How women's empowerment affects farm production and dietary quality in East Africa

Alliance

Bioversity International

CIAT
International Center for Tropical Agriculture
Since 1967 Science to cultivate change

CGIAR RESEARCH PROGRAM ON Agriculture for Nutrition and Health
Led by IFPRI

CGIAR
Science for a food-secure future

The **Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT)** delivers research-based solutions that address the global crises of malnutrition, climate change, biodiversity loss and environmental degradation.

The **Alliance** focuses on the nexus of agriculture, nutrition and environment. We work with local, national and multinational partners across Africa, Asia, Latin America and the Caribbean, and with the public and private sectors and civil society. With novel partnerships, the Alliance generates evidence and mainstreams innovations to transform food systems and landscapes so that they sustain the planet, drive prosperity and nourish people.

The **Alliance** is part of **CGIAR**, the world's largest agricultural research and innovation partnership for a food-secure future dedicated to reducing poverty, enhancing food and nutrition security, and improving natural resources.

https://alliancebioversityciat.org **www.cgiar.org**

How women's empowerment affects farm production and dietary quality in East Africa

Christine G.K.Chege
Kevin Onyango
Elijah N. Muange
Matthias Jäger

Alliance
Bioversity International
CIAT
International Center for Tropical Agriculture
Since 1967 Science to cultivate change
CGIAR
RESEARCH PROGRAM ON
Agriculture for Nutrition and Health
Led by IFPRI
CGIAR
Science for a food-secure future

Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT)
Africa Hub
c/o *icipe* (International Centre of Insect Physiology and Ecology)
Duduville Campus Off Kasarani Road
P.O. Box 823-00621
Nairobi, Kenya
Telephone: (+254) 0709134000
Website: https://alliancebioversityciat.org/

Citation

Chege CGK; Onyango K; Muange EN; Jäger M. 2021. How women's empowerment affects farm production and dietary quality in East Africa. CIAT Publication No. 520. International Center for Tropical Agriculture (CIAT). Nairobi, Kenya. 24 p.

About the authors

Christine Chege, Alliance of Bioversity International and CIAT, Africa Hub, Nairobi, Kenya. Tel.: (+254)721475770 c.chege@cgiar.org

Kevin Onyango, Alliance of Bioversity International and CIAT, Africa Hub, Nairobi, Kenya. k.onyango@cgiar.org

Elijah N. Muange, Machakos University, Department of Agribusiness Management, Machakos, Kenya. e_muange@yahoo.com

Matthias Jäger, Alliance of Bioversity International and CIAT, Regional Office for the Americas, Cali, Colombia (at the time of research). Current affiliation is the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH, (GIZ) Germany. matthias.jaeger@giz.de

November 2021

Abstract

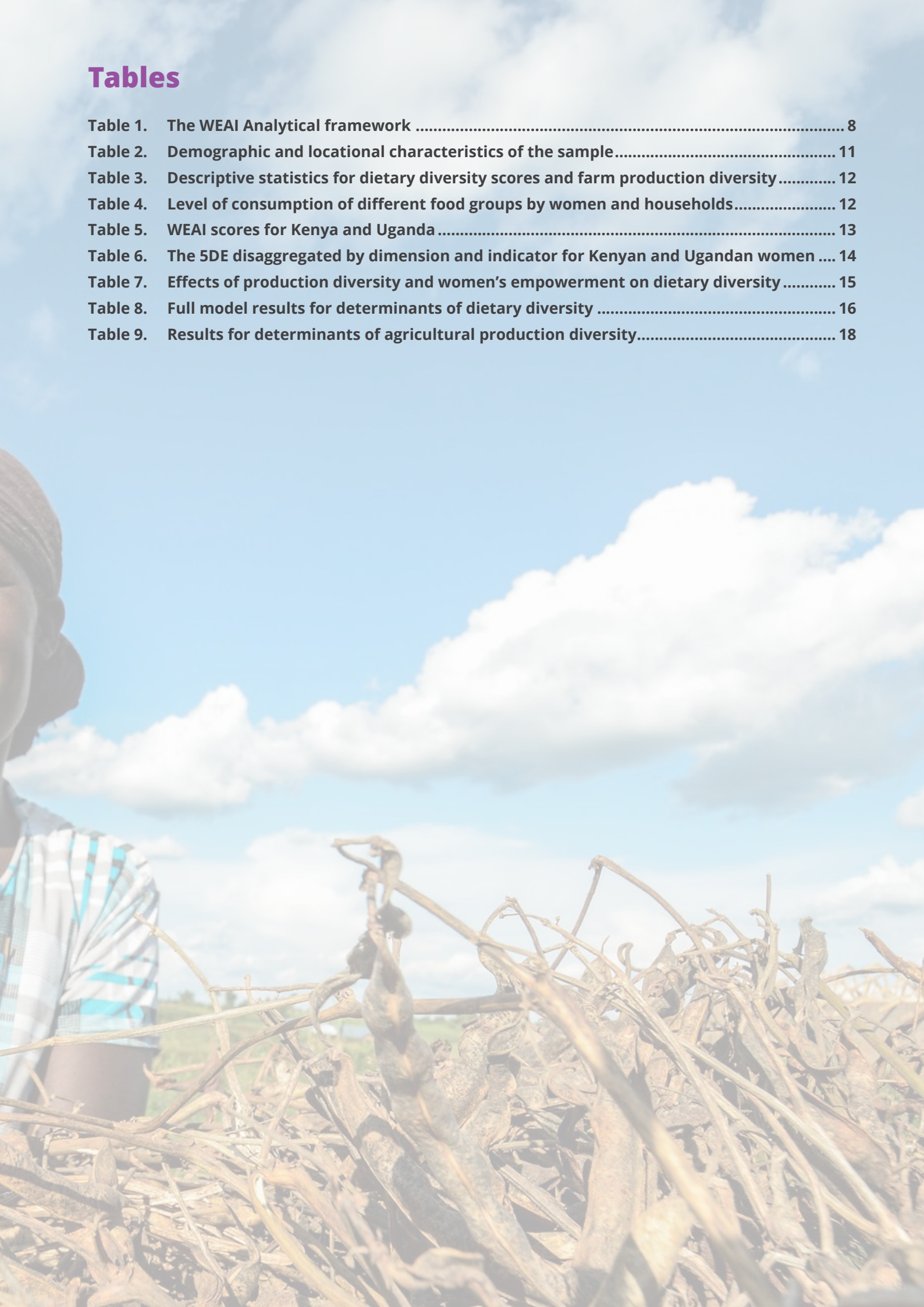
Malnutrition remains a key global challenge constraining social and economic development in most developing countries. Although women can play an important role in improving household diet quality, their participation is constrained by limited access to productive resources. Women's empowerment in agriculture is a viable strategy for improving dietary quality, but investigations on the important type(s) of empowerment are inconclusive. Using cross-sectional data collected from Uganda and Kenya, and analyzed using three-stage least squares, this paper investigates women's empowerment and its effect on dietary diversity. Women's empowerment is measured using the Women's Empowerment in Agriculture Index (WEAI). We find that control over use of income, autonomy in production and inadequate leisure time, are the major WEAI indicators contributing to women's disempowerment. Regression analysis shows that farm production diversity positively influences dietary diversity, but only the production autonomy indicator has a positive and significant effect on farm production diversity, implying that women's empowerment has an indirect positive effect on dietary diversity – through the farm production diversity pathway. Study implications are also explained.

Keywords

Women's empowerment; production diversity; dietary diversity; Africa; developing countries.

Contents

Tables



Introduction

Hunger and malnutrition are key global challenges constraining social and economic development in many developing countries. Although concerted efforts by the global community during the last two and half decades have significantly reduced hunger and malnutrition, as many as 815 million people worldwide remain undernourished (FAO, IFAD, UNICEF, WFP, and WHO, 2020). When compared with developed countries, the hunger and malnutrition burden is higher in developing countries, with sub-Saharan Africa (SSA) recording the highest rates.

Dietary diversification, a qualitative measure of access to a variety of foods, has been identified as a possible remedy for malnutrition (Sonntag *et al*., 2014). Agricultural production is key source of dietary diversity, particularly for rural people whose mainstay is farming. Rural people often eat most of what they produce. Therefore, producing a wider diversity of crops would potentially lead to consume a more diverse diet by those households (Pender and Alemu, 2007). Further, women can play an important role in improving dietary diversity in households because they are the main producers of food (Verhart *et al*., 2015). When compared with men however, their participation is constrained by limited access to productive resources such as land and capital, and services (FAO, 2016). The skewed participation in farm production activities to the disadvantage of women has been identified as an impediment to achieving food and nutritional security (The World Bank, FAO & IFAD, 2009). Hence, closing this gender gap could be a catalyst for improving both agricultural productivity and nutritional outcomes (Raney *et al*., 2011).

Empowering women is touted as a viable strategy for improving agricultural production and food and nutritional security, more so in sub-Saharan Africa (Farnworth *et al*, 2013). Thus, significant efforts and resources are increasingly being devoted to women's empowerment in a bid to identify and alleviate constraints faced by women in agriculture (Sraboni, *et al*., 2013; Malapit *et al*., 2014). This led to the development of the Women's Empowerment in Agriculture Index (WEAI) in 2012, which is a survey-based measure for assessing the empowerment, agency, and inclusion of women in the agricultural sector, in an effort to identify ways to overcome those obstacles and constraints (Alkire *et al*., 2012).

Over the last few years, researchers have investigated the link between women's empowerment and nutritional outcomes, with mixed results. For instance, Sraboni *et al*. (2015) studied women's empowerment in relation to agriculture and food security in Bangladesh and found that women's empowerment was positively associated with calorie availability and dietary diversity at the household level. Similarly, Cunningham *et al*. (2015) assessed the relationship between women's empowerment in agriculture and child nutritional status in rural Nepal, and reported a positive association between the women's empowerment and children nutrition indicators (length-for-age Z-scores (LAZ)[1]). However, women's empowerment was not correlated with the weight-for-length Z-scores (WLZ). In extending these studies, Malapit and Quisumbing (2015) investigated the linkages between specific domains of women's empowerment in agriculture and nutritional outcomes in Ghana. They found that dietary diversity and other improved nutritional outcomes correlated with empowerment in some, but not all domains. Other studies conducted in Ethiopia showed the importance of women's empowerment in determining child health (Abreha *et al*., 2020; Jones *et al*., 2019; Kuche *et al*., 2020). Studies investigating pathways through which women's empowerment in agriculture could translate to improved nutritional outcomes are rare. Yet, analyzing these pathways could reveal an indirect role of women's empowerment in improving nutritional outcomes that may not be detected if analyzed directly. Recent works by several authors identify a significant correlation between agricultural production diversity and dietary diversity (Jones *et al*., 2014; Sibhatu *et al*., 2018; *et al*., 2015). Hence, agricultural production diversity could be considered an important pathway for improved dietary quality and nutritional outcomes.

1 See more information on Length for Age Z-scores here: https://www.who.int/tools/child-growth-standards/standards/length-height-for-age

Study objectives

This study adds to the existing literature by investigating the effect of women's empowerment on the dietary diversity of women and households in general, while controlling for its effect on farm production diversity. The study uses survey data collected from Uganda and Kenya which are among sub-Saharan African countries with Global Hunger Index values that place them in the "serious" category on the hunger severity scale (Global Hunger Index, 2020).

The rest of the paper is organized as follows. Section two outlines the materials and methods used, section three presents study results and discussions, and section four offers the conclusion.

Material and methods

This study aims to increase understanding of the relationship between women's empowerment and dietary quality among smallholder farm households and the underlying pathways of influence. In this section we start by describing the surveys conducted in Kenya and Uganda and the sampling strategy used. Afterwards, we explain the different indictors used in the analysis, before presenting the analytical framework used.

Study area and sampling strategy

We use data from studies conducted in Kenya and Uganda in 2016/2017. In both countries, cross-sectional household surveys were conducted, targeting smallholder farm households. The sampling strategy was based on a multistage process. In Kenya, Kiambu and Nakuru Counties were identified as the vegetable and bean producing areas respectively. Kiambu is relatively close to Nairobi and is the capital's main source of horticultural produce (Rao & Qaim, 2011; Chege *et al.*, 2015). Most farmers in Kiambu produce rain-fed vegetables most months of the year and only irrigate during dry seasons. They produce a range of varieties of exotic vegetables such as kales, broccoli, and lettuce, and indigenous vegetables such as black nightshade and amaranth. Nakuru County on the other hand is one of the main bean-producing regions in Kenya. Smallholder bean farmers in the county produce beans for both subsistence and commercial purposes.

In Uganda, Wakiso and Rakai Districts were selected for the study. Wakiso is close to Kampala city and is one of the main vegetable sources for the city, while Rakai is among the main bean-producing zones in Uganda.

Once the counties and districts were selected, information from the County and District agricultural officers was used to purposively select two main vegetable- and bean-producing Wards in each county and district. A total of 594 households were interviewed in Kenya and Uganda.

The aim of the survey was to elicit the level of women's empowerment at the household level using the Women's empowerment in Agriculture Index (WEAI). The survey instrument consisted of three main sections. The first section was on household demographics, farm production activities, household nutrition, and household sources of income. The targeted respondent for this section was mainly the person who had information on farm production activities and food consumption. Mostly, this section was answered by both the household head and spouse. Sections two and three of the questionnaire were on WEAI. These sections were responded to only by households that had at least one adult woman participating in household decision-making. Therefore, only households with male and female adults, or only female adults were eligible for interview. Overall, 77 per cent of the sampled households had both male and female adults who participate in the household decision making, 18 per cent had female adults only, while 5 per cent had male adults only. In households where both adult male and female decision-makers were present, the two were interviewed separately so that the female adult answered section 2 of the questionnaire on WEAI, and the adult male answered same WEAI questions under Section 3 of the questionnaire. In households where there was no male adult in the household, the female adult answered section 2 of the questionnaire.

The survey also collected data on household food consumption of food by household members using 12 food groups over a 7-day recall period, as well as consumption by women of reproductive age using a 24-hour recall period. A wide range of socioeconomic data was collected including income sources of the households and details of agricultural production.

Women's Empowerment in Agriculture Index (WEAI)

This study employed the Women's Empowerment in Agriculture Index (WEAI) framework to assess women's empowerment in agriculture. The WEAI is an aggregate measure, consisting of two sub-indexes (Malapit *et al.*, 2015). The first sub-index measures the extent to which women are empowered in five domains of empowerment (5DE) in agriculture: production; resources; income; leadership, and time. Data requirements for calculation of WEAI and how they were generated and processed are summarized in Table 1. The 5DE score is the weighted average of indicators defined in Table 1. It depicts the number of domains in which women are empowered and accounts for 90 percent of the weighting within the WEAI (Sraboni *et al.*, 2013).

Table 1. The WEAI Analytical framework.

Domains	Description of the domains	Indicators	Weight
Production	Concerns decisions about agricultural production and refers to sole or joint decision making about food and cash crop farming, livestock and fisheries, and autonomy in agricultural production, with no judgment on whether sole or joint decision-making was better or reflected greater empowerment.	Input in productive decisions	1/10
		Autonomy in production	1/10
Resources	Concerns ownership of, access to, and decision-making power about productive resources such as land, livestock, agricultural equipment, consumer durables, and credit.	Ownership of assets	1/15
		Access to and decisions on credit	1/15
		Purchase, sale, or transfer of assets	1/15
Income	Concerns sole or joint control over the use of income and expenditures.	Control over use of income	1/5
Leadership	Concerns leadership in the community, measured by membership in economic or social groups and comfort speaking in public.	Group membership	1/10
		Speaking in Public	1/10
Time	This dimension concerns the allocation of time to productive and domestic tasks and satisfaction with the time available for leisure activities.	Workload	1/10
		Leisure	1/10

Source: Adapted from Alkire et al. (2012) Table 2.1.

The second sub-index, Gender Parity Index (GPI), is an indication of gender parity within surveyed households, measured as the percentage of women who are equally as empowered as the men in their households. It indicates inequality in the 5DE profiles between the primary adult male and female in each household (Sraboni *et al.*, 2013). Gender parity is achieved for a woman whose achievements in the five domains are at least as high as those of the primary adult male in her household.

Nutritional indicators

Many indicators exist for measuring nutritional status of individuals and households. Nutritional indicators assessed in this study are dietary diversity scores (DDS), measured at the household level and for women of reproductive age (15-49 years). Dietary diversity qualitatively measures household access to a variety of foods and is an indirect measure for nutrient adequacy of human diets owing to its correlation with macro- and micronutrient content in diets (Kennedy *et al.*, 2011). In this study, we use two types of dietary diversity scores: household dietary diversity score and minimum dietary diversity for women of reproductive age (15–49 years).

The household dietary diversity score (HDDS) is a count of food groups consumed by the household during the recall period and is used to assess access to dietary quality and quantity (Leroy *et al.*, 2015). We use the 12 groups of foods recommended by FAO and others to calculate the HDDS (Swindale & Blinsky, 2006; Kennedy, *et al.*, 2011). The 12 groups are: cereals; white tubers and roots; legumes, nuts, and seeds; vegetables; fruits; meat; eggs; fish and fish products; milk and milk products; sweets and sugars; oils and fats; and spices, condiments, and beverages. Data on consumption of these 12 food groups was collected using a 7-day recall period. A household with higher HDDS is deemed to have a better dietary quality than one with less diversity.

The Minimum Dietary Diversity for Women (MDD-W) is used to assess dietary diversity of women of reproductive age (FAO and FHI 360, 2016). This indicator better accounts for micronutrient supply, and it is calculated based on 10 food groups: all starchy staple foods (grains, white roots and tubers, and plantains); pulses (beans, peas and lentils); nuts and seeds; dairy products; flesh foods; eggs; vitamin-A rich dark green leafy vegetables; other vitamin-A rich vegetables and fruits; other vegetables; and other fruits. Consumption of more food groups is strongly associated with micronutrient adequacy. Consumption of food by the target women was collected using a 24-hour recall period.

Production diversity indicator

An indicator that is commonly used to assess the level of production diversity is a simple count of different types of commodities (species) produced (Sibhatu & Qaim, 2018; Sibhatu *et al.* 2015). It applies to production of food commodities because non-food cash crops do not have any nutritional value. Production of several food crops of the same food group, or botanical family or genus may not have as large a contribution to dietary and nutrition diversity compared to production of several foods from a diverse range of species (e.g. a farm producing maize, rice, wheat, and cassava would have less contribution to diet diversity compared to production of maize, vegetables, fruits, and sweet potatoes). This is because commodities from similar food group tend to provide a similar range of nutrients whereas those from different food groups have a wide range of nutrients.

In this study, we calculate farm production diversity using a simple count of commodity species produced by the study households grouped into different food groups (Koppmair *et al.*, 2017; Sibhatu & Qaim, 2015). The commodities are grouped into 16 food groups as presented by Kennedy *et al.*, (2011).

Econometric framework

To estimate the effect of women's empowerment, the following econometric model was used:

$$DDS_i = \beta_0 + \beta_1 APD_i + \sum_{j=1}^{J} \beta_j WED_{ji} + \sum_{k=1}^{K} \beta_k Hh_{ki} + \sum_{l=1}^{L} \beta_l Mkt_{li} + \sum_{m=1}^{M} \beta_m Loc_{mi} + e_i \quad (1)$$

Where for each household (i), *DDS* is the dietary diversity score (HDDS or MDD-W) measured as earlier described; *APD* is the agricultural production diversity, measured as the number of food groups produced by a farmer during the survey year, based on the grouping by Kennedy *et al*. (2011); *WED* is a vector of women's empowerment domain indicators measured as shown in Table 2; *Hh* is a vector of household characteristics including household head's age, sex and level of education, wealth indicator variables and household size; *Mkt* is a vector of market variables such as distance to nearest supermarket/ other market, and participation in agricultural (crop and livestock) markets; *Loc* is a vector of location (study region) dummies; and e is the normally distributed error term. Represented by β are unknown parameters to be estimated by the analysis. A detailed list of the variables used in this analysis is provided in the results section.

The variable *APD* is potentially endogenous in equation (1). Moreover, we hypothesize that production diversity is an important pathway through which women's empowerment in agriculture could be linked to dietary quality. Hence, we used a three-stage estimation procedure to analyse the effect of different domains of women's empowerment on both production diversity and dietary diversity.

In the three-stage model, agricultural production diversity was estimated as follows:

$$APD_i = \partial_0 + \sum_{j=1}^{J} \partial_j WED_{ji} + \sum_{k=1}^{K} \partial_k Hh_{ki} + \sum_{l=1}^{L} \partial_l Mkt_{li} + \sum_{m=1}^{M} \partial_m Loc_{mi} \sum_{p=1}^{P} \partial_p Inst_{pi} + \mu_i \quad (2)$$

Where $\boldsymbol{\mu}$ is a normally distributed error term, and the other variables are as defined in equation (1). Denoted by $\boldsymbol{\partial}$, are unknown parameters to be estimated, representing the effect of model variables in production diversity. Equations (1) and (2) were estimated simultaneously and two instruments (denoted by *Inst* in equation 2) were used. The instruments were the size of land owned by a surveyed household (acres) and altitude of homestead location (meters above sea level). Most smallholder farmers reside in their farms, hence geographical location of the homestead closely approximates that of the farm. Whereas the two variables could directly influence farm production diversity, we do not expect them to be directly correlated with the number of food groups consumed by women and households.

Results and discussion

Descriptive characteristics of the sample

Demographic and location characteristics of the sampled households are shown in Table 2. The mean age of household head was 50 years, while the level of education averaged 8.7 years (just completed primary school). About 30 per cent of interviewed women were from female-headed households comprising of 5 members on average. Although most of the surveyed households engaged in farming as the main occupation, 13 per cent of them also earned an off-farm income that can be hypothesized to provide households with the purchasing power for acquiring diversified foodstuffs. Slightly more than a half of the sample households lived in main houses with a modern floor (concrete, wooden or tiled), while the rest lived in houses with earthen floors. Due to the cost associated with fitting modern floors, we treat households with such floors as being wealthier than those with earthen floors and hence more likely to afford diversified diets.

Table 2. Demographic and locational characteristics of the sample.

Variable	Mean (N=594)	SD	Min	Max
Household characteristics				
Age of household head (years)	50.28	13.67	19	90
Education of household head (years completed)	8.66	4.26	0	23
Female-headed household (%)	30.00	-	0	1
Household size	5.61	2.35	1	18
Household earned off-farm income (%)	12.75	-	0	1
House has modern floor (%)	55.00	-	0	1
Agricultural market participation (%)	76.00	-	0	1
Distance to supermarket (km)	5.50	7.88	0	80
Region (Base=Kiambu)				
Nakuru (proportion of sample)	0.30	0.46	0	1
Rakai (proportion of sample)	0.27	0.44	0	1
Wakiso (proportion of sample)	0.15	0.36	0	1
Instruments				
Altitude (x1000 m)	1.83	0.54	0.34	2.41
Land size (acres)	1.06	1.09	0.03	8.5

About three-quarters of the interviewed households participated in agricultural markets as sellers of crop or livestock products. We hypothesize that such farmers earned more income than those who did not participate in markets, and therefore increased their likelihood of consuming more diversified diets. Distances to the nearest supermarkets averaged at 5.5 km. It was hypothesized that households living closer to supermarkets had a higher chance of accessing more diverse foodstuffs. Of the sample farmers, 30 per cent were from Nakuru, 27 per cent from Rakai, 15 per cent from Wakiso and 28 per cent from Kiambu. The sampled farms were located at elevations ranging from 340-2410 meters above sea level, and an average household owned 1.06 acres of land.

Dietary diversity scores and production diversity

Table 3 presents the dietary diversity scores and agricultural production diversity. The minimum dietary diversity for women (MDD-W) averaged at 5.61 out of a possible 10 (60% of the food groups). About 48 per cent of women consumed 5 or less food groups, hence failing to achieve the required minimum dietary diversity (FAO and FHI360, 2016). Average dietary diversity score at the household level was 8.97 out of a possible 12 (75% of the food groups). The average farm production diversity, defined here as the number food groups produced as per the categorization provided by FAO for measuring dietary diversity (Kennedy *et al.*, 2011), was 5.7 out of a possible 16, with some farmers producing up to 10 and others as few as one food group.

Table 3. Descriptive statistics for dietary diversity scores and farm production diversity.

Variable	Mean	SD	Min	Max
Minimum dietary diversity for women (MDD-W) (n=485)	5.61	1.61	1	10
Percentage of women not achieving MDD-W	47.80	-	0	1
Household dietary diversity score (HDDS) (n=594)	8.97	1.64	2	12
Farm production diversity (n=594)	5.68	1.67	1	10

The proportion of respondents that consumed each food group is shown in Table 4. Since grouping of foods when assessing MDD-W is different from that of HDDS, the two food-group categorizations are presented separately under Table 4. For women, starches (grains, white roots and tubers and plantains) were the most-consumed food group (97%) followed by non-dark green non-vitamin A vegetables (91%) and dark green leafy vegetables (85%). The least-consumed food categories were nuts and seeds (13%), eggs (18%) and meat, poultry, and fish (33%).

Table 4. Level of consumption of different food groups by women and households.

Food consumption by women (n=485)		Food consumption by households (n=594)	
Food Group	*Consumption (% women)*	*Food Group*	*Consumption (% households)*
1. Grains, white roots and tubers, and plantains	96.5	1. Cereals	98.7
2. Pulses (beans, peas, and lentils)	56.7	2. White tubers and roots	83.8
3. Nuts and seeds	13.4	3. Vegetables	99.7
4. Dairy products	65.2	4. Fruits	82.5
5. Meat, poultry, and fish	33.4	5. Meat	61.8
6. Eggs	18.1	6. Eggs	54.4
7. Dark green leafy vegetables	84.7	7. Fish and sea food	30.0
8. Other vitamin-A rich fruits and vegetables	55.5	8. Legumes, nuts and seeds	24.2
9. Other vegetables	91.1	9. Milk and milk products	76.4
10. Other fruits	46.2	10. Oils and fats	95.6
		11. Sweets and sugars	92.9
		12. Spices, condiments, beverages	96.8

At the household level, vegetables were the most commonly consumed food category (100%), followed by cereals (99%), spices, condiments and beverages (97%), oils and fats (96%) and sweets and sugars (93%), while the least-consumed food categories were legumes, nuts and seeds (24%), fish and sea food (30%) and eggs (54%).

Women's empowerment in agriculture (WEAI)

Levels of women's empowerment in agriculture at country level are presented in Table 5. The overall WEAI scores are 0.77 for Kenya and 0.71 for Uganda. Further, the percentage of women achieving empowerment (using the 5DE sub-index) is relatively higher in Kenya (34.3%) than Uganda (24.3%). In Kenya, the 65.7 per cent of women who are not yet empowered have inadequate achievements of empowerment in 37.6 per cent of the domains, while for Uganda, the 75.7 per cent of women not yet empowered are inadequate in 40.9 per cent of the domains. The Gender Parity Index (GPI) estimates show that 51.8 per cent of women in Kenyan households are as empowered as their primary male counterparts, compared to 50.0 per cent in Uganda. Additional results show that women who are less empowered than their primary male counterparts have empowerment gaps of 18.5 per cent in Kenya and 20.2 per cent in Uganda.

Table 5. WEAI scores for Kenya and Uganda.

Indicator	Kenya		Uganda	
	Women	Men	Women	Men
5DE (1-M0)	**0.753**	**0.749**	**0.69**	**0.74**
Disempowerment Score (M0)	0.247	0.251	0.31	0.26
N (Number of individuals)	297	198	247	194
% Achieving empowerment (100-H)	34.34	33.84	24.29	31.45
% Not achieving empowerment (H)	65.66	66.16	75.71	68.55
Mean 5DE score (1-A)	0.624	0.62	0.591	0.621
Mean Disempowerment (A)	0.376	0.38	0.409	0.379
GPI Score (1-Hgpi * Igpi)	**0.911**		**0.899**	
N (Number of male-female households)	197		192	
% Women achieving Gender parity (1-Hgpi)	0.518		0.500	
% Women not achieving Gender parity (Hgpi)	0.482		0.500	
Average empowerment Gap (I gpi)	0.185		0.202	
WEAI Score (0.9*5DE + 0.1*GPI)	**0.7688**		**0.7109**	

Women's empowerment in the various domains

Table 6 presents the disaggregated five domains of empowerment (5DE) in agriculture for both countries. The results show that in Kenya, control over use of income, production, and time are the major domains contributing to women's disempowerment by 41.5 per cent, 20.5 per cent and 16.7 per cent respectively. Similar results are obtained for Uganda, whereby control over use of income, production and time are the major contributors to women's disempowerment, accounting for 42.4 per cent, 17.0 per cent and 16.1 per cent, respectively.

Table 6. The 5DE disaggregated by dimension and indicator for Kenyan and Ugandan women.

Statistics	Production		Resources			Income	Leadership		Time	
	Input in productive decisions	Autonomy in production	Asset ownership	Purchase, sale, transfer of assets	Access to and decisions on credit	Control over use of income	Group membership	Speaking in public	Work load	Leisure
Indicator weight	0.1	0.1	0.07	0.07	0.07	0.2	0.1	0.1	0.1	0.1
Kenya										
Censored headcount	0.67	49.83	0.34	13.47	31.31	51.18	0	22.56	6.73	34.34
% Contribution	0.27	20.21	0.09	3.64	8.47	41.51	0	9.15	2.73	13.93
Contribution	0.001	0.050	0.000	0.009	0.021	0.102	0.000	0.023	0.007	0.034
% Contribution by dimension	20.48			12.2		41.51	9.15		16.66	
Uganda										
Censored headcount	0.81	51.82	2.43	19.03	39.68	65.59	4.45	30.77	41.58	35.22
% Contribution	0.26	16.74	0.52	4.1	8.54	42.37	1.44	9.94	4.71	11.38
Contribution	0.001	0.052	0.002	0.013	0.026	0.131	0.004	0.031	0.042	0.035
% Contribution by dimension	17			13.16		42.37	11.38		16.09	

Broken down to indicators, the leading contributors to women's disempowerment in both countries are: control over use of income (41.5% for Kenya and 42.4% for Uganda), autonomy in production (20.2% for Kenya and 16.7% for Uganda) and inadequate leisure time (13.9% for Kenya and 11.4% for Uganda). Across the two countries, only these three indicators contribute 10 per cent or more to women's empowerment. Moreover, control over use of income had over 40 per cent contribution to women's disempowerment, and therefore remains a key area of focus for full empowerment and gender parity.

Regression results

In this section, we present results of the regression models presented as equations 1 and 2. We start by presenting the effect of women's empowerment and production diversity on dietary quality, and later discuss how other variables affect dietary quality.

Effects of women's empowerment and production diversity on dietary quality

Results for the determinants of dietary diversity at woman and household levels and the role of women's empowerment and production diversity are shown in Tables 7 and 8. Table 7 presents results of the reduced model with variables of interest, while Table 8 presents the full model. At each level, we estimated an instrumental variable (IV) model that followed a three-stage least squares (3SLS) method presented under equations (1) and (2). Results presented in Tables 7 and 8 are those of the second-stage regressions of the equations.

Table 7. Effects of production diversity and women's empowerment on dietary diversity.

Variable	Model 1	Model 2
	Woman dietary diversity	Household dietary diversity
	3SLS	3SLS
Production diversity	0.098**	0.087**
	(0.050)	(0.043)
Empowerment indicator		
Decisions on income	-0.107	-0.047
	(0.149)	(0.133)
Leisure empowered	-0.248*	0.094
	(0.148)	**(0.135)**

*Notes: Robust standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.*

The results in models (1) and (2) of Table 7 show that production diversity is an important determinant of dietary diversity at both the woman and household levels. A unit increase in production diversity increases woman's dietary diversity by about 0.1 and household dietary diversity by 0.9. Jones *et al.* (2014) and Sibhatu *et al.* (2015) showed that farm production diversity has a positive influence on dietary diversity. This result implies that programs aimed at sustainably improving dietary quality of smallholder households could be more effective if they strongly focused on increasing farm production diversity, by encouraging farmers to produce especially foods whose consumption level was observed to be very low. However, as Sibhatu *et al.* (2015) demonstrate, the effect of production diversity on dietary diversity may decrease as farmers diversify more. Hence, for farmers with already high production diversity, other strategies to increase dietary diversity should be explored.

Malapit and Quisumbing (2015) emphasize the importance of identifying the greatest sources of women's disempowerment in agriculture and their correlation with nutritional indicators. Therefore, in this regression analysis, we included only empowerment domains contributing at least 10 per cent to women's disempowerment (that is, control over use of income, autonomy in production, and leisure time). We do not find significant direct influence of women's empowerment in agriculture indicators assessed, on dietary diversity at the household level. However, we find that women with adequate empowerment in leisure time surprisingly had lower dietary diversity than those not yet empowered (Model 1). This supports the mixed findings by Malapit and Quisumbing (2015), which show that in Ghana, adequate women's empowerment in the domains assessed had no significant effect on dietary diversity for boys, and that women's empowerment in some domains positively or negatively influenced dietary diversity for girls.

Effects of other variables on women and household dietary quality

Besides production diversity and women's empowerment, our main variables of interest, there are other variables that may affect dietary quality of women and household generally. These are presented in Table 8.

Table 8. Full model results for determinants of dietary diversity.

Variable	Model 1	Model 2
	Woman dietary diversity	Household dietary diversity
	3SLS	3SLS
Production diversity	0.098** (0.050)	0.087** (0.043)
Empowerment indicator		
Decisions on income	-0.107 (0.149)	-0.047(0.133)
Leisure empowered	-0.248* (0.148)	0.094 (0.135)
Other variables		
Agricultural market participation	0.560***(0.175)	0.381** (0.156)
Distance to supermarket	-0.019* (0.010)	-0.007 (0.009)
Earned off-farm income	0.029 (0.160)	0.360** (0.145)
House has modern floor	0.310** (0.151)	0.463*** (0.136)
Age of respondent	-0.000 (0.006)	-0.010** (0.005)
Education of respondent	0.105*** (0.018)	0.059*** (0.016)
Female headed household	0.052 (0.163)	-0.045 (0.146)
Household size	-0.030 (0.034)	0.015 (0.029)
Location (Base=Kiambu)		
Nakuru	-0.196 (0.199)	-0.146 (0.173)
Rakai	0.413* (0.231)	-0.701*** (0.214)
Wakiso	0.860*** (0.241)	0.752*** (0.214)
Constant	3.810*** (0.501)	7.721*** (0.453)
N	485	594

*Notes: Robust standard errors in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01.*

Access to consumer markets. Table 8 results show that dietary diversity score was negatively correlated with distance from the household to the nearest to supermarket, but this was significant only for the women's model. The result implies that dietary quality was lower for women in households located further away from supermarkets. A similar result was reported by Koppmair, Kassie & Qaim (2016) who found dietary diversity to be negatively correlated with walking time to district markets in Malawi. Our finding is plausible because supermarkets are increasingly becoming an important source of foodstuffs. Moreover, by stocking a variety of foodstuffs under one roof, supermarkets increase the convenience of shopping and hence probability of buying more diverse food items by consumers. As distance to supermarkets increases, it becomes increasingly costly for households to access such foodstuffs due to transportation and transaction costs.

Other results show that household participation in agricultural markets (specifically the output markets) was positively correlated with dietary diversity at household and woman levels. Households that sold agricultural produce reported higher dietary diversity than those that did not sell their farm output. This could be an implication that farm incomes played a key role in accessing food commodities that households did not produce on-farm, or had inadequate production. The results are in line with Demeke *et al*., (2017) who demonstrate a positive contribution of crop and livestock sales to dietary diversity. Hence, interventions aiming to improve dietary quality could benefit by including activities that improve market participation of farmers. This calls for identification of market linkage models that work best for each environment.

Off-farm income. Turning to off-farm income, we find that dietary diversity of households was positively correlated with off-farm income. Households that had an off-farm income reported a dietary diversity that was 0.4 units more than that of households without off-farm incomes. Although most of the rural poor in the region are employed on-farm, off-farm employment has been identified as a major source of rural household incomes (Government of Kenya, 2011). These results imply that off-farm income plays a critical role in accessing diversified foods by households. Hence, interventions aimed at improving nutritional quality of households should consider supporting rural off-farm income generating activities such as micro- and small businesses.

Demographic and location factors. We analyzed the data for other factors that may be key drivers of the quality of diets consumed by women and households, and found that a number of household and regional characteristics influenced dietary diversity. Respondent's age was negatively correlated with dietary diversity at household level, implying that dietary quality decreased as the principal female household member became older. This may be so because older women have lower levels of information than the younger women on the need to prepare diverse nutritious diets for their households. Conversely, the level of education of principal woman significantly and positively influenced dietary diversity at both the woman and household levels. This is consistent with theory since the level of education is expected to increase nutritional information among respondents. Gebremedhin *et al.* (2017) show that knowledge of feeding infants and young children significantly influenced dietary diversity among children in Ethiopia. An implication of this result is that nutritional interventions for increasing dietary quality could be more effective by incorporating an element of training on nutritional issues for the principal women.

Dietary diversity also varied significantly with economic status of households. Households living in houses with a 'modern floor', a proxy for economic well-being, had significantly higher dietary diversity scores for woman (0.31) and household (0.46) compared to those living in houses with inferior floor types. This shows that wealthier households consumed more diversified diets than poorer households, perhaps due to additional income with which they can access more nutritious food items.

Finally, dietary diversity score differed significantly among the study regions, but Kenyan regions did not show significant differences in dietary diversity scores. Controlling for all factors in the models, women's dietary diversity was higher in both study districts of Uganda compared to Kiambu County, Kenya. Similarly, women's dietary diversity scores in Rakai and Wakiso Districts in Uganda were higher than those in Kiambu County. However, while the average household dietary-diversity score in Wakiso district was greater than in Kiambu by about 0.75 units, the score in Rakai District was 0.70 units less than in Kiambu County.

Determinants of farm production diversity. The discussion above identified farm production diversity as a highly significant determinant of dietary quality. Hence, understanding its drivers is important in addressing dietary quality. We discuss the determinants of farm production diversity shown in Table 9, which are also the results of the first stage regressions of the 3SLS models discussed above.

Table 9. Results for determinants of agricultural production diversity.

Variable	Model 3	Model 4
	Production diversity	Production diversity
	First stage	First stage
Empowerment indicator		
Production autonomy	0.338**(0.149)	0.349**(0.139)
Decisions on income	0.157(0.151)	0.078(0.141)
Leisure empowered	(0.148)	0.179(0.137)
Other variables		
Distance to supermarket (Kms)	0.020**(0.009)	0.024***(0.009)
Earned off-farm income (Dummy)	0.041(0.154)	0.074(0.143)
House has modern floor (Dummy)	-0.156(0.145)	-0.329**(0.135)
Age of respondent (years)	0.017***(0.006)	0.017***(0.005)
Education of respondent (years)	0.005(0.017)	0.002(0.016)
Female headed household (Dummy)	-0.232(0.157)	-0.229(0.145)
Household size (numbers)	0.112***(0.032)	0.107***(0.028)
Region (Base=Kiambu)		
Nakuru	0.071 (0.192)	-0.133 (0.173)
Rakai	-2.064*(1.100)	-2.691***(0.650)
Wakiso	-2.066*(1.206)	-2.775***(0.707)
Land size (acres)	0.204***(0.063)	0.192***(0.058)
Altitude (x1000 m)	-0.747(1.025)	-1.100*(0.593)
Constant	5.786**(2.416)	6.910***(1.430)
N	485	594
Hansen-Sargan over-identification statistic	938.94	1156.99
P-Value	(0.0000)	(0.0000)

*Notes: Robust standard errors in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01.*

The two instruments used (altitude and land size) are found to be significant determinants of production diversity. The Hansen-Sargan over-identification statistic was 938.94 (model 3) and 1156.99 (model 4), both with p-values of 0.000, meaning that our instruments were valid. The relationship between agricultural production diversity and altitude is negative, implying that production diversity increased with decreasing altitude. This suggests that controlling for other factors, climatic conditions in lower-lying areas may be conducive for a more diversified agricultural production than the highlands, with a drop of altitude by about 900-1300 meters increasing production diversity score by a single unit. Moreover, production diversity is positively correlated with land size. Increasing land ownership by one acre increases production diversity by about 0.2 units. While literature exists showing negative correlation between land size and farm diversification (Mishra *et al*., 2004), this result is consistent with Culas (2006), and Makate *et al*., (2016), who found larger farms to be more diversified.

Only one domain indicator of women's empowerment in agriculture, (production autonomy) has a significant effect on farm production diversity. Households where the principal woman was fully empowered in production autonomy have a significantly higher farm production diversity (0.34-0.35 units) than households with disempowered women. This shows that even though our results did not show a significant direct effect of women's empowerment on dietary diversity, it had a significant indirect positive effect: through production diversity. Hence, interventions linking women's empowerment to nutritional outcomes in the study countries could focus on increasing the independence of women in making agricultural production decisions.

Several household and farm characteristics also influenced farm production diversity. Farmer's age is positively correlated with production diversity, perhaps because older people, who are considered more risk-averse (Kahan, 2013), are likely to diversify more in order to cope with farm production risks. Production diversity is further influenced positively by household size, which could be due to the need to meet increasingly diversified dietary requirements as household sizes increased. Household economic status is negatively correlated with farm production diversity. Households whose main houses had modern floors reported lower production diversities, compared to households whose main houses had inferior floor types, but this is significant only in model (4). This result implies that wealthier households tend to specialize in production of fewer agricultural commodities that earn them more income rather than diversifying extensively.

Farm production diversity is positively correlated with distance between households and supermarkets. While households located near supermarkets can easily access foodstuffs from the supermarkets, those living further from supermarkets may face challenges accessing some foodstuffs due to transport and transaction costs. Such households may tend to increase production diversity to enhance dietary diversity, since most agricultural producers also consume what they produce (Pender & Alemu, 2007). There were significant regional differences in production diversity. Controlling for other factors, both districts in Uganda reported production diversity that was more than two units lower than that in Kiambu, Kenya.

Conclusion and implications

Hunger and malnutrition are key global challenges constraining social and economic development today, with as many as 815 million people worldwide affected. Dietary diversification is a possible remedy to malnutrition, and rural people who often eat most of what they produce can increase their dietary diversity by producing more diversified foods. Although women can play an important role in improving dietary diversity in households, their participation is constrained by limited access to productive resources compared to their male counterparts. Women's empowerment is seen as a viable strategy for improving agricultural production and dietary quality and recent studies are investigating the link between women's empowerment and nutritional outcomes, with mixed results. Our paper adds to this growing literature by investigating the possible pathway through which women's empowerment would influence nutritional quality. We achieve this by assessing the effect of key domains of women's empowerment using the Women's empowerment in Agriculture Index (WEAI), not only on dietary diversity, but also on farm production diversity which is as a key driver of dietary quality. The study uses cross-sectional survey data collected from Wakiso and Rakai Districts in Uganda and Kiambu and Nakuru Counties Kenya, between November and December 2016. The data was analyzed using a three-stage least squares approach.

The paper finds an average woman dietary diversity score of 5.6 out of 10 food groups, with about 48 per cent of women failing to achieve a minimum adequate dietary diversity. The household dietary diversity score averaged at 8.9 out of 12 food groups, while the mean farm production diversity was 5.7 out of 16 food groups. Women consumed more starchy crops and vegetables, but less of nuts and seeds, and protein-rich foods such as eggs, meat, poultry, and fish. At the household level, consumption of most food groups was high, but legumes, nuts and seeds, eggs and meat products were consumed by less than two-thirds of surveyed households. These findings imply that programs aiming to improve dietary quality should address constraints in women and household consumption of nuts and seeds, eggs, legumes, meat, and fish. This can be achieved through increased consumer awareness on their nutrition benefits and ensuring their affordability and accessibility by the target consumers.

Women's empowerment in agriculture was marginally higher in Kenya than in Uganda. The overall WEAI score was 0.77 for Kenya and 0.71 for Uganda, while the proportion of women achieving empowerment in Kenya was 34.3 per cent compared to 24.3 per cent in Uganda. Further, about 51.8 per cent of women in Kenyan households are as empowered as their primary male counterparts, compared to 50.0 per cent in Uganda. Breaking down the WEAI into empowerment domains, control over use of income, production and time were found to be the major contributors to women's disempowerment in both countries. The domain indicators that contribute most to women's disempowerment are control over use of income, autonomy in production and inadequate leisure time, in that order. These remain the key areas of focus for full empowerment and gender parity.

Regressing the empowerment domain indicators contributing most to women's disempowerment on dietary diversity, we do not find any significant direct effect of women's empowerment domains at the household level, but there is evidence that women with adequate empowerment in leisure time surprisingly had lower dietary diversity than those not yet empowered. Farm production diversity significantly influenced dietary diversity, and first stage regression results show that only the production autonomy indicator had significant effect on farm production diversity. Households where the principal woman was fully empowered in production autonomy reported significantly higher farm production diversity than households with disempowered women. This means that even though women's empowerment had no significant direct effect on dietary diversity, it had a significant indirect positive effect through the farm production diversity pathway. Hence, interventions linking women's empowerment to nutritional outcomes could focus on increasing the independence of women in making agricultural production decisions.

Further analysis reveals other factors that also strongly influence dietary diversity, implying that women's empowerment is not the only solution for improving dietary quality. For instance, participation in agricultural output markets was positively correlated with dietary diversity at household and woman levels. Similarly, dietary diversity of households could be positively correlated with off-farm income. These findings show that programs aiming to improve dietary quality could more effective if they also included interventions that improve market participation of farmers, and those that support rural off-farm income generating activities. Moreover, the level of education of principal woman positively influenced dietary diversity, implying that nutritional quality interventions could be more beneficial if they incorporated training of principal women on nutritional issues.

Generally, findings of this paper emphasize on the need for enhancing women's empowerment in agriculture as a pathway for improving nutrition for households and their members, especially those suffering from malnutrition.

Acknowledgements

This work was undertaken as part of the CGIAR Research Program on Agriculture for Nutrition and Health (A4NH). Funding support for this study was provided by the German Federal Ministry for Economic Cooperation and Development (BMZ), Germany through the project number 15.7860.8-001.00 "Making Value Chains Work for Food and Nutrition Security in East Africa". Additional funding was provided by the flagship program "Food Systems for Healthier Diets" under the CGIAR Research Program on Agriculture for Nutrition and Health (A4NH). The opinions expressed here belong to the authors, and do not necessarily reflect those of A4NH or CGIAR.

The project was led by the International Center for Tropical Agriculture (CIAT) (now part of the Alliance of Bioversity International and CIAT) and implemented in partnership with other local and international organizations. The authors of this paper thank the National Agricultural Research Organization (NARO) in Uganda and the Kenya Agricultural and Livestock Research Organization (KALRO) for their cooperation and support during the fieldwork. The authors acknowledge Vincent Johnson for his editorial review.

Author contributions

Conceptualization, C.G.K.C, and M.J.; methodology, C.G.K.C.; data collection, C.G.K.C., Developing an analysis plan, C.G.K.C, and E.M.; formal analysis, E.M., KO., and C.G.K.C; writing—original draft preparation, E.M. and C.G.K.C.; writing—review and editing, E.M., C.G.K.C, K.O., and M.J.; visualization, N/A.; supervision, C.G.K.C.; project administration, C.G.K.C., and M.J.; funding acquisition, M.J. All authors have read and agreed to the published version of the manuscript.

Conflicts of interest

The authors declare no conflict of interest.

References

Abreha SK; Walelign SZ; Zereyesus YA. (2020). Associations between women's empowerment and children's health status in Ethiopia. *PLoS ONE* 15(7): e0235825. https://doi.org/10.1371/journal.pone.0235825

Alkire S; Meinzen-Dick R; Peterman A; Quisumbing AR; Seymour G; Vaz A. (2012). The Women's Empowerment in Agriculture Index. IFPRI Discussion Paper 1240. Washington, DC: International Food Policy Research Institute.

Chege CGK; Andersson CM; Qaim M. (2015). Impacts of supermarkets on farm household nutrition in Kenya. *World Development.* 394–407, vol. 72

Culas RJ. (2006). Causes of farm diversification over time: an Australian perspective on an Eastern Norway model. *Australasian Farm Business Management Journal* 3(1): 1-9.

Cunningham K; Ploubidis GB; Menon P; Ruel M; Kadiyala S; Uauy R; Ferguson E. (2015). Women's empowerment in agriculture and child nutritional status in rural Nepal. *Public Health Nutrition* 18(17): 3134–3145.

Demeke M; Meerman J; Scognamillo A; Romeo A; Asfaw S. (2017). Linking farm diversification to household diet diversification: Evidence from a sample of Kenyan ultra-poor farmers. *ESA Working Paper* No. 17–01. Rome: FAO.

FAO & FHI 360. (2016). *Minimum dietary diversity for women: A guide for measurement*. Rome: Food and Agriculture Organization of the United Nations.

FAO; IFAD; UNICEF; WFP; WHO. (2020). The State of Food Security and Nutrition in the World 2020. Transforming food systems for affordable healthy diets. Rome, FAO. https://doi.org/10.4060/ca9692en

Farnworth C; Sundell MF; Nzioki A; Shivutse V; Davis M. (2013). *Transforming Gender Relations in Agriculture in Sub-Saharan Africa*. Stockholm: Swedish International Agricultural Network Initiative (SIANI).

Gebremedhin S; Baye K; Bekele T; Tharaney M; Asrat Y; Abebe Y; Reta N. (2017). Predictors of dietary diversity in children ages 6 to 23 months in largely food-insecure area of South Wollo, Ethiopia. *Nutrition* 33: 163–168.

Global Hunger Index. (2020). www.globalhungerindex.org/concern-worldwide.html

Government of Kenya. (2011). *National Food and Nutrition Security Policy*. Nairobi: Agricultural Sector Coordination Unit (ASCU).

Jones R; Haardo¨ rfer R; Ramakrishnan U; Yount KM; Miedema S; Girard AW. (2019). Women's empowerment and child nutrition: The role of intrinsic agency. SSM Population Health. 2019; 9: 100475. https://doi.org/10.1016/j.ssmph.2019.100475 PMID: 31993480

Jones AD; Shrinivas A; Bezner-Kerr R. (2014). Farm production diversity is associated with greater household dietary diversity in Malawi: Findings from nationally representative data. *Food Policy* 46: 1–12.

Kahan D. (2013). *Farm management extension guide: Managing risk in farming*. Rome: Food and Agriculture Organization of the United Nations (FAO).

Kennedy G; Ballard T; Dop M. (2011). *Guidelines for Measuring Household and Individual Dietary Diversity.* Rome: Food and Agriculture Organization of the United Nations (FAO).

Koppmair S; Kassie M; Qaim M. (2016). Farm production, market access and dietary diversity in Malawi. *Public Health Nutrition* 20(2), 325–335.

Kuche D; Moss C; Eshetu S; Ayana G; Salasibew M; Dangour AD; *et al*. (2020). Factors associated with dietary diversity and length-for-age z-score in rural Ethiopian children aged 6–23 months: A novel approach to the analysis of baseline data from the Sustainable Undernutrition Reduction in Ethiopia evaluation. *Maternal & Child Nutrition*; 16: e12852.

Leroy JL; Ruel M; Frongillo EA; Harris J; Ballard TJ. (2015). Measuring the Food Access Dimension of Food Security: A critical review and Mapping of Indicators. *Food and Nutrition Bulletin* 36(2): 167–195.

Makate C; Wang R; Makate M; Mango N. (2016). Crop diversification and livelihoods of smallholder farmers in Zimbabwe: Adaptive management for environmental change. *Springerplus* 5(1): 1135.

Malapit HJ; Sproule K; Kovarik C; Meinzen-Dick R; Quisumbing A; Ramzan F; Hogue E; Alkire S. (2014). Women's Empowerment in Agriculture Index: Baseline Report. Washington, DC: International Food Policy Research Institute (IFPRI).

Malapit HJ; Kovarik C; Sproule K; Meinzen-Dick RS; Quisumbing AR. (2015). Instructional guide on the abbreviated Women's Empowerment in Agriculture Index (A-WEAI). Washington, D.C.: International Food Policy Research Institute (IFPRI).

Malapit HJL; Quisumbing AR. (2015). What dimensions of women's empowerment in agriculture matter for nutrition in Ghana? *Food Policy* 52: 54–63.

Mishra AK; El-Osta HS; Sandretto CL. (2004). Factors affecting farm enterprise diversification. *Agricultural Finance Review* 64(2):151–166.

Pender J; Alemu D. (2007). Determinants of Smallholder Commercialization of Food Crops: Theory and Evidence from Ethiopia. Washington, DC, International Food Policy Research Institute (IFPRI), FPRI Discussion Paper 00745.

Raney T; Anríquez G; Croppenstedt A; Gerosa S; Lowder S; Matuscke I; Skoet J; Doss C. (2011). The role of women in agriculture. ESA Working Paper No. 11–02, Agricultural Development Economics Division, The Food and Agriculture Organization of the United Nations (FAO), Rome.

Rao E; Qaim M. 2011. Supermarkets, farm household income and poverty: Insights from Kenya. *World Development* 39 (5): 784–796.

Sibhatu KT; Qaim M. (2018). Review: Meta-analysis of the association between production diversity, diets, and nutrition in smallholder farm households. *Food Policy* 77 (2018) 1-18. https://doi.org/10.1016/j.foodpol.2018.04.013

Sibhatu KT; Krishna VV; Qaim M. (2015). Production diversity and dietary diversity in smallholder farm households. *PNAS* 112(34): 10657–10662.

Sonntag A; Neubauer L; Olive T; von Grebmer K; Yin S. (2014). (eds). *2014 Global Hunger Index: The challenge of hidden hunger*. Bonn/Washington, D.C./Dublin: Welthungerhilfe, International Food Policy Research Institute and Concern Worldwide.

Sraboni E; Malapit HJ; Quisumbing AR; Ahmed AU. (2015). Women's Empowerment in Agriculture: What Role for Food Security in Bangladesh? *World Development* 61: 11–52.

Sraboni E; Quisumbing AR; Ahmed AU. (2013). The Women's Empowerment in Agriculture Index (WEAI): Results from the 2011-2012 Bangladesh Integrated Household Survey. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Swindale A; Blinsky P. (2006). *Household Dietary Diversity Score (HDDS) for Measurement Of Household Food Access: Indicator Guide*. Washington, DC: Academy for Educational Development.

The World Bank; FAO; IFAD. (2009). *Gender in Agriculture Sourcebook*. Washington, DC: The International Bank for Reconstruction and Development/The World Bank.

Verhart N; van den Wijngaart A; Dhamankar M; Danielsen K. (2015). Bringing agriculture and nutrition together using a gender lens. Amsterdam: KIT Royal Tropical Institute and SNV, *KIT Working Papers* 2015-6.

Alliance

Bioversity International

CIAT
International Center for Tropical Agriculture
Since 1967 Science to cultivate change

CGIAR
RESEARCH PROGRAM ON
Agriculture for Nutrition and Health
Led by IFPRI

CGIAR
Science for a food-secure future

Bioversity International and the International Center for Tropical Agriculture (CIAT) are part of CGIAR, a global research partnership for a food-secure future.

Bioversity International is the operating name of the International Plant Genetic Resources Institute (IPGRI).

Africa Hub
c/o icipe (International Centre of Insect Physiology and Ecology)
Duduville Campus Off Kasarani Road
P.O. Box 823-00621
Nairobi, Kenya

https://alliancebioversityciat.org
www.cgiar.org