Crop Production Diversity and Women Dietary Diversity in Rural Kenya[1]

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Bringing Rigour and Evidence to Economic Policy Making in Africa

Crop Production Diversity and Women Dietary Diversity in Rural Kenya[1]

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Abstract

Despite the commitments and efforts to fight all forms of malnutrition, malnutrition among women in Kenya persists. Using the Kenya Integrated Household Budget Survey data this paper examined, (i) the extent to which crop diversification and diet diversity among women in rural Kenya vary by region; (ii) the impact of crop diversification on dietary diversity among women in rural Kenya; and (iii) the extent to which market access and participation mediates the impact of crop diversification on diet diversity among women (WDDS) in rural Kenya. Our findings show that there exist wide disparities in crop and diet diversity across regions. Second, we find that higher crop production diversity has a positive and significant association with women dietary diversity which is plausible in a smallholder subsistence-oriented farming system like rural Kenya where a significant portion of what is produced is consumed. Third, we establish that higher household diet diversity is negatively associated with women diet diversity which affirms the existence of significant differences in intrahousehold such that non-female household. This could be an indicator of preferential food 'channelling' to within households where women act as buffers during episodes of food-insecure conditions. Finally, the effect of distance to the nearest market on women's diet is positive albeit insignificant while market participation has a significant positive effect on women's dietary diversity and its effect is largest than that of crop diversity.

Keywords: *Crop production diversity, Diet Diversity, Women, Rural Kenya.*

1. Introduction

One-third of the global population experiences micronutrient malnutrition and are especially found in Africa and Asia (Sibhatu & Qaim, 2017). As a result, food insecurity and nutrition deficiency are a major public policy problem in most developing countries and particularly in Sub-Saharan Africa (SSA) as the rate of population growth exceeds the production of food required to feed the population (Adjimoti & Kwadzo, 2018). As a result of malnutrition sustainable development of countries are affected in many ways. First, at the individual level, it is associated with both short-run and long run costs. In the short-run, malnutrition is associated with reduced productivity among the workforce and thus reduced outputs. In the long run, it is associated with increased health care costs due to the disease burden associated with poor nutrition. Similarly, it results to the loss of human capital due to fighting the disease burden (Hoddinott, 2016).

In developing countries, agriculture plays a significant role not only towards economic growth but also in ensuring food security and nutrition for all is achieved (Tamang, Paudel, & Shrestha, 2014; IFAD, 2013; Acharya, 2006; Ellis, Kutengule & Nyasulu, 2003). Yet, despite smallholder farmers being food producers that are disproportionately affected by food insecurity and malnutrition. With the rising and volatile food prices and climate changes, the need for diversity in production as an adaptation strategy against shocks is compelling (Di Falco and Veronesi, 2013; Ellis, 2000; Seo and Mendelshon, 2008; Wang et al., 2010). In addition, diversification of small-holder agricultural production ensured food security and access to nutritious diets is achieved (Jones, Shrinivas and Benzner-Kerr, 2014; Gillespie et al. 2012; Herforth & Harris 2014).

Recognizing the serious implications of the continued high levels of malnutrition in all forms, governments of developing countries have adopted policy interventions of promoting the adoption of investments aimed at improving agricultural productivity and production as well as committing to increase budgetary allocations to the sector to 10% of gross domestic product (GDP) under the Maputo declaration (African Union, 2003). With the guiding principles for these interventions being to attain food and nutrition security to protect its citizens against malnutrition by ensuring agricultural production is diverse and market-systems are well developed (Sibhatu & Qaim, 2017). Yet, notwithstanding the unarguably significant benefits, the promotion of agricultural crop diversification for improved nutritional outcomes is not without challenges and

Njeru (2013) notes that the adoption remains low due to policy incoordination. For instance, where policies aimed at improving nutritional outcomes and agricultural productivity limited synergies have been realised.

The role of agriculture in influencing nutrition has been theorised to occur through multiple channels (see for example Haddad 2000; World Bank, 2007; Hawkes & Ruel 2006, Gillespie et al. 2012; Herforth & Harris 2014; Jones et al. 2014;). These pathways include: (i) consumption from own production. Smallholder farmers consume a sizable amount of what they produce thereby, underlying the relationship between crop diversification and dietary diversity; (ii) through the channel of increased incomes from diversification. Similarly, most farm households also buy some of their food from the markets. This has led to suggestions that market access mediates the relationship between crop diversification and dietary variety; (iii) reduced food prices emanating from improved productivity of food crops (i.e. supply-demand dynamics) and (iv) through altering women's time use in production and consumption decisions.

In this paper, we examine the effect of; (i) crop production diversity (ii) household dietary diversity and (iii) market access among rural smallholder farms on women's dietary diversity. In examining these issues, we focus on two pathways through which agriculture influences nutrition namely, own-consumption and market access pathway. In addition, we incorporate intra-household dynamics by hypothesising that household dietary diversity also influences women's dietary diversity. This is important in understanding intra-household food allocation patterns in rural settings where the distribution of food resources is marked by significant heterogeneity (Gete et al., 2015, Abdullah, 1983; Gittelsohn, 1991; Madjdian, & Bras, 2016; Ramachandran, 2007). The intrahousehold food allocation dynamics are important as they have important implication on nutrition. For instance, food allocations may not be shared equally among the household members and in some cases the allocation pattern may be skewed to benefit groups which may not necessarily be nutritionally valuable. This may be the case especially in instances where household resources are under stress, and the caregivers in these case women may decide to reduce their consumption in favour of other household members.

Using nationally representative data from Kenya, the findings show that crop production diversity is low and on average households grow three crops. We also find that women's dietary diversity is low and on average four food groups are consumed while at the household level the food groups consumed is five. Further, higher crop production diversity has a significant positive effect on women's dietary diversity thus implying that rural smallholder farms in Kenya produce for own-consumption and therefore leading to improved diets among women. Looking at the intrahousehold food allocation dynamics, we find that higher household dietary diversity has a negative effect on women's diets an indication of food allocations being skewed towards non-women members of the household. Lastly, the results show that market access is also important in improving women's diets. This has policy implication as it suggests that improving access to markets through better infrastructure and promoting programs that link farmers to the market are promising strategies to improve women's nutrition.

National policies on agriculture and nutrition in Kenya

Recognizing the role of agriculture in improving nutritional outcomes, there have been significant strides over the last three decades in the formulation and adoption of legal and regulatory frameworks and policies to support the sector. To start with, in the early 1980s and mid-1990s, two policies were adopted. First in 1981, the Food Policy (Sessional Paper No. 4 of 1981) later consolidated into the Sessional Paper No. 1 of 1986 on Economic Management for Renewed Growth was adopted. These policies were meant to ensure self-sufficiency and equity in distribution of diverse and nutritious foodstuff among all Kenyans. Second in 1994, a second Kenya National Food Policy (Sessional Paper No. 2 of 1994) was adopted. This policy was market-based and was adopted in response to the drought experienced in the country during 1991-1994 with the aim of ensuring a market-driven approach to access to food.

In the period 2000 to 2010, four policy frameworks were adopted. First in 2001, the Poverty Reduction Strategy Paper and in 2003 the Economic Recovery Strategy (ERS) for Wealth and Employment Creation focusing on the period 2003-2007 were adopted. The adoption of these policies sought to ensure that the country was food and nutrition secure. Similarly, these policies sought to bolster the role of agriculture on poverty alleviation and supporting economic growth and development. In 2004, the ERS policy was further supported by the adoption of the Strategy for Revitalizing Agriculture (SRA) which focussed on the period 2004-2014. The aim of this policy was to create an innovative, commercially oriented and modern agriculture to ensure a food-secure and prosperous nation.

Third in 2008, the Vision 2030 policy was adopted. This policy has seven pillars with one of the pillars of economic and social pillars seeking to enhance agricultural productivity in crop and livestock production with a view to not only raising the sector's contribution to the economy but also in ensuring food security and nutrition. To achieve this, the initiatives included the transformation of uncultivable lands in agriculture, developing more irrigable areas in arid and semi-arid lands for both crops and livestock and improving market access for smallholders through better supply chain management.

In 2010, the Agriculture Sector Development Strategy (ASDS) focusing on the period 2010 to 2020 was also adopted with the sole purpose of creating an innovative, commercially oriented and modern agriculture to ensure a food-secure and prosperous nation. Given the limited progress and limited success of past food and nutrition policy initiatives, the National Food Security and Nutrition Policy (FSNP) of 2011 was adopted with three broad objectives. First, it was meant to ensure food was always available, accessible and affordable to all Kenyans. Second, to achieve good nutrition for optimum health of all Kenyans. Lastly, the FSNP policy of 2011 was meant to protect the vulnerable populations using innovative and cost-effective safety nets linked to long-term development.

Overall, all these policies have been geared towards promoting crop diversification and bio-fortification that would be essential in ensuring that the household's food

security and nutrition is achieved. However, despite the increased attention and awareness of the important role of smallholder agricultural households to diversify, the empirical base on the effectiveness of the policies adopted by the government to bolster diversification is limited. Admittedly, there is an urgent need to interrogate the role of these policies more specifically those that enhance crop diversification as a means of ensuring that access to diverse and nutrient-rich diets is achieved. This is further reinforced by the fact that while diversification in smallholder production in helping reduce malnutrition, this potential is yet to be realised in East Africa and more importantly in Kenya (Hodge, et.al., 2015).

The need to focus on women dietary diversity

In Kenya, although significant reductions in malnutrition have been witnessed among women of reproductive ages (WRA)[2], women malnutrition remains rampant. For instance, according to the KDHS 2014, the average mean body mass index (BMI) among WRA was 23.7kg\/m_2. In the same period 9% were undernourished, 6% moderately undernourished and 3% severely malnourished. Equally, heterogeneity in undernourishment is also evident along other dimensions. First, young rural-based women are likely to be undernourished.

On the regional front, disparities are also evident with 29% from the North Eastern region are being undernourished compared to 2.8% in Nairobi, 11.8% in Rift Valley and 9.8% in the Eastern region[3]. Further, women with low levels of education (25%) are likely to be malnourished compared to those with higher educational attainments (12%). Similarly, malnourishment is 22% in the lower wealth quintile are five times more likely to be undernourished than WRA (4%) in the highest wealth quintile. Further, 33% of women were overweight or obese.

Given this background, we seek to focus on the linkages between crop production diversification and women's dietary diversity in rural Kenya for four reasons. First, women play a significant role in the agricultural sector and more importantly to rural economy in Kenya as the main food producers, yet they are disproportionally affected by hunger and malnourishment. In addition, women often manage complex household decisions such as food consumption which ultimately affects not only their nutritional status but also the nutritional status of their children. Further, women are also typically involved in the production of agricultural food crops and livestock and they make up to 80 percent of Kenya's farmers.

Second, women require food rich in nutrients especially during pregnancy and lactation periods yet are often in resource-poor surroundings with a high risk of limited micronutrients intake despite contributing 60% to 70% to the labour force in the agricultural sector. Further, outside of these periods, though their nutrient requirements are more like those of men because they tend to eat less, they require a bit higher nutrient-rich diet (Torheim & Arimond, 2013). Third, the implementation of malnutrition programmes reaching adolescent girls and WRA has historically been in the context of prenatal care. With the need to hasten the progress of ensuring zero

hunger, the contemporary multi-dimensional approach has brought to fore the need for agricultural diversification as a means of reducing the extent of malnutrition.

Fourth, not only is the nature and depth of malnutrition more important among WRA, but it also has long-term implications on human capital and a country's economic development (Shively & Sununtnasuk 2015). For instance, malnutrition has been associated with an 11% loss of GDP in Asia and Africa (Ilyasov et. al., 2016). In addition, it has dire consequences on an individual's health and consequently their productivity[4]. With these adverse consequences, tackling malnutrition is thus of a policy interest at all levels (globally, national and grassroots levels).

Statement of the problem

Since pre-independence period, agriculture is the backbone of Kenya's economy's and accounts for 51% of Kenyan GDP (KNBS, 2018)[5]. The sector in addition, contributes 60% of the merchandise exports and 56% of the country's population is employed in the sector. Similarly, 80% of the country derive their livelihood from the sector which is characterized by different small-scale farming and differences in crops patterns[6]. Despite the smallholder farming, 75% of the country's total food production is from smallholder farmers (CAADP, 2013) and production is under threat due to climate change[7]. Further, the country's agricultural production remains low and productivity of the sector on a decline, yet it should play a crucial role in ensuring food security and nutrition for all is attained.

Despite the acknowledge of the role of agriculture in ensuring the country is food and nutrition safe, malnutrition among women persists. According to the Demographic Health Survey (2004), 23 percent of women are obese. Similarly, 41% of women between 45 and 49 years are overweight, while 8% of women between 15 and 19 years are overweight. In 2014, 9% were undernourished, 6% moderately undernourished and 3% severely malnourished. Over the two periods; 2004 and 2014, the prevalence of malnutrition remains high in rural areas compared to urban areas with women being disproportionately affected despite the agricultural policies being implemented towards ensuring food security and nutrition for all is achieved.

Studies examining the effectiveness of national policies such as agricultural diversification policies on diet diversity and more particularly among smallholder rural farmers is scarce. In addition, role of intrahousehold food distribution dynamics remains unexplored yet in many African settings inequitable food distribution is prevalent among the households. Thus, the need for a better understanding of the nexus between agriculture and nutrition, particularly among women of reproductive age is compelling. This study, therefore, seeks to examine the role of crop production diversity on women diet diversity through household diet diversity channel. Second, it examines the linkages between women and household diet diversity and lastly, it looks at the role of market access in bolstering the nexus between crop diversification and women diet diversity.

Objectives

The study seeks to analyse the impact of crop diversification on women's dietary diversity. Specifically, it seeks to;

i) Examine whether crop diversification and women diet diversity among women in rural Kenya varies by region.
ii) Determine the effect of crop diversification on women diet diversity in rural Kenya
iii) Evaluate the extent to which access to market mediates the impact of crop diversification on women diet diversity in rural Kenya.

Justification of the study

In this paper, we provide some insights into the issues of prevalence of malnutrition among rural women by investigating agriculture-nutrition linkages in Kenya against the backdrop that malnutrition (undernutrition and overnutrition alike) among women remain prevalent despite substantially contributing to the agricultural labor force. Thus, the investigation of the link between agriculture and nutrition is critical in the current face of food insecurity, hunger, and malnutrition, globally and of policy shifts towards how agriculture can be made more nutrition-sensitive, particularly. This study is therefore instrumental understanding the role of agriculture in improving nutrition outcomes through the lens of the disproportionately affected population who live in rural areas. In trying to understand whether farming systems contribute to improved nutrition outcomes, we use the Kenyan context for two reasons: (i) with the increased adoption and promotion of agricultural policies by the Kenyan government, it is important to examine the efficacy of these initiatives in improving nutrition outcomes especially in the rural areas where smallholder farming is the most dominant form, and (ii) the fact that agriculture is a predominant primary livelihood base for over seventy-five per cent of the Kenyan populace and the fact that the burden falls disproportionately on the lowest-income groups who also double up as rural residents.

2. Empirical evidence

Several studies have investigated the importance of crop diversity in improving nutrition and health. Crop diversification affects dietary diversity since most smallholder farmers consume a significant proportion of food produced (Gonder, 2011). In the Far East, Malapit et al. (2015) revealed that agricultural production diversification had a positive impact on the dietary of children and maternal in Nepal. In Southern Africa, Jones et al. (2014), using household data from Malawi, established the existence of a positive association between diversity in agricultural production and nutritional diversity. Although their study revealed a positive linkage, their results indicated that the model's constant was highly significant and would be improved by adding more covariates to reduce the problem of omitted variable bias, which our study will address through the inclusion of variables such as market access. Slavchevska (2015) also examined these linkages; using panel data from Tanzania, the study establishes the existence of a positive linkage between them even after controlling for the household's socio-economic characteristics.

Lovo & Veronesi (2015) investigated the effects of crop diversification on dietary diversity on children health in Tanzania. The study found out greater crop diversification lead to improvement in children's health especially for younger children or those who live in households that do not have any access to markets. Using a Margalef index of food consumption, the study found a significant relationship between crop diversification and dietary diversity. Crop diversification had a strong positive effect on child height-for-age z score and hence, child health among young children. The results of the study are not surprising since young children from the ages of 0 and 5 are severely affected by changes in nutritional value and have high growth rates. In addition, they also examine the effects of access to markets on the relationship between crop diversification and children's health by dividing the the household according to the proximity to the markets by classifying them into close (0-5 km), medium (6-11 km), and far (12-82 km). The results showed that crop diversification had significant and strong effects on child health for households very far from the markets. In contrast, households close to the markets had very effects on children's health.

Mofya-Mukuka and Kuhlgatz (2014) also found varied results when investigating the effects of agricultural diversification and commercialization on the nutritional status of children. Although these two were critical, the study established that the intensity

of treatment was equally important. For instance, high levels of diversification have significant effects in improving nutritional status while smaller levels do not have any effects. In addition, the impacts of crop diversification depend on the food crops. For instance, protein diversification seemed to have positive significant effects on nutrition diversity at high levels of diversification for short and medium-term effects on nutritional status. However, protein diversification did not have any significant effects on long-term malnutrition. Diversification in calorie production has a non-linear effect on nutritional status meaning specialization in the production of few crops results in a less diversified diet causing long-term consequences on child health status. They also found commercialization to have negative effects on dietary diversity and hence, short-term and long-term nutritional effects on children.

On the other hand, Tischler, Biberman, & Alkhafaji (2008) analysed the role of nutrition education on crop diversification, commercialization (market participation), and dietary diversity among women and children in Zimbabwe. Using negative binomial regression analysis, the study showed that nutrition education, especially on child feeding information, has a positive association with the households' dietary diversity. Moreover, farm diversification also had a positive and significant relationship with households and women dietary diversity since they produce a large part of what is produced in the farms.

Contrary to previous studies, Chen & Salas (2015) found that agricultural diversification had insignificant effects on the nutritional status of children. Theoretically, increased incomes can improve the nutritional status of children since it enables households to purchase a variety of food from the markets. Other factors such as access to safe water supply seemed to have a significant effect on the anthropometric outcomes in children such as height for weight. According to the study, availability of safe water supply has a stronger effect on nutritional status in children since it lowers the incidences of the water-borne diseases especially if the child begins transits from breast milk to supplemental foods. The study found diversification to have no effect on stunting. Other variables such as the farm size, the type of crop under cultivation whether food crop or cash crops affected the effect of commercialization on children's health outcomes such as anthropometric measures including weight and height.

Closer to our study, Koppmair et al. (2017) found a positive association between agricultural production diversity and market access among Malawian maternal and child dietary diversity. Similarly, Snapp & Fisher (2015), while investigating the relationship between crop diversity and market, revealed that despite crop diversity showing a positive association with market access, those households that had better-improved storage technologies have a higher dietary diversity. These findings imply that households living closer to markets have higher dietary diversity than those far away from and therefore suggests that suggests the need for more farm production diversity in remote areas far from markets. In addition, the small effects of food production diversification mean that improving dietary diversity would require a very large improvement in crop production diversity.

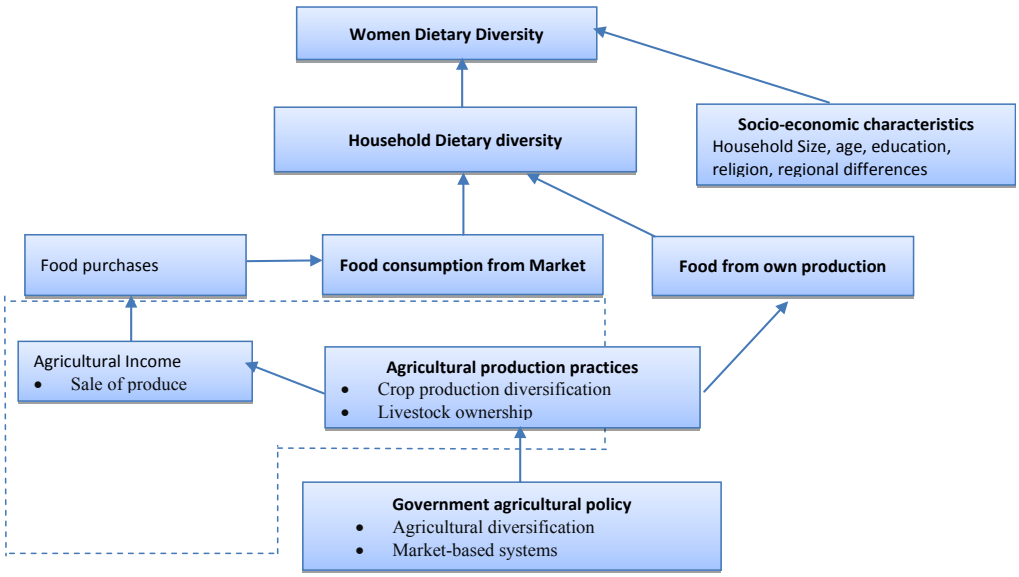
Despite, the complexity in unearthing the linkages between agricultural production diversity and dietary diversity, empirical evidence examining the link between them has been increasing but they remain limited and their methodological approach insufficient to adduce evidence of causality (Webb & Kennedy, 2014). Some of the studies are cross-sectional in nature and therefore, fail to consider time-invariant and unobserved heterogeneity and therefore their estimates are potentially biased (Jones et. al., 2014; Rajendran et. al., 2014; Kumar, Harris & Rawat, 2015; Koppmair, Kassie & Qaim, 2017; Shively & Sununtnasuk, 2015). In addition, limited studies exist in SSA with none of these on Kenya that jointly investigate the role of either farm production diversity or market access on women diet diversity- an area this study wish to contribute. Finally, whilst there is recognition that agricultural production is key for improved diet access for households, it is worth noting that this agricultural diversity and diet diversity across countries is not uniform and hence the need to look at how country specificities play out on the agricultural production diversity and diet diversity nexus.

3. Conceptual framework

Figure 1 elucidates the conceptual framework adopted in the study and shows the pathways through which agriculture affects nutrition and the role of household socio-economic characteristics. In this study we conceptualize that investments in government agricultural policy on diversification would lead to increased crop diversification through two channels. First, subsistence-oriented production for own consumption, particularly in the presence of market failures which are common in developing countries with the extreme case of market failure occurring when a market for a particular good is non-existent (Janvry, Fafchamps, & Sadoulet, 1991). Second, income-oriented consumption arising from sale of agricultural produce in markets. That is, higher agricultural production should lead to higher incomes for agricultural households enabling them to purchase more and better food, provided markets are complete, and households can access safe and nutritious food at a reasonable price. Consequently, consumption from own production and from income from sale of produce in the markets ensures that household members have diverse and nutritious diets.

However, the picture is not complete without an examination of the intra-household food allocation dynamics that explains the divergences in women's and other household member's nutrition. As such, we hypothesize that women may get a lesser share of the food consumed by the household compared to their other members of the households. And that these differences are compounded by differences in socio-economic characteristics of the women members in the households. This additional linkage is especially important especially given that improvements in household dietary diversity do not necessarily translate into improvements in nutritional status, especially of women especially in poor rural smallholder farming systems (Amugsi, Mittelmark and Oduro 2015; Skafida 2013). Women in food insecure households thus tend act as buffers (Abdullah, 1983; Gittelsohn, 1991; Madjdian, & Bras, 2016; Ramachandran, 2007).

Figure 1: Agriculture-nutrition-food security conceptual framework



4. Method of analysis

Description of the data

To explore how crop diversification affects dietary diversity among women, this study uses a nationally representative household survey from Kenya, namely the Integrated Household Budget Survey (IHBS) conducted in 2005/06. The sample was drawn under the National Sample Survey and Evaluation Programme (NASSEP) IV Sampling frame. The NASSEP frame is a household-based master sampling frame developed and maintained by KNBS. The frame was implemented using a multi-tiered structure, in which a set of 4 sub-samples (C1, C2, C3, C4) were developed. It is based on the list of enumeration areas (EAs) from the 2009 Kenya Population and Housing Census. The frame is stratified according to County and further into rural and urban. Each of the sub-samples is representative at county level and at national (i.e. Urban/rural) level and contains 1,340 clusters.

The sampling adopted was a two-stage stratified approach. In the first stage, 1,343 clusters were selected with equal probability within a district. In the second stage, 10 households were selected with equal probability in each cluster and thus a total sample of 13,430 households was selected. The survey was conducted over a 12-month period to obtain up-to-date data on a range of socio-economic indicators used to monitor the implementation of development initiatives. The Survey collected data on household characteristics, housing conditions, education, general health characteristics, nutrition, household income and credit, household transfers, agricultural production among others.

Identification and estimation strategy

We estimate the effect of crop diversification on women's dietary diversity based on a sub-sample of women of reproductive age between 15 years and 49 years using a model of the form:

$$(y_i|x_i) = \exp(\alpha + \boldsymbol{X}'\beta)\, y_i = 0,1,\ldots,i \qquad (1)$$

Where y_i represents the women's dietary diversity score which is measured as a count of the number of food groups[8] from a list of 10 defined food groups consumed in the past 7 days. X' represents a vector of explanatory variables; household dietary diversity score, crop diversification score which is measured by the number of food groups produced since it reflects diversity from a dietary point of view (Koppmair, Kassie & Qaim, 2017; Hirvonen, & Hoddinott, 2016; Sibhatu, & Qaim, 2018), a measure of market access and participation, age, household size, education level, religion and marital status.

The choice of these variables are informed by the extant literature and may influence women's dietary diversity either positively or negatively. Household dietary diversity is hypothesised to have a negative effect on women dietary diversity and thismay occur when food allocations are not be shared equally among the household members especially in instances where household resources are under stress, and the caregivers may decide to reduce their consumption in favour of other household members. On the other hand, a higher diversity in crop production is expected to be positively related to women's dietary diversity so is the case with market access and participation. The other variables are adopted as control variables and may either have a positive or negative association with a woman's dietary diversity.

The dependent variable, women's dietary diversity score is a count variable and hence the use of a Poisson model is the most appropriate (Cameron & Trivedi, 1998, Green, 2012). The Poisson distribution presented in equation (2) is anticipated to have a conditional mean λ_i, with a log-linear specification as is common in the literature.

$$E(y_i|x_i,\varepsilon) = \exp(\alpha + \boldsymbol{X}'\beta + \varepsilon) \text{ with variance } var(y_i|x_i,\varepsilon) = \lambda - \grave{}\alpha\lambda_i \quad (2)$$

Equation (3) is estimated to find the effect between crop production diversification and dietary diversity among women. To determine the class of Poisson models to adopt we test whether the (conditional) mean of the dependent variable is equal the (conditional) variance. The null hypothesis of equidispersion is rejected[9] and we estimate equation (3) using Poisson Generalized Linear Model (PGLM) with a negative binomial link and a Poisson family. We used robust standard errors clustered at the household level to correct the standard errors (Cameron & Trivedi, 2010).

$$\begin{aligned} WDDS_i = {} & \beta_0 + \beta_1 HDDS_i + \beta_2 CD_i + \beta_3 MA_i + \beta_4 MP_i + \beta_5 FP_i + \\ & \beta_6 X_{1i} + \beta_7 X_{2i} + \beta_8 X_{3i} + \beta_9 X_{4i} + \beta_{10} X_{5i} + \beta_{11} CD_i . MA_i + \\ & \beta_{12} CD_i . MP_i + \beta_{13} MA_i . FP_i + + \beta_{43} Region_i + \varepsilon_i \end{aligned} \quad (3)$$

Where WDDS_i represents the woman's dietary diversity score, $HDDS_i$ represents the household dietary diversity score, CD_i represents the measure of crop production diversification, MA_i represents a measure of market access and is measured by the distance to the daily market, MP_i represents market participation and is measured

by whether a household sold produce to the markets, FP_i represents expenditure on food in natural logarithm, X_{1i} represents the age, X_{2i} represents household size, X_{3i} represents education level, X_{4i} represents religion and; X_{5i} represents marital status. $CD_i.MA_i$ is an interaction term between crop production diversity and market access, $CD_i.MP_i$ is the interaction term between crop production diversity and market participation and are meant to capture the crosseffect of market access and participation on women's dietary diversity while $MA_i.FP$ is an interactio term between market access and food purchases and captures the cross effects of the two terms on women's dietary diversity. $Region_i$ represents the regional dummies. $\beta's$ are parameters to be estimated and are interpreted as semi-elasticities (Green, 2012).

Descriptive statistics

Table 1 describes the dietary diversity at the household and individual level (i.e. among women of reproductive age), crop diversification and individual and household characteristics. At the household level, the mean dietary diversity is 6; this implies that on average a household consumed six food groups during the reference period. On average the women's diets is composed of four food groups implying that the women's diets are less diversified compared to those of the household. This finding is intuitive since, at the household level, the consumption of all the members are covered including those of children and adult males and is consistent with the finding of Koppmair, Kassie, and Qaim, 2017) in their study in Malawi.

Table 1: Summary statistics of crop production diversity, dietary diversity and socio-economic characteristics

Variables	N	Mean	St. Dev
Women's Dietary Diversity	6452	4.252	1.791
Crop Production Diversity	6452	3.181	1.636
Household's Dietary Diversity Score	6452	5.958	2.016
Expenditure on food (Natural logarithm)	6445	10.283	0.863
Age, years	6452	26.93	10.325
Household Size (number)	6452	7.001	3.042
Primary Education (=1 if primary education, 0 otherwise)	6452	0.193	0.395
Secondary Education (=1 if secondary education, 0 otherwise)	6452	0.068	0.251
Above Secondary education (=1 if above secondary education, 0 otherwise)	6452	0.207	0.405
Religion (=1 if Christian, 0 Otherwise)	6452	0.906	0.292
Marital Status (=1 if Married, 0 Otherwise)	6452	0.537	0.499
Produce Sold to Market (=1 if sold, 0 Otherwise)	6452	0.292	0.455
Distance to the Market in Kms (Natural logarithm)	6433	2.252	1.308

On average smallholder farm households grew 3 food crops which also vary regionally. In terms of market participation (i.e. sold their produce in the market), 29% participated in the market. The average age of the sample analysed was 27 years with the household composition comprising of 7 members. On education 19% had primary education, 7% had secondary education, 21% had education beyond secondary schooling while 54% comprised of those with no education and informal education. Our sample also comprised of 91% Christians with 9% being Non-Christians and is in line with the fact that Kenya has most of its populace being Christian. On marital status, 54% of the women were married.

4. The effects of crop diversification on women dietary diversity

Crop diversity and women diet diversity by region

In this section, we look at whether women's diet patterns and crop production diversity exhibit variations regionally. Table 2 shows the distribution of both the women's diets and crop production diversity in the seven 7 regions. Evidently, there exist wide disparities in crop and diet diversity across regions with North Eastern Kenya having the lowest crop diversification. Eastern province has the highest crop diversification score with four crops being grown. On the other hand, Central, Western, Nyanza and Coast province grow three crops while Rift Valley province is the least diversified with only two crops being grown.

On dietary diversity among women of reproductive age, the evidence also reveals the existence of differences though marginal across regions with different patterns from that of crop diversification being evident. Whereas Eastern province is the most diversified in terms of crop production it does not have a diverse diet (i.e. 3.94 food groups are consumed) as opposed to Coast province that consumes the highest (i.e. it consumes 4.02 food groups). On the other hand, consistent with the observation that North Eastern province is the least diversified in terms of crop production it is also the least diversified region in terms of women's diet intake at 2.79 food groups being consumed. Overall, the results point to the existence of regional differences in both crop and diet diversity.

Table 2: Level of crop production diversity and women's diet diversity by regions

Region	Crop Production Diversity Score	Women's Diet Diversity Score
Rift Valley Province	2.32 (1.13)	4.15 (1.67)
Western Province	3.29 (1.71)	4.46 (1.65)
Nyanza Province	2.85 (1.31)	4.42 (1.72)
North Eastern Province	1.50 (0.52)	2.79 (1.31)
Eastern Province	4.13 (1.79)	3.94 (1.94)
Coast Province	3.00 (1.50)	4.02 (1.87)
Central Province	3.49 (1.42)	4.63 (1.80)

Standard deviations in brackets

Effect of crop diversification on women's dietary diversity, controlling for household socio demographic factors.

We now look at results from the regression models explained in equation (3) to examine the effect of crop production diversity, household dietary diversity and market access on women's dietary diversity using the Poisson Generalized Linear Model (PGLM) with a negative binomial link and a Poisson family. The choice of this estimator is guided by the rejection of the null-hypothesis of equi-dispersion[10] and the results are reported in Table 3 with the robust standard errors clustered at the village level to control for the possibility of correlated village common effects. The PGLM allows overdispersion such that the conditional variance of the outcome is assumed to be a quadratic function of the conditional mean.

First, we analyse the role of crop production diversity on women's dietary diversity. The results in Table 3 shows that crop production diversity has a positive and significant effect on diet diversity of women. This finding is plausible is, because much of what smallholder farmers produce is mainly consumed at home and is in congruence with the extant literature that also establishes the positive effect between crop production diversity and dietary diversity (Jones et al., 2014; Pellegrini and Tasciotti 2014; Hirvonen and Hoddinott, 2017; Sibhatu et al., 2015a; Kumar et al., 2015; Dillon et al., 2015; Koppmair et al., 2017). Yet the marginal effects are relatively small. Increasing farm production diversity by one food group is associated with only a 0.218 increase in the number of food groups consumed by women.

Whereas crop production diversification leads to higher dietary diversity, it is also the case that that it may contribute to income if some of what is produced is sold in the markets and what is not produced is purchased. Second, we analyze role of food purchases on women's dietary diversity. We establish that food purchases have a significant positive effect on women's dietary diversity. More importantly, a 1% increase in expenditure on food would lead to 0.133 increases in the number of food groups consumed with the magnitude of this effect compared to the effect of crop diversity being lower by 0.085. This implies that a higher dietary diversity can be achieved by supplementing the diets with purchases and that facilitating commercialization of smallholder farms would complements the role of crop diversity in enhancing women's diets.

Third, we analyse the effect of household dietary diversity on women's diet diversity. The results show that household diet diversity has a negative and significant effect on women's diet diversity. The marginal effects results of the Poisson estimator show that increasing household diet diversity by one food group is associated with only a 0.168 reduction in the number of food groups consumed by women. Clearly, this shows there exist differences in intra-household food allocation among rural households in Kenya to the disadvantage of women. This is in line with the view of Gete et al. (2015) who noted that in many African

communities substantial intrahousehold food distribution differences exist with certain household members having higher access to some foods than others. This possibly points to the that the existence of preferential food 'channelling' to non-women members within the household. In addition, given the African culture, women are seen to be of lower status, frugal, and subservient and therefore they act as buffers in food-insecure households (Abdullah, 1983; Gittelsohn, 1991; Madjdian, & Bras, 2016; Ramachandran, 2007).

Fourth, we analyse the effect of market access as being an enabler to smallholder farmers selling produce and buying non-produced foods. In this paper we capture the role of market access using two other proxies other than food purchases namely, distance to the nearest daily market, and sale of farm produce. We find that distance to the nearest daily market has a positive effect on diet diversity among women albeit insignificant, implying that households in remoter regions have higher dietary diversity compared to those nearer to markets. On the other hand, market participation a dummy additional explanatory variable that takes a value of one if the household sells at least parts of its farm produce to the market is established to also have a positive effect on women's dietary diversity. More importantly, its effect is largest than that of crop diversity with its coefficient being 0.331 implying that the dietary diversity of those who sell some of their produce in the market is higher than that of non-market participants by 0.331. Furthermore, the negative and significant interaction term confirms that market participation and access is more important in remoter regions where farms tend to be more subsistence oriented.

We further analyse the role of non-farm and non-market factors in line with existing evidence that diets are also influenced by factors other than crop production diversity and market access. Table 3 also shows estimates for the role of other socio-economic and demographic factors. We establish a bigger household has a significant negative effect on women's dietary diversity. The results also reveal that the older the women gets the more diverse their diets gets. In terms of education, we also find the effect on women's dietary diversity to be positive with the magnitude of the effect of secondary education being the largest compared to that of primary and tertiary education. This suggests that secondary education translates to improved dietary diversity scores (Patel et al. 2012). Similarly, the effect of religion is positive and the effect of marital status on women's diet diversity is negative with both effects being statistically significant. This observation is in line with the view of Van (1985) that religion is a key determinant in food distribution decisions, particularly through influence on food classifications systems. On the other hand, the negative effect of marital status could be tied to bigger household and the existence of preferential food 'channelling' to the different members of the households.

Table 3: The effect of Crop Production Diversity on Women's Diet Diversity in Rural Kenya

Dep. Variable (Women's Dietary Diversity)	Coeff.	Marginal Effects
Crop production diversity	0.0101***	0.218***
	(0.0015)	(6.88)
Household's dietary diversity	-0.008***	-0.168***
	(0.0005)	(17.38)
Expenditure on food (Natural logarithm)	0.0061***	0.133***
	(0.0016)	(3.71)
Age, years	0.0005***	0.010***
	(0.0001)	(3.60)
Household size (number)	-0.0018**	-0.038**
	(0.0007)	(2.58)
Primary education (=1 if a woman has primary education, 0 otherwise)	0.0062**	0.137**
	(0.0029)	(2.13)
Secondary education (=1 if a woman has secondary education, 0 otherwise)	0.0134***	0.306***
	(0.0024)	(4.93)
Above Secondary Education (=1 if a woman has above secondary education, 0 otherwise)	0.0040*	0.089*
	(0.0023)	(1.71)
Religion (=1 if Christian, 0 otherwise)	0.0286***	0.559***
	(0.0068)	(4.98)
Marital status (=1 if married, 0 otherwise)	-0.013***	-0.273***
	(0.0034)	(3.57)
Market participation (=1 if produce sold in the market, 0 otherwise)	0.0148***	0.331***
	(0.0021)	(6.82)
Market access (natural logarithm of distance to the market in Kms)	0.0018	0.040
	(0.0016)	(1.20)
[Market Access] x [Market participation]	-0.0000	-0.001
	(0.0001)	(0.21)
[Market Access] x [Crop Production Diversity]	-0.0009*	-0.020*
	(0.0005)	(1.73)
[Market Access] x [Food purchases]	-0.001***	-0.001***
	(0.001)	(6.29)
Central Province (=1 if Central province, 0 otherwise)	-0.0014	-0.030
	(0.0047)	(0.30)
Coast Province (=1 if Coast province, 0 otherwise)	-0.030***	-0.609***
	(0.004)	(8.49)
Eastern Province (=1 if Eastern province, 0 otherwise)	-0.0681*	-1.120*
	(0.0392)	(2.24)

continued next page

Table 3 Continued

Dep. Variable (Women's Dietary Diversity)	Coeff.	Marginal Effects
North Eastern Province (=1 if North Eastern province, 0 otherwise)	-0.0049	-0.105
	(0.0035)	(1.45)
Nyanza Province (=1 if Nyanza province, 0 otherwise)	-0.0061	-0.131
	(0.0046)	(1.37)
Rift Valley province (=1 if Rift Valley province, 0 otherwise)	-0.0003	-0.007
	(0.0031)	(0.11)
Constant	-0.271***	
	(0.0190)	
Number of Observations	6,426	6,426

Notes: Coefficients are shown with robust SEs clustered at the household-level in parentheses. *, **, ***Statistically significant at the 10%, 5%, and 1% level, respectively.

Robustness checks

For robustness purposes we estimated equation 2 using OLS regression and the results are reported in Table 4. Consistent with the estimates reported in Table 3 we find that higher crop production diversity has a positive and significant association with women dietary diversity. In addition, results display similar findings and confirm that market participation through the sale of produce is found to have a positive and significant association with women diet diversity. Similarly, the distance to the nearest market has a positive effect on women's dietary diversity. Based on these observations we find the evidence qualitatively similar despite the model specification adopted though with slight differences in magnitudes.

Table 4: Robustness checks on the effect of crop diversity on women's diet diversity in rural Kenya

Dep. Variable (Women's Dietary Diversity)	OLS
Crop production diversity	0.2678***
	(0.0419)
Household's dietary diversity	-0.1809***
	(0.0090)
Expenditure on food (Natural logarithm)	0.1345***
	(0.0413)
Age, years	0.0110***
	(0.0029)
Household size (number)	-0.0355**
	(0.0151)
Primary education (=1 if a woman has primary education, 0 otherwise)	0.1500*
	(0.0687)

continued next page

Table 4 Continued

Dep. Variable (Women's Dietary Diversity)	OLS
Secondary education (=1 if a woman has secondary education, 0 otherwise)	0.3509***
	(0.0686)
Above Secondary Education (=1 if a woman has above secondary education, 0 otherwise)	0.1027
	(0.0590)
Religion (=1 if Christian, 0 otherwise)	0.5252***
	(0.1116)
Marital status (=1 if married, 0 otherwise)	-0.2865***
	(0.0784)
Market participation (=1 if produce sold in the market, 0 otherwise)	0.4023***
	(0.0541)
Market access (natural logarithm of distance to the market in Kms)	0.0798*
	(0.0411)
[Market Access] x [Market participation]	-0.0023
	(0.0023)
[Market Access] x [Crop Production Diversity]	-0.0327*
	(0.0151)
[Market Access] x [Food purchases]	-0.0009***
	(0.0001)
Central Province (=1 if Central province, 0 otherwise)	-0.0898
	(0.1049)
Coast Province (=1 if Coast province, 0 otherwise)	-0.7144***
	(0.0893)
Eastern Province (=1 if Eastern province, 0 otherwise)	-1.1034**
	(0.3992)
North Eastern Province (=1 if North Eastern province, 0 otherwise)	-0.0993
	(0.0827)
Nyanza Province (=1 if Nyanza province, 0 otherwise)	-0.1614
	(0.1147)
Rift Valley province (=1 if Rift Valley province, 0 otherwise)	0.0212
	(0.0854)
Constant	2.9590***
	(0.4877)
Observations	6,426
R-squared	0.1151

Notes: Coefficients are shown with robust SEs clustered at the household-level in parentheses. *, **, ***Statistically significant at the 10%, 5%, and 1% level, respectively.

6. Conclusion and policy implications

In the preceding section, we have examined three issues. First, we examine the extent to which crop diversification and women diet diversity in rural Kenya vary by region. Second, we examined the impact of crop diversification on dietary diversity among women in rural Kenya and third, the extent to which market access and participation mediate the effect of crop diversification on women diet diversity in rural Kenya. We used Kenya Integrated Household Budget Survey (KIHBS), a nationally representative data conducted in 2005 and only focus on the women's sample from the rural areas.

First, the results reveal the existence of wide disparities in crop and diet diversity across regions with North Eastern Kenya having the lowest crop diversification and Eastern province has the highest crop diversification. Nonetheless, the level of crop diversity in our sample remains very low. Similarly, we also find disparities in women's diets across regions with diets of women in Coast province being the most diversified and least diversified among women from North Eastern province. In line with the discussions on the agriculture-nutrition linkages (Hoddinott, 2011) we set to examine the pathways through which agriculture improves diets among women. To do so, we apply the negative binomial Poisson estimator and we find that, higher crop production diversity has a significant positive effect on women's dietary diversity. This shows that in smallholder farms in rural Kenya produce for own-consumption and therefore the potential of higher production diversification would result to improved diets among women.

Second, we find that higher household dietary diversity has a negative effect on women's diets. This clearly indicates that there exists intrahousehold food allocation inequality with non-women members having diverse diets than women members in the households. On the part of children, this is understandably so as they require diverse diets for their development. As for male adults this could arise due to the existence of discriminatory practices among women to the extent that men receive a better share of the food composition as they are deemed to require more than women as they are often involved in physically strenuous than women's home-based work and is in line with the extant literature on differential food distribution which proposes that this could be attributable to cultural-related, resource control and functional issues. From a cultural perspective it is the case that an individual's status in the household if reflected through the type and quantum of food they eat with the high ranking often men and children tending to get more food allocations. The resource

control view asserts that households who control resources or food budgets are more likely to receive priority in food allocation (Whitehead, 1981) while the functional view suggests that food allocation would be in favour of the most productive members of the household.

Third, the results show that market access is also important in improving women's diets and underscores the important role of market access and participation affecting diet diversity. That is, the effect of distance to the nearest market on women's diet is positive albeit insignificant implying that households in remoter regions have higher dietary diversity compared to those nearer to markets. Further, we find that market participation also has a positive effect on women's dietary diversity and its effect is largest than that of crop diversity. This has policy implication as it suggests that improving access to markets through better infrastructure and institutions and promoting programs that link farmers to the market are promising strategies to improve women's nutrition.

Notes

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2. Where WRA (women of reproductive age) are defined as those 15–49 years of age

3. These disparities at the regional level could be as a result of the differences in the extent of engagement in agricultural production and productive economic activities that would otherwise have facilitated access to food through the market (Poulton, Dorward & Kydd, 2010).

4. e.g. a woman with poor nutritional status, as indicated by a low body mass index (BMI), short stature, or micronutrient deficiencies, has a greater risk of obstructed labor, of having a baby with a low birth weight, of death from postpartum hemorrhages, and of morbidity for both herself and her baby.

5. 25% is a direct contribution while 26% is indirect

6. High rainfall areas in the highlands, coastal plains and the lake region produce maize, rice, wheat, sorghum, potato, cassava, vegetables and beans as well as tea, coffee, sugar cane and other cash crops

7. Droughts have recently affected almost 10 percent of the population and left around 3.7 million people in need of food aid (CAADP, 2013).

8. The food groups used for the indicators' construction are: (1) Grains, roots, tubers (2) Legumes (3) Nuts, seeds; (4) Dairy products; (5) Meat, poultry, fish; (6) Eggs; (7) Dark

leafy green vegetables; (8) Other Vitamin-A rich fruits and vegetables; (9) Other not Vitamin-A rich vegetables; and (10) Other not Vitamin-A rich fruits

9. Based on the Overdispersion test implemented in Stata with the null-hypothesis of equidispersion the uhat coefficient obtained is -0.07495 with a standard error of 0.0027 and a t-statistic of -27.67 and thus the null hypothesis is rejected. As to whether there is under-dispersion or over dispersion the $\alpha = 0.685$, we rule out the existence of overdispersion and thus an indication of underdispersion.

10. We implement the test in Stata using the OVERDISP test written by Luiz Paulo Fávero & Patrìcia Belfiore (2018).

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