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Nutritional deficiency and women's empowerment in agriculture: Evidence from Nigeria

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Abstract

This study investigates the relationship between women's empowerment in agriculture, their nutritional status and those of their children. Growing empirical evidence suggests that there is a positive link, but that not all empowerment dimensions influence nutritional outcomes. Using longitudinal data from the Nigeria Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA), covering the period from 2010 to 2016, specific evidence on this topic is provided. Our findings show no relationship between women's empowerment as measured by women who own agricultural land and have access to credit, and their caloric energy intake. Nevertheless, if women jointly own land and other agricultural inputs with their spouse, it has a positive influence on their caloric energy intake. The children's anthropometric scores responded positively to women's empowerment indicators, although with differential effects for boys and girls. Women's access to agricultural inputs and land rights are necessary conditions for maximising the potential benefits derived from the women-empowerment-nutrition link. Improvements in the anthropometric scores of girl children of empowered women should be considered a priority for intervention programmes.

Key words: Nutrition; empowerment; women; children; agriculture

1. Introduction

Gender inequality with respect to asset ownership has received increased attention in the literature in the last one and a half decades. Doss *et al*. (2014) documented the significant gender asset gap in some parts of sub-Saharan Africa (SSA), Asia and South America. They found that the gender-agricultural land gap was more pronounced in Ghana and Karnataka, India compared to Ecuador. Ecuador has witnessed rapid urbanisation and increased preferences for other assets. The adoption of a legal regime of joint asset ownership by both genders has also reduced the gender asset gap in Ecuador.

It has been shown that the equitable allocation of resources to both men and women can increase smallholder productivity and reduce the incidence of poverty (Food and Agriculture Organization [FAO] 2011, in IFPRI & ILRI 2015). Many developing countries have recognised the importance of agriculture to their economies, particularly in terms of its foreign exchange earnings capacity and employment provision. In SSA and Asia (excluding Japan), women constitute 48.7% and 42% of the agricultural labour force respectively (USAID 2016), but own only 15% and 11% of agricultural land respectively. In Ghana specifically, men and women own 64% and 29% of agricultural land respectively. In Ecuador, women own 30% of agricultural land and men own 25% (Doss *et al*. 2014).

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The effect of women's empowerment on nutrition has been demonstrated empirically. Women's empowerment is considered vital for improving nutritional outcomes (Van den Bold *et al*. 2013). The studies by Kamiya (2011), Shroff *et al*. (2011), Arulampalam *et al*. (2012), Bhagowalia *et al*. (2012) and Alaofe *et al*. (2017) document the positive influence of women's empowerment on nutrition. Women's empowerment can take various forms, such as higher educational attainment, participation in household decision-making, ability to act independently, mobility and asset holdings (Van den Bold *et al*. 2013).

The literature, however, is mixed on the relative influence of women's empowerment dimensions on nutritional outcomes (see Shroff *et al*. 2011; Bhagowalia *et al*. 2012; Sraboni *et al*. 2014; Malapit *et al*. 2015; Malapit & Quisumbing 2015). In Nigeria, women's access to agricultural land is limited. Female agricultural land value as a proportion of total agricultural land value was only 10% in 2010. In addition, the share of agricultural land area that is owned by women was 15.8% in 2010 (FAO 2022). Only 10% of women are agricultural landholders. Since women largely dominate the agricultural sector in Nigeria, accounting for more than 60% of the workforce (SOFA Team & Doss 2011), this suggests that their disempowerment through lack of access to agricultural land may negatively affect their income generation, economic status and nutrition. The Nigerian Land Use Act of 1977, which was supposed to give preference to agricultural land, is faulty in many respects. Oshio (1986) asserts that the Act did not make specific reference to the provision of land for agricultural purposes. The declining ability of women to have access to agricultural land due to the increase in land value in SSA is also noted by Gray and Kevane (1999).

Although the nutritional outcomes of women and children are improving in Nigeria, they still fall below acceptable international standards. In 2011, about 49% of women of reproductive age (15 to 49) were anaemic (Development Initiatives 2015; World Bank 2016). In 2016, Nigeria had the fourth largest number of anaemic women (ages 15 to 49 years), accounting for 50% of the female population (Development Initiatives 2017). In addition, the prevalence of overweight for women was 40% in 2014 (Development Initiatives 2017), and about 31.5% of children under five years of age were underweight in 2016. The prevalence of stunting was 33% in 2015 (National Bureau of Statistics [NBS] 2015) and 43.6% in 2016 (UNICEF/WHO/World Bank 2019).

It has been argued that women are primary caregivers for themselves and their children and are responsible for their health and nutrition (Smith *et al*. 2003). It therefore is important to examine how women's nutritional status can be improved through empowerment. The statistics presented earlier show that greater efforts are required if Nigeria is to achieve Goal 2 of the Sustainable Development Goals (SDGs), which aims to achieve food security and improved nutrition and to promote sustainable agriculture by 2030. The goal specifically targets the nutritional status of women and children.

As reiterated in Nigeria's National Strategic Plan of Action for Nutrition (2014-2019) (Ministry of Health 2014), malnutrition and nutrition-related diseases are lingering challenges to public health in the country. Going by the plan, it was expected that, by 2018, wasting among children would decline by 10%, stunting among under-fives would reduce by 20%, and anaemia among women would drop by half. It is worth noting, however, that the planned interventions were not premised on empirical evidence. The literature has shown that nutritional improvement responds differently to different dimensions of women empowerment. It therefore is important that policy interventions meant to empower women and improve their nutrition are based on an understanding of which specific domains of empowerment matter for nutritional outcomes (Malapit & Quisumbing 2015).

Smith *et al*.'s (2003) work is very relevant for empowerment in Nigeria and adopted women's decision-making power relative to that of men and societal gender equality as women's empowerment status. The study did not control for the potential endogeneity effect of the women's relative decision-making power variable, which could result in inconsistent estimates if the ordinary least squares technique is used. Similarly, the study's findings relate to almost three decades ago. It should be noted that a number of efforts have been made to improve women's empowerment and nutritional status over the years. Consequently, the findings of the study may no longer be relevant for policy guidance.

This present study fills these gaps by examining the influence of women's empowerment through agricultural landholding on maternal and child nutrition. Specifically, it uses two indicators of women's empowerment in agriculture – access to land and access to credit This is because the LSMS-ISA data does not provide adequate information on other indicators to compute the WEAI (Women Empowerment in Agriculture Index). This is considered a limitation of this study. In doing so, we use the Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA) covering the periods 2010/2011, 2012/2013 and 2015/2016. We adopted the World Health Organization's (WHO) definition of children under the age of five, which ranges from 0 to 59 months, in our estimation. This will ensure an unbiased comparison with related studies.

This study also adds to the scanty literature on the topic in Nigeria and provides guidance to policy actors on addressing the challenges of nutritional deficiencies. The findings of this study would ensure that specific interventions aimed at empowering women and improving their nutritional outcomes are well targeted, thus reducing policy mismatch. Two research questions motivating this study are as follows:

1. Does women's holding of agricultural land affect their nutritional outcomes and that of their children?
2. What other dimensions of women's empowerment in agriculture matter for positive nutritional status?

The rest of the paper is structured as follows. Section 2 discusses women's empowerment in agriculture in Nigeria and Africa. The model and data are described in Section 3. The results are presented and discussed in Section 4, while Section 5 concludes the paper with policy implications.

2. Women's empowerment in agriculture

Agriculture plays a vibrant role in SSA due to its large employment-generation capacity and linkage with other sectors. Women are increasingly constituting a larger fraction of workers in the agriculture sector, due largely to the migration of men to cities. In SSA, women account for 48.7% of the agriculture labour force (USAID 2016), while in Nigeria they account for 60%. However, they own less than 20% of the agricultural land (USAID 2016).

In most developing countries, women are disadvantaged in relation to the distribution of agricultural inputs, especially land. Discussions on the gender gap in land ownership and women's inadequate access to rural land dominate the literature (Namubiru-Mwaura 2014). In Zambia, for example, the size of farms owned by female-headed households were 0.6 hectares smaller than those owned by male-headed households (Jayne *et al*. 2009). The landholding bias against women persists amid the limitless benefits derivable from women's control of agricultural land. Allendorf (2007) showed that children of women who own land in Nepal are significantly less likely to be severely underweight.

Insecure land rights constitute a major limiting factor to women's agricultural land access in Africa (Cotula *et al*. 2006). They prevent farmers from investing resources in soil quality, which could boost its productivity (Faure 1995). Africa is still immersed in bureaucratic bottlenecks relating to land registration and title (Deininger 2003). Only 10% of rural land in Africa is registered

(Byamugisha 2013). The plight of women in accessing land for agricultural purposes is worsened by existing formal land tenure and customary practices in rural areas. Although most land legislation across Africa specifies equal gender rights and prohibits gender discrimination, this is often not implemented in rural areas (Cotula *et al*. 2006). Customary norms and religion prevail in rural areas and are more important in determining women's land rights (Namubiru-Mwuara 2014). The extensive application of customary law in the rural areas of Africa prevents women from exercising their land rights due to cultural attitudes and customs (Cotula *et al*. 2006).

Generally, women do not hold any right to land in the African setting. In patrilineal society, land is allocated to male family heads and transferred to lineages (Lastarria-Cornhiel 1997). Women only have secondary rights to land, which are derived from their association with male landholders such as husbands (Cotula *et al*. 2006). Although women are entitled to land through their mother's lineage under the matrilineal practice, the land often is held in the custody of a male family member who allocates the land (Cotula *et al*. 2006).

It is worth noting that customary practices regarding landholding are gradually changing to favour women (Lastarria-Cornhiel 1997). The increased commercialisation of agriculture, migration, population pressure on land and urbanisation have made a transition to individualised ownership of land more prominent. In Nigeria, female children in the Wudili district of Kano have had their inheritance rights to land recognised by their brothers and the community (Ross 1987). Men do not see women's landholding as a threat, as women live in purdah and cannot cultivate the land themselves, but do so through male family members (Ross 1987).

Nevertheless, the growing individualisation of land ownership suggests that poor women in rural areas may not possess the financial resources to acquire land. Affluent women who can afford land reside mainly in urban areas. Despite these hindrances, women are making strides in land acquisition through the negotiation of land rights (Freudenberger 1993), collective land purchases, joint titling, and support from international organisations to obtain land collectively (Cotula *et al*. 2006). Women in rural areas have also been able to secure land titles and gain access to high-priced agricultural lands through group ownership (ACORD 2011). Legislation in countries such as Brazil, Ethiopia and South Africa favours equal land rights by both sexes and joint titling (Cotula *et al*. 2006; Namubira-Mwaura 2014). Joint land titling among spouses secures land for women and ensures that they are not dispossessed of their land in the case of divorce or abandonment by their husband (ICRW 2005). Their decision-making power concerning activities on the farm is also enhanced (ICRW 2005).

In Nigeria, women in the rural areas are also deprived of equal access to agriculture empowerment tools such as land and credit. Cotula *et al*. (2006) note that complementary factors, such as credit accessibility, markets and inputs are equally important when supporting players in the agricultural sector. If women have equal access to productive resources as men it will increase the yields on their farms by about 30% (FAO 2011). This could further raise agricultural output in developing countries by about 4%. Women in Nigeria owned only 10% of agricultural land in 2010 (USAID 2016).

Land ownership in the rural agricultural sector in Nigeria is mainly communal, family-owned and governed by customary land tenure (Ike 1984). Under this arrangement, the family, clan, village or community owns the land. Each member of a family or the community is entitled to a subsistent portion of the land for cultivation (Famoriyo 1979; Ike 1984), and the family land cannot be alienated without the consent of family members (Famoriyo 1979). In this land-sharing arrangement, women are often disadvantaged, as customary practices and cultural barriers can prevent them from inheriting or owning land (African Development Bank [AfDB] 2015). The patrilineal system of land inheritance dominates most parts of Nigeria, and women's rights to the use of land only derives from their husband or a male relative (Soetan 1999).

The Nigerian land tenure system as instituted in the Land Use Act of 1978 does not explicitly state that women have equal rights to land as men. It vests all land within the urban areas under the control and management of the state governor (Section 2a). Rural lands are under the control of the local government administrator (Section 2b). Regardless of Section 2b, the governor has overall power to grant statutory rights of occupancy of any land, either in urban or rural areas. According to Nwabueze (2009), the Nigerian Land Use Act of 1978 has failed to achieve its goal of equitable land redistribution, since land is still unaffordable to low-income earners.

Chigbu *et al*. (2019) notes that Nigerian women who directly derive land-use rights from their husbands or relations only use the land for farming and as directed by their husbands or the true owners of the land. These authors emphasise heterogeneous differences among women in their quest for land access and tenure security. They also note that homogenising their land needs may lead to overgeneralisation in land policy and programmes.

It should be noted that land ownership backed by law or custom empowers women to make decisions on how the land is used. Thus, a woman may have access to land without having a legal right to it, and this often limits her ability to plant crops of her choice (Namubiru-Mwaura 2014). Although land legislation and policies such as joint land titling of a spouse are not common in Nigeria, efforts are being made by the government to amend the Land Tenure Act of 1978 to be gender-sensitive in land provision. Group land ownership by women's associations is also becoming a prominent way of acquiring land for rural women. One key programme that has had a positively influence on women in agriculture is African Women in Agricultural Research and Development (AWARD).[2] Since its inception, about 493 women scientists have benefitted from the AWARD fellowships, which are aimed at promoting agricultural innovations (AWARD 2018). The Nigerian arm of AWARD is NiWARD, which serves as a platform for fellows to improve the well-being of smallholder women farmers through scientific research outcomes.

3. Methodology

3.1 Data

The 2010/2011, 2012/2013 and 2015/16 panel data from the Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA) for Nigeria was used for analysis in this study. The data captures information on the same respondents over time. The longitudinal characteristic of the data enabled us to monitor changes in the nutritional pattern of households over time. The panel survey is nationally representative and consists of 5 000 randomly selected households. Attrition rates in the surveys are low, representing 4.9% and 8.4% in wave 2 (2012/2013) and wave 3 (2015/2016) respectively compared to the baseline survey in 2010/2011 (National Bureau of Statistics [NBS] 2016). The enumeration areas were distributed across the six geopolitical zones in the country. The survey is divided into agricultural, household and community sections. We restrict our samples to households engaged in agriculture in rural and urban areas.

The WEAI, developed by Alkire *et al*. (2013), has become an acceptable measure of women's empowerment in the literature. A uniform measure of empowerment enables comparisons of findings among studies. The LSMS-ISA data does not explicitly provide information on all five

[2] AWARD was established in 2008 to promote gender-responsive agricultural research and development, and to correct the observed gender gap in agricultural productivity (African Women in Agricultural Research and Development [AWARD] 2018).

domains of women's empowerment (production, resources, income, leadership and time) required for the computation of WEAI. The absence of all the five indicators making up the aggregate WEAI precludes the use of WEAI as an aggregate empowerment measure in this study. Nevertheless, in the same spirit as the WEAI, indicators of women's empowerment that capture control over resources within the agricultural sector (access to land, access to and decisions over credit) are used in this study. Detailed information on food consumption in the survey allows for the computation of calorie availability for women. Information on the weight, height/length and age of children is also available to compute anthropometry scores for children below 59 months of age.

Wave 1 (2010/2011), Wave 2 (2012/2013) and Wave 3 (2015/2016) of the LSMS-ISA data contain 4 997, 4 746 and 4 611 households respectively. Since this study focuses on women's empowerment in agriculture, the sample is restricted to households whose occupation is agriculture and contains at least a woman within the reproductive age of 15 to 49 years, and this could be leveraged by the longitudinal nature of the data. We include women who are heads of single-headed female households and those in households headed by either a male or a female. Our final estimated sample consists of 1 238 women aged 15 to 49 years.

In household surveys, addressing the problem of seasonality is important. Harttgen and Klasen (2012) and Sraboni *et al*. (2014) note that seasonality could lead to over- or underestimation of food consumed in a single-round household survey. To circumvent this potential problem, we used a double-round survey conducted during post-planting and post-harvesting periods (one-year period). In addition, we adjusted for the potential seasonality effect using the average data on food consumption in both the post-planting and post-harvest periods. Data on food consumption in the LSMS-ISA is provided on a seven-day recall and at the household level. In order to obtain food consumed by women in the household on a 24-hour recall basis, we divided total household consumption by seven days and by the household size.

3.2 Model

This study models the relationship between nutritional outcomes in women and children and women's empowerment in agriculture using a panel regression model, specified in equations (1), (2) and (3). A fixed-effects model was adopted to model the relationship among the variables. The preference for a fixed-effects over a random-effects model was to enable us to control for unobserved heterogeneity, such as food preferences among female respondents, which could influence their nutritional status. A Hausman test (shown in Table 3) was conducted, which favoured the use of a fixed-effects estimation model.

An instrumental variable (IV) fixed-effects regression method was used due to the potential endogeneity of the empowerment variables employed in this study. This measurement error is widely documented in the literature on nutrition and women's empowerment (Sraboni *et al*. 2014; Malapit & Quisumbing 2015; Malapit *et al*. 2015). This may bias the coefficient of the empowerment variables, leading to inconsistent estimates. To circumvent this problem, we used instruments to purge the empowerment variables of potential simultaneity bias. The equation for the model is a two-step one as specified below, which controlled for the potential endogeneity of women's empowerment indicators in the model. We specified an instrumental variable model, shown in Equation (1).

$$X_{it} = B_1 Y_{it} + B_2 Z_{it} + \delta_i + \varepsilon_{it}, \tag{1}$$

where X_{it} is women's empowerment as measured by asset ownership (agricultural landholding), and access to or decision-making power over credit. Agricultural landholding is represented by a dummy (= 1 if the woman owns land, and 0 otherwise). A woman can own land through various acquisition channels, such as outright purchase (OP), rented for cash or in kind (RC), used free of charge (FOC), and distributed by community or family (DBCF). This measure of empowerment has been identified as a major empowerment instrument for women in sub-Saharan Africa (Soetan 1999; Doss 2005). The binary variable, access to credit, also assumes a value of 1 if a woman is in a household that has taken an agricultural loan, and 0 otherwise.

Y_{it} is a vector of individual and household characteristics that may affect nutritional outcomes. It includes age of woman (in years); literate (whether woman can read and write in any language); household size; logarithm of plot size (measure of wealth); geopolitical zone of woman; urban or rural location of woman; plot acquisition type – outright purchase (OP), rented for cash or in kind (RC), used free of charge (FOC), and distributed by community or family (DBCF); minimum dietary diversity of women (MDD-W);[3] gender of household head, consumer price index (CPI);[4] and food security condition of households, measured by Fsec1 (days the household relied on less preferred food), Fsec2 (days the household reduced its number of meals), Fsec3 (days the household reduced portion size at mealtimes), and Fsec4 (days the household had no food in the house). These definitions capture mild and severe food insecurity.

Z_{it} represents the set of instruments. The instruments are age difference between primary male and female decision makers and proportion of male children in total number of children. The instruments are assumed to be strongly correlated with the empowerment variable, but uncorrelated with the error term, except indirectly through the dependent variable. Some of these instruments draw largely from related literature on empowerment (Sraboni *et al*. 2014; Malapit *et al*. 2015).

Equations (2) and (3) represent the second-stage regression for women's and children's nutrition outcomes respectively.

$$N_{it}^{w} = B_3 X_{it} + B_4 Y_{it} + B_5 Lsecurity_{it} * X_{it} + B_6\, farminputs_{it} * X_{it} + \alpha_i + u_{it} \tag{2}$$

$$N_{it}^{c} = B_7 X_{it} + B_8 Y_{it} + \beta_9\, boy_{it} + B_{10}\, boy_{it} * X_{it} + \alpha_i + u_{it}, \tag{3}$$

where N_{it}^{w} and N_{it}^{c} represent the nutritional outcomes for women and children. The nutritional outcomes for women is measured by calorie availability. This indicator measures the energy intake by women of reproductive age (15 to 49 years) based on 24-hour recall. The LSMS-ISA survey provides information on food groups consumed from different sources, their quantity, and the units of measurement. We define calorie availability as a continuous variable. Calorie intake has been used widely, alongside body mass index and women's dietary diversity, in the literature examining the link between women's empowerment and their nutritional status (Stillman & Thomas 2008; Sraboni *et al*. 2014; Malapit & Quisumbing 2015). Women's dietary diversity was adopted as a secondary measure of nutritional status in this study. Our data does not provide the required information to compute women's body mass index.

The LSMS-ISA standard conversion table was used to convert food quantity consumed into standard measures (in our case gram). We followed the method used by Moltedo *et al*. (2014) to convert the food consumed by women into equivalent calories. This process is a two-step method

[3] The MDD-W measures the number of food groups consumed by women of reproductive age (15 to 49 years) based on a 24-hour recall. Based on the FAO and FANTA (2014), the minimum food requirement is set at the consumption of five out of ten food groups. It is a continuous variable from 0 to 10 in our model.

[4] We adjusted for the effect of price changes on energy calories consumed by women. The state-level food consumer price index was used. This captures both urban and rural food prices.

that involves first converting the food group into a standard measure (grams), and then multiplying the result by the quantity consumed. The second step involves converting food into kilocalories (kcal). We used equivalent calories for food as provided by the FAO (2012) in its food composition table for West Africa. The calorie is then multiplied by food grams to give calories consumed by the household. We aggregated calories across all food groups consumed by the household, and then divided by 100 to arrive at kilocalories per 100 grams (kcal/100 g). To calculate what is consumed by women in a household, we divided the aggregate calories by household size and then by seven days to arrive at calorie availability to woman in a household in a 24-hour recall period.

The LSMS-ISA survey only provides information on food consumption at the household level. Information on women's consumption was not available. In circumventing this challenge, calorie availability for women was derived using calorie availability for the household divided by the household size (per capita calorie). The justification for this is that household consumption reflects women's consumption patterns in the household. Often, all dwellers in a household consume the same food. In addition, questions on food consumption in the survey were directed at the most senior female or the person most knowledgeable about food consumption. According to Haughton and Khander (2009), distinguishing calorie intake among household members could be challenging, thus proxies such as calories per person have been widely adopted in the literature. X_{it} and Y_{it} are as defined in Equation (1).

The measure of women's nutritional outcome (calorie availability) in our study is dependent on farm yield and quantity consumed. Farm yield and investment in land quality are influenced by factors such as the availability and use of farm inputs, and land rights (Faure 1995; Cotula *et al*. 2006; FAO 2011). Therefore, we interacted the women's access to land variable with the use of farm technology, land rights, use of herbicides, quality of soil, and type of seedlings used in planting. This is represented by $Lsecurity_{it} * X_{it}$ and $farm\ inputs_{it} * X_{it}$ in Equation (2). This enabled us to examine the joint impact of farm inputs and land security, and women's access to land, on nutritional outcomes. α_i (I = 1 … n) is the unknown intercept for each individual, and U_{it} is the error term.

Child anthropometry scores for 0 to 59 months were used as a measure of child nutritional outcomes. The child anthropometry scores height for age (HAZ), weight for height (WHZ), and weight for age (WAZ) for children under the age of five were adopted. The z scores or anthropometry scores were computed using the WHO Anthro software developed by the World Health Organization ([WHO] 2010).[5] A child is categorised as stunted, wasted and underweight if the HAZ, WHZ and WAZ measurements are two or more standard deviations below the median reference group.

In the equation for children, Y_{it} includes additional control variables such as water source (dummy = 1 for safe water source, 0 otherwise); child's age; boy = 1, and 0 otherwise; child's health status (if the child visited a clinic in the past four weeks); number of meals eaten by children; dummy = 1 for children who are 0 to 2 years of age, and 0 for children who are two to five years old; and other explanatory variables as defined earlier. The interaction of the empowerment variable with boy in Equation (3) is to test whether women's empowerment has a different impact on boys and girls separately. The variable boy takes on value of 1, while it is 0 for girls. A detailed description of the variables in the model is presented in Table 1.

[5] The upper and lower bounds of the World Health Organization for z scores were used in this study. These bounds ensure that extreme or potentially incorrect z-score values are flagged and identified.

Table 1: Description of variables

Variable	Description	Source
Women's calorie availability	Calories consumed by woman in a 24-hour recall period. Calculated by dividing aggregate calories consumed by household size and by seven days	LSMS-ISA, FAO
MDD-W	Minimum dietary diversity for women, taking a count of 1 to 10. The MDD-W is based on the FAO grouping of food categories into 10	LSMS-ISA, FAO
Age of woman in years	Continuous variable, ranging from 15 to 49 years	LSMS-ISA
Woman is literate	1 if woman is literate, and 0 otherwise	LSMS-ISA
Household head is male	0 if household head is female, and 1 otherwise (male)	LSMS-ISA
Urban	1 if woman lives in an urban area, and 0 if rural	LSMS-ISA
Marital status	Married (monogamous), married (polygamous), divorced, separated and widowed, never married	LSMS-ISA
Access to land	1 if female has access to land, and 0 otherwise.	LSMS-ISA
Access to credit	1 if a woman in a household took an agricultural loan, and 0 otherwise	LSMS-ISA
Household size	Continuous variable counting the number of individuals in a household	LSMS-ISA
Plot size owned by women	Measured in square metres using a global positioning system (GPS)	LSMS-ISA
Agricultural technology	1 if technology is used on the farm, and 0 otherwise	LSMS-ISA
Herbicide	1 if herbicide is applied on the farm, and 0 otherwise	LSMS-ISA
Land registration/ securitisation	This is defined as land that is legally registered or has title documents; 1 if the land has a title deed or is registered, and 0 otherwise	LSMS-ISA
Soil quality	1 if soil is good, and 0 if soil is fair. Sandy, clay and mixture of sand and clay were categorised as fair; loamy and rich clayey loamy were categorised as good	LSMS-ISA
Seed type	1 if seed is hybrid/improved, and 0 if seed is local/traditional	LSMS-ISA
Consumer price index	State-level urban and rural food consumer price index	NBS
Land ownership	Outright purchase, rented for cash or in kind, used free of charge, distributed by community/family or inheritance	LSMS-ISA
Food security 1	Days household relied on less-preferred food	LSMS-ISA
Food security 2	Days household reduced number of meals	LSMS-ISA
Food security 3	Days household limited portion size during meals	LSMS-ISA
Food security 4	Days the household had no food in the house	LSMS-ISA
Geopolitical zone	North East, North Central, North West, South East, South South, South West	LSMS-ISA
Spousal age gap	Age difference between male and female decision maker	LSMS-ISA
Proportion of male children	Number of male children expressed as a share of total number of children	LSMS-ISA
HAZ	Height-for-age score for children under five years of age	LSMS-ISA, computed using WHO Anthro software
WAZ	Weight-for-age score for children under five years of age	LSMS-ISA, computed using WHO Anthro software
WHZ	Weight-for-height score for children under five years of age	LSMS-ISA, computed using WHO Anthro software
Child's age	Continuous variable ranging from 0 to 59 months	LSMS-ISA
Boy	1 if gender is male, and 0 if female	LSMS-ISA
Child is unhealthy	1 if child is unhealthy, and 0 otherwise. Unhealthy is defined as frequent visits to the hospital in the last four weeks	LSMS-ISA
Safe water	1 if child drinks from a safe water source, and 0 otherwise	LSMS-ISA
Meals eaten by a child	Number of meals eaten by a child in a day	LSMS-ISA
Age dummy	1 if child is 0 to 2 years old, and 0 if older than two	LSMS-ISA

4. Results and discussion

4.1 Results of women's energy calorie intake

The estimated results of the influence of women's access to land on their energy calorie intake is presented in Table 2. The second-stage regression of the instrumental variable technique is presented in the first column of Table 2.[6] The endogeneity of the women's empowerment variable is well documented in the literature. Failure to purge the variable of endogeneity would result in inconsistent estimates. To avoid this error, a pre-estimation test was carried out to establish if the women's empowerment variable (women's access to land) in our model is truly endogenous.

The result of the endogeneity test fails to reject the null hypothesis of exogeneity.[7] The non-validity of the instruments may be attributed largely to the exogenous nature of the empowerment variable in the model. Sraboni *et al*. (2014) also failed to reject the exogeneity of the gender parity gap as an empowerment variable for women.

The fixed-effects results as shown in columns 2 to 4 of Table 2 therefore are taken to be valid for our sample. The Hausman test presented in Table 3 to choose between the fixed- and random-effects model is statistically significant, implying that the null hypothesis of the random-effects model can be rejected. The null hypothesis is that the conditional mean of the disturbances given the regressors is zero (Baltagi *et al*. 2003).

The result of the fixed-effects estimation presented in column 2 of Table 2 has an overall good fit, as indicated by the statistical significance of the F-statistic. The coefficients of the variables have the expected signs, except for women's access to land, which is not statistically significant. The coefficient of women's access to land suggests that women's landholding has no relationship with the number of calories they consume. This result contrasts with that of Sraboni *et al*. (2014), who found a positive association between women's empowerment and per capita calorie availability. Berti *et al*. (2003) have also shown that women's empowerment in the form of capital investment has a very large positive effect on their nutrition. Another study that found a significant positive effect of women's access to land on their nutrition is that of Doss (2005).

Although our findings appear counterintuitive, they reinforce some studies that have found that access to land without the use of farm inputs may reduce expected farm yields (Cotula *et al*. 2006). Faure (1995) points out that disputes over agricultural land or insecure land rights may prevent investment in soil quality, which could further reduce farm yields. The AfDB (2015) report shows that cassava yield on women's farms in Nigeria is about one-quarter less than that on men's farms due to the constraint of quality inputs and fertiliser. Equation (2) was estimated along this reasoning by interacting women's access to land with their use of farm technology and herbicides. The results are presented in columns 4 and 5 of Table 2. The findings show that there is a significant difference in the calories available to women who adopted technology in farming and used herbicides and those who did not. Specifically, women who had access to land and complemented it with technology and herbicides are more likely to increase their available calorie intake than women with land but with no access to these inputs.

[6] The first-stage regression is presented in Table A in the Appendix.
[7] The Hausman test of exogeneity, the Cragg-Donald test and the Kleibergen-Paap test also performed unsatisfactorily, suggesting that the instruments are weak.

Table 2: Women's calorie intake and women's access to land (empowerment)

Variables	IV fixed effect	Fixed effect (within estimator)		
Dependent variable: log women's calorie availability	(1)	(2)	(3)	(4)
Women's access to land	1.4127 (2.4881)	-0.0854 (0.0654)	-0.1012 (0.0778)	-0.0936 (0.0749)
Technology			-0.0441* (0.0238)	
Herbicide				0.0525* (0.0246)
Women's access to land × Technology			0.0830*** (0.0120)	
Women's access to land × Herbicide				0.0148*** (0.0047)
Household head is male	-0.2912*** (0.0770)	-0.3305*** (0.0381)	-0.3360*** (0.0381)	-0.3290*** (0.0382)
Household size	-0.1028*** (0.0133)	-0.1087*** (0.0083)	-0.1085*** (0.0092)	-0.1089*** (0.0083)
Age of women (years)	-0.0120*** (0.0032)	-0.0118*** (0.0031)	-0.0116*** (0.0031)	-0.0118*** (0.0031)
Woman is literate	0.0067 (0.0377)	0.0222 (0.0248)	0.0261 (0.0250)	0.0215 (0.0248)
Fsec1	-0.0128 (0.0095)	-0.0155** (0.0077)	-0.0154** (0.0077)	-0.0154** (0.0076)
Fsec2	0.0126 (0.0150)	0.0153 (0.0116)	0.0157 (0.0116)	0.0150 (0.0116)
Fsec3	-0.0648*** (0.0234)	-0.0533*** (0.0116)	-0.0552*** (0.0117)	-0.0524*** (0.0116)
Fsec4	0.0610 (0.0398)	0.0429* (0.0232)	0.0406* (0.0234)	0.0426* (0.0232)
Rented for cash	-0.0905 (0.0734)	-0.0918 (0.0695)	-0.0878 (0.0697)	-0.0959 (0.0694)
Free of charge	-0.2237*** (0.0469)	-0.2393*** (0.0336)	-0.2343*** (0.0341)	-0.2381*** (0.0337)
Distributed by community	-0.0483 (0.0363)	-0.0584** (0.0271)	-0.0533* (0.0271)	-0.0581** (0.0272)
Married (polygamous)	0.0963** (0.0397)	0.1072*** (0.0363)	0.1026*** (0.0363)	0.1081*** (0.0366)
Divorced/separated/widowed	-1.2951 (2.009)	-0.0890 (0.1210)	-0.0895 (0.1218)	-0.0854 (0.1204)
Never married	-0.1194 (0.1109)	-0.1125 (0.1039)	-0.1141 (0.1032)	-0.1085 (0.1032)
Log women plot size	-0.0084 (0.0133)	-0.0055 (0.0112)	-0.0062 (0.0113)	-0.0054 (0.0112)
Log CPI	-0.5541** (0.2357)	-0.6861*** (0.0879)	-0.6974*** (0.0887)	-0.6987*** (0.0883)
MDDW	0.0595*** (0.0096)	0.0596*** (0.0090)	0.0592*** (0.0091)	0.0589*** (0.0091)
Observations	3616	3616	3,588	3,612
F-statistic	24.37	30.80	26.52	27.81
Prob > F	0.0000	0.0000	0.0000	0.0000

Note: robust standard errors are in parentheses. *** significant at 1%; ** significant at 5%; * significant at 10%

Table 3: Hausman test: Selection between fixed effect and random effects

Null: Difference in coefficients between fixed effects and random effects not systematic	
Chi^2 (18)	168.27
P-value	0.0000

We further examined the joint effect of women's access to land and soil quality, seed type and land securitisation on their nutrition. The results are presented in Table B in the Appendix. Women who had access to fertile land were more likely to increase their energy calorie intake by 10.4% compared to those who did not have access to fertile land. Using improved seed increased women's calorie availability by 13.2% compared to the use of local seeds.[8] The interaction of women's access to land and land securitisation was positive and statistically significant, thus supporting the literature that ownership of land rights motivates landowners to invest in the quality of land (Faure 1995). Our findings show that women who had access to land with secure rights increased their calorie availability by 41.3% more than those who had access to insecure land. The large magnitude of the coefficient points to the relative importance of land securitisation more than any other farm inputs.

Column 2 of Table 2 shows that households in which women are the head are more likely to increase their energy calories consumed by 28.1% compared to households headed by men. The coefficient of household size is statistically significant at 1%, and negative. This suggests that an additional member added to a household reduces the energy calories available to the women in the household by almost 11%. This finding is consistent with the literature, since food is shared among household members. Sraboni *et al*. (2014) also reported similar findings.

Women's age is strongly and statistically significant and negatively influences their energy calorie consumption. One year added to the age of a woman between 15 and 49 years reduces her calorie intake marginally, by 1.1%. Intuitively, this result appears logical, as women's energy requirements and absorption decline as they grow older since less physical activity is carried out at an older age (Wakimoto & Block 2001).

Only two out of the four food insecurity indicators were statistically significant and had negative coefficients. Women in households that relied on less-preferred food will have their calorie intake reduced by 1.5%, while women in households that limit the size of their meals will reduce their calorie intake by a larger amount, of 5.1%. The latter measure of food insecurity is more severe, and this explains why an additional day in which meal size is reduced will lead to a significant decline of 5.1% in women's calorie intake.

Women who acquired their land free of charge or through community distribution are less likely to increase their calorie availability compared to those who acquired it through outright purchase. Women's marital status also plays an important role in determining their nutritional outcome. Married women in polygamous families are more likely to increase their calorie availability by 11.3% compared to women in monogamous family settings. This may be explained by the positive rival effect and its influence on family consumption. In a polygamous family setting, women take turns to prepare meals for their husband. The size of agricultural land (plot size) owned by women does not have any relationship with their energy calorie intake. This supports our previous finding that what matters is not the size of land, but complementary inputs and land securitisation.

Higher consumer prices significantly reduce the energy calories available to women. A 1% increase in food prices will reduce women's calorie intake by 68%. The reasoning behind this finding is that higher food prices reduce the quantity of food items that are purchased and available to women, and consequently the energy calories derived from the food. We included women's dietary diversity scores as an independent variable in the model to examine if higher dietary diversity in food consumption affects calorie intake. Our findings indicate a positive and statistically significant relationship between women's dietary diversity and their calorie intake. This indicates that, as

[8] Halvorsen and Palmquist (1980) provide explicit information on the appropriate interpretation of dummy variables in semilogarithmic equations.

dietary intake by women becomes more diverse, their energy calorie intake increases. Thus, an increase in women's dietary diversity score by one food group increases calorie intake by 5.9%.

The estimated results of the model using access to credit as an empowerment variable are presented in Table 4. The empowerment variable (credit) is a dummy variable, which takes a value of 1 if a woman in a household obtained credit for agricultural purpose, and 0 otherwise. Although the credit decision may be regarded as endogenous, we do not have appropriate instruments to model household credit decisions. We therefore interpreted the relationship between the variables as associative, rather than causative (Malapit & Quisumbing 2015; Malapit *et al*. 2015).

Table 4: Women's calorie intake and women's access to credit (empowerment)

Variables	**Fixed effect (within estimator)**
Dependent variable: Log women's calorie availability	
Women access to credit	0.0243 (0.0216)
Household head is female	-0.3232*** (0.0380)
Household size	-0.1095*** (0.0031)
Age of woman (years)	-0.0122*** (0.0031)
Woman is literate	0.0224 (0.0250)
Fsec1	-0.0176** (0.0077)
Fsec2	0.0120 (0.0116)
Fsec3	-0.0501*** (0.0117)
Fsec4	0.0382 (0.0233)
Rented for cash	-0.0800 (0.0694)
Free of charge	-0.2463*** (0.0338)
Distributed by community	-0.0640** (0.0274)
Married (polygamous)	0.1016*** (0.0366)
Divorced/separated/widowed	-0.1549 (0.1043)
Never married	-0.0945 (0.0970)
Log plot size	0.0015 (0.0111)
Log CPI	-0.6653*** (0.0870)
MDD-W	0.0587*** (0.0090)
No. of observations	3 607
F-statistics	31.12
Prob > F	0.0000

Note: robust standard errors are in parentheses. *** significant at 1%, ** significant at 5% and * significant at 10%.

The coefficient signs and statistical significance of the estimated variables are similar to what is presented in Table 2. The decision on credit does not correlate statistically with the calories available to women in the household. A plausible explanation for this finding is that women's access to credit for agricultural purposes does not compulsorily imply that borrowed funds are used for agricultural purposes. Malapit and Quisumbing (2015) also found no association between women's empowerment in credit decisions and their body mass index (BMI).

A larger household size is negatively associated with women's calorie intake. Similarly, women's advancement in age has a negative and statistically significant association with the calories available to them. The number of days that a household relies on less-preferred foods and limits the amount of food during mealtimes has a negative effect on women's calorie availability. The association between food price changes and women's calorie intake is negative and statistically significant. Consumption of food varieties by women is positively associated with their calorie intake.

4.2 Children's anthropometry results

Tables 5 and 6 present the estimation results of the effect of women's empowerment on child nutrition, as measured by their anthropometry.[9] The pre-estimation endogeneity tests that were conducted indicate that women's access to land and agricultural credit is exogenous. In the absence of endogeneity problems, we therefore adopted the ordinary least squares (OLS) estimation technique. The effect of women's access to land on children's height for age (HAZ), weight for age (WAZ) and weight for height (WHZ) is presented in Table 5. The model has a good overall fit, as indicated by the statistical significance of the F-statistic at 1% and 5%.

The coefficient of the women's empowerment variable (women's access to land) has a positive sign and is statistically significant in the HAZ and WAZ model specifications, suggesting that women who have access to land are more likely to increase their children's height-for-age and weight-for-age anthropometry scores by 0.55 and 0.37 respectively.

Women's access to land has no relationship with a child's WHZ. The general inference from our findings is that women's access to land has positive influence on the nutritional status of their children through the use of farm income to purchase a nutritious diet and to consume own-farm produce. Our study is in harmony with Smith *et al*. (2003), who found a positive association between women's relative decision-making and the WAZ scores of their children in Nigeria. Schijven (2016) also reported a positive relationship between women's landholding in Zambia and Uganda and their children's HAZ and WHZ. Similarly, Alaofe *et al*. (2017) showed a positive link between women's empowerment and anthropometry scores for boys and girls in Northern Benin.

Malapit and Quisumbing (2015) and Malapit *et al*. (2015), however, found a weak association between women's empowerment scores and children's anthropometry. The latter found that the production diversity of the household had a greater positive effect on children's nutrition and that women's control over income in a dual decision-maker household had a significant association with HAZ score. The choice of the disaggregated women's empowerment indicators in these studies may be a basis for our different findings. Malapit *et al*. (2015) explicitly excluded land ownership as one of their women's empowerment indicators because asset ownership contributes only 2.4% to women's disempowerment in Nepal.

The influence of other independent variables on the anthropometry scores of children is also presented in Table 5. In line with the findings of Guha-Khasnobis and Hazarika (2006), the location of children – whether urban or rural – does not influence their nutritional status. An additional

[9] The analysis of the children's estimation was restricted to the most recent cross-sectional data (2015/2016) due to a significant reduction in sample size when tracking children within the age bracket of 0 to 59 months over the three LSMS-ISA waves.

month to a child's age reduces his/her weight-for-height (WHZ) scores by 0.0002. Similar results were found by Malapit *et al*. (2015) for Nepal, Guha-Khasnobis and Hazarika (2006) for Pakistan, and Schijven (2016) for Zambia and Uganda.

Table 5: Children's anthropometry z-scores and women's empowerment (women access to land): OLS

Independent variable	Height for age (HAZ)	Weight for age (WAZ)	Weight for height (WHZ)
Women's access to land	0.5551** (0.2513)	0.3795** (0.1661)	0.0624 (0.1624)
Urban	0.2786 (0.2461)	0.2093 (0.1826)	-0.0564 (0.1833)
Child's age (months)	-0.0128 (0.0094)	-0.0027 (0.0072)	-0.0002** (0.0068)
Boy = 1	-0.2817* (0.1608)	-0.3135* (0.1222)	-0.0431 (0.1098)
Child is unhealthy = 1 (0 otherwise)	-0.1642 (0.2553)	-0.2693 (0.1990)	-0.2974* (0.1676)
Child drinks from safe water source	0.0682 (0.1667)	-0.0031 (0.1275)	-0.0244 (0.1170)
Mother's age in years	0.0210* (0.0123)	0.0150* (0.0091)	0.0021 (0.0074)
Women access to land × Boy	-0.8887* (0.4596)	-0.5417* (0.3079)	-0.0723 (0.3084)
Household size	-0.0839** (0.0425)	-0.0354 (0.0302)	0.0258 (0.0270)
Mother is literate	0.7173*** (0.1638)	0.1624 (0.1241)	-0.3597*** (0.1137)
No. of meals eaten by child per day	-0.0313 (0.0680)	0.0230 (0.0504)	-0.0157 (0.0476)
Age dummy (= 1 if child is 0 to 2 years old)	0.2940 (0.3308)	-0.0345 (0.2596)	-0.1885 (0.2312)
Constant	-0.0952 (0.6838)	-2.3535 (0.5456)	0.1037 (0.4910)
Observations	841	871	805
F-statistic	6.53	2.68	1.96
Prob.	0.0000	0.0022	0.0291
R-squared	0.0678	0.0242	0.0238

Note: robust standard errors are in parentheses. *** significant at 1%, ** significant at 5% and * significant at 10%

Girls are more likely to have better nourishment in terms of HAZ and WAZ and to increase their anthropometry scores by 0.2817 and 0.3135 respectively than boys, as reflected in the negative coefficient of the boy (dummy) variable. Schijven (2016) found similar results. The sanitation practices of households do not affect children's nutritional status, as indicated in the non-statistical significance of the water source variable. Being unhealthy reduces a child's WHZ by 0.297. The variable is not statistically significant for HAZ and WAZ. This is not surprising, since our indicator of child's health (frequent visits to the hospital in four weeks) is related to the growth and development of a child, rather than being age based. An additional year to a woman's age increases her children's HAZ and WAZ by 0.021 and 0.015 respectively. This implies that older women implement better childcare practices, which can improve the nutritional status of their children.

The statistical significance of the interaction of the women's empowerment variable with gender (boy) shows that women's empowerment has a different impact on boys' and girls' anthropometry. Girls in households in which the woman is empowered through ownership of agricultural land are more likely to have their HAZ and WAZ scores improved by 0.881 and 0.541 respectively compared to boys. Children in larger household have a lower HAZ, as indicated by the negative correlation and statistical significance between HAZ and household size. Our findings also suggest that the literacy of mothers has a positive and significant relationship with their children's HAZ. However, it correlates negatively with WHZ.

The number of daily meals eaten by children does not have a statistical and significant relationship with their anthropometry scores. Similarly, there is no differential impact between the anthropometry scores of younger children (ages 0 to 2), who are expected to have received the required immunisations recently, and older children (older than two years), who received them a long time ago.

Table 6 shows that access to agricultural credit by women has a positive and statistically significant correlation with the HAZ of their children. This finding is consistent with the results in the literature (Malapit & Quisumbing 2015). Borrowing from Malapit and Quisumbing (2015), a probable explanation is that credit empowerment gives women the ability to smooth consumption and enables them to cope during periods of food shortages. However, credit as an empowerment tool has less of an influence on child anthropometry compared to women's access to land, as indicated by the larger coefficient of the women's access to land variable. Other variables in the credit model have the expected signs and mimic the findings in the women's access to land model.

Table 6: Children's anthropometry z-scores and women's empowerment (women's access to credit): OLS

Independent variable	Height for age (HAZ)	Weight for age (WAZ)	Weight for height (WHZ)
Urban	0.3634 (0.2407)	0.2666 (0.1778)	-0.0491 (0.1764)
Child's age (months)	-0.0131 (0.0093)	-0.0029 (0.0072)	-0.0002 (0.0068)
Boy = 1	-0.3002* (0.1606)	-0.3213*** (0.1222)	-0.0436 (0.1096)
Child is unhealthy = 1 (0 otherwise)	-0.1651 (0.2577)	-0.2562 (0.2001)	-0.2863* (0.1670)
Child drinks from safe water source	0.0762 (0.1657)	0.0056 (0.1275)	-0.0182 (0.1166)
Mother's age in years	0.0250** (0.0123)	0.0172* (0.0090)	0.0020 (0.0073)
Women's access to credit	0.3723* (0.2025)	-0.0402 (0.1465)	-0.1693 (0.1364)
Women access to credit × Boy	0.0757 (0.4060)	0.0877 (0.2916)	0.1287 (0.2749)
Household size	-0.0960** (0.0430)	-0.0415 (0.0302)	0.0263 (0.0271)
Mother is literate	0.7588*** (0.1632)	0.1836 (0.1235)	-0.3618*** (0.1123)
No. of meals eaten by child per day	-0.0394 (0.0671)	0.0151 (0.0503)	-0.0200 (0.0474)
Age dummy (= 1 if child is 0-2 years)	0.2909 (0.3305)	-0.3522 (0.2595)	-0.1899 (0.2308)
Constant	-0.1474 (0.6890)	-0.2106 (0.5482)	0.1522 (0.4893)
Observations	841	871	805
F-statistic	6.12	1.95	2.09
Probability	0.0000	0.0306	0.0186
R-squared	0.0676	0.0211	0.0254

Note: robust standard errors are in parentheses. *** significant at 1%, ** significant at 5% and * significant at 10%

Generally, mother's age has a positive influence on the child's anthropometry. A larger household size has a negative effect on the long-term nutritional measure – HAZ. Increasingly larger households, without a corresponding increase in food expenditure, will reduce the meal portions available to children, thus leading to stunting. The number of meals eaten by children does not have an influence on their nutritional status, possibly implying that what matters is the quality of diet and not its quantity.

5. Policy implications

This study provides empirical evidence for the link between women's empowerment through access to agricultural land and credit, their energy calorie intake, and the anthropometry scores of their children. Our findings show no relationship between women who have access to land or credit and their energy calorie intake. Nevertheless, the effect of women's access to land on their calorie intake is strongly observed when women's access to land is interacted with agricultural inputs such as herbicides, soil quality, seed type and secure land rights. Access to land by women is necessary, but insufficient, to improve their nutritional calorie intake. This finding reiterates the argument in the literature that women's access to land must be complemented by access to key agricultural inputs to fully harness the benefits of landholding and women's empowerment as far as landholding is concerned.

In this respect, it is important that the proposed revision of the National Strategic Plan of Action for Nutrition (2014-2019) incorporates into it women's joint holding of land and other agricultural inputs. In addition, the proposed amendments to the Land Tenure Act should also consider women not only as landowners, but also as holders of other agricultural inputs.

Another inference from the findings is that, since women are biased against when land is allocated, whether due to communal practices or poor implementation of legal rights that favour them, it is important that they have access to secure land. This would ensure optimal investment in the quality of the soil and consequently om its productivity, which would increase their calorie intake. One of the ways to achieve land securitisation for women is through legislation favouring joint spousal land ownership. This can be anchored in a stronger marriage institution and abandoning cultural practices that do not favour women's land ownership. Government at all tiers should enforce strict compliance with this law and others.

We found that dietary diversity plays an important role in increasing the calorie intake of women. Policy interventions through food programmes aimed at women should incorporate diversity in diets to ensure that women in the reproductive ages get their adequate calorie requirement.

Women's access to land and credit positively affects their children's short- and long-term nutritional measures. Credit availability as a form of empowerment has less of an effect on children's nutrition, however, compared to women's access to land. This shows that quick wins can be achieved if nutrition-based intervention programmes focus more on increasing women's access to agricultural land. Women's empowerment has different effects on boys' and girls' anthropometry, in the favour of the latter. The implication is that, since women's empowerment is likely to have a greater effect on girls' HAZ and WAZ scores, improving girls' nutrition can be considered a priority for intervention programmes. Our findings also suggest that, as a woman advances in age, her child's anthropometry scores improve. We interpret this to mean that older women have a greater ability to provide the required childcare resources and practice necessary for child development.

Our contribution to the nutrition-women empowerment link examined only one of the five domains of women's empowerment in agriculture based on the Women's Empowerment in Agriculture Index (WEAI) by using two resource indicators, namely access to land and credit. Both resources constitute significant disempowerment of women in Nigeria. Due to data unavailability, we were limited to indicators of land ownership and credit access. This is a limitation of this study. We noted earlier that the literature shows that different empowerment measures have different effects on nutritional outcomes. Studies that use disaggregated women's empowerment measures have different findings, depending on the domain and measurement of women's empowerment. It therefore is important that this should be considered when comparing the findings of studies in order to ensure that studies with similar women's empowerment domains are compared closely.

It would be interesting to see future studies on Nigeria explore the effect of other domains of empowerment on mother and child nutrition using the WEAI. The WEAI pilot is becoming increasingly available for many countries (currently available for 19 countries). That being said, our study brings to the fore the important influence of women's access to agricultural land and credit on the nutrition of their children, particularly girls.

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Appendix

Table A: First-stage regression analysis of women's calorie intake and access to land (empowerment)

Variables	**IV fixed effect**
Dependent variable: Access to land	(1)
Household head is female	-0.0263*** (0.0120)
Household size	-0.0036 (0.0027)
Age of women (years)	-0.0004 (0.0009)
Woman is literate	0.0105 (0.0078)
Fsec1	-0.0017 (0.0024)
Fsec2	0.0018 (0.0037)
Fsec3	0.0079** (0.0036)
Fsec4	-0.0121* (0.0067)
Rented for cash	-0.0015 (0.0200)
Free of charge	-0.0103 (0.0122)
Distributed by community	-0.0065 (0.0097)
Married (polygamous)	0.0071 (0.0104)
Divorced/separated/widowed	0.7416*** (0.0552)
Never married	0.0040 (0.0361)
Log plot size	0.0018 (0.0033)
Log CPI	-0.0828*** (0.0257)
MDDW	0.00001*** (0.0026)
Age gap	-0.0012 (0.0008)
Proportion of male children	-0.0082 (0.0287)
Observations	3 616
F-statistic	30
Prob > F	0.0000
R-square	0.3799

Note: robust standard errors are in parentheses. *** significant at 1%, ** significant at 5% and * significant at 10%.

Table B: Women's calorie intake and access to land (interacted with soil quality, seed type and land securitisation), 2015/2016

Variables	**Ordinary least squares**		
Dependent variable: log women calorie availability	(1)	(2)	(3)
Access to land	-0.3006 (0.4500)	-0.2632 (0.2826)	-0.1943 (0.2693)
Soil quality	0.0485* (0.0266)		
Seed type		0.0642** (0.0305)	
Land securitisation			0.1293*** (0.0345)
Access to land × soil quality	0.0994** (0.0401)		
Access to land × seed type		0.1246*** (0.0159)	
Access to land × land securitisation			0.3464** (0.1415)
Household head is female	0.0950*** (0.0335)	0.0901*** (0.0347)	0.0997*** (0.0342)
Household size	-0.0486*** (0.0040)	-0.0480*** (0.0040)	-0.0468*** (0.0043)
Age of women (years)	-0.0022* (0.0013)	-0.0022* (0.0013)	-0.0019 (0.0014)
Woman is literate	-0.0457 (0.0207)	-0.0414 (0.0210)	0.0202 (0.0224)
Fsec1	-0.0022 (0.0073)	-0.0038 (0.0074)	0.0019 (0.0074)
Fsec2	-0.0304*** (0.0115)	-0.0290** (0.0116)	-0.0240** (0.0117)
Fsec3	-0.0400*** (0.0110)	-0.0366*** (0.0112)	-0.0436*** (0.0107)
Fsec4	-0.0347* (0.0199)	-0.0343* (0.0203)	-0.0382* (0.0208)
Rented for cash	-0.0508 (0.0551)	-0.0915 (0.0573)	-0.1238 (0.1025)
Free of charge	-0.0003 (0.0358)	0.0004*** (0.0381)	-0.2371* (0.1355)
Distributed by community	0.0607 (0.0417)	0.0552 (0.0416)	0.0790* (0.0421)
Married (polygamous)	0.0723*** (0.0251)	0.0724*** (0.0254)	0.0820*** (0.0266)
Divorced/separated/widowed	0.2462*** (0.0854)	0.2261*** (0.0832)	0.2040** (0.0925)
Never married	0.7857*** (0.1969)	0.7841*** (0.2027)	0.4789* (0.2777)
Log plot size	0.0434*** (0.0084)	0.0471*** (0.0083)	0.0538*** (0.0087)
Log CPI	-0.5673 (0.3629)	-0.6192 (0.3815)	-0.4476 (0.4060)
MDDW	0.0535*** (0.0072)	0.0558*** (0.0073)	0.0551*** (0.0076)
Observations	1 740	1 688	1 506
F-statistic	17.97	16.90	16.91
Prob > F	0.0000	0.0000	0.0000
R-squared	0.1718	0.1703	0.1738

Note: robust standard errors are in parentheses. *** significant at 1%, ** significant at 5% and * significant at 10%