POLICY BRIEF

Crop Diversification, Household Nutrition, and Child Growth: Empirical Evidence from Ethiopia

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October 2023 / No.795

Abstract

Recently, there is a resurgence of interest in crop diversification as a strategy to deal with a variety of issues, including malnutrition in the context of a changing climate and poorly developed markets. However, the empirical evidence base to justify this policy position is thin. This research seeks to contribute to the growing literature and the policy discourse by providing empirical evidence on the impact of crop diversification on child growth using panel survey data, combined with historical weather data. The study finds that crop diversification has a positive but small impact on child growth. Results from analysis of heterogeneous effects

show that the positive effects are more pronounced in areas with limited access to markets. The study demonstrates that the positive effects of crop diversification on child growth could be mediated through its positive impacts on household diet diversity, diet quality, and income.

Introduction

Despite some progress to reduce the prevalence of malnutrition in Sub-Saharan Africa (SSA), recent evidence shows that high risks of nutrition insecurity and staggering levels of child malnutrition remain ubiquitous particularly in rural areas of the region (FAO et al., 2021; Gillespie and van den Bold, 2017; IFPRI, 2016). Rural households are plagued by undernutrition and chronic deficiency of micronutrients or essential vitamins and minerals ("hidden hunger") that often coexist in the same household or individuals (Gillespie and van den Bold, 2017; Koppmair et al., 2017; Sibhatu et al., 2015). Children pay the heaviest toll as malnutrition due to undernutrition or nutrient deficiency is the cause for about 45% of all deaths of children under 5 years of age (Gillespie and van den Bold, 2017; IFPRI, 2016). Childhood malnutrition has an adverse effect on the child's future potential during adulthood due to its negative impact on physical stature, educational and cognitive development, and productivity (Gillespie and van den Bold, 2017; IFPRI, 2016; Lovo and Veronesi, 2019). Thus, malnutrition might take children and communities into a cycle of intergenerational poverty and entrench inequalities. Reducing the burden of malnutrition would, therefore, have crucial implications for economic development. Given that many of the undernourished people are smallholder farmers and majority of the malnourished children are from rural areas, the question remains how to leverage the benefit of agriculture to improve nutrition (Sibhatu et al., 2018).

Due to its dual role as both the source of income and diverse foods for consumption, agriculture remains the most important sector to improve nutrition and break the generational cycle of malnutrition (Carletto et al., 2015; Ruel and Alderman, 2013). Despite this potential, for many years, nutrition policies have been aligned with the health sector with less or no equal push to align them with the agriculture sector (Hoddinott et al., 2015; Kumar et al., 2015). As a result, agriculture has been slow to respond to the persistent problem of malnutrition (Koppmair et al., 2017; Pingali, 2015). The capacity of agricultural policies to achieve better nutritional outcomes is also constrained due to a bias towards improving the productivity of only a few staple crops as a strategy to spur agricultural productivity and improve welfare (Khoury et al., 2014; Pingali, 2015). Although increased farm specialization has contributed to poverty reduction in developing countries, reliance on a few staple crops has led to a decrease in agricultural and dietary diversity (Pellegrini and Tasciotti, 2014), low agricultural productivity (Teklewold et al., 2013) and exposes farmers to production and price shocks (Benson et al., 2008; Chibwana et al., 2012; Hooper et al., 2012; Saenz and Thompson, 2017). As the challenges of malnutrition and climate change come together as an opportunity in agriculture, there seems to be a growing consensus that the solution to tackle them lies on identifying climate-smart agricultural practices that could also improve nutrition (Global Panel, 2015).

In the current policy discourse, crop diversification is promoted and preferred over monocropping as it is deemed important to increase agricultural production, enhance nutrition security, and aid sustainable agricultural transformation (Asfaw et al., 2018; FAO, 2012; Massawe et al., 2016; Michler and Josephson, 2017). This is also echoed in recent agricultural development policies that aim to spur agricultural development and improve human health and nutrition by increasing investment on agriculture (Dillon et al., 2018). The United Nation's Sustainable Development Goals (SDGs) accentuate that increasing crop diversification is of paramount importance to simultaneously improve agricultural production and nutrition in a sustainable manner (Fiorella et al., 2016). Crop diversification is among the productive agricultural adaptation approaches available to farmers in SSA who face liquidity, asset, or other constraints (Covarrubias, 2015). As such, crop diversification is one of the several climate-smart agricultural practices that would help to improve nutrition among low-income households (Donfouet et al., 2017; Global Panel, 2015; Joshi et al., 2004).

While assessment of the economics of crop diversification has a long story in the development and agricultural economics literature, its impact on diets and nutrition receives interest only in contemporary work. The literature on crop diversification and nutrition can be divided into two strands: (i) those that examine the link between production diversification and dietary diversity (Dillon et al., 2015; Hirvonen and Hoddinott, 2017; Jones et al., 2014; Jones, 2017b,a; Sibhatu et al., 2015; Snapp and Fisher, 2015) and (ii) studies that link production diversification with child growth outcomes (Kumar et al., 2015; Lovo and Veronesi, 2019). A recent comprehensive review of existing studies that analysed the associations between farm production diversification, dietary diversity and/or nutrition in developing country farm households reports that the evidence regarding the impact of farm production diversification on diets and nutrition is mixed, hence inconclusive (Sibhatu et al., 2018). While the existing few studies are informative of the agriculture-nutrition linkage, empirical work on this topic is still sparse to assist policy making.

This study seeks to make important contributions to the literature by illuminating the link between agriculture and nutrition in the small farm sector in a developing country context using Ethiopia as a case study. First, most studies rely on cross-sectional data, which limits the ability to account for unobserved endogeneity (Lovo and Veronesi, 2019; Sibhatu et al., 2018). This study utilizes rich panel survey data combined with historical weather data that allows one to control for the effects of a variety of household and individual characteristics, climatic and agro-ecological conditions and institutional characteristics on crop choice and nutrition. The panel nature of the data enables capturing the dynamics in crop diversification and its implications on nutrition. Second, unlike previous studies that focus on the link between production diversification and nutrition either at the household or individual level, this study considers the link at both levels. Third, existing studies rely on a single or few measures of crop diversification and nutrition. To address this gap, the study measures the level of crop diversification using various crop diversification indices that also allow one to study the different aspects of multi-cropping regimes and to test the sensitivity of results to different crop diversification measures. The nutrition outcome indicators include household nutrient production gaps, diet quality, food intake, diet diversity, and child growth.

The other contribution of the study stems from the estimation of the heterogeneous effect of crop diversification on child growth by gender of the child, market access and exposure to drought shocks. In relation to this, the study also explores if drought shocks have a negative effect on child growth and if crop diversification mitigates the effect of drought shocks. As an add on to the few studies that employed instrumental variables (IV) methods beyond simple statistical methods (Sibhatu et al., 2018), this study utilizes panel data IV methods that enable producing robust causal inference by addressing the econometric challenges of potential endogeneity and reverse causality. The study exploits the exogenous variation in crop diversification decisions due to network externality or neighbourhood effects to instrument crop diversification. The rich nature of the data and the selected empirical strategy helps resolve disagreements in the literature by addressing fundamental issues regarding the exogeneity and measurement of crop diversification and its impact on nutrition.

In addition to contributions to the literature, the findings of the study provide relevant insights to the policy discourse. The results will help policy making that aims to improve nutrition in agriculture-based economies characterized by repeated exposure to shocks and limited access to markets. The study provides evidence that could be used for the design of policies and strategies to improve nutrition in areas plagued by the challenges of micronutrient deficiencies and increased prevalence of diet-related disease (Romeo et al., 2016). The results from the impact heterogeneity analysis provide policy-relevant evidence that could help in targeting nutrition improving policies and interventions. Overall, the findings of the study provide useful insights for evidence-enhanced decision-making regarding nutrition interventions and to influence the multi-sectoral approach in addressing the challenges of child malnutrition.

Country context

Ethiopia is largely an agricultural country. The agriculture sector employs about 70% of the labour force. The sector is predominantly rain-fed and vulnerable to climate variability and extremes. As a result, climate change is a challenge for food security and food consumption in the country. Like other Sub-Saharan Africa (SSA) countries, climatic variability and extremes have serious implications for a significant proportion (85%) of the population that resides in rural Ethiopia.

The country faces a wide range of development challenges, including low agricultural productivity, poverty, and high food insecurity (Beyero et al., 2015). Malnutrition is also a long-standing pressing issue in Ethiopia despite improvements in the last two decades. This is evident from the unacceptably high rates of stunted growth among children under five (5) years of age and micronutrient deficiencies (Christiaensen and Alderman, 2004; Hirvonen and Hoddinott, 2017; Porter and Goyal, 2016). The cost associated with child malnutrition alone is estimated to be more than 16% of the country's annual Gross Domestic Product (GDP) (Gillespie and van den Bold, 2017). The Government of Ethiopia has made a firm commitment to combat malnutrition. In this regard, the government has been implementing different strategies and programmes as part of its national development agenda.

While the food and agriculture sector has fuelled economic growth in the country, there is now an increasing interest to leverage agriculture to improve nutrition. This is emphasized in the National Nutrition Plan (NNP) that engages agriculture for improving nutrition and the Growth and Transformation Plan (GTP) II, which emphasizes addressing malnutrition (Beyero et al., 2015). The country has also established various strategies and programmes to mainstream nutrition in agriculture (Beyero et al., 2015). Given that children's diets in Ethiopia are among the least diverse in the world, the Government of Ethiopia has committed to improving the nutritional status of children. For this purpose, the Government of Ethiopia has developed the third National Nutrition Programme (2016–2020) to drive policy actions across multiple key sectors, including health and agriculture.

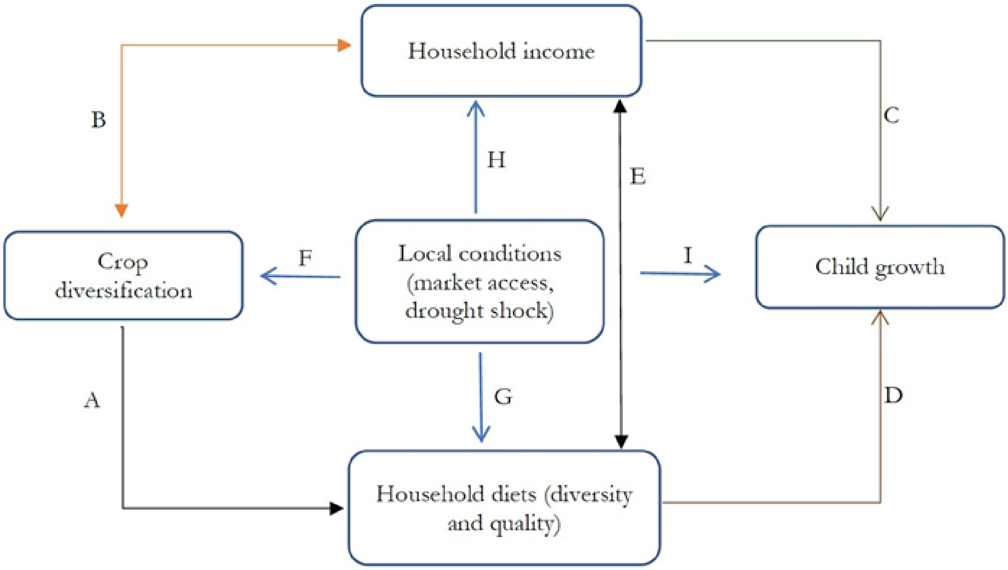
The programme also calls for the promotion of nutrition-sensitive interventions to improve child dietary diversity and, consequently, reduce stunting. The previous NNPs focused on integration and coordination of nutrition-specific interventions that addressed the immediate and underlying causes of sub-optimal growth and development and malnutrition. The National Food and Nutrition Policy (NFP) was endorsed by the Council of Ministers in 2018 based on the global conceptual framework for nutrition security as a change model to address the existing causes of nutrition insecurity at various levels. The policy framework focuses on short, medium, and long-term strategies in an integrated way to address the different layers of nutrition problems. The government has been implementing the Sustainable Undernutrition Reduction in Ethiopia (SURE) programme, the first Government-led integrated health and agriculture sector programme for improving nutrition among children. The Seqota Declaration (SD) launched in 2015 building on the NNP is a high-level commitment of the Government of Ethiopia to end stunting in children under two years by 2030.

Because of the challenges of climate change and malnutrition, there is an increasing interest to adopt agricultural practices such as production of diverse crops that are both climate- and nutrition-smart. Ethiopia is home to rich plant genetic diversity, which would contribute to world biodiversity resources and play a crucial role in improving human nutrition (Michler and Josephson, 2017). The country has also diverse agro-climatic conditions that enable growing a variety of foods across the country (Hirvonen and Hoddinott, 2017). Therefore, Ethiopia makes a good case to test whether and how increased crop diversification affects household nutrition and child growth.

Conceptual framework

Economic theory asserts that the main driving forces that lead to diversification are the desire for risk management and income smoothing (Barrett et al., 2001; Morduch, 1995; Rosenzweig, 1988). Crop diversification reduces the risk of the return of crop production portfolio by spreading risk across the crops in the portfolio (Benin et al., 2004; Just, 1975). Subsistence farmers often diversify their production to protect themselves from food price risks, downside risks, or lack of food in local markets. The desire for profit maximization and risk minimization are, however, not the only stimuli for diversification in agricultural production (Omamo, 1998; Pope and Prescott, 1980). In rural economies burdened by market imperfections and poorly developed and less integrated markets, crop diversification decisions may also be motivated by nutritional considerations (Bezabih and Di Falco, 2012; Hoddinott et al., 2015; Pellegrini and Tasciotti, 2014). This study utilizes a simplified conceptual framework drawing on the work of Lovo and Veronesi (2019) to guide the analysis of the link between crop diversification and child growth (Figure 1). It considers two sets of mechanisms: (i) household diet diversity and quality, and (ii) crop income, among other possible mechanisms (Ecker and Qaim, 2011; Go´mez et al., 2013; Sibhatu et al., 2015).

Figure 1: The link from crop diversification to child growth



Source: Based on Lovo and Veronesi (2019)

Household diets

Regarding the first mechanism (link A in Figure 1), previous empirical evidence provides support for a direct relationship between agricultural diversification and dietary diversity and quality (Dillon et al., 2015; 2018; Hirvonen and Hoddinott, 2017). Given that smallholder farmers typically consume most of what they produce, increasing production diversity could improve household diets and nutrition (Sibhatu et al., 2018; Jones, 2017b, a). For subsistence households, the choice of agricultural outputs largely determines the diversity and quality of their diets.

This mechanism or pathway is likely to be more effective when households have limited access to markets and are exposed to climate variability and extremes (Ecker and Qaim, 2011; Lovo and Veronesi, 2019). Incomplete markets mean that households cannot easily insure themselves from exogenous shocks, and they cannot depend on markets to fully satisfy their food demand. In particular, the absence of an output market is a condition that determines the non-separability between production and consumption decisions of farm households (de Janvry et al., 1991; Singh et al., 1986; Taylor and Adelman, 2003). This is an indication that increased agricultural diversification can directly influence nutrition (Carletto et al., 2017; Hoddinott et al., 2015). The relationship between crop diversification and household diets is expected to diminish as households get more access to markets (Lovo and Veronesi, 2019). In the absence of markets, diversification of production becomes a more prominent determinant of dietary diversity.

The pathway from crop diversification to child health outcomes is explained by the effect of dietary diversity (link D in Figure 1). The relationship between dietary diversity and child growth outcomes has been investigated separately in the literature. Studies show that dietary diversity plays a crucial role in children's health status in low-income countries such as those in SSA (Aboagye et al., 2021; Arimond and Ruel, 2004). These studies document a significant association between dietary diversity and children's undernutrition outcomes, including stunting, wasting, and height-for-age Z-scores (HAZ). Dietary diversity is also found to reflect diet quality and nutritional status in several developing countries (Jones et al., 2014). This is partly explained by the positive relationship between dietary diversity and micronutrient intakes (Lovo and Veronesi, 2019).

Income mechanism

The second mechanism that relates crop diversification to child growth is the income effect (links B and C in Figure 1). Households might diversify their production for income purposes depending on their market orientation and market access. The resulting income would allow households to purchase food and nutrients from markets, ultimately improving the quality of diets and reducing household micronutrient consumption gaps. The relationship between crop diversification and income is, a priori, ambiguous (Lovo and Veronesi, 2019). Diversification reduces the overall production risk and can help households cope better with negative weather or price shocks (Lovo and Veronesi, 2019). It would improve the capacity of local food systems to produce diverse crops in the face of environmental shocks (Global Panel, 2015). It can also allow farmers to produce crops that can be sold at different times during the year (Di Falco and Perrings, 2005). Diversification can have opposite (negative) effects on income due to possible foregone benefits from specialization (opportunity cost of diversification). The Ricardian theory of comparative advantage asserts that specializing in cash crops could increase income and consumption (Govereh and Jayne, 2003; Masanjala, 2006). In the absence of insurance markets and reliable (cash) crop markets, however, high transaction costs may limit the attractiveness of crop specialization to enable households to earn more income and maximize profit (Goetz, 1993). Reliance on monocropping contributes to low agricultural productivity and exposes rural households to production and price risks (Tesfaye and Tirivayi, 2020). Few studies relate crop diversification to household income in the literature and find a positive association between the two (Pellegrini and Tasciotti, 2014; Michler and Josephson, 2017). Considering link C, Lovo and Veronesi (2019) document a positive association between income and child growth outcomes.

Other conditions

Crop choices are likely to be driven by profit considerations and consumption-related factors in semi-subsistence economies. Profit considerations are determined by farm-specific conditions such as land, labour, agroecological conditions, and access to input and output markets. Therefore, the possible interaction between production choices, income and consumption, and the presence of unobservable factors that can affect both crop choices and child growth would complicate establishing a causal relationship between crop diversification and child growth. For example, parents' skills, health, decision-making responsibility, and awareness about crop varieties and nutrition would affect both crop diversification and child growth outcomes. Hirvonen et al. (2017), for example, find that nutrition knowledge leads to considerable improvements in children's diet in areas with good market access. The role of the gender of the decision-maker in terms of crop choices is also likely to matter. As documented in Smale et al. (2015), there is a close relationship between women's diets and the diets of their children, and this is likely to affect their crop choices when in charge of agricultural decisions.

Agroecological and local market conditions could influence crop choices (link F in Figure 1). Geographic and agroecological conditions might limit the benefits of crop choices, for instance that of specializing in cash crops (Orr, 2000). Another important determinant of crop choices is access to inputs such as seeds. Better access to seeds could be correlated with both greater crop variety and better access to other infrastructure or information, and therefore better child growth outcomes (link I in Figure 1). Overall, local conditions determine the availability of crop varieties at the local level. Thus, crop diversification at the household level can also influence children's growth by capturing the local availability of crops if neighbours' choices are correlated (link G in Figure 1). A positive correlation is more likely to emerge in areas where markets are small and less connected with national or sub-national food markets (Ecker and Qaim, 2011). The empirical analysis that follows attempts to disentangle the effects of crop diversification on child health, with a greater focus on household diets and income mechanisms.

Data source

The data for this study comes from the Ethiopian Socio-economic Survey (ESS) administered under the Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) of the World Bank in collaboration with the Central Statistical Agency (CSA) of Ethiopia. The survey collects data on household and children over the period 2011-2016 in three waves (2011/12, 2013/14 and 2015/16). Detailed information is collected on household demographics, anthropometric measurement for children, housing conditions, food and non-food consumption expenditure, food security, and shocks, among others. ESS has an agriculture module that captures detailed information on post-planting and post-harvest activities, including landholding, crop production and disposition, and livestock ownership. The survey also solicited community-level information on access to services such as infrastructure, markets, and health services. This research is restricted to the rural domain of the ESS.

The household location in ESS is geo-referenced, which enables linking the household data with geographic and climate datasets at the enumeration area (EA). Using the geo-references, historical rainfall data are extracted from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS). CHIRPS is a quasi-global spatial database (50'S-50'N) with 0.05' resolution (Funk et al., 2015). It uses satellite imagery with insitu station data to create a gridded rainfall time series (Funk et al., 2015; Michler et al., 2018). From the dataset, rainfall data are extracted for 15 years from 2001 to 2015. This enables the calculation of historical average and standard deviation of rainfall, a proxy for long-term rainfall variability. Annual temperature data are readily available at the household level as part of the ESS.

Crop diversification measures and pattern

Crop diversity is measured using interspecific crop diversity indices: the number of crop groups (richness) and the Shannon-Weaver. The number of crop groups, like the commonly used crop count index or the number of crops, is a measure of crop diversity richness based on the number of crops grown by the farm household (Asfaw et al., 2018; Jones et al., 2014; Sibhatu et al., 2015). The index assumes the equal contribution of the crop groups to the household's crop portfolio. The Shannon's (Shannon-Weaver) index is another popular measure of diversity that captures both richness and evenness, i.e., the level of equality of the abundance of different crops (Saenz and Thompson, 2017). Since the index has an upper limit, this depends on the number of crops grown. This presents a challenge for comparing the degree of diversification across different locations. Two additional crop diversification measures are used to show the crop diversification patterns: the number of crops and the Composite entropy index. Calculation of the crop diversity indices excludes crops that could have little contribution to nutrition, such as spices and cash crops (e.g., cotton).

Child growth

Child growth or malnutrition outcomes are based on child anthropometric measures that are calculated using measures of height and weight for all children under five (5) years of age obtained from the ESS (LSMS-ISA) data. First, height-for-age (HAZ) and weight-for-height (WHZ) z-scores are computed. The z-scores describe the number of standard deviations by which the child's anthropometric measurement deviates from the median in the 2006 WHO child growth standard. Second, a z-score cut-off point of -2 is used to generate binary indicators for stunting (a long-term indicator of child nutritional status) and wasting (a short-term indicator of acute malnutrition). A z-score of less than -2 classifies low height-for-age as stunted and low weight-for-height as wasted (WHO, 1995; 1997).

By exploiting the panel nature of the data and using a transition matrix, the study depicts the persistence of child malnutrition. The data show that about 72% of the children that were not stunted in one period remain non-stunted in the next period. About 51% that were stunted in one period remain stunted in the next period, suggesting high persistence of stunting. About 49% of the non-stunted children in one period become stunted in the next period, an indication of a high risk of stunting. On average, about 28% of stunted children in one period become non-stunted in the next period. Overall, the results suggest the presence of dramatic path dependence in child malnutrition and mobility of children in and out of stunting.

Diet diversity, quality, and income

Diet diversity is an intermediate nutrition outcome indicator and proxy for food access and diet quality (Jones et al., 2014). An indicator of dietary diversity score (DDS) is developed for each household from 12 food groups consumed in a week before the survey. Additional outcome measures are food (energy) production per adult equivalent per day and diet quality, which is calculated as the proportion of calories obtained from nutritious non-staples cultivated by the household.

Food intake and production nutrient gaps

Production nutrient gaps (surplus or deficit) are calculated by comparing reported production of nutrients relative to recommended daily allowances (RDA). RDA refers to the household level total nutrient requirements calculated as the sum of the RDA of all members of the households. It is the level that meets 97.5% of the nutrient requirements and is used to assess the nutrient adequacy gaps at the household level (Dillon et al., 2018). Individual energy and nutrient requirements are adjusted for household composition according to sex, age, weight, and assuming moderate activity of individuals in each household to account for within-person variation for each household (FAO, 2004). Household level estimates are obtained by aggregating the individual values. The energy and nutrient requirements of the households are calculated for each survey round year (2012, 2014 and 2016).

Estimation of the nutrient gap indicators is based on the list of nutrients that are often limited in diets or related to nutrition-related problems in less-developed countries such as stunted growth or anemia (Dillon et al., 2018). The nutrients of interest include iron, thiamine (vitamin B1), riboflavin (vitamin B2), niacin (vitamin B3) and vitamins A and C. The total nutrient production by the household is calculated using the food composition table for Ethiopia, which provides nutrient values of food consumption items. First, nutrient values are assigned for food items listed in the production modules of the agriculture questionnaire. The total nutrient production amounts are then converted to edible amounts by multiplying the edible amount by the nutrient value. The calculation is done for each nutrient separately for each household. In addition, energy intake gap from production is computed. All production amounts are converted to per adult equivalent daily amounts.

Conclusion

Child malnutrition is predominant in sub-Saharan Africa (SSA). Agricultural diversification has been recognized as a strategy to improve nutrition and human health, in addition to its benefit as a climate risk coping strategy. However, very little empirical evidence exists on the links between crop diversification and child growth. This study seeks to contribute to the literature and the policy discourse by investigating the impact of crop diversification on child growth using three-wave panel data that span the period 2012-2016 from the Ethiopian Socio-economic Survey (ESS), conducted as part of the Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA) of the World Bank, combined with historical rainfall data. The study also elucidates two possible pathways – household diets and income – through which crop diversification would impact child growth.

The results show that crop diversification has a positive but small impact on child growth by reducing the risk of stunting and wasting. The positive impact of crop diversification on child growth suggests that agricultural policies should have a greater focus on agricultural diversification in general and on crop diversification and nutritional quality of the production. Although crop diversification exerts positive child health effects, the study does not find evidence that crop diversification mitigates the negative impact of drought shocks on child health. This could be because a household's exposure to drought shock does not translate to catastrophe in terms of child stunting or wasting. Furthermore, the study highlights that crop diversification has stronger child growth benefits among girls and in areas with limited access to markets.

Rural Ethiopians' diet is diversified; however, their diet seems to be dominated by non-nutritious staples as indicated by a lower share of calories produced from non-staple nutritious crops. The econometric model results show that crop diversification has a positive and significant but small impact on diet diversity. Crop diversification, particularly increasing the number of crops cultivated by the household, has a positive impact on diet quality. The study also finds evidence that crop diversification has a positive impact on crop income. The findings of the study also show that dietary diversity is the strongest channel through which crop diversification affects child growth. Diet quality and crop income appear to be mechanisms through which crop diversification through equitable allocation of land among crops cultivated by the household impacts child growth by reducing the risk of child wasting.

From a policy perspective, the findings of the study suggest that policies that target achieving nutritional gains should promote crop diversification to improve the quality and variety of the products from their production. This need supporting farmers through alleviating resource constraints and providing access to reliable price information and inputs. Integrating diversification strategies into the extension system of the country could also help promote diverse production systems that feature cereals, cash crops, and legumes. Given the possibly high opportunity cost of crop diversification, further research is required to compare the nutrition impacts of crop diversification with other agricultural policies and interventions. This would help to identify complementary strategies that would improve the contribution of crop diversification to human nutrition. The results further suggest that policies that target crop diversification as a nutrition-enhancing strategy need to consider the economic and agro-ecological conditions that could mediate the nutrition impacts of crop diversification.

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