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Can women's empowerment in livestock farming improve household food security? Empirical evidence from rural households in Malawi

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Abstract

Background Over the years the Government of Malawi has launched several initiatives to improve food security in the country. Despite these efforts there have been limited improvements in food security, raising the spectre of persistently elevated levels of food insecurity. Efforts to reduce food insecurity may involve women who play a central role in the production, processing, preparation and control of vital livestock products for food security. However, women's ability to achieve food security is limited by their lack of access to productive resources and limited ability to participate in decision-making. The main objective of this study is to estimate the impact of women's empowerment in household livestock production and marketing decisions on household food security.

Methods This study uses data from a proportionate random sample of 400 households in two major livestock producing Extension Planning Areas in the Nsanje district to estimate the relationship between women's empowerment and household food security in rural households in Malawi.

Results Tobit regression results show that the empowerment of women in the livestock sector, especially in decisions pertaining to agricultural production, nutrition, and income control, improves household food security. In addition, factors such as household income, household size, and the main occupation of the household head play a significant role in ensuring household food security.

Conclusion The results suggest that nutrition-sensitive programmes should target women's agency in livestock production and nutrition decisions for improved food security among rural households in Malawi. As part of their food security strategy, Government of Malawi could develop programs to sensitize households on the importance of enhancing women's agency in agriculture and nutrition decision-making, while also providing targeted income-support for women.

Keywords Food security, Women's Empowerment in Livestock Index, Tobit model, Malawi

Background

Food security is an important development priority as evidenced by its inclusion in the 2030 United Nations Agenda for Sustainable Development (UN, 2030). However, food insecurity remains a significant challenge across the world despite efforts by countries to implement strategies to eradicate it and ensure improved

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nutrition [20]. The percentage of the world's population affected by severe/moderate food insecurity increased from 23.2% in 2014 to 26.4% in 2019. Furthermore, economic slowdown and interruptions in food value chains following the COVID-19 pandemic have worsened the food insecurity situation. The prevalence of undernourishment (POU) increased to 9.9% in the year 2020 compared to 8.4% in 2019, after remaining constant from 2014 to 2019 [22].

Malawi's food security is often associated with adequate access to staple food needed for a household to meet the caloric needs of its members [2, 38]. This traditional way of measuring food security misses the importance of quality of dietary intake because it lacks consideration of the intake of nutrient-rich foods, whose consumption are usually in small quantities or not at all, especially in rural areas [35]. Food security is an important priority area for agriculture in the country, while nutrition is still considered a health issue. Furthermore, the country's previous food security policies only partly addressed food security because of their limited focus on nutrition [2].

Factors such as poor agricultural planning and practices, unreliable rainfall, overdependence on rainfed agriculture, high levels of extreme poverty and gender inequalities have contributed to food insecurity in Malawi [2]. The country experienced a drop in the occurrence of severe food insecurity among its population from 53.9% in 2014 to 51.8% in 2019. Despite this drop, the figure remains the highest in Sub-Saharan Africa, surpassing the regional average of 24.6% [21, 31]. This situation has no doubt been exacerbated by the COVID-19 pandemic. According to Dzimbiri et al. [17] COVID-19 lockdowns worsened food insecurity in urban areas of Blantyre Malawi by impairing their ability to maintain their livelihoods.

Malnutrition is a major problem in Malawi. Approximately 39% of children below the age of five are stunted and three percent are wasted; the prevalence of stunting is approximately 29.1% [31]. In addition, 63% of children are anaemic [57, 68]. These indicators show that most Malawian diets are not rich in nutrient dense foods and are also lacking in regards to quality and quantity [1, 2]. Much effort is still needed to reduce the prevalence of undernourishment in the population, a figure that has been rising from 17% in 2015 to 18.8% in 2019 [23].

The impacts of food insecurity are felt by people of all ages [34]. Food insecure children have a higher chance of becoming anaemic and tend to recover slowly from illnesses [18]. Furthermore, chronic undernutrition in children is associated with cognitive development problems [20, 36]. Notable effects among food insecure adults include low levels of nutrient uptake and increased physical and mental health problems [42]. Furthermore, food insecure adults experience higher levels of stress, anxiety, and depression, and have a higher risk of chronic diseases [34, 69]. These consequences of food insecurity raise concerns at both the household and national levels.

Livestock farming provides both opportunities and challenges to women in developing countries. They can more easily obtain livestock assets compared to immobile assets such as land [26]. However, women face several challenges in livestock production and marketing. For instance, despite women managing larger herds of livestock than men, they control fewer valuable species and earn less even though they are more commercially-oriented [27, 56]. Furthermore, in instances where they own livestock, they face limited access to marketing opportunities. In addition, they represent the world's poorest livestock keepers despite being actively involved in livestock farming [26, 56].

Over the years, Malawi has launched multiple initiatives to achieve food and nutrition security. These include the 2005 Farm Input Subsidy programme which was implemented in 28 districts and was aimed at increasing food self-sufficiency for farmers who could not afford the resources to produce maize [15]. Similarly, Malawi participates in the Scaling up Nutrition (SUN) programme, a multi-sectoral approach to addressing malnutrition at the community level [72]. Under SUN, a stunting prevention programme was implemented in the Central region. In addition, the country has been implementing cash transfer programmes since 2006; this is aimed at improving food security through the provision of cash to the poorest 10% of labour constrained households across the country [47]. Recently, the government developed the Multisectoral Nutrition policy, which aims to promote better nutrition for the population through a multifaceted approach involving the government, the private sector and civil society. The National Agriculture Policy (NAP) represents another attempt by the Malawian government to promote food security through increased production of diversified food crops for better nutrition [2].

Despite the government's food security initiatives, there have only been limited improvements in food security in Malawi, raising concerns among policymakers due to pernicious effects of food insecurity, especially on vulnerable populations [2]. When designing food security initiatives, government should consider women's role in household food and nutrition decisions. Women play a leading role in food production, processing, and preparation and hence maintain a significant responsibility in ensuring food security in developing countries [19, 39, 65]. They control vital livestock products for food security and are the main food producers [56]. However, their

ability to achieve food security is constrained by their lack of access to productive resources and inability to participate in much of the decision-making. Women in developing countries have limited control over productive resources and lack decision making authority [41].

Evidence suggests that increasing women's access and control over productive resources contributes to the achievement of food security because unlike men, women are more likely to spend their income on food [44, 61]. Furthermore, raising livestock provides an opportunity to empower women because they can have greater access and control of livestock and their products compared to other productive resources [26]. Several strategies have been used to empower women in agriculture. While some have focused on empowerment through resources and achievements such as education levels [37, 53], one empowerment dimension that has received far less attention is agency that involves decision-making processes. Therefore, this study seeks to understand how the empowerment of women in livestock decision-making affects household food security.

Although previous studies have provided evidence that the empowerment of women in livestock is necessary for household food security, no study has been conducted in a Malawian context to investigate this relationship. Furthermore, most of the studies have measured the empowerment of women in the agriculture sector using the Women's Empowerment in Agriculture Index (WEAI), a commonly used tool for measuring women's empowerment, agency, and their involvement in the agriculture sector [9]. Despite its reliability in most agricultural contexts, the index pays little attention to livestock-related issues and does not investigate how women's agency in nutrition affects household food security. This study, therefore, uses the Women's Empowerment in Livestock Index (WELI). This improved index which not only includes livestock related issues, features an additional empowerment dimension on decisions related to nutrition which might offer important insights on how it is related to household food security [27]. The study used the Household Dietary Diversity Score (HDDS), a measure related to the access and utilisation dimensions of food security, as a proxy for food security.

This study provides answers to the following research questions: Firstly, what is the level of women's empowerment in livestock-dependent households in rural Malawi? Secondly, what is the status of food security in rural Malawian households? Lastly, how, and to what extent, does the empowerment of women in livestock dependent households affect household food security?

The results provide insights into the role played by women's empowerment in livestock on household food security. Such results will help government and policymakers to develop more inclusive policies for women's empowerment and ensure better food security in Malawi and other developing countries. In addition, the results will provide useful inputs for any future private sector and international Non-Governmental Organizations (NGOs) activities that aim to empower women for food security. Lastly, the empirical results obtained from this study will serve as a reliable source of information for researchers of this subject. This study will contribute to the empirical literature on the link between women's empowerment in livestock and household food security.

Data and methods

Study area, sampling and data collection

The study was conducted in the Nsanje district, located in Southern Malawi. This region was selected because of its high levels of food insecurity, particularly when compared to other regions [24]. This district is the one that is worst hit by food insecurity because of frequent floods and droughts [52]. Most rural households keep livestock for food, income and as an important safety net for times of crisis. Livestock offer households a good source of protein. Poultry makes a vital contribution to food security, particularly for vulnerable groups such as women [25]. The second important livelihood activity and main source of income after crop production in the Nsanje district is livestock farming [25].

Nsanje district has five Extension Planning Areas (EPAs): (i) Makhanga, (ii) Magoti, (iii) Mpatsa, (iv) Zunde, and (v) Nyachilenda. The researchers purposively selected two livestock dependent EPAs—Zunde and Mpatsa. In 2017, the Zunde and Mpatsa EPAs had projected populations of 20,938 and 16,277, respectively. The researchers used proportionate random sampling to determine the sample size within these two EPAs and randomly selected households whose livelihoods depend on livestock. In total, the researchers interviewed 400 women (225 from Zunde and 175 Mpatsa). Government extension officers assisted with the selection of households from the EPAs. A structured questionnaire was used to conduct face to face interviews and collect data relating to social and demographic attributes, household food security, and women's empowerment in livestock production and marketing.

Calculating WELI and HDDS

To understand the level of women's empowerment in livestock dependent households, the study used the WELI tool. The index was used to examine five out of six dimensions (i) agricultural production decisions; (ii) nutrition related decisions; (iii) income use and control; (iv) resources access and control; and (v) opportunities

access and control. The study did not use the workload and control over own time dimension because of time limitations.

The WELI questionnaire was administered to women from households whose livelihood was derived from livestock production in the Nsanje district. The index was computed using the five livestock empowerment dimensions mentioned above. Each of these dimensions has its own indicators as described in Table 1. The first step was to assign equal weights of 1/5 to each of the five dimensions [9]. Secondly, indicator weights were calculated by dividing the weight of the dimension by the number of indicators within each dimension. Dimensions such as income control and use, and resources access and control had three indicators and received a weighting of 1/15 each. Decisions related to agricultural production had a weighting of 1/10 since two indicators were used. Lastly, dimensions such as nutrition related decisions and opportunities access and control received a weighting of 1/5 since each had one indicator [9].

Computation of the WELI was based on an individual's responses to questions at the indicator level. At the question level, an individual's response was assessed to find out if they had achieved a minimum level of empowerment for that specific question. According to Galiè et al. [27], a woman achieves a minimum level of empowerment if she solely makes decisions regarding the livestock or provides input into the decision. A woman was considered adequate on questions related to autonomy in production if she is able to act according to personal values (regarding raising the livestock, marketing and income use) and engaged in activities for personal satisfaction rather than to avoid punishment or please others [9]. Furthermore, the minimum level of empowerment for questions related to resources access and control was based on a woman's sole/joint ownership and control of land, crop and livestock assets and access to credit. Finally, a woman's membership in influential groups was necessary to achieve minimum empowerment for questions related to access and control of opportunities [9]. To assess empowerment levels at the indicator level, related dummy variables were coded 1 if a woman achieves minimum level of empowerment and 0 otherwise, and summed up to arrive at the number of questions for which the woman achieved the minimum level of empowerment. Following Galiè et al. [27], this study used the one-third threshold for empowerment at the indicator level. That is, achieving approximately one third of the questions that were included was deemed necessary for indicator adequacy. A value of 1 was then assigned for indicators for which adequacy had been achieved. The values for the indicators were then weighted and totalled to produce the WELI score, which ranges from 0 (least empowered women) to 1 (most empowered women).

The WELI score was computed as below:

$$WELI_i = w_1 I_{1i} + w_2 I_{2i} + \cdots + w_d I_{di} \quad (1)$$

$WELI_i$is the WELI score for an individual woman *i;* I_{di} is a dummy variable for adequacy, with code 1 if a woman had indicator adequacy and 0 otherwise. w_d is the weight allocated to indicator *d*. In the original WELI index, 13 indicator weights add up to 1 [27]. The index applied in this study uses one less empowerment dimension, hence why there are only 10 indicators. Table 1 shows the WELI dimensions, indicators and their associated weights.

HDDS was calculated at the household level using a 24 h recall period, and this variable measures the variety of food groups a household consumes [63]. The questionnaire included twelve food groups; each group was given a score of one (1) if it was consumed by the household

Table 1 WELI dimensions and weights

Empowerment dimension	Dimension weight	Indicator	Indicator weight
Agricultural production related decisions	1/5	a. Production decisions input	1/10
		b. Production autonomy	1/10
Decisions related to nutrition	1/5	a. Nutrition related decisions	1/5
Income control and use	1/5	a. Farm income control	1/15
		b. non-farm income control	1/15
		c. Expense's control	1/15
Resources access and control	1/5	a. Ownership and control over land and crop assets	1/15
		b. Ownership and control over livestock assets	1/15
		c. Credit access	1/15
Opportunities access and control	1/5	a. Membership to influential groups	1/5

The researchers dropped the workload and control over own time dimension from the initial list of empowerment dimensions because it was deemed less relevant to household food security. It also takes more time and resources to administer. The researchers believe that this omission does not affect the study's outcome.

and zero (0) if not. The household scores ranged between 0 and 12 [63], with higher HDDS values representing higher food security. As there is no normative data on the ideal levels of household dietary diversity [63], average consumption was used as the threshold for delineating food security classifications. While households that consumed food groups below the average were considered food insecure, those that had consumption at or above the average were considered food secure.

Tobit model of women's empowerment in livestock on household food security

The study's primary aim was to examine how and to what extent, the empowerment of women in livestock-dependent households affects the household's food security. The study hypothesized that higher levels of women's empowerment in decisions relating to livestock would be associated with greater household food security. This study assessed how WELI, a proxy for women's empowerment, influences household food security.

Tobit regression was used in models involving HDDS, because of the possibility of censoring in the dependent variable. The Tobit model examines the relationship between a censored continuous variable and independent variables [64]. Since the dependent variable was observed on limited range of 0–12, the model was best represented as a doubly censored regression. Both censoring from above and below were evident in this model. Following Greene [33], this study used a doubly censored Tobit regression with HDDS as the dependent variable.

The independent variables included the WELI score and control variables such as the age of the household head, the education level of the household head, household size, the household head's primary occupation, government food security interventions, the gender of household head, the marital status of the household head, and the household's monthly income. Furthermore, the following five-empowerment dimensions were included as sub-variables in separate models; (i) agricultural production decisions, (ii) nutrition related

Table 2 Definition of model variables

Variable	Variable definition		
Interval variables		**Mean**	**Standard deviation**
Age	Age of the household head (years)	45	16
Household income	Household monthly income from both farm and non-farm sources (Malawi Kwacha)	16,239.5	18484.8
Household size	Number of household members	5.255	1.913
WELI score	Summation of weighted values for WELI indicators ranging from 0 to 1, indicating least and most empowered women in livestock respectively (index)	0.354	0.185
HDDS	Food security measure captures the number of food groups consumed within a designated period	4.163	2.005
Nominal variables		**Category**	**Percentage**
Education level	Level of education attained by the household head (1 = no formal education, 2 = primary education, 3 = secondary education & 4 = tertiary education)	1 2 3 4	25.8 48.0 25.5 0.8
Occupation	Main source of income/livelihood activity for the household (1 = crop farming, 2 = livestock farming, 3 = trading; 4 = formal employment/civil service, 5 = piecework)	1 2 3 4 5	63.2 23.3 4.8 1.3 7.5
Gender	Gender of household head (1 = male, 0 = female)	1 0	68.8 31.3
Marital status	Marital status of household head (1 = unmarried, 2 = married, 3 = widow/widower, 4 = divorced or separated)	1 2 3 4	0.3 71.5 21.3 7.0
Government food security interventions	Whether households benefited from any government food security interventions (1 = Affordable Input subsidy programme, 2 = Scaling Up nutrition, 3 = cash transfer, 4 = food for work projects, and 5 = did not benefit) over the past year	1 2 3 4 5	10.5 1.0 4.5 0.8 83.3

decisions, (iii) income use and control, (iv) opportunities access and control, and (v) resources access and control. Data was analysed using STATA statistical software.

Results and discussion

Descriptive statistics

Table 2 presents the model variables, definitions, means and standard deviations. The age of the household head determines the likelihood of making decisions about or participating in economic activities that affect household food security. Some studies suggest that, in comparison to older household heads, younger household heads have higher labour productivity, and consequently higher wages, both of which contribute to household food security [51]. Others have argued that older household heads are less productive and more reliant on gifts and remittances [29, 74]. Furthermore, older household heads who are retired or have low incomes are more susceptible to food insecurity [7]. Conversely, older household heads may have greater food security knowledge, more farming experience, and better access to farmland, which mean that the farmer is more risk averse and more likely to produce a diversity of food [6]. Age is, therefore, hypothesized to influence household food security. Table 2 shows that the average age for the household head was 45 years. The mean age of 44 for male heads was lower than the mean age of 49 for female household heads. Overall, there were more male household heads (68.75%), compared to female household heads (31.25%).

Education is one of the key determinants of household income and food security because it provides opportunities to access economic resources and enhances an individual's ability to make the right food choices [46]. Unlike uneducated household heads, educated household heads have access to better employment opportunities and higher income as a result of greater productivity [11, 51]. These factors ensure household food security. In addition, education is linked with better management techniques for securing an all-year supply of preferred and diversified food [43]. The majority (74% of household heads), had at least a primary education, with only 26% of household heads having no formal education. Among the group with some level of formal education, approximately 65% had completed primary education, 34% had completed secondary education. Only 1% had completed tertiary education. Overall, male household heads had higher levels of formal education than female household heads. For instance, among household heads who had completed primary education approximately 69% were male; for those with secondary education, nearly 82% were male. These findings agree with the extant literature which shows that women have lower levels of education than men, particularly in developing countries [45].

The study obtained data on the monthly household income for households in the Nsanje district. Income is an important factor in ensuring household food security because it determines the amount and quality of food that a household can purchase [7, 51, 54]. The overall monthly household income for the sample was MK16,239.50 (US$20.38). This means that the average amount of money available per person to cater for the daily cost of food, clothing and shelter was approximately $0.14/person/day ($20.38/5(avg household size)/30 days). These findings show that a majority of households in the district were living well below the poverty line of $1.90 [71] at the time the study was conducted. Overall, the total monthly income of MK16,988.36 (US$21.32) for male-headed households was not significantly higher than the total monthly income of MK14,592.00 or US$18.31 for female-headed households. The study also examined monthly income across households that indicated crop and livestock farming as their main occupation. The results show that the average monthly income for households whose main occupation was livestock farming (MK 17,797.94/US$22.33) was significantly higher compared to those engaged in crop farming (Mk 14,401.95/US$ 18.07). The Nsanje district is prone to floods and dry spells, both of which contribute to low yields and income obtained from crop sales [32]. In times of distress or food insecurity, households can sell livestock year-round and as the need arises; in contrast, crop farming is mostly seasonal.

Most household heads were engaged in crop farming (63.25%), followed by livestock farming (23.25%). Only a few household heads (1.25%) were formally employed, with 7.5% depending on piecework for their income. Of the total number of households in the sample, the proportion of male household heads involved in crop farming whether as a main or secondary activity was approximately 65%, while those involved in livestock farming as a main activity or secondary activity was 22.5%. However a higher proportion of female-headed households (24.80%) considered livestock farming to be their main occupation compared to male headed households (22.55%). Having farm and non-farm income sources reduces the likelihood of a household becoming food insecure. In addition, non-farm income sources provide a diversified livelihood strategy thereby reducing the risk of food insecurity [60].

Marital status is believed to influence household food security. Acquiring a higher level of food security is a likely outcome among married household heads because male partners have better opportunities to access productive assets [12]. Furthermore, households with couples might pool resources together and generate more income compared to single-headed households [66]. Most household heads in the Nsanje district were married (71.50%). While around 21.25% were widowed, only approximately 7% were divorced or separated. There were

more male household heads (94.18%) in the married category compared to female heads (21.6%) in the same category. The majority of the female households heads were widowed (85.9%) compared to male household heads (14.11%).

The average household size for the sample was five persons per household, which is higher than the national average (4) for rural areas in Malawi [57]. On average, male-headed households had larger households (5 members) compared to female-headed households (4 members). The differences in household size between male and female headed households were statistically significant (see Appendix Table 7), an indication that the number of household members is greater for male-headed households than female headed households. Household size is an important determinant of household food security because it signifies the level of food requirements by members of the household. A larger household requires more food and it influences the choice and amount of food that can be consumed in the household [16]. In most circumstances, pressure is created on household food security with increases in food and non-food expenditures [49]. However, larger households might indicate the availability of productive labour that can be used to achieve household food security [50].

The main government food security and nutrition interventions include the Affordable Farm Input Subsidy Programme (AFIP), Scaling UP Nutrition Programme (SUN), Cash Transfer Projects, and Food for Work. Very few of the participating households (17%) benefited from these interventions. Only 10.50% of the households were beneficiaries of the AFIP. Of the total households that were beneficiaries of these interventions, only 4.50% and 1.5% benefited from cash transfer and food for work programmes, respectively. A very small percentage had benefited from SUN (0.50%). Among that small cohort of beneficiary households, approximately 71% were food secure. These results suggest that such programmes have increased food security and should thus be targeted to households that are vulnerable to food insecurity.

Level of women's empowerment in Malawian households

A woman is considered to have achieved a minimum level of empowerment if she has adequacy in 80% or more of the weighted indicators [9]. The average WELI score for the women in Nsanje was 0.3. This empowerment score implies that on average most women in the Nsanje district have achieved adequacy in only three of the 10 empowerment indicators. Approximately 0.75% of women in the Nsanje district scored 0.8; that is, they were adequate in 80% of the weighted indicators. In addition, 3% had a WELI score of 0; that is, they did not achieve adequacy in any weighted indicator. Furthermore, 17.75% of the women had a WELI score lower than 0.1. Similar observations have been made in Tanzania where only 2% of the women had a WELI score of 0.8; most had a score that fell between 0.3 and 0.4 [28]. These findings indicate that the empowerment levels of women in livestock dependent households are low.

The study also examined the WELI score for women from households that indicated livestock and crop farming as their primary occupations. The findings suggest that the average score for women who indicated that livestock farming was their primary occupation (0.4) was higher compared to those in cropping (0.3). These differences were not statistically significant.

Status of food security in Malawian households

To understand the status of food security in the Nsanje district, households were asked if they had consumed any of the 12 food groups in the 24 h prior to data collection. There is no cut off point to achieving adequate dietary diversity [63]. However, our study used the average number of food groups consumed by households in our sample as the cut-off point. Households that consumed food groups equal to or greater than the average consumption were considered food secure. The results show that the average consumption for the study population was four food groups in the 24 h preceding the survey. Using this criterion, the results show that more than half of the households had adequate dietary diversity (55.75%). Less than half (44.25%) of the households did not have adequate dietary diversity.

Further analysis was done to estimate the average, minimum and maximum number of food groups consumed by households. The minimum and maximum household dietary diversity scores in the sample were 0 and 11,

Table 3 Proportion of households consuming each food group

Food group	Frequency (n = 400)	Percentage
Cereals	393	98.25
Vegetables	372	93
Fish & fish products	225	56.25
Oils & fats	179	44.75
Legumes & nuts	134	33.50
Meat	93	23.25
Sugar/honey	79	19.75
Fruits	63	15.75
Eggs	60	15.04
Milk & milk products	25	6.25
White tubers	32	8
Miscellaneous	11	2.76

respectively. This finding means that in the 24 h preceding the survey, some households did not consume any food group. Other households consumed up to 11 food groups. Approximately 0.25% and 0.75% of the households had a score of 0 and 11, respectively.

Table 3 presents the percentage of households that consumed each of the 12 food groups. Most households had consumed cereals (98.25%), vegetables (93%), fish and fish products (56.25%) oils and fats (44.75%) and legumes and nuts (33.50%). The least consumed food groups included fruits (15.75%), white tubers (8%), and milk and milk products (6.25%). It is not surprising that most households in the Nsanje district had consumed cereals as the country's staple food is maize, which constitutes more than two thirds of typical household diets [35, 38]. The study data indicates that after cereals and vegetables, fish is one of the most commonly consumed food groups, and is the main source of protein in the Nsanje district. The district is close to the Shire River, which provides a source of cheap fish to surrounding communities. A study conducted in urban Malawian cities, also found that cereals, vegetables, oils and fats were the most commonly consumed food groups [48]. Similarly, a study conducted in Ethiopia found that cereals (96%), vegetables (81.6%), and oils and fats (75.4%) were the most commonly consumed food groups [73]. Results in Appendix Table 7 reveal disparities in household food insecurity between male and female headed households. Addai et al. [3], Gebre et al. [30], and Broussard [13], all arrived at a similar conclusion.

Differences between food insecure and food secure households

This section compares the HDDS, WELI scores and some socioeconomic variables, between food insecure and food secure households. The t-test statistics reveal significant differences for most variables.

The results in Table 4 show differences between food secure and food insecure households in relation to HDDS, WELI and other independent variables. The average HDDS values were 5.5 and 2.4 for food secure and food insecure households, respectively. These results indicate that food secure households consume almost three more food groups (or have more diverse diets) than their food insecure counterparts. Furthermore, on average, food secure households have a higher monthly income (MK 19,493.30) compared to food insecure households (MK 12,140.10). The average age for food insecure household heads is higher (47) than that of food secure households (45). Lastly, food secure households have more members (a larger household size) compared to food insecure households.

The results from the t-test show statistically significant differences between food secure and food insecure households for the following variables: HDDS, the WELI score, the age of household head, and monthly household income. These findings indicate that women from food secure households are more empowered in making livestock decisions compared to those from food insecure households. Furthermore, they indicate that households that are food secure have more diverse diets, have higher monthly incomes, and have younger household heads compared to households that are food insecure.

Effect of women's empowerment on household food security

This study employed a Tobit regression model to assess the effect of women's empowerment in livestock on household nutrition security. Table 5 presents the findings from the main model which addresses the third research question: "what is the impact of women's empowerment in livestock on household food security". HDDS was used as a measure of food security. The second column of Table 5 (Model 1) shows the results from the Tobit regression of the HDDS on the aggregate WELI score and the socio-demographic characteristics of the households. The third to the seventh column of Table 5 (i.e., Model 2 to Model 6) show results from regressing HDDS on each of the five dimensions of empowerment, as well as the socio-demographic variables. While Model 1 measured the impact of the aggregate WELI index on household food security, Models 2 to 6 were designed to

Table 4 Comparing HDDS, WELI and other model variables

Variable	Mean Food insecure	Mean Food secure	Mean difference	t-statistic
HDDS	2.4407 (0.6013)	5.5291 (1.6434)	− 3.088[a]	− 23.7671
WELI score	0.3158 (0.1735)	0.3843 (0.1893)	− 0.0685[a]	− 3.7285
Age of household head	47.5537 (16.5814)	44.1479 (14.6611)	3.406[b]	2.1771
Monthly income	12.1401 (13.2389)	19.4933 (21.2399)	− 7.353[a]	− 4.0262
Household size	5.1017 (1.9131)	5.3767 (1.9082)	− 0.275	− 1.4299

[a], [b] imply statistical significance at 1% and 5% respectively. Standard errors are in parenthesis

Table 5 Impact of women's empowerment on household food security

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
WELIscore	2.0466[a] (0.5224)					
Agricultural production decisions		10.5254[a] (1.5877)				
Nutrition decisions			1.7706[c] (1.0224)			
Income control				4.5146[c] (2.5669)		
Resources access & control					− 1.0758 (2.1686)	
Opportunities access & control						1.5062 (1.0606)
Education of household head	0.0047 (0.1472)	0.0593 (0.1413)	0.0449 (0.1493)	0.0637 (0.1484)	0.0808 (0.1493)	0.0630 (0.1487)
Age of household head	− 0.0043 (0.0067)	− 0.0028 (0.0064)	− 0.0035 (0.0068)	− 0.0025 (0.0067)	− 0.0017 (0.0067)	− 0.0017 (0.0067)
Household size	0.1111[b] (0.0524)	0.0709 (0.0513)	0.1252[b] (0.0531)	0.1437[a] (0.0531)	0.1323[b] (0.1323)	0.1281[b] (0.0532)
Marital status	0.1081 (0.2329)	− 0.0846 (0.2250)	0.0663 (0.2365)	0.0012 (0.2361)	0.0032 (0.2425)	0.0531 (0.2361)
Monthly income	0.0121[b] (0.0055)	0.0126[b] (0.0053)	0.0129[b] (0.0056)	0.0145[a] (0.0056)	0.0137[a] (0.0056)	0.0132[a] (0.0056)
Govt food security interventions	− 0.2021 (0.2521)	− 0.0846 (0.2250)	− 0.2931 (0.2556)	− 0.3447 (0.2527)	− 0.3695 (0.2539)	− 0.3559 (0.2529)
Livestock farming	− 0.4213[c] (0.2264)	− 0.4732[b] (0.2191)	− 0.4223[c] (0.2304)	− 0.4170[b] (0.2301)	− 0.3965[a] (0.2307)	− 0.3740 (0.2303)
Formal employment	2.6576[a] (0.8647)	2.8861[a] (0.8344)	2.7665[a] (0.8781)	2.8660[a] (0.8760)	2.9140[a] (0.8839)	2.8620[a] (0.8772)
Trading	− 0.7553[c] (0.4431)	− 0.5812 (0.4291)	− 0.7949 (0.4509)	− 0.7432[c] (0.4497)	− 0.7402 (0.4513)	− 0.72649 (0.4505)
Piece works	− 1.1157[a] (0.3625)	− 1.2276[a] (0.3508)	− 1.1606[a] (0.3684)	− 1.1312[b] (0.3679)	− 1.1484[a] (0.3711)	− 1.1048[a] (0.3689)
Cons	3.3199[a] (0.7122)	3.4320[a] (0.6738)	3.8219[a] (0.7084)	3.579[a] (0.7390)	4.0421[a] (0.7138)	3.9287[a] (0.7041)
Var (e. HDDS_N)	3.31989 (0.7122)	3.1869 (0.2258)	3.5141 (0.2489)	3.5128 (0.2489)	3.5380 (0.2506)	3.5226 (0.2495)
Pseudo R2	0.0394	0.0551	0.0323	0.0323	0.0307	0.0317

[a], [b], [c] imply statistical significance at 1%, 5% and 10%, respectively. Standard errors are in parenthesis

gauge both the impact of the individual empowerment dimensions on household food security and to determine which of the empowerment dimensions exerts the largest influence on household food security.

Results from the Tobit regression revealed that seven variables influence dietary diversity at varying levels of significance in the first model, Model 1. These variables include the WELI score, the household's monthly income, household size, livestock farming, formal employment, piecework, and trading. The likelihood ratio test was statistically significant, implying that the model fits significantly better than the null model. When the aggregate WELI score was disaggregated into its component dimensions in Models 2 to 6, it was observed that decisions related to agricultural production were most responsible for the impact of WELI on food security. Other dimensions like decisions related to nutrition and control over the use of income were marginally statistically significant. Among household socio-demographic variables, household size, monthly income, livestock farming, trading, formal employment, and piecework were statistically significant across most models.

The findings from Model 1 show a positive and statistically significant WELI score, implying that if a woman becomes empowered, the chance of a household consuming a diversified diet increases. This finding is consistent with literature that connects women's empowerment to the status of family nutrition [58]. A woman who has the power to make decisions about livestock production and marketing, as well as income, is more likely to decide on the quantity and quality of food to purchase for the household, thereby ensuring better household nutrition [58, 65]. Similarly, Kaluwa et al. [40] have reported that with women's agency comes improved decision-making related to agricultural productivity, food security, and livelihoods, as well as greater control over resources. To develop evidence-based food security and other development policies, it is important to measure women's empowerment.

Models 2 to 6 measure the association between specific dimensions of WELI on the dietary diversity index. The study found that decisions related to agricultural production had a statistically significant positive effect on HDDS in the second model. This finding means that a woman with higher agency or decision-making power and autonomy in crops grown and livestock kept for household consumption and sale increases the chances of the household consuming a more diverse diet. These findings are consistent with prior literature which indicates that women's involvement in decisions related to agricultural

production (the ability to set aside land for farming purposes) is associated with improved nutrition of their families as they are mostly responsible for their household's food needs [5, 44]. Their participation enables them to select diverse crops and livestock/products for their household's consumption. It also strengthens their intra-household ability and bargaining power in deciding how to use the produce and income generated from the sale of the produce [5, 10, 44].

Furthermore, the results show that decisions related to nutrition have a positive and statistically significant association with household dietary diversity in the third model. This result implies that a woman with sole or joint decision-making on how much output from farm and non-farm economic activities to save for household consumption, will likely increase the chances of the household consuming a more diverse diet. This finding is consistent with literature that indicates that women care more about their family's nutrition than the men [58]. For instance, women are concerned with making sure that their children consume sufficient calories and that they have a diverse diet; therefore, any chance to decide how much to keep aside for household consumption will have a favourable effect upon the family members' nutritional needs.

Lastly, as illustrated in Model 4, control over the use of income had a positive effect on household dietary diversity. Women who had joint or sole control over the use of income obtained from farm and non-farm activities had more diverse diets. Women's increased access and control over income is believed to increase both their self-esteem and bargaining power, which may lead to greater household food security [70]. Furthermore, unlike men, women spend a large proportion of their income on food for the household [59].

Some socio-demographic characteristics are statistically significant. For example, household monthly income had a significantly positive effect on HDDS, suggesting that an increase in the household income increases the likelihood of a household having a more diverse diet. These findings are consistent with literature which considers income to be a crucial factor in ensuring household dietary diversity by providing households with the ability to procure the right quantities and qualities of food [4, 54].

Similarly, household size had a statistically significant positive effect on HDDS. This finding implies that as the number of household members increases, so too does the likelihood of the household consuming a diverse diet. This finding contradicts most literature which argue that larger households are more likely to experience food insecurity [3, 8, 49]. However, some studies provide support for these findings, indicating that if more household members are productive, then a larger household (size) might increase the availability of productive labour, leading to improvements in a household's food security status [50].

Furthermore, formal employment had a significantly positive effect on HDDS. In short, being in formal employment increases the likelihood that members of a household will have a more diverse diet when compared to those who are crop farmers. Formal employment provides a stable income that can be used to procure the right quantities and qualities of food. In contrast, income from crop farming is mostly seasonal and subject to greater uncertainty. Livestock farming, trading and piecework had significant negative effects on HDDS. Households that depend on these occupations are less likely to consume diverse diets compared to households that depend on crop farming. These results are not surprising considering that most households that rely on livestock farming in the district are subsistence farmers and occasionally sell livestock on a need basis (e.g., to pay school fees) as a coping strategy in times of crisis; these activities rarely meet a household's food requirements. Furthermore, piecework and trading do not guarantee a stable income; both are typically low paying compared to crop farming. In addition, landless households who exchange their labour to meet food requirements often engage in such occupations.

The researchers re-estimated Models 1 to 6 using OLS to ensure the robustness of the study results. The Tobit model is similar to a linear regression model with the added capacity to handle censored data. Both Tobit and OLS assume a normal distribution. Results from the re-estimated models are presented in Appendix Table 8. The results are almost identical to the Tobit regression results.

Marginal effects of women's empowerment on household food security

The researchers estimated three types of marginal effects for the Tobit model to understand the direct effects of the changes in the independent variables on HDDS. The first type was the change on the unconditional expected value of HDDS (E ($y*0<y*<12$)). This marginal effect measures changes in the unobserved values of HDDS with respect to changes in the independent variables. The second marginal effect was on the probability of the HDDS being uncensored (Pr ($0<y*<12$)). This marginal effect measures changes in the independent variables on the probability that HDDS was not observed on a limited range (censored). Lastly, the researchers computed the marginal effects of the censored expected value of

Table 6 Marginal effects of women's empowerment on household food security

Variable	M_1	M_2	M_3
WELI score	1.8663[a] (0.4737)	0.0453[b] (0.0146)	2.0090[a] (0.5112)
Education of household head	0.0043 (0.1342)	0.0001 (0.0032)	0.0046 (0.1445)
Age of household head	− 0.0039 (0.0061)	− 0.0001 (0.0001)	− 0.0042 (0.0065)
Household size	0.1013[b] (0.0477)	0.0025[b] (0.0012)	0.1090[b] (0.0514)
Marital status	0.0986 (0.2124)	0.0024 (0.0052)	0.1061 (0.2286)
Monthly income	0.01103[b] (0.0050)	0.0003[b] (0.0001)	0.0119[b] (0.0054)
Government food security interventions	− 0.1843 (0.2298)	− 0.0044 (0.0056)	− 0.1984 (0.2474)
Livestock farming	− 0.3858[c] (0.2055)	− 0.0088[c] (0.0056)	− -0.4144[c] (0.2221)
Formal employment	2.5761[b] (0.8341)	0.0072 (0.0064)	2.6465[b] (0.8603)
Piecework	− 0.9863[a] (0.3044)	− 0.0351[b] (0.0178)	− 1.0860[b] (0.3469)
Trading	− 0.6809[c] (0.3862)	− 0.0193 (0.0160)	− 0.7396[b] (0.4296)

M_1 (Means of marginal effect on the unconditional expected value of HDDS), M_2 (marginal effects of the probability of being uncensored) and M_3 (marginal effects of the censored expected value).

[a], [b], [c] imply statistical significance at 1%, 5% and 10%, respectively. Standard errors are in parenthesis.

HDDS (E (y∗)). They describe changes in the observed values of HDDS with respect to the independent variables. Cong [14] and Ng'ombe and Boyer [55] provide explanations of the models needed to estimate these marginal effects. Table 6 shows the three marginal effects.

The marginal effects of the following variables were statistically significant across all models: the WELI score, monthly household income, household size, livestock farming, formal employment, piecework, and trading. The magnitude of change in food security induced by empowering women was large. Both M_1 and M_3 suggest that a marginal increase in women's empowerment will increase dietary diversity by up to two additional food groups. Similarly, M_2 reveals that a 1% increase in women's empowerment will increase dietary diversity by 4.5%. Although the marginal effects are negative at the level (M_1 and M_3), the probability change shown in M_2 is not statistically significant. While having livestock farming as the main occupation appears to lower dietary diversity relative to crop farming (as the main occupation), women are currently not empowered in livestock decision-making. In this study, only approximately 1% of women in the study households (3 out of 400) were considered empowered. As the WELI score indicates, the full positive effect of livestock farming will be realised when women are empowered in terms of decision-making related to the livestock value chain. Other explanatory variables with relatively larger magnitudes of change were engagement in piecework and taking on formal employment.

Conclusions and recommendations

The study was designed to understand household food security status and women's empowerment levels among livestock-dependent households in rural Malawi. More specifically, the study sought to determine whether women's empowerment in livestock would influence household food security. The results show that most households consumed three or more food groups. Overall, women in the Nsanje district are disempowered as they only managed to achieve adequacy in three out of 10 WELI indicators. The empowerment of women in livestock decision-making plays a significant role in ensuring household food security. Furthermore, separating the WELI into component dimensions demonstrates that agricultural production decisions, nutrition-related decisions, and income control and use play a significant role in ensuring household dietary diversity. In addition to women's empowerment dimensions, factors such as household income, household size, and occupation of household head play a significant role in ensuring household dietary diversity.

Malawi may achieve the Food Security priority of NAP by empowering women in livestock. NAP is a Malawi government plan for sustainable agricultural transformation. Its aim is to enable significant agricultural sector growth, the expansion of the farming household's income and the provision of improved food security for all Malawians. Over the past years, most government policies and programs have emphasised increased maize production by promoting fertilizer intensification and encouraging the adoption of improved seed varieties. However, such efforts have failed to improve food security as diets remain undiversified. In addition, while empowering women is one of the priority areas of the NAP, it is only limited to increasing their access to productive resources. These policy aspirations could be

achieved through increasing women's agency in agricultural production.

The study recommends that government and non-governmental aid organizations implement food security interventions that target women's agency in livestock production and nutrition decisions; such changes would improve food security in low income and lower middle-income households. Furthermore, there is need for the sensitization of households on the importance of increasing women's agricultural and nutrition decision-making. In addition, the government and private sector could consider financial inclusion mechanisms for household food security. Lastly, women's empowerment in livestock is an important area for policy intervention in food security since it results in increased dietary diversity.

This study has several limitations. One limitation relates to the analytical approach. Endogeneity in WELI, the key explanatory variable cannot be ruled out due to the possibility that there are unobserved characteristics that affect both WELI and household food security. However, the primary data used in this study was collected long before the issue arose. Hence an appropriate instrument was not identified and included in the survey. Consequently, the analysis does not account for this potential problem. Another limitation relates to the use of five of six empowerment dimensions in computing WELI. While the researchers believe that this does not influence the results, future studies should consider using the complete complement of the WELI empowerment dimensions.

Appendix

See Tables 7, 8

Table 7 Gender differences in model interval variables

Variable	Mean		Difference	t-stat
	Male HH	Female HH		
Age	43.79	49.76	− 5.9709	− 3.5981[a]
Household income	16,988.36	14,592.00	2396.36	1.2025
Household size	5.3963	4.944	0.4523	2.2028[b]
WELI score	0.3596	0.3416	0.0180	0.9017
HDDS	4.320	3.816	0.504	2.3430[b]

[a], [b], [c] imply statistical significance at 1% and %, respectively

Table 8 OLS estimation of women's empowerment on household food security

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
WELIscore	2.0451[a] (0.5292)					
Agricultural production decisions		10.5559[a] (1.6081)				
Nutrition decisions			1.7603[c] (1.0358)			
Income control				4.5313[c] (2.6006)		
Resources access & control					− 1.0942 (2.1970)	
Opportunities access & control						1.4976 (1.0745)
Education of household head	− 0.0013 (0.1490)	0.05417 (0.1431)	0.0389 (0.1512)	0.0577 (0.1503)	0.0748 (0.1512)	0.0569 (0.1506)
Age of household head	− 0.0045 (0.0068)	− 0.0030 (0.0065)	− 0.0038 (0.0069)	− 0.0028 (0.0068)	− 0.0019 (0.0069)	− 0.0019 (0.0068)
Household size	0.1096[b] (0.0531)	0.0695 (0.05193)	0.1237[b] (0.0539)	0.1423[a] (0.0538)	0.1308[b] (0.0540)	0.1266[b] (0.0538)
Marital status	0.1134 (0.2359)	− 0.0805 (0.2279)	0.0717 (0.2396)	0.0066 (0.2392)	0.0082 (0.2457)	0.0505 (0.2391)
Monthly income	0.0122[b] (0.0056)	0.0127[b] (0.0054)	0.0129[b] (0.0057)	0.0146[b] (0.0057)	0.0139[b] (0.0057)	0.0133[b] (0.0057)
Govt Food security Interventions	− 0.2007 (0.2554)	− 0.1018 (0.2468)	− 0.2919 (0.2589)	− 0.3431 (0.2560)	− 0.3681 (0.2573)	− 0.3544 (0.2562)
Livestock farming	− 0.4233[c] (0.2294)	− 0.4751[b] (0.2219)	− 0.4243[c] (0.2334)	− 0.4191[c] (0.2332)	− 0.3987[c] (0.2338)	− 0.3762 (0.2334)
Formal employment	2.6550[a] (0.8760)	2.8839[a] (0.8453)	2.7643[a] (0.8897)	2.8633[a] (0.8875)	2.9119[a] (0.8955)	2.8592[a] (0.8888)
Trading	− 0.7596[c] (0.4489)	− 0.5845 (0.4347)	− 0.7990[c] (0.4569)	− 0.7476 (0.4556)	− 0.7446 (0.4573)	− 0.7310 (0.4564)
Piece works	− 1.1172[a] (0.3673)	− 1.2291[a] (0.3554)	− 1.1619[a] (0.3733)	− 1.1328[a] (0.3728)	− 1.1503[a] (0.3706)	− 1.1065[a] (0.3737)
Cons	3.3437[a] (0.7212)	3.4498[a] (0.6824)	3.8469[a] (0.7174)	3.6009[a] (0.7485)	4.0668[a] (0.7229)	3.9529[a] (0.7130)
R2	0.1538	0.2091	0.1277	0.1281	0.1218	0.1256

[a], [b], [c] imply statistical significance at 1%, 5% and 10%, respectively. Standard errors are in parenthesis

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Author contributions
The study was conceptualized by TM, SK and NNR. TM led the development of the questionnaire, data collection and analysis, and wrote the initial draft, with supervision provided by SK and NNR. SK and NNR reviewed and edited the initial draft. SK edited the final manuscript. All authors approved the final manuscript.

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Availability of data and materials
The datasets are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
Lincoln University Ethics Committee reviewed and approved the ethics application for this study. Informed consent was sought from study participants in Malawi, and those who gave consent were told about the purpose of the study and advised that they could withdraw from participation at any time during the interview or refuse to answer any question they deemed inappropriate.

Consent for publication
All authors agree and consent for the article to be published.

Competing interests
The authors declare no competing interests.

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