**Protocol**

# Title: Impact of agricultural interventions that aim to improve nutritional status of children: a systematic review replication and update of Masset et al. (2012)

*David Sarfo Ameyaw, Sheila Agyemang Oppong, Kwadwo Danso-Mensah, Symphorien Agbahoungba, Joseph Clottey, Clarice Panyin Nyan, Howard White, Edoardo Masset, Miriam Oppong, Desmond Kaledzi, Nana Esi Badu-Ansah, Isaac Lesta, Mueni Sevu*

***Corresponding Author***
*Name: Sheila Agyemang Oppong*
*Email: sagyemangoppong@iced-eval.org*
*Institution: International Centre for Evaluation and Development (ICED)*

## Abstract

*Background:* Agricultural interventions have the potential to improve children's nutritional outcomes by addressing underlying determinants of malnutrition, including food security and income. A systematic review by Masset et al. (2012) provided valuable insights into this relationship. However, the field has evolved significantly since then, necessitating an updated synthesis of evidence to account for new studies and advances in methodologies.

*Objective:* This systematic review aims to replicate and update the findings of Masset et al. (2012) by examining the impact of agricultural interventions on children's nutritional outcomes. The review will assess the effectiveness of various interventions, identify contextual factors influencing outcomes, and explore variations across intervention types, regions, and population groups.

*Methods:* The review will follow Campbell Collaboration guidelines for systematic reviews. Comprehensive searches will be conducted in academic databases and grey literature to identify relevant studies. Eligibility criteria will include studies assessing agricultural interventions with measurable impacts on children's nutrition. Title and abstract screening, full-text review, and critical appraisal will be conducted by two independent reviewers. Data extraction will focus on intervention types, outcomes, and contextual factors. A meta-analysis will be performed to synthesize effect sizes, and results will be presented using forest plots and subgroup analyses.

*Expected Outcomes:* This updated review will provide policymakers, practitioners, and researchers with rigorous evidence on the effectiveness of agricultural interventions in improving children's nutrition. It will contribute to evidence-based decision-making in designing and implementing nutrition-sensitive agricultural programs.

*Implications:* The findings will inform the development of targeted policies and interventions, promote efficient resource allocation, and identify evidence gaps for future research.

*Keywords:* systematic review, agricultural interventions, nutrition, replication, meta-analysis

## 1.0 BACKGROUND

### 1.1 The problem, condition, or issue

The relationship between agriculture and nutrition has affected development programs since the 1960s, with early initiatives aimed at raising food production to combat hunger. However, as the original paper - Masset et al. (2012) pointed out, increasing food supply does not ensure better nutrition because food must also reach the very needy. Theoretical breakthroughs, such as Amartya Sen's work on food security, changed the development focus away from food production and toward guaranteeing access for those in greatest need (Sen, 1981). With this, interventions began to focus on both income production and food availability, with the notion that higher income will improve dietary outcomes. However, as previous research has shown (Reutlinger & Pellekaan, 1986; Haddad et al., 2003), income increases alone frequently fail to significantly improve food quality.

Since the 1990s, agricultural interventions have become more focused on both income generation and nutrition enhancement. Production diversification programs have centered on nutrient-dense foods such as vegetables and dairy, whereas bio-fortification activities have targeted Despite the potential of agricultural interventions to improve food production and profitability, Masset et al. (2012) found that the evidence linking these interventions to child nutrition outcomes was limited and inconclusive. Rather than concluding a lack of impact, the study highlighted the poor quality of the available evidence, driven by the small number of studies and their limited sample sizes. This made it difficult to draw robust conclusions.

Building on Masset et al.'s (2012) assessment, this replication study aims to reassess and update its conclusions by utilizing new studies on agricultural-nutrition interventions published after 2012. Our evaluation follows the format of the original study, focusing on interventions including production diversification and bio-fortification, both of which were major issues in the previous measures have affected income and nutrition, particularly in developing countries' rural areas.

However, our study differs in several ways. First, Masset et al. examined data from 1990 to 2012, this study will include evidence from interventions undertaken from 1990 to 2024. This allows us to investigate the impact of evolving techniques and developments in agricultural technology, which may have enhanced the link between agricultural review. We will investigate, as Masset et al. did, the extent to which these

benefits and nutritional outcomes. Furthermore, we intend to refine and build upon Masset et al.'s criteria for evaluating causal inference by using updated methodological standards and a meta-analysis to estimate their effect size. Conducting a meta-analysis overcomes the underpowered study problems identified in the original study, which was mainly due to small number of studies and sample sizes.

### 1.2 The intervention

Eligible interventions are agricultural initiatives to reduce malnutrition in developing nations through two key approaches: production diversification and biofortification. These approaches are intended to target both income generating and nutritional improvement among rural populations.

Production diversification schemes assist small-scale farmers to expand their agricultural activities outside conventional base crops. This involves introducing vegetable gardens, livestock husbandry, and fisheries to offer homes with a more diverse choice of food supplies. The goal is to increase both income and dietary diversity, ensuring that families have access to nutritious foods such as vegetables, dairy, and meat. Bio-fortification efforts involve the creation and spread of crop types that are rich in micronutrients including iron, zinc, and vitamins.

Following the original study, Table 1 below shows the types of agricultural interventions that would be included and excluded.

**Types of agricultural interventions to be included and excluded by the review**

| **Included** | **Excluded** |
|---|---|
| Bio-fortification | Irrigation |
| Home gardening | Watershed development |
| Aquaculture | Credit and microfinance |
| Small scale fisheries | Land reforms |
| Poultry development | Marketing |
| Animal husbandry | Agricultural extension |
| Dairy development | Food processing and storage |

### 1.3 How the intervention might work

Production diversification works by expanding the range of food products available to households, enhancing dietary diversity and overall nutritious consumption. This strategy also provides diversified income streams, reducing sensitivity to agricultural shocks and increasing financial stability. According to research, diverse farming techniques can improve food security and nutritional outcomes since households are less reliant on a single crop and have access to a greater range of nutrients (Herforth & Harris, 2014; Jones et al., 2014). Surplus produce revenue can be invested in other areas of well-being, such as healthcare and education, helping to achieve larger development goals (Pellegrini & Tasciotti, 2014).

Bio-fortification combats malnutrition by incorporating critical nutrients directly into staple crops, which comprise the majority of the diet in many developing countries. Households can improve their nutritional outcomes by consuming bio-fortified crops without having to dramatically alter their dietary habits. Biofortification has been proven in studies to effectively reduce micronutrient deficiencies, particularly in resource-poor settings with little dietary diversification (Bouis et al., 2011). The strategy is also argued to be cost-effective and sustainable, providing a long-term solution to micronutrient deficiency in the population (Nestel et al., 2006). The widespread use of bio-fortified crops, such as vitamin A-rich sweet potatoes or iron-rich beans, has been linked in some studies to considerable benefits in public health outcomes in diverse countries (Saltzman et al., 2013).

### 1.4 Why it is important to do this replication and update

The original study was published more than a decade ago and since then, new primary studies and data on the effectiveness of agricultural interventions on nutritional outcomes for children have emerged, providing new insights. An attempt at replicating and updating the review is important

as recent findings will be incorporated to ensure that the most current evidence on the theme is reflected in the conclusions. In addition, replication of systematic reviews is a new, largely unexplored, field, so this study will also contribute to the development of systematic review replication techniques.

Furthermore, as summarized in Table 1, new systematic reviews have been undertaken since 2012 (Al Daccache et al., 2024; Birda et al., 2018; Adu et al., 2022; Sharma et al., 2021; Sharma et al, 2021).

**Table 1: Summary of Reviews of the Impact of Agricultural Interventions on Nutrition (Post-Masset et al. 2012)**

| Review | Period Covered | Number of Studies | Interventions | Nutritional Impact |
|---|---|---|---|---|
| Al Daccache et al. (2024) | 2013–2023 | 6 | Agricultural interventions in complex humanitarian settings | Mixed results on dietary diversity and food security, little evidence on child nutrition |
| Birda et al. (2018) | 2012–2017 | 6 (reported in 9 papers) | Home gardening, livestock, aquaculture, training | Positive impact on dietary quality and diversity; limited evidence on child anthropometry |
| Adu et al. (2022) | 2006–2016 | 22 | Extension services, capacity building, market access, irrigation, input supply | Mixed results on production, weak evidence on food security improvements, insufficient counterfactuals |
| Sharma et al. (2021) | 2000–2018 | 43 | Nutrition-sensitive agriculture, nutrition education, women's empowerment | Improvement in dietary practices; limited impact on nutritional status |
| Girard et al. (2012) | 1990–2010 | 36 | Biofortification, home gardens, animal husbandry | Positive outcomes on intermediate measures like dietary intake; less consistent on final nutritional status |

In summary, earlier systematic examinations of agricultural interventions' effects on nutritional status have generated contradictory results. Al Daccache et al. (2024) found little evidence on child nutrition in complicated emergencies. Birda et al. (2018) discovered modest dietary changes in South Asia, but with limited evidence on child anthropometry. Adu et al. (2022) discovered contradictory results in Northern Ghana, but with inadequate counterfactuals. Sharma et al. (2021) observed that while dietary patterns have improved, substantial nutritional reform required multisectoral techniques. Girard et al. (2012) verified improved dietary results but observed variable impacts on nutritional status.

Furthermore, this review will incorporate contemporary innovations in systematic review methods, such as meta-analyses using recent approaches and tools for assessing evidence. For instance, we will utilize the upgraded MECCIR tool launched by Campbell Collaboration in 2014.

## 2.0 OBJECTIVES

Following the original study, the aim of this systematic review is to systematically assess the evidence on the effectiveness of agricultural interventions that promote the adoption of new technologies in order to both increase income and improve the diets of poor households in rural areas of developing countries.

This systematic review pursues the following specific objectives:

- Summarize the existing evidence on agricultural interventions aiming at increasing incomes and diversifying diets of the target population.
- Summarize the existing evidence along the programme theory of the interventions, by looking at indicators of participation, food expenditure, diversity of diet and nutritional status.
- Replicate the original study as a methods contribution to the systematic review field regarding replication of reviews, and to assess the validity of the conclusions of the original review.
- As an update of the original study, we will disaggregate summary evidence of programme effects across groups that are vulnerable to chronic poverty: infants and mothers.
- Identify gaps in our knowledge and understanding of the operation of agricultural programmes that may inform future impact evaluations.
- Update the evidence baseline that already exists using the available evidence and knowledge accumulated.

## 3.0 METHODS

### 3.1 Criteria for considering studies for this review

#### 3.1.1 Types of studies

Both experimental and non-experimental studies will be included. Studies employing experimental or quasi-experimental methodologies to assess program impact will be considered. This includes randomized field trials, regression-discontinuity designs, propensity score matching analyses, difference-in-difference regression studies, regression analyses utilizing instrumental variables, and selection models. Thus, studies with adequate control groups will be considered.

Studies will be categorized based on their use of control groups and analytic approaches, including randomized field trials, panel project-control comparisons over time, cross-sectional comparisons with efforts to control for selection bias, and other credible methods. Studies without a control group or based solely on before-after comparisons will be excluded. This rigorous screening ensures that only studies making meaningful efforts to mitigate selection bias, such as through randomization, longitudinal designs, or matching methods, are included in the review.

Studies published from 1990 onward will form the basis for the search and inclusion criteria, ensuring a focus on recent evidence and methodological advancements in the field

### 3.1.2 Types of participants

The target population for this review is individuals or groups carrying out interventions of interest in low-income, lower-middle-income, and upper-middle-income countries. To accurately reflect the diversity of our target population, we broaden its definition to encompass rural households and groups involved in agricultural operations across a range of techniques. This comprises not just traditional farmers, but also pastoralists, fishers, and those who engage in home gardening and other community-based agricultural practices. Recognizing that rural households frequently engage in various livelihood activities at the same time, our review does not restrict the population to those who are technically classified as "farmers." Rather, we intend to include all people or groups conducting agricultural interventions, realizing that these initiatives influence numerous rural actors whose livelihoods may be varied and who contribute to food security, income generation, and nutritional outcomes within their communities. Hence we may also include interventions targeted at those who work with farmers such as extension workers and input suppliers, if the intent of the intervention is for improved nutritional outcomes.

### 3.1.3 Types of interventions

Studies will be included in the review if they focus on biofortification (including both conventional breeding and genetic modification), or diversification such as home gardening, aquaculture/fisheries, poultry development, animal husbandry, or dairy development. Additionally, studies will be considered if they contain multiple interventions and can clearly demonstrate a link between these interventions and our outcome of interest.

### 3.1.4 Types of outcome measures

This review will utilize five outcome indicators similar to the original review, which are detailed in Table 1.

**Table 1: Outcome, measure and indicator**

| **Outcome** | **Measurement/ Indicator** |
|---|---|
| Program Participation | Participation rate |
| Income & expenditure | – Income or expenditure and associated measures such as net farm income |
| Dietary diversity: | – Consumption of vegetables and fruit<br>– Consume orange-fleshed sweet potato, dark-green leaves<br>– Consumed yellow and green leafy vegetables<br>– Consumption of vegetables and fruit, Consumption of vitamin A rich foods<br>– Dietary intake of calories, protein, vitamin A, iron, vitamin C and fats Consumption of Carotene-rich foods<br>– Consumption of fish<br>– Consumption of milk, chicken, eggs |

| | |
|---|---|
| | – Dietary diversity indices, and biomarkers eg. IDDS, HDDS |
| Micronutrient intake | – Vitamin A intake<br>– Serum retinol<br>– Hemoglobin (anemia)<br>– Beta carotene and Vitamin E<br>– Prevalence of Night blindness<br>– Prevalence of Bitot's spots |
| Nutritional status | – Stunting<br>– Wasting<br>– Underweight<br>– Body Mass Index (BMI) |
| Food security | – Food availability<br>– Food accessibility |

Indicators for malnutrition rates (such as stunting, wasting, and underweight) in populations under five years old, or Z-scores for height-for-age, weight-for-height, and weight-for-age.

The quality of the diet can be assessed in three ways: through detailed expenditure data, dietary diversity indices, and biomarkers. When detailed data on the consumption of each food item is accessible, household intake of calories, proteins, and micronutrients can be estimated using appropriate conversion tables. In cases where data on food item consumption is unavailable, surveys typically gather information on foods or food groups consumed over recall periods of 1, 3, or 7 days.

Dietary diversity is a qualitative measure of food consumption at the individual or household level, reflecting access to a variety of food groups. It serves as a proxy for the nutrient adequacy of an individual's diet (INDDEX, 2015; INDDEX, 2018). Typically, nine food groups are identified, which are: (1) cereals, (2) starchy roots, (3) legumes, (4) vegetables and fruits, (5) sugars, preserves, and syrups, (6) meat, fish, and eggs, (7) milk and milk products, (8) fats and oils, and (9) beverages.

### 3.1.5 Duration of follow-up

To take into consideration the different lengths of follow-up across studies, all follow-up times would be uniformly coded starting from the endline. The endline post-intervention measurement will be uniformly coded as 0 months. This allows for standardization of the data collection timeline and makes studies with different lengths of follow-up comparable.

## 3.2 Search methods for identification of studies

Published and unpublished studies from grey literature sources and academic sources will be used for this review. This procedure follows Campbell searching for studies guide as relevant reference list (Kugley et al., 2017). Wide range of databases will be searched replicating the databases used in the original study while adding on some new relevant databases. Also, some databases from the

original study will not be used due to lack of access to the database or the database currently being defunct.

The following databases will be used for the search

### 3.2.1 Electronic searches

*Academic Sources*

The following academic databases will be used for the study: PubMed, Web of Science, IBSS and CAB Abstract. The original study included Econlit academic database, however, we excluded this database due to lack of access to the website. We decided to replace it with CAB Abstract, which is a good database for agricultural publications. The search strategy will be tailored to each database based on the combination of keys words from the interventions and study population.

*Grey literature sources*

Replicating the work done by Masset et al., 2012, we will search for grey literature in the following registries: World Bank, IFPRI, Eldis, Ideas and Agris. The Jolis grey literature source used by the original study is no longer available and as a result will not be searched. For the update, we will identify new sites which were not available at the time of the Masset review e.g. J-PAL's ATAI studies.

*Keywords creation*

The keywords to be used for the replication will be a slight variation of the search terms used by the original study. Initial results show that some variations of the original search terms used by Masset et al., 2012 gives more hits and more relevant papers. Also, due to the introduction of a new database (Cab Abstract), the search terms will also be edited to suit the database. A table will be provided to show the variations for each database.

*Limiters*

The year of publication limiter used for the present study will be different from that of Masset et al., 2012. In this study, we will include both published and unpublished studies from 1990 to 2024 representing an extension of the original study which covered 1990-2010. This will be done to capture all recent papers since the last study was done. This study will also focus on all countries except those in high income countries as classified by the World Bank in 2023 (The World Bank, 2024). Thus, both Low-income, Low-middle and Upper-middle income countries would be included. Similar to the original study, only publications in the English language will be considered for this review

### 3.2.2 Searching other resources

Similar to the work done by Masset et al., 2012, key authors will be contacted to provide references of relevant studies that can be considered for the review. In addition, we will also examine the reference lists of included studies including systematic and scoping reviews to identify further relevant work.

### 3.3 Data collection and analysis

Similar to the original review, we will adhere to the established standards for conducting systematic reviews, specifically following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021). This ensures transparency, reproducibility, and comprehensiveness in the reporting and execution of the review process.

We will code and critically appraise the included studies like Masset et al. 2012 did, but with a more comprehensive tool – the SURE tool, to determine their validity and reliability. This includes assessing the design, data collection methods, and analysis techniques employed by the primary research studies to ensure they meet the required standards for inclusion in the review. By adhering to PRISMA guidelines, the replication would provide rigorous and unbiased synthesis of the evidence

Another addition to the original study is that this replication will do a meta-analysis of included studies adopting the effect size calculation tool developed by Hugh Waddington to estimate their effect size. While meta-analysis was done for the impact on retinol (Vitamin A) in Masset et al. (2012), it did not perform meta-analyses for the anthropometric outcomes due to the small number of comparable studies. This review will fill this gap.

### 3.3.2 Selection of studies

Masset et al. (2012) used the EPPI-Reviewer to manage the selection process. We will either adopt using the same software for data management. The studies identified through the search strategy will be imported into EPPI-Reviewer and deduplicated. Following this, two independent reviewers will undertake a two-phase screening process. Initially, studies will be screened based on their titles and abstracts to quickly identify those that clearly do not meet the inclusion criteria. In the second phase, the full texts of the remaining studies will be assessed to confirm their eligibility for inclusion in the review.

During this process, both reviewers will independently evaluate each study to minimize bias and increase the reliability of the selection process. Any disagreements between the two reviewers will be resolved through discussion. If consensus cannot be reached, a third reviewer will be consulted to make the final decision, this process follows exactly what was done in the original review. This rigorous process ensures that only studies meeting the predefined inclusion criteria are selected, thus maintaining the integrity of the replication review.

### 3.3.3 Data extraction and management

The data extraction processes will follow the original review. From eligible studies, data will be extracted by two independent authors from the team using a standardized extraction form. The extraction form will be piloted by the authors involved in the data extraction to ensure clarity and completeness. In extracting the data, the following information will be included – author, and publication year, region, country, population, study status, intervention, outcome and study design.

Should there be any disparity between any two authors regarding the data extraction, a third author will be invited to resolve it. Where information or data regarding a particular study is unclear, the study authors will be contacted to provide further details.

### 3.3.4 Assessment of risk of bias in included studies

As an update to the original study, we will adopt a better and a more comprehensive tool compared tool to appraise the included studies– the SURE tools would be used to assess the level of

confidence of these studies. The confidence level for each study will be assessed by two independent reviewers utilizing the appropriate screening tool, and a third independent reviewer will resolve any conflicts.

### 3.3.5 Measures of treatment effect

In measuring treatment effects, we will separate the synthesis of observational studies reporting odds ratio (ORs) from those reporting Risk Ratios (RRs) or Hazard Ratios (HRs). For studies where outcomes are measured on a continuous scale, mean difference and standard error (SE) will be estimated if the mean (SD) is reported in different groups instead of beta-coefficient. Studies reporting beta-coefficient and SE, or 95% confidence intervals will then be pooled. We will use the Hedge's "g" effect size measure for continuous outcomes, though the original review might have used the Cohen's "d". This is a more accurate measure that includes a correction factor to reduce bias in estimates when combining data from various studies with small sample sizes.

### 3.3.6 Unit of analysis issues

There could be unit-of-analysis issues in studies that do not classify the interventions as either implemented or not but rather report a number of levels of intensity or duration. In such cases, the lowest level of intervention will be termed as "low-intensity intervention group" and the highest level of intensity as "high-intensity intervention group," acting as a reference for comparisons. For clear pairwise comparisons, intermediate groups will be combined to make one "moderate-intensity intervention group". When studies report on interventions as a simple yes/no, they are analyzed separately. This approach ensures consistency and allows for meaningful comparison among studies.

There may be multiple treatment arms in a study, in which case each treatment arm will be analyzed separately.

### 3.3.7 Criteria for Determination of Independent Findings

To ensure statistical validity in meta-analysis, it is essential to address dependent effect sizes. Independent findings will be determined by selecting the most relevant or comprehensive effect size from studies reporting multiple effect sizes for the same intervention and outcome. This selection will be based on study-specific factors, such as the largest sample size or the longest follow-up period. For studies reporting effect sizes for multiple outcomes, each effect size will be included separately, while within-study dependence will be accounted for using robust variance estimation methods (Hedges et al., 2010). Additionally, studies with overlapping samples or duplicate reporting will be carefully screened, and only one effect size per unique study sample will be included in the meta-analysis. This approach ensures that the pooled estimates remain unbiased and statistically valid.

### 3.3.8 Dealing with Missing Data

In this review, missing data refers to the absence of key statistics required to calculate effect sizes, such as means, standard deviations, sample sizes, or confidence intervals. To address this issue, we will contact study authors to request missing data wherever feasible. If this data cannot be obtained, imputation methods will be used to estimate standard deviations from reported p-values, t-statistics, or confidence intervals, following established guidelines (Higgins et al., 2021). In cases

where neither imputation nor estimation is possible, studies with insufficient data will be excluded. To ensure the robustness of findings, sensitivity analyses will be conducted to evaluate the impact of missing data on the results. This approach minimizes data loss while maintaining the integrity and reliability of the meta-analysis.

### 3.3.9 Assessment of heterogeneity

Heterogeneity can be explained with meta-regression models. There are two ways in which the heterogeneity of impact can be captured in meta regression models. The first consists of including in the model the main determinants or correlations of the status of health care and caring practices in the areas of intervention. These include access to health services; quality of water and sanitation; women's literacy rates; indices of women's control over resources; and poverty. This data can be obtained from secondary sources, like for example the DHS datasets. This data, however, may not be always available, and their collection might require an effort beyond the scope of the present review. The second way to account for contextual factors consists of including geographic dummy variables in the meta-regression model.

### 3.3.10 Assessment of reporting biases

When studies included in the review are of low confidence level, the review can produce misleading results in one direction or another. To avoid this type of bias, studies will undergo a thorough process of critical appraisal. This assessment will use a check list reporting judgments on internal and external validity of the studies included. Judgments will be summarized in an overall narrative assessment of the state-of-the-art in the assessment of the programmes subject of this review. Main gaps and common risks will be identified, and recommendations will be provided in order to guide future impact evaluations of interventions.

We will try to avoid publication bias by extensive search of grey literature. In addition, publication bias will be explored using funnel plots (Stanley and Doucouliagos 2010), and the overall time devoted to searching grey literature will be informed by the publication bias detected via funnel plot analysis.

### 3.3.11 Data synthesis

Results of the individual studies will be pooled using the generic inverse variance method. As an update to Masset et al. (2012) a random effect meta-analysis will be performed, thereby weighting studies by their sample size. A meta-analysis will be conducted for each outcome measure. Standardized mean differences (SMD) with 95% CI will be calculated for continuous outcomes, and OR with 95% CIs for dichotomous outcomes. We will present effect estimates with 95% CI, and a heterogeneity analysis, with the threshold for statistical significance will be set at $p = 0.05$. Pooled estimates for different observational study designs will be presented in forest plots separately (prospective vs. retrospective/cross-sectional studies), together with the overall pooled estimate. When meta-analysis is not feasible, data will be synthesized following the Synthesis Without Meta-Analysis (SWiM) guidelines (Campbell et al., 2020).

### 3.3.12 Subgroup analysis and investigation of heterogeneity

We will explore potential sources of heterogeneity by conducting a subgroup analysis on the overall risk of bias and various moderators such as intervention and outcome types. This heterogeneity would be explained by mete-regression.

### 3.3.13 Sensitivity analysis

We will conduct a drop-one sensitivity analysis by sequentially excluding each study from the meta-analysis to assess its impact on the overall results. This process will help identify studies with a high or unclear risk of bias (in two or more domains) or those including subjects outside the target population that may disproportionately influence the findings. The results will be reanalyzed after each exclusion to ensure the robustness of the conclusions. The execution of this sensitivity analysis will depend on data availability.

### 3.3.14 Treatment of qualitative research

We will not incorporate qualitative research.

### 3.3.15 Summary of findings and assessment of the certainty of the evidence

The certainty of the evidence will be graded using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach (Guyatt et al., 2008). Based on the GRADE evaluation, the quality of the body of evidence for each outcome will be graded as "high," "moderate," "low," or "very low" by outcome. Several GRADE domains (e.g., risk of bias, inconsistency, imprecision, indirectness, or publication bias) will be considered, and based on these, evidence may be downgraded or upgraded with transparent reasoning. A summary of findings table will be created using GRADEpro GDT. This information will inform the confidence in the effect estimates.

## ACKNOWLEDGMENTS

The authors acknowledged and are grateful for the support of Professor Howard White, International Director of the Centre for Evidence-Based Social Sciences at Lanzhou University, in assisting with conceptualizing and reviewing this protocol.

## CONTRIBUTIONS OF AUTHORS

All authors have read and approved the above protocol. Sheila Agyemang Oppong, Kwadwo Danso-Mensah, Symphorien Agbahoungba, Joseph Clottey, Clarice Panyin Nyan drafted the content of the manuscript. David Sarfo Ameyaw, Howard White, and Edoardo Masset are co-authors who reviewed, provided their expert opinion on our content as well as provided methodological expertise on systematic reviews. Miriam Oppong, Desmond Kaledzi, Nana Esi Badu-Ansah, Isaac Lesta, and Rachael Mueni Sevu will offer the statistical expertise necessary to execute the analysis and will provide information retrieval expertise.

## DECLARATIONS OF INTEREST

The authors have no conflict of interest to declare.

## PRELIMINARY TIMEFRAME

| Activities | Time frame |
|---|---|

| | |
|---|---|
| Review of Original paper. | 1 week |
| Define Research Question and Scope | 2 weeks |
| Draft a Replication Protocol | 3 weeks |
| Preliminary search for definite includes (Edoardo's study) | 1 week |
| Develop/ adopt coding form and coding of definite includes & piloting | 1 week |
| Conduct Preliminary Search | 3 weeks |
| Refine Search Strategy | 3 weeks |
| Comprehensive Search (academic and grey) | 3 weeks |
| Develop or Adopt Screening tool | 1 week |
| Pilot T & A (Sampled searched studies from databases) | 1 week |
| Screening of Studies (Title and Abstract) | 5 weeks |
| Pilot Full text (Sampled screened studies) | 1 week |
| Full-Text Review | 6 weeks |
| Critical Appraisal of included studies | 3 weeks |
| Data Extraction | 2 weeks |
| Prepare Data for Meta-Analysis | 3 weeks |
| Conduct Meta-Analysis synthesis of Results | 3 weeks |
| Drafting the Report | 7 weeks |
| Review and Finalize Report | 2 weeks |
| Submitted Review for publication | 2 weeks |

## PLANS FOR UPDATING THIS REVIEW

The authors do not intend to update the review upon publication.

## SOURCES OF SUPPORT


### Internal sources

The authors have no sources of support to declare.

### New Source of support, Other

The authors have no sources of support to declare.

### External sources

The authors have no sources of support to declare.


### Authors' information


David Sarfo Ameyaw
dameyaw@iced-eval.org
International Centre for Evaluation and Development (ICED)

Sheila Agyemang Oppong
sagyemangoppong@iced-eval.org / agyemangsheils1988@gmail.com
International Centre for Evaluation and Development (ICED)

https://orcid.org/0009-0003-1932-4427

Kwadwo Danso-Mensah
kdansomensah@iced-eval.org / kodmen28@gmail.com
International Centre for Evaluation and Development (ICED)
https://orcid.org/0000-0003-0504-3547

Symphorien Agbahoungba
International Centre for Evaluation and Development (ICED)
Email: sagbahoungba@iced-eval.org
https://orcid.org/0000-0001-8454-7297

Clarice Panyin Nyan
clarice-panyin@iced-eval.org / claricenyan@yahoo.com
International Centre for Evaluation and Development (ICED)/ University of Ghana
https://orcid.org/0009-0001-3934-456X

Joseph Clottey
josephclottey24@gmail.com / jclottey@iced-eval.org
International Centre for Evaluation and Development (ICED)
https://orcid.org/0000-0002-4317-1630

Edoardo Masset
e.masset@niesr.ac.uk
The National Institute of Economic and Social Research (NIESR)
https://orcid.org/0000-0002-8826-0776

Howard White
hwhite@campbellcollaboration.org
Centre for Evidence-Based Social Sciences at Lanzhou University
https://orcid.org/0000-0002-6298-0310

Miriam Oppong
omiriam@iced-eval.org / mimiopp2014@gmail.com
International Centre for Evaluation and Development (ICED)

Nana Esi Badu-Ansah
nbaduansah@gmail.com /nenaduansah@iced-eval.org
International Centre for Evaluation and Development (ICED)

Sevu Mueni
rechaelsevu@gmail.com /rmsevu@iced-eval.org
International Centre for Evaluation and Development (ICED)

Desmond Kaledzi
dkaledzi@gmail.com / dkaledzi@iced-eval.org

International Centre for Evaluation and Development (ICED)

Isaac Letsa
iletsa@iced-eval.org / isaacletsa@gmail.com
International Centre for Evaluation and Development (ICED)

## References

Adu, M. O., Yawson, D. O., Armah, F. A., Abano, E. E., & Quansah, R. (2022). Systematic review of the effects of agricultural interventions on food security in Northern Ghana. University of Cape Coast and University of Ghana. https://doi.org/10.1371/journal.pone.0203605Al

Birda, F. A., Pradhan, A., Bhavani, R. V., & Dangour, A. D. (2018). Interventions in agriculture for nutrition outcomes: A systematic review focused on South Asia. London School of Hygiene & Tropical Medicine. https://doi.org/10.1016/j.foodpol.2018.10.015

Bouis, H. E., & Saltzman, A. (2017). Improving nutrition through biofortification: A review of evidence from HarvestPlus, 2003 through 2016. Global Food Security, 12, 49-58. https://doi.org/10.1016/j.gfs.2017.01.009

Bouis, H. E., Hotz, C., McClafferty, B., Meenakshi, J. V., & Pfeiffer, W. H. (2011). Biofortification: A new tool to reduce micronutrient malnutrition. Food and Nutrition Bulletin, 32(S1), S31-S40. https://journals.sagepub.com/doi/pdf/10.1177/15648265110321s105

Daccache, M., Baliki, G., Brück, T., Ghattas, H., Zero Hunger Lab, Humboldt-University of Berlin, Leibniz Institute of Vegetable and Ornamental Crops, & Arnold School of Public Health, University of South Carolina. (2024). The impact of agricultural interventions on food security and nutrition in complex humanitarian emergencies: A systematic review. BMC Nutrition, 10(60). https://doi.org/10.1186/s40795-024-00864-8

Girard, A. W., Self, J. L., McAuliffe, C., & Olude, O. (2012). The effects of household food production strategies on the health and nutrition outcomes of women and young children: A systematic review. Paediatric and Perinatal Epidemiology, 26(Suppl 1), 205-222. https://doi.org/10.1111/j.1365-3016.2012.01282.x

Haddad, L., Alderman, H., Appleton, S., Song, L., & Yohannes, Y. (2003). Reducing child malnutrition: How far does income growth take us? The World Bank Economic Review, 17(1), 107-131. https://doi.org/10.1093/wber/lhg012

Herforth, A., & Harris, J. (2014). Understanding and applying primary pathways and principles. Improving Nutrition through Agriculture Technical Brief Series. USAID/Strengthening Partnerships, Results, and Innovations in Nutrition Globally (SPRING) Project. https://agris.fao.org/search/en/providers/122566/records/6473921368b4c299a3fa0177

INDDEX 2015 INDDEX Project. (2015). Dietary diversity. https://inddex.nutrition.tufts.edu/data4diets/data-source/dietary-diversity

INDDEX 2018 INDDEX Project. (2018). Data4Diets: Building blocks for diet-related food security analysis. https://inddex.nutrition.tufts.edu/data4diets

Jones, A. D., Shrinivas, A., & Bezner-Kerr, R. (2014). Farm production diversity is associated with greater household dietary diversity in Malawi: Findings from nationally representative data. Food Policy, 46, 1-12. https://doi.org/10.1016/j.foodpol.2014.02.001

Masset, E., Haddad, L., Cornelius, A., & Isaza-Castro, J. (2012). Effectiveness of agricultural interventions that aim to improve nutritional status of children: systematic review. Bmj, 344. https://doi.org/10.1136/bmj.d8222

Nestel, P., Bouis, H. E., Meenakshi, J. V., & Pfeiffer, W. (2006). Biofortification of staple food crops. Journal of Nutrition, 136(4), 1064-1067. https://doi.org/10.1093/jn/136.4.1064

Pellegrini, L., & Tasciotti, L. (2014). Crop diversification, dietary diversity, and agricultural income: Empirical evidence from eight developing countries. Canadian Journal of Development Studies/Revue canadienne d'études du développement, 35(2), 211-227. https://doi.org/10.1080/02255189.2014.898580

Reutlinger, S., & Pellekaan, H. (1986). Poverty and hunger: Issues and options for food security in developing countries. World Bank Publications. https://www.cabidigitallibrary.org/doi/full/10.5555/19861833064

Ruel, M. T., Alderman, H., & Maternal and Child Nutrition Study Group. (2013). Nutrition-sensitive interventions and programmes: how can they help to accelerate progress in improving maternal and child nutrition? The Lancet, 382(9891), 536-551. https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(13)60843-0/abstract

Saltzman, A., Birol, E., Bouis, H. E., Boy, E., De Moura, F. F., Islam, Y., & Pfeiffer, W. H. (2013). Biofortification: Progress toward a more nourishing future. Global Food Security, 2(1), 9-17. https://doi.org/10.1016/j.gfs.2012.12.003

Sen, A. (1981). Poverty and Famines: An Essay on Entitlement and Deprivation. Oxford University Press. https://www.iwanami.co.jp/moreinfo/tachiyomi/6003660.pdf

Sharma, I. K., Di Prima, S., Essink, D., & Broerse, J. E. W. (2021). Nutrition-sensitive agriculture: A systematic review of impact pathways to nutrition outcomes. Advances in Nutrition, 12(251-275). https://doi.org/10.1093/advances/nmaa109

World Bank. (2007). From agriculture to nutrition: Pathways, synergies and outcomes. World Bank Publications. http://documents.worldbank.org/curated/en/241231468201835433/From-agriculture-to-nutrition-pathways-synergies-and-outcomes

World Bank. (2022). World Bank country and lending groups. World Bank Data Help Desk. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups