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Review

Review: Meta-analysis of the association between production diversity, diets, and nutrition in smallholder farm households

Kibrom T. Sibhatu[a,*], Matin Qaim[a,b]

[a] Department of Agricultural Economics and Rural Development, University of Goettingen, 37073 Goettingen, Germany
[b] Center of Biodiversity and Sustainable Land Use, University of Goettingen, 37073 Goettingen, Germany

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ABSTRACT

Undernutrition and low dietary diversity remain big problems in many developing countries. A large proportion of the people affected are smallholder farmers. Hence, it is often assumed that further diversifying small-farm production would be a good strategy to improve nutrition, but the evidence is mixed. We systematically review studies that have analyzed associations between production diversity, dietary diversity, and nutrition in smallholder households and provide a meta-analysis of estimated effects. We identified 45 original studies reporting results from 26 countries and using various indicators of diets and nutrition. While in the majority of these studies positive results are highlighted, less than 20% of the studies report consistently positive and significant associations between production diversity and dietary diversity and/or nutrition. Around 60% report positive associations only for certain subsamples or indicators, the rest found no significant associations at all. The average marginal effect of production diversity on dietary diversity is positive but small. The mean effect of 0.062 implies that farms would have to produce 16 additional crop or livestock species to increase dietary diversity by one food group. The mean effect is somewhat larger in Sub-Saharan Africa than in other regions, but even in Africa farms would have to produce around 9 additional species to increase dietary diversity by one food group. While results may look differently under very specific conditions, there is little evidence to support the assumption that increasing farm production diversity is a highly effective strategy to improve smallholder diets and nutrition in most or all situations.

1. Introduction

Growth in agricultural productivity and food production has helped to reduce global hunger considerably over the last few decades (Gödecke et al., 2018; Khoury et al., 2014; Pingali, 2012). Nevertheless, nutritional deficiencies remain widespread, especially in Sub-Saharan Africa and Asia (FAO, 2017; IFPRI, 2017). Of particular concern are micronutrient deficiencies, which are less related to general food shortages than to low dietary quality and diversity (Headey and Ecker, 2013). In developing countries, nutritional deficiencies are still among the major causes of premature deaths, infectious diseases, physical and mental growth retardation in children, and other types of health problems (IFPRI, 2017). Eradicating malnutrition in all its forms is a fundamental part of the United Nations' Sustainable Development Goals.

Many of the world's undernourished people are smallholder farmers (FAO, 2014). Therefore, the question as to how smallholder agriculture can be made more nutrition-sensitive is of central importance (Qaim, 2017; Sibhatu and Qaim, 2017; Frelat et al., 2016; Chamberlin et al., 2014; Ruel and Alderman, 2013). Given that smallholder farmers typically consume a sizeable part of what they produce at home, increasing production diversity on their farms through introducing additional crop and livestock species is often seen as a promising strategy to improve dietary diversity and nutrition (Jones, 2017a, 2017b; Powell et al., 2015; Burlingame and Dernini, 2012; Fanzo et al., 2013). However, systematic evidence of this strategy's effectiveness is limited. While several studies have analyzed the links between production diversity and dietary diversity, results are mixed and context-specific (Sibhatu and Qaim, 2018; Fanzo, 2017; Powell et al., 2015; Sibhatu et al., 2015).

Powell et al. (2015) summarized 12 studies and noted that there may be a potential bias in terms of only reporting or highlighting significantly positive associations. Another recent review article found that 19 of the 21 original studies reviewed had reported positive associations between farm production diversity and dietary diversity and nutrition (Jones, 2017b). However, taking a closer look at the 21 original studies reveals that many of those that reported positive associations also included insignificant or even negative estimates for certain regions or for some of the indicators used. Mixed results within the

* Corresponding author.
E-mail addresses: ksibhat@uni-goettingen.de (K.T. Sibhatu), mqaim@uni-goettingen.de (M. Qaim).

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same original studies are not uncommon. For example, using data from four countries, Sibhatu et al. (2015) reported positive and significant associations between production diversity and dietary diversity in Indonesia and Malawi, but not in Ethiopia and Kenya. Using household-level data from Malawi, Jones et al. (2014) found positive associations between farm production diversity and aggregate dietary diversity scores, whereas some of the associations between production diversity and the frequency of consumption of certain healthy food groups (e.g., fruits, vegetables, meat, fish, dairy) were not statistically significant, or even negative and significant.

Here, we review existing studies about the associations between farm production diversity and dietary diversity and/or nutrition in developing-country farm households, adding to the literature in three important ways. First, while previous review articles provided qualitative summaries of existing studies (Jones, 2017a, 2017b; Powell et al., 2015), we use a more structured approach and conduct a systematic review of published results and a meta-analysis of the estimated effects, effect sizes, and levels of statistical significance. Second, we explicitly consider all results reported in the original studies, not only those highlighted as main results. Third, we include a larger number of original studies than previous review articles. Using transparent search criteria, we identified 45 studies for inclusion in our systematic review. The main objective of our research is to shed additional light on the question whether further farm diversification can be considered a generally-applicable strategy to make smallholder agriculture more nutrition-sensitive.

2. Methods

2.1. Literature search

We searched relevant documents according to PRISMA guidelines (Moher et al., 2009), with the objective to systematically review original studies that have analyzed associations between farm production diversity and household or individual diets and nutrition in developing countries. We used transparent, best-practice approaches for systematic reviews and meta-analyses (Stanley et al., 2013), following PICOS (Population, Intervention, Comparator, Outcomes, and Settings) criteria (Table A1 in the Online Appendix).

Studies for inclusion in the systematic review were identified through keyword searches in the Web of Knowledge, Google Scholar, PubMed, Scopus, EconLit, AgEcon Search, Agris (a literature search platform of the Food and Agriculture Organization of the United Nations), and the International Food Policy Research Institute (IFPRI). We also screened reference lists of relevant documents that we found. Where full-text documents of studies were not publicly available, we contacted study authors and asked them to share their papers and additional details.

We used English search terms without making restrictions concerning publication year and language. The key search terms we used for characterizing farm production diversity were “agrobiodiversity”, “production diversity”, “farm production diversity”, “crop diversity”, and “farm species richness”. These were combined with the following search terms to characterize diets and nutrition: “dietary diversity”, “dietary quality”, “food consumption”, “food variety”, “food security”, “nutrient consumption”, “nutrient intake”, “nutrition”, “body mass index”, “child anthropometrics”, “stunting”, “wasting”, and “underweight”. The search was completed on August 31, 2017. The authors of this review conducted literature searches and study classifications independently following the criteria described below; cases of disagreement were resolved with mutual consent.

2.2. Inclusion criteria

We included studies that explicitly attempted to associate at least one indicator of production diversity at farm scale with any indicator of dietary diversity, dietary quality, food security, and/or associated nutrition outcomes at household or individual level in farm households in developing countries. Specifically, a study was included if:

- It investigated the association of at least one indicator of production diversity (e.g., crop species diversity, crop varietal diversity, livestock species diversity, crop and livestock species diversity, food groups produced, nutritional function diversity, crop species richness, crop species evenness) with at least one indicator of dietary diversity (e.g., household and individual dietary diversity scores, food variety scores, weighted food consumption scores, frequency of individual food items and food groups consumed, child feeding index), or an indicator of calorie and nutrient consumption (e.g., calories, protein, iron, zinc, vitamin A, nutrient adequacy ratios), or an indicator of nutrition outcomes (e.g., body mass index, child height-for-age, weight-for-age, weight-for-height, mid-upper-arm circumference), or an indicator of food security (e.g., hunger index, household food insecurity access scale), or nutrient traces in blood samples (e.g., serum iron and hemoglobin).
- It reported association coefficients and levels of statistical significance at household or individual level. We excluded studies conducted at village or higher levels.
- It reported farm production diversity data, referring to intentionally grown crops and livestock reared at the farm level. We excluded studies that focused only on homestead gardening and/or wild plants and trees.

Using these criteria, we identified 45 studies that were included in the systematic review (a PRISMA flow diagram is shown in Fig. A1 in the Online Appendix). Of these 45 studies, 30 were published in academic journals, the other 15 were conference papers, dissertations, or studies published in books and institutional series. We decided to include studies not published in academic journals for at least three reasons. First, studies published in books, institutional series, and other formats often have a wide distribution and therefore also influence research and policy debates (Klümper and Qaim, 2014). Second, especially in the social sciences, conference papers and similar “grey literature” publications often report results of studies that are later published in academic journals. Third, a clear distinction between journal articles being peer-reviewed and other publications not being peer-reviewed is not always possible, because conferences, books, and institutional series often use a peer-review process as well (Rothstein and Hopewell, 2009). However, we control for the type of publication in meta-regressions. A full list of studies included is provided in Table 1.

We also considered excluding studies with small sample sizes, as these are generally less likely to produce statistically significant results. For the field of medical research it was also shown that studies with small sample sizes are less likely to be published in academic journals (Schmucker et al., 2017). However, universally-applicable rules for minimum sample sizes do not exist, so introducing such an inclusion criterion would have been associated with a certain level of arbitrariness. Of the 45 studies included in our review, four had a sample size < 100 (Table 1). However, these four studies are all published in academic journals, so that we decided to leave them in. It can easily be verified that the general conclusions would not change if these four studies were excluded. In the meta-regressions, we use sample size as an explanatory variable.

2.3. Procedure of study classification for analysis

Because of the large heterogeneity in the analytical methods and indicators used in the original studies to assess production diversity, diets, and nutrition, we start with a narrative approach for data synthesis (this is complemented by meta-analysis as described below). We classify each original study by assigning one of three possible labels, namely a “yes” label if positive associations are reported, a “no” label if