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Agricultural market access and dietary diversity in Kenya: Gender considerations towards improved household nutritional outcomes

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A B S T R A C T

Achieving food and nutritional security by all people at all times is a key development goal at the global, regional and national levels. To achieve access to sufficient safe food of acceptable quality at all times, gender mainstreaming in food and nutritional policies, programmes and projects is increasingly being recognized as important to the realization of this goal. In addition, access to well-functioning markets is likely to improve farmers profitability and their access to diverse nutritious foods. This paper avails evidence on the effect of gendered access to organized agricultural markets on household dietary diversity scores in Kenya using nationwide survey data. Using an inverse probability weighted treatment-effect estimator, we evaluate whether improving women's and men's access to well-functioning agricultural markets facilitates diet diversity among households. The analysis shows that while improving both women and men's agricultural commercialization through organised marketing systems improves the dietary diversity outcomes of households, the effect of women is double that of men. However, greater effects are achieved when both the female and male in the same household have access to well-functioning agricultural markets. Further, addressing human and socio-economic needs of households are also important in enhancing households' dietary diversity quality.

1. Introduction

Improved nutrition is a core concept in development dialogues alongside priorities such as poverty eradication, health, education and food security. The African Union's Agenda 2063 aims at Africa being amongst the best performance in nutrition among other development areas (AUC, 2015). The above goal echoes the sustainable development goal (SDG) number 2 of ending hunger, achieving food security and ending all forms of malnutrition by 2030. Though nutrition is mentioned as a goal in SDG No. 2, nutrition is linked to all the 17 goals (Webb, 2014). The United Nations System Standing Committee on Nutrition, 2004, highlights that nutrition can strengthen key development mechanisms and instruments such as poverty reduction, improved governance and human rights, health sector reforms and trade liberalization (Haddad et al., 2004). The multidirectional relationship among nutrition and the developmental goals underscores its importance as it underpins sustainable development.

For a long time, adequate nutrition has been equated to food accessibility. While access to food is necessary for adequate nutrition, it does not guarantee it (UNICEF, 1990). Webb, (2014) defines nutrition as a characteristic of the quality of an individual's diet in relation to their nutrient needs. From the definition, good nutrition goes beyond eradication of hunger; it is significant in the foundations of the well-being of an individual, at the economic, social and cultural levels (Republic of Kenya, 2011; Webb, 2014; UNICEF, 2018). Dietary diversity (DD) is recognized as an indicator of diet quality, which influences nutrition outcomes (Fischer & Qaim, 2012;Webb, 2014; Sraboni et al., 2014; Luckett et al., 2015; Sibhatu et al., 2015; Hoddinott et al., 2015; Abay & Hirvonen, 2017; Koppmair et al., 2017; Sibhatu & Qaim, 2018). DD has a central role in human nutritional outcomes and human capital; a fundamental human asset (Luckett et al., 2015). To underscore the importance of adequate and diversified diets on nutrition, the UNICEF framework of causality in malnutrition highlights inadequate dietary diets as a key immediate cause of maternal and child undernutrition (Lele et al., 2016; UNICEF, 2015; UNICEF, 1990).

Research studies further illustrate the use of household dietary diversity score (HDDS) as the best indicator to approximate dietary diversity at the household level (Gillespie et al., 2012; Headey & Ecker, 2013; Ecker, 2018). While the importance of adequate diet is acknowledged, there are few discussions on how dietary diversity is achieved at the household level (Luckett et al., 2015). Identification of the pathways to achieving household dietary diversity is crucial for integration in policies, programmes, projects and other designed interventions intended to have a positive impact on nutritional outcomes.

Right at the household level, gender sensitive approaches are likely to have greater impact in delivering developmental outcomes such as

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access to adequate and appropriate diets. Consideration of gender in development programmes is especially important in the African context where there is a broad division in the responsibilities of men and women and how they use their personal income (World Bank et al., 2009; Akresh, 2008; Djebbari, 2005). Relative to men, women are documented in various studies to invest a higher proportion of their incomes within their households and towards consumption of the various food groups that is Pareto-superior to that chosen by men (Djebbari, 2005; World Bank et al., 2009). Thus, women's access to and control over and utilisation of agricultural resources is significant to household's food security and has the potential of creating tangible benefits to household dietary diversity.

Further, literature shows that access to well-functioning markets is likely to: support the diversification of agricultural production and expansion of the export market base; facilitate food access through movement of farm output from glut areas reducing losses; link farmers to high end markets thereby facilitating access to more productive technologies and improving overall profitability; and enhance household dietary diversity improving nutrition which is the focus of this study (FAO, 2011; KIPPRA, 2018; Republic of Kenya, 2018; Signorelli et al., 2017). However, though both women and men are highly active in the production of agricultural products, women in agriculture experience limitations to market opportunities.

Differences in market opportunities arise due to various factors including: lack of informed policies and structures that take into consideration the differing needs and potential of women and men; lack of security and mobility; high cost of transportation; lack of adequate financial assets to support businesses; stigmatization of women in male-dominated fields; limited information and access to training; subsistence production orientation which limits market competitiveness and capacity to comply with international standards; and time constraints (Adam et al., 2017; Benjamin & Meyers, 2016; HBF, 2015; Quisumbing & Pandolfelli, 2010). Women may also be limited by traditional social norms on what they may grow and in turn this would limit the market opportunities, including formal market opportunities, they are likely to exploit (Benjamin & Meyers, 2016).

Due to the challenges faced, women engagement diminishes in the post-production stages of the agricultural supply chain, despite representing a significant proportion of labour in agricultural production related tasks, where their activity and visibility is significantly reduced (Johnson et al., 2016; Quisumbing & Pandolfelli, 2010). The agricultural income of women is thus affected negatively with possible negative effects on nutritional outcomes of households.

While most agricultural interventions assume a unitary household where income and resources are pooled and allocated according to a joint utility function, this rarely occurs in most households (Njuki et al., 2011). With the broad division of responsibilities between men and women in households, less income accruing to women would affect their share of responsibilities including provision of nutritious meals. Women are also likely to lack control of income from higher agricultural output, such as proceeds from exports, despite providing labour to produce the output.

Though there are various regional initiatives which focus on empowering women in business in the agricultural sector, there are very few country specific policies in Kenya seeking to address gender issues in agricultural market participation. For instance, the African Union's 2014 Malabo Declaration on *Accelerated Agricultural Growth and Transformation* commits to halve poverty in Africa by the year 2025, through among other measures, supporting and facilitating the preferential entry and participation of women and youth in gainful and attractive agribusiness opportunities (AUC, 2014). In Kenya, as well as other sub-Saharan African countries, there is need for specific initiatives in agriculture for the realization of such regional commitments that countries are signatories to. There is need for country specific policy action to closing the gender gaps in access to agricultural markets for improved nutritional outcomes. As highlighted by Pandey et al., (2016) a key hindrance to this is the poor evidence to base the extent to which women's empowerment, in areas such as access to well-functioning markets, can bring about an improvement in nutritional status in families.

Towards filling this gap, this paper aims at assessing evidence of gendered access to organized agricultural markets- where farmers are linked with buyers in advance of production-on household dietary diversity scores in Kenya. We hypothesize that women's access to organized agricultural markets, will enable female farmers to regularly market their produce at stipulated prices. In addition, organized markets are likely to reduce various transactional costs, such as costs related to searching for buyers and would also allow intermediaries to be bypassed. Market assurance coupled with reduced transactional costs are likely to improve agricultural income accruing to women and thereby promote their contribution to household's healthy and diversified dietary intake. The analysis will help strengthen policy recommendations based on evidence regarding gender specific agricultural interventions for improved nutrition.

The rest of the study is structured as follows: In Section 2, we present an overview of the nutritional status in Kenya. Section 3 presents the nexus between agriculture, gender, dietary diversity and markets while Section 4 presents the conceptual framework upon which the study is based on. Section 5 describes the data and methods used in the analysis. Section 6 presents and discusses the regression results. Lastly, Section 7 presents the conclusion and draws policy implications from the study.

2. Overview of the nutrition status in Kenya

Kenya's 2010 Constitution recognises adequate nutrition as a human right. The constitution states that every person has the right to adequate food of acceptable quality and that every child has the right to basic nutrition (Republic of Kenya, 2011). In support of this, the government aims guaranteeing food security and nutrition to all Kenyans by 2022 (Republic of Kenya, 2018). Despite the government's commitment, malnutrition – defined as "a condition that results from lack of food, from not eating the right foods or from the inability to absorb the necessary nutrients from food" (IFRC, 2013)- remains of concern in the country (see Table 1).

Looking at the various facets of malnutrition, in 2015 as shown in Table 1, about 27 per cent of Kenyans were either overweight or obese (UNICEF, 2018). A higher percentage of women (37.5 per cent) are either obese or overweight compared to men (17.5 per cent). The latest demographic health survey in the country, the Kenya Demographic and Health Survey 2014, observed that 4 percent of children under 5 years[1] were overweight/obese (KNBS et al., 2015).

Other facets of malnutrition include micronutrient and macronutrient deficiencies. The body requires macronutrients such as carbohydrates, proteins and fats, to function correctly and grow normally (IFRC, 2013). Protein-energy malnutrition is associated with wasting, stunting, and underweight (De Onis et al., 1993; Oluchina, 2017). Micronutrient deficiencies, on the other hand, can reduce the body's capacity to fight diseases, hamper its use of foods and the absorption of the nutrients that the body requires to grow and function (IFRC, 2013). Micronutrient deficiencies can also cause wasting, stunting and nutritional oedema (IFRC, 2013).

Some key outcomes from the most recent national micronutrient survey in the country, the Kenya National Micronutrient Survey of 2011, are highlighted in Table 1. Children were observed to have high levels of Iron, Zinc and Iodine deficiencies. Majority of the men population had Zinc deficiencies while women were observed to have Iron, Folate, Zinc and Vitamin B_{12} deficiencies.

Children are most vulnerable to stunting, wasting and being

[1] Children with +2 standard deviation (SD) above the median weight-for-height are considered overweight or obese

Table 1
Status of Various Forms of Malnutrition in Kenya.

Overweight or obese	%		%
National Level	27	Men	17.5
Women	37.5	Children	4
Micronutrient Deficiencies			
Iron Deficiency		*Zinc Deficiency*	
Pre-School Children	21.8	Pre-School Children	81.6
School Age Children	9.4	School Age Children	79
Pregnant Women	36.1	Pregnant Women	67.9
Non-pregnant Women	21.3	Non-pregnant Women	79.9
Men	3.6	Men	77.4
Vitamin B_{12} Deficiency		*Iodine Deficiency*	
Pregnant Women	7.7	School age Children	22.1
Non-pregnant Women	34.7	Non-pregnant Women	25.6
Additional Children Nutritional Status			
Stunted	26		
Wasted	4		
Underweight	11		

Sources: Highlighted from various key report findings: KNBS et al., (2015); UNICEF (2018); Kenya National Micronutrient Survey of 2011(KNBS, 2011)

underweight (IFRC, 2013). In the National Nutrition Action Plan 2012–2017, the government of Kenya had committed to reduce stunting to 14%, wasting to 2% and underweight levels among children under 5 years to 10% by 2017 (Republic of Kenya, 2012). Trends over the years indicate that stunting and wasting are declining too slowly while still impacting the lives of far too many young children and thus the government is likely not to have achieved its target (Fig. 1 and Appendix A).

Poor nutritional outcomes have particularly devastating consequences on development of children with lasting impacts on their physical, mental and social development. Malnutrition in children is particularly associated with poor feeding practices, poor maternal nutrition, inadequate access to health and low access to adequate and diversified diets which is the focus of this study (Republic of Kenya, 2012). Apart from reducing wasting and stunting, there are positive impacts of alleviating micronutrient and macronutrient deficiencies on health, productivity, and in the long run on national economies through promotion of healthy and diversified dietary practices (Darnton-Hill et al., 2005; Republic of Kenya, 2012).

3. Agriculture, Gender, nutrition and Markets- the nexus

3.1. Gender, agriculture and nutrition

Agriculture is recognized as having the potential for providing nutritious food for all and promote sustainable livelihoods (UN, 2015). The link between nutrition and women's empowerment in the agricultural sector is particularly important given their involvement in the sector (IFPRI, 2011). Various studies have been carried out to establish pathways through which agriculture can improve nutrient intake and nutritional outcomes of households. Increased agricultural production and productivity of diverse nutrition rich products including animal sourced foods increase household's food supplies and can potentially improve dietary intake and nutritional outcomes of households (Johnson et al., 2016; Kadiyala et al., 2014; Pandey et al., 2016; Signorelli et al., 2017). Further, agricultural income may directly or indirectly contribute to improved nutrition. Rising incomes are reported to have a strong positive gradient with household dietary diversity (Kadiyala et al., 2014). Increased incomes have a significant positive effect on increased food expenditure, and this may play an important role in diet diversification (Pandey et al., 2016).

Narrowing to women in agriculture, studies covering South Asian countries illustrate that women's empowerment, measured using the Women's Empowerment in Agriculture Index (WEAI), has a positive association with household dietary diversity (Malapit et al., 2015; Sraboni et al., 2014; Sraboni & Quisumbing, 2018). Women's empowerment is particularly shown to mitigate the negative effect of low production diversity on household's diets, that is, women's empowerment extenuates negative outcomes in households with less diverse production (Malapit et al., 2015). In situations where diversification of household's agricultural production maybe limited, women's empowerment may be an important pathway for improving diets and long-term nutritional status in households (Malapit et al., 2015).

Female headship of households is shown to have a positive effect on household dietary diversity (Signorelli et al., 2017) suggesting the importance of improving females management and control over resources in interventions that aim to promote household's dietary diversity. The dichotomy between men and women responsibilities and their differential expenditure patterns are observed to be in line with traditional cultures and the model of intrahousehold resource allocation (Ngigi et al., 2017; Njuki et al., 2011; Quisumbing et al., 2015). The traditional responsibilities within households are such that the issues of food are expected to be deal with by women (Njuki et al., 2011). In a model of intrahousehold resource allocation, income is not always pooled within households but can be held and managed separately by individuals (Ngigi et al., 2017; Njuki et al., 2011; Quisumbing et al., 2015).

The above pathways highlight the important role women in agriculture play in improving dietary scores for their families. In Kenya, women particularly play an important role in the agricultural sector. The 2018 UNCTAD report on *East African Community Regional Integration: Trade and Gender Implications* indicates that 76 per cent of women in Kenya are employed in agriculture. There are both shared roles and gender specific roles where men and women perform certain traditionally distinctive roles in agriculture (Benjamin & Meyers, 2016). Women often grow food crops to provide food for their families and sell the surplus to obtain additional income. Given that women generally serve as the gatekeepers of household nutrition, their role in agriculture has the potential of creating tangible benefits to households through provision of greater variety of foods for their families. Food consumption is however strongly affected by availability/access of food and availability of income among other factors.

3.2. Gender, agricultural markets and nutrition

Policymakers, governments, private-sector actors, development practitioners, and donors recognize the need for improving agricultural markets functioning to address food and nutrition insecurity (FAO, 2011; von Braun, 2009). In a review of four agricultural project interventions in Mozambique, Bangladesh, Burkina Faso and Uganda (Quisumbing et al., 2015), market oriented and high value agriculture are considered as profitable livelihood strategies which can increase women's status in income and stock of assets (Quisumbing et al., 2015). Higher women's status on the other hand is likely to impact positively on the household's nutritional outcomes as shown by Smith et al., (2003) in South Asia, Sub-Saharan Africa (SSA), and Latin America and the Caribbean (LAC). The higher a woman status, the higher the nutritional status for the family is likely to be via her effective care for herself and her family. However, across diverse regions and contexts, women face difficulties in accessing marketing channels, particularly those that allow added value (FAO, 2011; Republic of Kenya, 2019).

Research findings in East Africa suggest that nutrition-sensitive agricultural interventions that promote productivity so to increase household incomes together with a push for deeper market integration are more effective in improving diet diversity than those encouraging households to produce a diverse basket of foods (Hirvonen & Hoddinott, 2014). Production diversity is however found to be particularly strong with limited market access. Another piece of empirical evidence from Koppmair et al., (2017) in Malawi indicates that though production diversity positively impacts on dietary diversity, the estimated effect is small. Contrary, Ecker (2018) in Ghana notes that while production diversity and income matter for household dietary diversity, the effect of

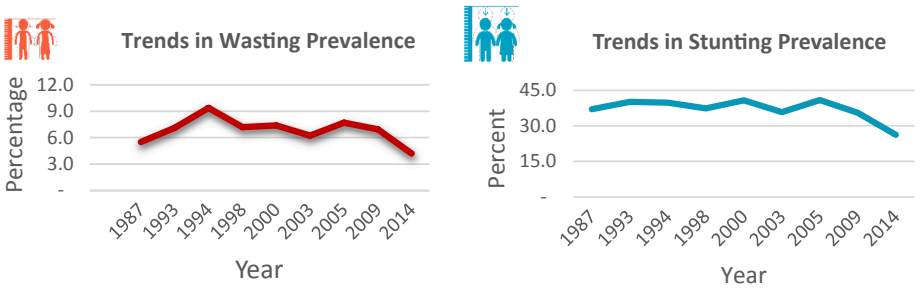


Fig. 1. Percentage of stunted and wasted children under 5, 1987–2014. Source: UNICEF Data and Analytics: https://data.unicef.org/resources/JME/

production diversity is greater than the indirect income effect. Similarly, in Ghana, Signorelli et al., (2017) indicate that while agricultural production diversity and productivity positively affect dietary diversity, production diversity gets stronger with limited access to markets. Bhagowalia et al., (2012) also find agricultural productivity to have a substantial impact on household dietary diversity in India. While the importance of farm production diversity versus income on household dietary diversity is context specific, it is clear that both agricultural production diversity and productivity, and thus income, positively affect dietary diversity, with the effect of increased productivity coupled with better market access mitigating the effects of less diverse production.

Further evidence in Northern Ethiopia indicates that children located closer to food markets consume more diverse diets and are better nourished compared to those located in more remote areas (Abay & Hirvonen, 2017). Drawing on insights from their study, Hirvonen et al., (2017) find that the effect of nutrition knowledge on children's dietary diversity is positive only in areas with relatively good market access in Ethiopia. The effect of nutritional knowledge on nutritional outcomes decreases as households are located farther from the main markets. Evidence from East Africa, in Malawi, Tanzania and Uganda, indicates that even the poor and smallest land holders participate in markets where a considerable percentage of the market presence is driven not necessarily by cash crops but by the sale of staple and other food crops (Carletto et al., 2017). However, the agricultural commercialization involves sale of relatively small quantities of food commodities resulting in low household crop commercialization index.

In addition, though female farmers are found to participate less in market activities, greater involvement by women in commercialization reduces the likelihood of a child being wasted, an indication that the owner of the revenue from agricultural sales could be important for improved nutritional outcomes (Carletto et al., 2017). Yet another piece of empirical evidence in Nepal in South Asia indicates that women empowerment through strategies such as group membership (e.g. in agricultural marketing groups), control over use of income among others mitigates the negative effects of less diverse production on nutritional status of household members (Malapit et al., 2015).

While the evidence presented illustrates women's disempowerment in markets may negatively impact on dietary diversity of households, improved status in agriculture may increase demands on women's time. An increase in demand for women's time may dampen the possible positive effects on households diets and overall nutrition due to sacrifices made in other areas such as time allocated to family care (Carletto et al., 2017;Quisumbing et al., 2015). Similar observations are made by Johnson et al., (2016) in their synthesize of findings from projects in seven countries in Africa and South Asia. It is therefore important to establish country specific correlation between household dietary diversity scores and empowerment across various indicators such as access to well-functioning agricultural markets.

4. Conceptual framework

Our conceptual framework (Fig. 2) shows the links between agricultural markets access and households' dietary intake with a special focus on the role of women in households obtaining adequate dietary intake. The conceptual framework is built on Kenya's National Food and Nutrition Security Policy Implementation Framework 2017–2022 and the 1990 UNICEF's framework on nutrition (UNICEF, 1990, 2015).

Access to organized agricultural markets facilitates trade of agricultural produce. Households may also benefit from increased and stable incomes from farm product sales given organized markets allow farmers to regularly market their produce. This enables the farmers to produce for the market rather than trying to market what they produce as mentioned earlier in the study.

Food access, a key dimension of food security, is achieved either through own production or purchases made. While the study acknowledges that adequate dietary intake can be achieved either through production of diverse nutrition rich products and/or the agricultural income channel, the focus of this study is the latter channel. From literature, there exist gender differences on income spending where women spending towards food and nutrition has been observed to be Pareto-superior to that of men. Women are likely to spend more towards accessing sufficient, safe and nutritious food to meet households' dietary needs.

When adequate dietary intake is achieved, and assuming appropriate intra-household distribution of food and proper health care, the households are then likely to realize improved nutrition. This paper hypothesizes that women's access to adequate agricultural markets is positively associated with improved dietary intake of households. Given women's provisioning role in the country, we postulate that women are better able to command agricultural resources from markets needed to improve household's dietary diversity.

5. Data and methods

5.1. Data and variables

The data is drawn from the Kenyan Agricultural Sector Development Support Programme (ASDSP) household baseline survey carried during September–October 2013. The ASDSP household survey was carried out in all the 47 counties of Kenya by the Ministry of Agriculture, Livestock and Fisheries (MoALF) through the ASDSP, in collaboration with the Kenya Agricultural Research Institute (KARI) and the University of Nairobi (UoN). The overall sample size of the household survey was 12,651 agricultural households focusing on resources, climate change and food security. Gender sensitive analyses require data collection approaches whereby females and males in a household are interviewed individually-intra household level data (Ngigi et al., 2017). Intra household level data is especially important in identifying gender differences in agriculture for appropriate policy action (Ngigi et al., 2017; Njuki et al., 2011; Quisumbing et al., 2015). A key strength of the ASDP household survey is that it contains gender-disaggregated data for effective gender analysis.

Dietary diversity at the household level can be measured by a

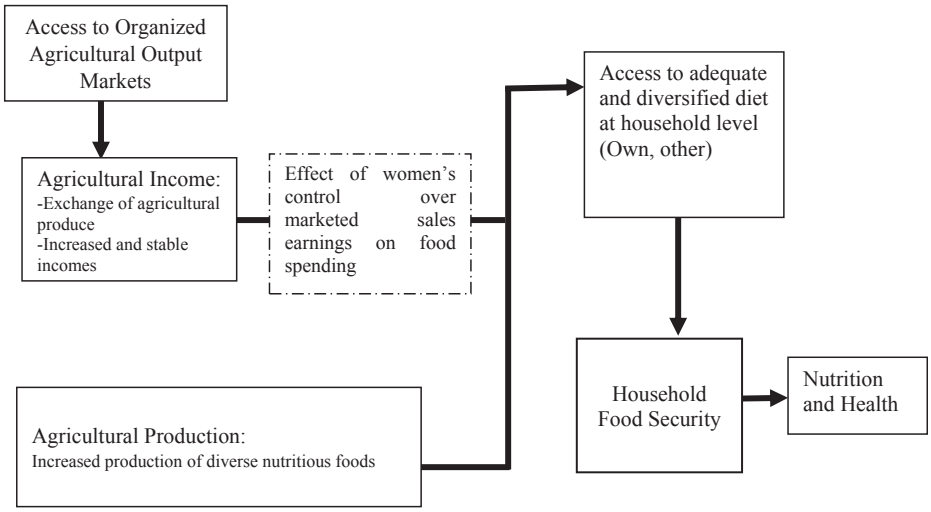


Fig. 2. Conceptual framework linking market access to dietary diversity. Source: Adapted from UNICEF 1990 and Kenya's National Food and Nutrition Security Policy Implementation Framework 2017–2022

household dietary diversity score (Swindale & Bilinsky, 2006). Household Dietary Diversity Score (HDDS) is normally constructed using information on household food consumption based on a 24-hours recall period (Swindale & Bilinsky, 2006). HDDS is measured as the count of 12 different food groups consumed on a 24-hours recall period using household food consumption data. The food groups used to calculate the HDDS include: Cereals; Roots and tubers; Vegetables; Fruits; Meat, poultry, offal; Eggs; Fish and seafood; Pulses/legumes/nuts; Milk and milk products; Oils/fats; Sugar/honey; and Miscellaneous which include spices, condiments and beverages (Swindale & Bilinsky, 2006).

However, the dataset employed in this study does not have dietary data based on a 24 -hour recall period. Due to the data limitation, HDDS has been based on a 7-day diet recalls as used in various other studies faced with the same limitation (Sibhatu et al., 2015; Sibhatu & Qaim, 2018; Sraboni et al., 2014; Thorne-Lyman et al., 2010). HDDS is thus calculated the number of different food groups consumed over a 7 days reference period (Thorne-Lyman et al., 2010). Each food group counts towards the household score if a food item from the group was consumed in the household over the 7- day recall period. HDDS is therefore a continuous score (Jones et al., 2014) with the lowest score being zero and the highest possible being eighty-four (Thorne-Lyman et al., 2010).

The key independent variable, access to organized agricultural markets, is defined as access to markets where the farmer has been linked to a buyer (Njuki et al., 2011). Agricultural market-oriented interventions aimed at facilitating women's market access will be more effective if women have control of their market sales. In addition, the interventions will be effective if the market channels allow the female farmers to regularly market their produce, that is, enable the women to produce for the market rather than trying to market what they produce (Kaaria et al., 2008). Linking with farmers with buyers through contractual agreements in advance of production, assures farmers of markets while the agreed prices helps in reducing income volatility (Njuki et al., 2011).To construct the market access variable, we capture who within the household controls market sales to get a sense of decision making (Fischer & Qaim, 2012) and the market sold, identifying the presence or absence of contractual agreements with the buyer, as has been used in existing studies(Kaaria et al., 2008; Njuki et al., 2011). Table A1 in the Appendix shows a description of the variables employed in analysing the effect of gendered access to organized agricultural markets on household dietary diversity scores in Kenya.

5.2. Empirical estimation

In the analysis, we aim at finding out if access to organized markets in agriculture has an effect on household dietary diversity scores (HDDS). To be able to evaluate the effect of women's access to organized agricultural markets has on household dietary, in an ideal world, we would observe the same subject before and after they have access to the markets under identical conditions such that the difference is only attributed to the presence or absence of markets. That is, we would need the counterfactual outcome for the subject under study. The ideal experiment described is however almost never possible as it is impossible to observe the same subject having access to markets and not having access to markets. A classic solution to the problem is to randomize the sample under study. However, in our study, as is the characteristic of observational data, access to organized markets is not randomized.

The study employs a treatment-effect estimator which allows us to estimate the effectiveness of treatment using observational data where treatment status, in this case access to organized markets, is not randomized (Wooldridge, 2004). The estimators enable us to estimate the outcome for that same subject if they had been exposed to treatment; counterfactual outcomes.

To estimate the treatment effects, this study employs the Inverse-Probability-Weighted Regression-Adjustment (IPWRA) estimator. The IPWRA estimator is a general approach to solving the non-random sampling problem in treatment effects estimation and combines the Regression Adjustment (RA) and Inverse Probability Weighted (IPW) estimators as a way to enhance robustness; a doubly robust estimator (Jordà & Taylor, 2013; Wooldridge, 2004, 2010). Rather than using the simple group means consisting of the difference between two subpopulations to obtaining an estimate of the average treatment effect (ATE), the RA estimator uses a regression model to predict potential means adjusted for covariates. That is, the ATE in an RA estimation is estimated using the conditional mean average predicted by regression estimates of each subpopulation (Jordà & Taylor, 2013). IPW estimator on the other hand uses weights to generate a pseudorandomized sample from which the simple difference in group means will deliver the correct effects of treatment (Jordà & Taylor, 2013; StataCorp, 2013).

The basic specification of the average effects of treatment would be the sample average of dietary score of households with market access(H_{dSMA}) minus dietary score of households with no market access(H_{dSNMA}) conditional to control variables:

$$ATE = E(H_{dSMA} - H_{dSNMA}) = E(H_{dSMA}) - E(H_{dSNMA}) \quad (1)$$

The availability of gender sensitive data allows the study to carry out estimations that will help evaluate gender differences in the effect access to organized agricultural markets has on household dietary diversity. The analysis will therefore carry three estimations to assess (i) women's access, (ii) men's access, and (iii) cases where both the woman and man in a household have access to organized agricultural markets.

To examine the relationship between women's access to markets and household dietary diversity score, we estimate the following equation:

$$d = \beta_0 + \beta_1 T_W + \beta_2 \boldsymbol{X} + \varepsilon \quad (2)$$

where d is the dependent variable defined as household dietary diversity scores, β_i are coefficients to be estimated, T_W is the treatment variable representing 1 if the woman in the household has access to markets and 0 otherwise; $\boldsymbol{X}$ is a vector of household-level characteristics, and ε is an error term.

The analysis then proceeds to investigates the average treatment effects of men ($T_M = 1$ if the man in the household has access to markets and 0 otherwise) on household dietary diversity:

$$d = \beta_0 + \beta_1 T_M + \beta_2 \boldsymbol{X} + \varepsilon \quad (3)$$

Finally, the analysis examines the treatment effect of both the man and woman in the same household ($T_{W\&M} = 1$ if both the man and woman have access to markets and 0 otherwise) on household dietary diversity. A detailed explanation of the estimation model can be seen in Appendix B.

6. Results and discussion

This section presents the treatment effects results from an Inverse-Probability-Weighted Regression-Adjustment estimation. We estimated the effect of access to organized agricultural markets on household dietary diversity score, controlling for household characteristics. Before proceeding with the average treatment effect results, we present the descriptive statistics of the variables used in the study in Table 2. The average dietary diversity score of households is about 29.9 with a standard deviation of 11.5[2]. The mean household size is six with an average annual per capita gross wealth of 164,086.9 Kenyan shillings. Most households are male headed (about 92%) and average age of the head of the household is about 51 years. Majority of household heads have farming as their primary occupation and their highest level of education is primary education. A large share of households in the dataset have both a primary female and male adult (88.6%), while 6.9% and 4.6% only have a primary female adult and primary male adult in the household, respectively. A greater percentage (67%) of the land cultivated are arid or semi-arid lands. Although most of the households do not have access to market, about 15.6%, 5.4% and 3.1% of men, women and both the woman and man in a household have access to organized agricultural markets, respectively.

In the case of either men's and women's market access treatment, we observed significant difference between the treated and control groups for almost all the variables except household head who are in formal salaried employment and have tertiary education. However, for the combined treatment of both man and woman market access, no significant difference is found for self-employment, household size, age and secondary education between treated and control groups. In Fig. 3, it can be seen that generally, treated groups have higher household dietary diversity score than the control groups. This is also confirmed in columns (3)-(5) of Table 2.

In this study, three regressions were carried out: (a) in the first , we evaluated the effect of women's access to organized agricultural markets on household dietary diversity scores; (b) in the second we evaluated the effect of men's access to organized agricultural markets and assess how the results differed with that of women ; and (c) lastly, we evaluated the effect of access to organized agricultural markets where both the man and woman in a household have access to organized agricultural markets. The last regression helps to identify the presence or absence of synergy between men's and women's access to organized agricultural markets on household dietary diversity.

In each of the 3 regressions, we present results on the Average treatment effect (ATE) and potential-outcome means (POMs). POMs represent the means of the outcome variable where the subject with access to organized agricultural market (Y_1), and the outcome variable where the subject has no access to organized agricultural markets in the population (Y_0). ATE is the difference in mean (average) outcomes between $Y_1$and Y_0 (Y_1- Y_0). Further, for each regression, we present the output for those without access to organized markets, that is the untreated potential-outcome, and those with access to organized markets also referred to as the treated potential-outcomes.

In carrying out the analysis, we focus on households with both a primary female and male adult. This will allow for intrahousehold analysis (Ragasa et al., 2019) in assessing gender differences in the effects of market access on household dietary diversity scores.

The results for the three estimations are presented in Table 3-5. In all the three regressions, the dependent variable is the household dietary diversity score, as discussed earlier. The results obtained when evaluating the effect of women's and men's access to organized agricultural markets on household dietary diversity are reported in Tables 3 and 4 respectively. Table 5 presents the results obtained when assessing the combined effect of both the man and woman in a household have access to organized agricultural markets.

As can be seen in Tables 3-5, the estimated coefficients in all the

Table 2
Descriptive statistics.

Variables	(1) Full Sample Mean	(2) Full Sample SD	(3) Women's access Diff. in mean (treated vrs control)	(4) Men's access Diff. in mean (treated vrs control)	(5) Combined access Diff. in mean (treated vrs control)
HH Dietary Diversity Score	29.90	11.47	5.12***	3.32***	5.58***
Primary occupation					
Formal salaried employ	0.104	0.306	−0.004	−0.007	−0 0.004
Farming	0.673	0.469	0.058*	0.115***	0.108**
Self-employed	0.110	0.313	−0.013	−0.03**	−0.032
Household size	6.192	2.790	−0.295	−0.45***	−0.278
Age of household head	51.42	13.83	1.848*	1.319**	0 0.626
Highest level of education					
No education	0.182	0.386	−0.12***	−0.104***	−0.133***
Primary	0.467	0.499	0.093**	0.035	0.137***
Secondary	0.264	0.441	0.029	0.07***	0.039
Tertiary	0.087	0.282	−0.005	−0.001	−0.043**
Annual per capita gross wealth (log)	11.18	1.402	0.575***	0.495***	0.618***
Sex of HHead	0.923	0.267	0.07***	0.079***	0.07***
Productivity of Land	0.673	0.469	0.233***	0.269***	0.245***
HH_female adult	0.069	0.253	−0.063***	−0.074***	−0.058***
HH_male adult	0.046	0.209	−0.161	0.015	−0.010
HH_female_male adults	0.886	0.318	0.086***	0.067***	0.075***
Women's access	0.054	0.226			
Men's access	0.156	0.363			
Combined access	0.031	0.173			
Observations	3,559				

*** p < 0.01, ** p < 0.05

[2] The minimum and maximum value of the household dietary diversity score is 0 and 66 respectively.

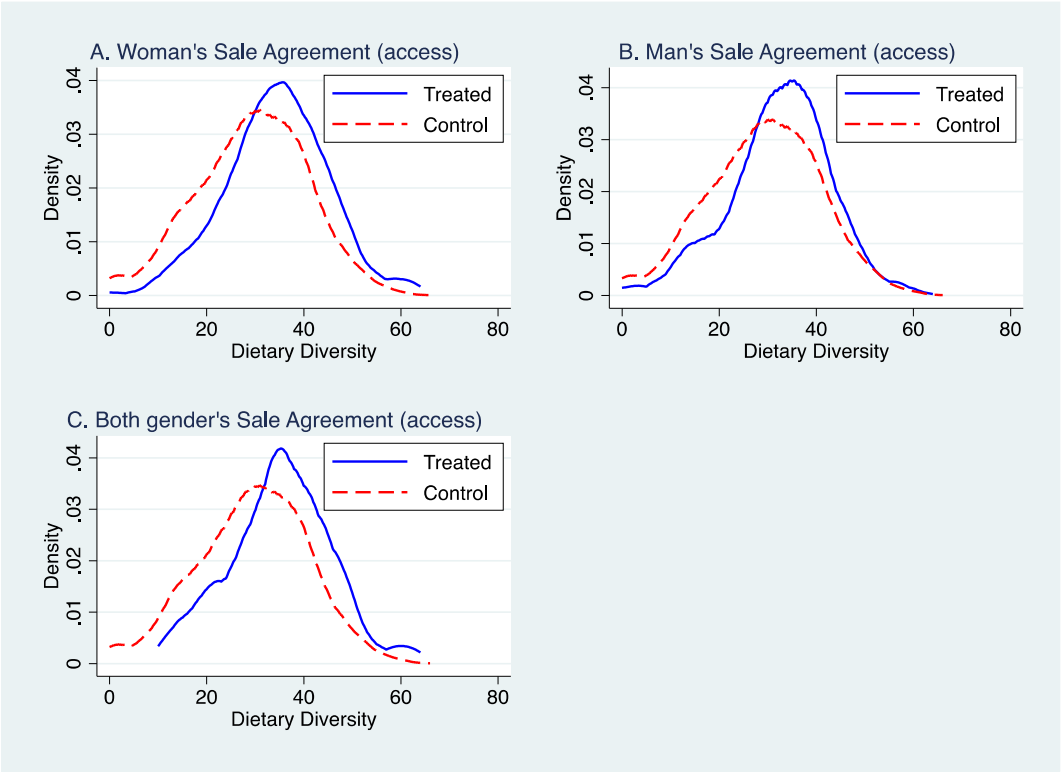


Fig. 3. Kernel density distribution of dietary diversity by treatment group. Source: Authors Estimations

three regressions, other than the gender related variables, are similar in the three regression as the attributes of the households have not been changed. The results imply that changes observed on the gender related variables can be attributed to the gender differences across the 3 regressions. The significant differences in the gender related variables strongly indicate the importance of gender specific analyses in food and nutritional studies (Kassie et al., 2014).

6.1. *Impact of access to organized agricultural markets on food security.*

The results reveal that access to organized agricultural markets significantly influences household dietary diversity scores (Tables 3-5). In Table 3 column 1, after controlling for observable characteristics, we observe that, on average, when a woman in a household has access to organized agricultural markets, the household dietary diversity score improves by 5.297 points.

The results indicate that women's access to organized agricultural output markets seems to be associated with improvements in households' diets. Given production alone may not be sufficient to provide agricultural households with highly diversified output to support diversified diets, agricultural income from enhanced access to organized markets supports expenditure on additional food categories (Fig. 2). Thus, the results suggest that enhanced marketed sales of agricultural produce, through its effects on agricultural income, is a key pathway to improved household dietary diversity scores. The identified pathway is as follows: Agriculture—Marketed sales of agricultural produce— Income —food expenditure— household dietary diversity scores.

When a man in a household has access to organized agricultural markets, the household dietary diversity score improves by 1.880 points (Table 4, column 1). While both women's and men's access to organized agricultural markets influences household dietary diversity scores positively, the women's effect is much larger; more than double that of men. The results indicate that where a woman's socioeconomic power in a household is improved through enhanced access to organized agricultural markets, their control of such earnings can significantly improve household dietary diversity scores relative to men.

The results are similar to the findings by Njuki et al., (2011) in Malawi and Uganda where women spent a significantly larger share of their proceeds from agricultural commercialization on food items compared to men. Women prioritize food in their expenditure items while the largest share of men's income goes towards assets (Njuki et al., 2011). Similar observations are also made in Malapit & Quisumbing, (2015) where dietary diversity scores are greater in female decision maker households compared to male decision households. Thus, enhancement of women's income, through marketed sale of agricultural produce in organized markets, and subsequently its control is recognized as an additional important pathway to improved household dietary diversity scores. The identified pathway is as follows: Agriculture—-Women's marketed sales of agricultural produce— Income —food expenditure— household dietary diversity scores. The highlighted pathway is especially important in the Kenyan household setting where majority of the household heads are male where they play a more dominant role in household decision-making.

The effect on household dietary diversity is however largest when both the woman and man in the same household have access to organized agricultural markets. The treatment effect of having both women and men within the same household accessing organized markets has a positive significant effect of 8.054 points on the household dietary score (Table 5, column 1). The results highlight that while it is important to improve women's access to agricultural markets towards greater dietary diversity scores within households, efforts geared towards gender equity in agricultural markets access are likely to provide better results. In addition, policies that aim at improving both women's and men's access in a household are likely to eliminate the predominant zero-sum power conceptions in households that undermine the effectiveness of development initiatives (Aberman et al., 2018). The identified pathway from these results is as follows: Agriculture—Equitable access to agricultural markets— Income —food expenditure— household dietary diversity scores.

Table 3
Impact of woman's sale agreements (market access) on Household's Dietary Diversity Score.

VARIABLES	(1) ATE	(2) POmean	(3) OME0	(4) OME1
Treated vs Control	5.297***			
	(0.890)			
Control		29.784***		
		(0.209)		
Treated		35.081***		
		(0.866)		
Primary occupation:				
Formal salaried employ			0.831	−4.512
			(0.926)	(4.201)
Farming			0.307	−1.125
			(0.672)	(3.650)
Self-employed			1.515*	3.620
			(0.854)	(3.872)
Household size			−0.291***	−0.185
			(0.077)	(0.332)
Age of household head			0.022	−0.101
			(0.015)	(0.068)
Highest level of edu. of HH Head; Base (None = 0)				
Primary			2.407***	−4.464*
			(0.615)	(2.651)
Secondary			3.973***	−3.017
			(0.701)	(2.615)
Tertiary			3.091***	0.803
			(0.952)	(4.157)
Gross wealth (log)			1.377***	1.018
			(0.156)	(0.654)
Sex of HHead (Female = 0)			−0.449	−13.906***
			(1.679)	(2.513)
Land (Arid and Semi-Arid = 0)			2.193***	−2.185
			(0.504)	(2.299)
Constant			11.061***	48.824***
			(2.588)	(11.514)
Observations	3,157	3,157	3,157	3,157

ATE = Average treatment effect (ATE) [the mean of the difference (Y1 - Y0)]
PO mean = Potential-outcome means (means of Y1 and Y0 in the population]
OME0 = Untreated potential-outcome equations
OME1 = Treated potential-outcome equations
Robust standard errors in parentheses: *** p < 0.01, ** p < 0.05,

Table 4
Impact of Men's sale agreements (market access) on Household's Dietary Diversity Score.

VARIABLES	(1) ATE	(2) POmean	(3) OME0	(4) OME1
Treated vs Control	1.880***			
	(0.697)			
Control		29.764***		
		(0.224)		
Treated		31.664***		
		(0.663)		
Primary occupation:				
Formal salaried employ			0.610	−3.928
			(0.974)	(3.257)
Farming			0.047	−1.032
			(0.714)	(2.901)
Self-employed			1.314	0.965
			(0.902)	(3.359)
Household size			−0.305***	0.091
			(0.081)	(0.225)
Age of household head			0.015	0.002
			(0.017)	(0.049)
Highest level of education of HH Head; Base (None = 0)				
Primary			2.440***	1.883
			(0.660)	(2.335)
Secondary			3.954***	3.146
			(0.754)	(2.409)
Tertiary			3.174***	0.590
			(1.058)	(2.984)
Gross_wealth (log)			1.319***	1.560***
			(0.167)	(0.476)
Sex of HHead (Female = 0)			−0.413	−5.015*
			(1.956)	(2.574)
Land (Arid and Semi-Arid = 0)			2.238***	−0.195
			(0.526)	(1.880)
Constant			12.311***	17.834**
			(2.840)	(8.534)
Observations	3,157	3,157	3,157	3,157

ATE = Average treatment effect (ATE) [the mean of the difference (Y1 - Y0)]
PO mean = Potential-outcome means (means of Y1 and Y0 in the population]
OME0 = Untreated potential-outcome equations
OME1 = Treated potential-outcome equations
Robust standard errors in parentheses: *** p < 0.01, ** p < 0.05,

6.2. Additional determinants of household dietary diversity scores

a) Untreated potential-outcomes

The untreated potential outcomes refer to the outcome that a household would obtain if given no treatment. When not having access to organized markets, key determinants of HDDS include education of the household head, household wealth and potential of land across all the three equations.

From the base of having no education, having at least primary, secondary and tertiary level of education improves HDDS by approximately 2.4, 4, and 3 points respectively (Tables 3-5, column 3). On average, the highest educational benefits can be achieved when the household head has at least secondary education. The findings are comparable to that of Sibhatu & Qaim (2018) and Kassie et al., (2014) where education level of household head contributes to better household diets and probability of being food-secure.

Similar to the findings by Sraboni et al., (2014), having a household head who is self-employed, which mainly involves trade , improves HHDS by 1.52 points (Table 3, column 3) and 1.66 (Tables 5, column 3). In addition, HDDS improves by approximately 2.2 points in the high productive areas compared to the arid and semi-arid lands (Tables 3-5, column 3). Increased productivity, and thereby increased farm income, coupled with market access is likely to improve dietary diversity scores of households (Hirvonen & Hoddinott, 2014; Koppmair et al., 2017; Signorelli et al., 2017). Similarly, household wealth increases HDDS by approximately 1.4 points across all the three equations (Tables 3-5, column 3).

On average, household wealth increases HDDS by 1.4 points (Tables 3 and 5, column 3) and 1.2 points (Table 4, column 3). Household size was found to have a negative effect on HDDS. Increasing household sizes reduce HDDS by approximately 0.3 points (Tables 3-5, column 3). A high dependency burden is likely to exacerbate the effect of poor access to markets on dietary scores (Fischer & Qaim, 2012; Gaiha et al., 2014).

b) Treated potential-outcomes

Similar to the untreated potential outcomes, primary occupation of the household head significantly influences HDDS, but the effect is only observed when both the man and woman in a household have access to organized agricultural markets (Table 5, column 4). When primary occupation of the household is in formal salaried employment, HDDS on average reduces by about 9.1 points. This is likely due to the changing lifestyles and eating habits involving less healthy diets associated with these groups (Republic of Kenya, 2012).

Investment in education significantly influences HDDS where higher investment levels improve HDDS by about 14.4 points (Table 5, column 4). Sex of the household head, not surprisingly, had a significant impact on household dietary diversity scores. On average, male headship of

Table 5
Impact of combined gender's sale agreements (market access) on Household's Dietary Diversity Score.

VARIABLES	(1) ATE	(2) POmean	(3) OME0	(4) OME1
Treated vs Control	8.054***			
	(1.025)			
Control		29.829***		
		(0.206)		
Treated		37.883***		
		(1.004)		
Primary occupation:				
Formal salaried employ			0.868	−9.111**
			(0.910)	(4.281)
Farming			0.340	−5.877
			(0.660)	(4.144)
Self-employed			1.660**	−2.274
			(0.839)	(4.994)
Household size			−0.293***	−0.500
			(0.076)	(0.331)
Age of household head			0.020	0.041
			(0.015)	(0.059)
Highest level of edu. HH Head (ref:no edu)				
Primary			2.332***	−5.280*
			(0.607)	(2.902)
Secondary			3.843***	−0.792
			(0.692)	(2.848)
Tertiary			2.974***	14.403***
			(0.939)	(5.071)
Gross_wealth (log)			1.386***	−0.256
			(0.153)	(0.647)
Sex of HHead (Female = 0)			−0.634	−15.441***
			(1.629)	(1.351)
Land (Arid and Semi-Arid = 0)			2.239***	−4.721*
			(0.498)	(2.572)
Constant			11.320***	66.855***
			(2.541)	(12.034)
Observations	3,157	3,157	3,157	3,157

ATE = Average treatment effect (ATE) [the mean of the difference (Y1 - Y0)]
PO mean = Potential-outcome means (means of Y1 and Y0 in the population]
OME0 = Untreated potential-outcome equations
OME1 = Treated potential-outcome equations
Robust standard errors in parentheses: *** $p < 0.01$, ** $p < 0.05$,

households worsens HDDS by 13.91 points when evaluating for the effect of women's access to organized agricultural markets (Table 3, column 4). Further, HDDS are observed to be lower in male headed households by 5.02 points (Table 4, column 4) when evaluating the effect of men's access to organized agricultural markets and by 15.4 points (Table 5, column 4) when both the man and woman in a household have access to organized agricultural markets. As highlighted earlier, there exists intra-household resource flows where women are likely to spend more towards improving their households' food and nutritional incomes compared to men (World Bank et al., 2009). Expenditure on food items is however affected by who in the household makes decisions. Where men are in control, women may lose control of commodities, and thereby income, when commodities become profitable (Njuki et al., 2011; Quisumbing & Pandolfelli, 2010) and thus the negative effect of the male headship on dietary diversity scores (Tables 3-5, column 4). The effect is observed to be least where men have access to organized agricultural markets (Table 4, column 4), compared to cases where women haves access (Tables 3 and 5, column 4) further underscoring the importance of women's access to organized markets is likely to have on HHDS.

Among other factors, these results highlight gender differences in household dietary diversity scores and the importance of considering these differences in efforts towards improving access to markets for improved households' diets.

7. Conclusion and policy implications

This study adds to the literature on the role that gender sensitive approaches in agriculture play in promoting food and nutrition security in households. Gender considerations in efforts to increase the participation of farmers in organized agricultural markets have the potential of improving dietary diversity of households and thereby likely to have important implications for household's food and nutrition security. Our results indicate that improved access to well organized agricultural market systems for both men and women are likely to improve dietary diversity scores of households. However the improvement of women's access has a greater effect; more than double that of men. The differential gender effects can be attributed to the different spending patterns towards food and nutrtional secuity between meńand women where women spending towards food and nutrtion has been observed to be Pareto-superior to that of men. The crucial role played by women in household's dietary diversity scores is further emphasized by the negative effect of male headship in households.

Greater positive effects on household's dietary diversity scores are however observed where both men and women in households have access to well organized markets. The observed synergy when both women and men within the same household have access to organized agricultural markets underscores the need of taking a whole family approach in market initiatives aimed at improving the quality of household diets. The zero-sum conceptualization of power within majority of households is likely to reduce the potential benefits on household diets when market initiatives target women only.

Additional factors having a positive impact on the dietary diversity include investment in education by the household head, household wealth and productivity of land farmed by households. Household size and engagement in formal employments are however found to negatively affect household's dietary diversity scores.

The results have important national policy implications. The country's Agricultural Sector Transformation and Growth Strategy (ASTGS) 2019–2029 aspires to deliver a vibrant commercial agricultural sector to support the country's development in areas such as achieving 100 per cent food and nutrition security and global commitments such as the SDGs. Towards achieving food and nutrition security, the results highlight the need for policy to enhance equitable access to markets by both men and women for optimal household dietary diversity. As such, barriers to the effective participation of men and women in agricultural markets, should be explicitly be examined and recognized in policy. Secondly, while diet and nutrition related matters in the country fall under the ministry of Health, the ministry has little to do with enhancing access to agricultural markets. Enabling services such as adequate market infrastructure, access to trading credit facilities and greater marketing channels, which are key for enhanced agricultural market access, are provided by different sectors of the economy. This highlights the need for cross-sector coordination to enhance markets access and thereby household's capacity to tackle dietary and nutritional issues. The Kenyan National Food and Nutrition Security Policy Implementation Framework 2017–2022 endorses the creation of a multi-sectoral Food Security and Nutrition Secretariat to ensure broad, cross-sectoral implementation, coordination and monitoring mechanisms. However, this is yet to occur. It would be the task of such a committee to ensure that there are gender sensitive solutions towards greater opportunities for both women and men opportunities to participate in organized agricultural markets.

The results also highlight presence of gender intra-household dynamics in household's dietary effects. Government efforts focusing on diet and nutrition improvement among rural households need to recognize the role of women's socio-economic power in contributing towards adequate diets at the household level. Specific recommendations towards women's greater socio-economic include, linking women to organized agricultural markets, investment in human capital, and greater opportunities to wealth creation. Further, on human capital,

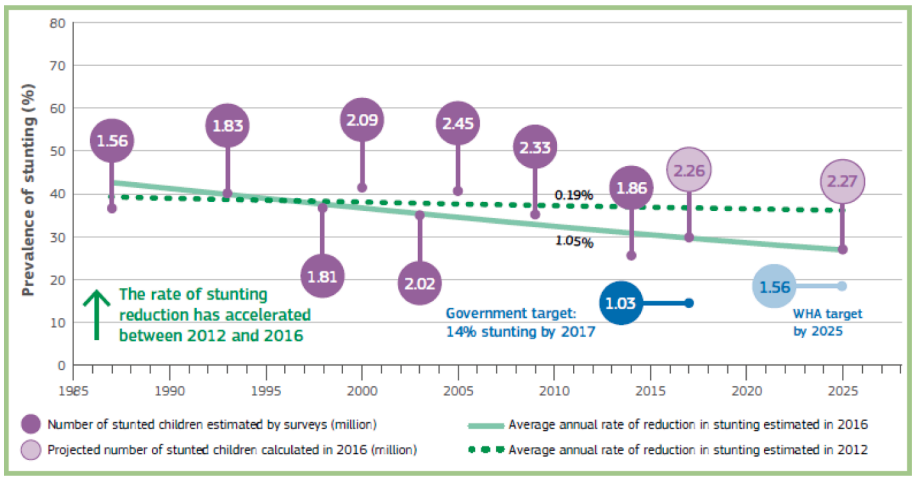
given the positive impacts of education on household dietary diversity scores, learning institutions can maximize returns to educational investments in both men and women by incorporating diet and nutrition education in schools. Education can be instrumental in achieving adequate awareness and knowledge on nutritionally adequate diets, and also acquiring the capacity to support diet and nutritional national programs in the country.

We recommend future analysis to assess gender specific challenges in accessing new and advanced agricultural markets. The path to achieving improved household's dietary diversity scores must address the unique constraints and opportunities to enhance women's participation in organized markets by incorporating tailored solutions. In addition, analysis using a gendered spatial analysis approach to examine the effects of access to markets on other nutritional outcomes, such as anthropometric measures, may be needed to further exploit the market effects on access to nutritious food to meet households' dietary needs. In addition, we suggest that future analysis preferably using panel data may be carried out to control for unobserved heterogeneity.

CRediT authorship contribution statement

Evelyne Nyathira Kihiu: Conceptualization, Methodology, Software, Formal analysis, Data curation, Writing - original draft, Investigation, Writing - review & editing, Visualization. **Franklin Amuakwa-Mensah:** Software, Formal analysis, Data curation, Validation, Writing - review & editing, Visualization.

Appendix A:. Trend, projection and targets in the prevalence and number of children (under-five) stunted in Kenya



Source: EU-Country Profile on Nutrition-Kenya. European Commission, International Cooperation and Development: https://ec.europa.eu/europeaid/nutrition-map_en- July 2017

Appendix B:. Estimation model

A counterfactual setting and Ignorability/ unconfoundedness of treatment

Following Wooldridge (2007), Wooldridge (2010) and Jordà & Taylor, (2013), let y_1 be the outcome we would observe with treatment (s = 1) and let $y_0$be the outcome without treatment (s = 0).

For every observation *i*, we observe equation (A2.1) plus a set of controls that explain treatment in presence of selection into treatment.

$$y_i = (1 - s_i)y_{i0} + s_i y_{i1} \tag{A2.1}$$

Further, when *s* and $(y_0 and y_1)$ are allowed to be correlated, in order to identify treatment effects, the ignorability of treatment (given observed covariates $\boldsymbol{x}$) assumption is applied: Conditional on $\boldsymbol{x}$, *s* and $(y_0 and y_1)$ are independent. This implies that if we can observe enough information (contained in $\boldsymbol{x}$) that determines treatment, then $(y_0 and y_1)$ might be mean independent of *s*, conditional on $\boldsymbol{x}$ (Wooldridge, 2010) (see Table A1).

The probability of treatment, propensity score, is denoted as:

$$p(x) = P(s = 1|x) \tag{A2.2}$$

Defining $\mu_1 = E(y_1)$and $\mu_0 = E(y_0)$, the average treatment effect (ATE) is given by:

$$\tau_{ATE} = \mu_1 - \mu_0 \tag{A2.3}$$

A consistent estimator of μ_1 is given by:

$$\hat{\mu_1} = N^{-1} \sum_{i=1}^{N} s_i y_1 / p(x_i) \tag{A2.4}$$

The arguments are symmetric forμ_0.

Suppose $m_1(x,\beta)$is a parametric model for $E(y_1|x)$ and $G(x,\gamma)$ for $p(x)$, then $\hat{\mu_1}$is consistent for $\mu_1$if $G(x,\gamma)$ is correctly specified or $m_1(x,\beta)$or both-double robustness (Wooldridge, 2004, 2010).

The robust estimator expression would transit to:

$$\mu^{\wedge} = N^{-1} \sum_{i=1}^{N} \frac{s_i m(x_i \beta^{\wedge})}{G(x_i \gamma^{\wedge})} \tag{A2.5}$$

The estimator $\mu^{\wedge}$ in equation (A2.5) can be used for estimating $\mu_0^{\wedge}$and $\mu_1^{\wedge}$. ATE by inverse propensity-score weighted estimator with regression adjustment (IPWRA) is then given by:

$$\tau_{ATE,IPWRA}^{\wedge} = N^{-1} \sum_{i=1}^{N} \left[\frac{s_1 m_1(x_i \overset{\wedge}{\beta_1})}{G(x_i \gamma^{\wedge})} - \frac{s_0 m_0(x_i \overset{\wedge}{\beta_0})}{1 - G(x_i \gamma^{\wedge})} \right] \tag{A2.6}$$

Simplifying equation (A2.6), sample-average treatment effect would be the sample average of dietary score of households with market access(H_{dSMA}) minus dietary score of households with no market access(H_{dSNMA}) conditional to control variables:

$$ATE = E(H_{dSMA} - H_{dSNMA}) = E(H_{dSMA}) - E(H_{dSNMA}) \tag{A2.7}$$

Table A1
Variable Description.

Variables	Description	Unit
HH Dietary Diversity Score	Household Dietary Diversity Score (7-day recall, 12 food groups)	Index (continuous variable)
Primary occupation	*Primary occupation of the household head*	
Formal salaried employ	Formal Salary Employment	Binary variable *(YES = 1)*
Farming	Farming is the primary occupation	Binary variable *(YES = 1)*
Self-employed	Self-employment	Binary variable *(YES = 1)*
Household size	Number of people in a household	Continuous variable
Age of household head	Age (in years) of household head	Years (continuous variable)
Highest level of education	*Highest level of education of household head*	
No education	No education	Binary variable *(YES = 1)*
Primary	Attained at least Primary Education	Binary variable *(YES = 1)*
Secondary	Attained at least Secondary Education	Binary variable *(YES = 1)*
Tertiary	Attained at least Tertiary	Binary variable *(YES = 1)*
Annual per capita gross wealth	Gross_wealth (log). Measured by ASDSP as sum of value of all livestock owned, value of household assets and total household income	Log (continuous variable)
Sex of HHead	Sex of the household head	Binary variable *(Male = 1, Female = 0)*
Productivity of Land	Broad Land Classification according to its potential	Binary variable *(*Arid and Semi-arid = 0; Higher Potential Land = 1*)*
HH_female adult	HH has only female adults	Binary variable *(YES = 1)*
HH_male adult	HH has only male adults	Binary variable *(YES = 1)*
HH_female_male adults	HH has both male and female households	Binary variable *(YES = 1)*
Women's access	Woman in the household has access to organized agricultural markets	Binary variable *(YES = 1)*
Men's access	Man in the household has access to organized agricultural markets	Binary variable *(YES = 1)*
Combined access	Both Man and Woman in the household have access to organized agricultural markets	Binary variable *(YES = 1)*

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