, diverse food consumption and nutrition status at household level.

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