Research on the potential impact of interventions in agriculture on nutrition outcomes is of particular relevance in South Asia where agriculture-related activities are a major source of livelihoods for large sections of society and where the population suffers from one of the highest global burdens of malnutrition in all its forms. This systematic review aims to assess the strength of the available evidence that agricultural interventions have an impact on intermediate and final nutrition outcomes in India, Bangladesh, Nepal, Pakistan and Afghanistan. We searched five literature databases and reference lists of previous systematic reviews to identify peer-reviewed studies published between 2012 and 2017, detailing impacts of household- or farm-level agricultural interventions on nutritional outcomes in South Asia. We identified six intervention studies (reported in nine papers) conducted in Bangladesh (two studies), India (two studies) and Nepal (two studies). The majority of studies examined the impact of provision of seed, plants and training to increase home garden fruit and vegetable production with or without integrated poultry provision and training. Other studies evaluated the impact of livestock or aquaculture provision and training. Study designs and quality were mixed; heterogeneity across studies precluded formal meta-analysis. Interventions had a positive impact on intermediate outcomes on the pathway from agricultural intervention to nutritional or health status including dietary quality and dietary diversity of households and individuals (reported in seven papers). The evidence on the impact on final nutritional outcomes was mixed: one paper reported that home gardens with poultry reduced the odds of anaemia but there was no convincing evidence of an impact of agricultural interventions on child anthropometric measurement (reported in four papers). In recent years, the Leveraging Agriculture for Nutrition in South Asia (LANSA) research programme consortium has significantly expanded research on agricultural interventions for nutrition outcomes by conducting and commissioning a suite of formative and feasibility studies that have extended both the range and geographic location of interventions under study. This expanding body of research should, in the future, enable the identification of cost-effective interventions to enhance the impact of agricultural interventions sustainably to improve nutrition outcomes especially in women and children in South Asia.

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Interventions in agriculture for nutrition outcomes: A systematic review focused on South Asia

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ABSTRACT

Research on the potential impact of interventions in agriculture on nutrition outcomes is of particular relevance in South Asia where agriculture-related activities are a major source of livelihoods for large sections of society and where the population suffers from one of the highest global burdens of malnutrition in all its forms. This systematic review aims to assess the strength of the available evidence that agricultural interventions have an impact on intermediate and final nutrition outcomes in India, Bangladesh, Nepal, Pakistan and Afghanistan. We searched five literature databases and reference lists of previous systematic reviews to identify peer-reviewed studies published between 2012 and 2017, detailing impacts of household- or farm-level agricultural interventions on nutritional outcomes in South Asia. We identified six intervention studies (reported in nine papers) conducted in Bangladesh (two studies), India (two studies) and Nepal (two studies). The majority of studies examined the impact of provision of seed, plants and training to increase home garden fruit and vegetable production with or without integrated poultry provision and training. Other studies evaluated the impact of livestock or aquaculture provision and training. Study designs and quality were mixed; heterogeneity across studies precluded formal meta-analysis. Interventions had a positive impact on intermediate outcomes on the pathway from agricultural intervention to nutritional or health status including dietary quality and dietary diversity of households and individuals (reported in seven papers). The evidence on the impact on final nutritional outcomes was mixed: one paper reported that home gardens with poultry reduced the odds of anaemia but there was no convincing evidence of an impact of agricultural interventions on child anthropometric measurement (reported in four papers). In recent years, the Leveraging Agriculture for Nutrition in South Asia (LANSA) research programme consortium has significantly expanded research on agricultural interventions for nutrition outcomes by conducting and commissioning a suite of formative and feasibility studies that have extended both the range and geographic location of interventions under study. This expanding body of research should, in the future, enable the identification of cost-effective interventions to enhance the impact of agricultural interventions sustainably to improve nutrition outcomes especially in women and children in South Asia.

1. Introduction

A better understanding of the potential pathways linking agriculture and nutrition has, since the 1980s, led to a significant increase in research on the design, feasibility and impact of nutrition-sensitive agricultural interventions. These interventions typically aim to improve the underlying determinants of nutrition outcomes through targeting dietary quality, household food security, income and women's empowerment (Ruel and Alderman, 2013). The increase in published research outputs on the impact of nutrition-sensitive agricultural interventions in South Asia since the mid-1990s has been particularly striking (Fig. 1). Interventions in South Asia have to-date mainly targeted the improvement of dietary quality through enhancing dietary diversity and the consumption of animal-sourced foods. However, in recent years there has been growing interest in other nutrition-sensitive agricultural approaches, such as the introduction of micronutrient-biofortified crop varieties that, for example, have had success in improving micronutrient status in Africa (Bouis and Saltzman, 2017).

There have been several previous reviews assessing the evidence between nutrition-sensitive agriculture interventions and nutritional outcomes (Berti et al., 2004, Girard et al., 2012, Ruel et al., 2017, Ruel and Alderman, 2013, Masset et al., 2012, DFID, 2014, Pandey et al.,

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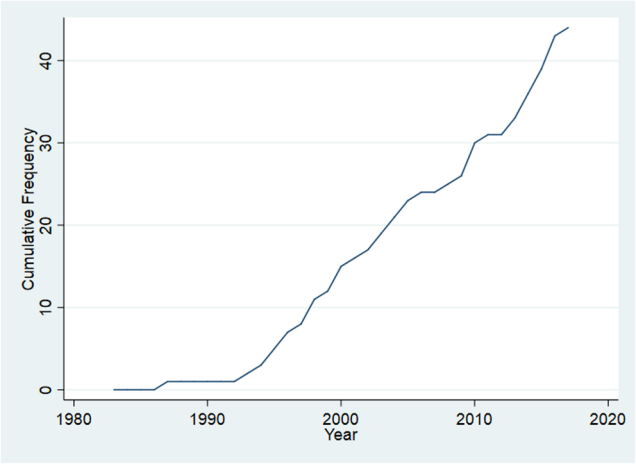

Fig. 1. Cumulative number of published research papers on the impact of nutrition-sensitive agricultural interventions in South Asia (1983–2018).

2016). Reviews of the global literature have largely concluded that the strength of the evidence supporting the hypothesised pathways linking agricultural interventions with nutrition outcomes is limited. In the South Asian region, a recent systematic review (Pandey et al., 2016) that included studies reporting findings between 2000 and 2013, highlighted evidence that interventions such as home gardens, introduction of livestock, poultry and aquaculture may improve production diversity, animal ownership and women's empowerment, leading to beneficial effects on intermediate nutritional outcomes such dietary diversity and consumption of nutrient-rich crops. While there is currently little robust evidence to suggest that nutrition-sensitive agriculture interventions have a significant impact on major nutrition and health endpoints such as child growth, positive impacts on intermediate outcomes that lie on the pathway to child growth have helped to inform the design of subsequent interventions.

The Leveraging Agriculture for Nutrition in South Asia (LANSA) research programme consortium has had a particular focus on the design of nutrition-sensitive interventions in agriculture and has undertaken feasibility research in the focus countries under the programme. In 2015, the LANSA consortium engaged external regional researchers and wider stakeholders through an online discussion to gather stories of successful and innovative nutrition-sensitive agriculture approaches (FAO, 2015). These discussions identified the need for interventions to be context-specific, gender-sensitive and cost-effective, but also stimulated ideas to incorporate nutritional education parameters, youth engagement and whole farming system approaches to ensure sustainable impacts. Following this engagement, a call for formative research activities led by regional research and development partners was initiated to extend the existing literature and develop a suite of evidence on the design and feasibility of locally-relevant nutrition-sensitive agriculture interventions.

In this paper we systematically review the strength of the available evidence, published over the life-course of the LANSA programme (2012 and 2017), that agricultural interventions have an impact on nutritional outcomes in India, Bangladesh, Nepal, Pakistan and Afghanistan. We also incorporate in the discussion the new suite of research studies coming out of LANSA on the design and feasibility of nutrition-sensitive agriculture interventions.

2. Methods

This systematic review follows the PRISMA Checklist (Preferred Reporting Items for Systematic review and Meta-Analysis).

2.1. Screening and study selection

The purpose of this review was to identify and evaluate the strength of evidence from intervention studies conducted in India, Pakistan, Bangladesh, Afghanistan and Nepal and published between 2012 and 2017, that assessed the impact of household- or farm-level agricultural interventions on nutritional outcomes. Previous reviews on nutrition-sensitive agriculture techniques helped develop the search strategy and identify keywords (Pandey et al., 2016, Ruel et al., 2017, Ruel and Alderman, 2013). The keywords used for the search came under four search concepts: "South Asia", "agriculture", "interventions" & "nutritional outcomes" (Table 1).

The search was conducted in November 2017 on five literature databases: Web of Science, Scopus, PubMed, CAB Abstracts and AGRIS. We limited our literature search to peer-reviewed reports of experimental studies (including peer-reviewed "working papers") published in English between January 2012 and November 2017. Review articles and grey literature were excluded. We hand-searched the reference lists of identified papers.

Studies were included if they reported on a household- or farm-level agricultural intervention that reported at least one nutritional outcome at the household or individual level, in one of the five LANSA countries (India, Pakistan, Bangladesh, Afghanistan and Nepal). Relevant nutritional outcomes include both intermediate outcomes (measures of individual and household dietary intake; indicators of individual and household dietary diversity; nutrition-related knowledge and behaviour) and final outcomes (biochemical indicators of micronutrient status; anthropometric measurements). Included studies compared an intervention group with a comparison group either via a baseline-endline comparison or a separate comparison/control group.

A single reviewer (FB) screened titles. Abstract and full text screening was conducted independently in duplicate (FB, AP) and any discrepancies were discussed with a third reviewer (ADD) to produce a final list of included studies.

2.2. Data extraction and quality assessment

Data extraction was conducted by a single reviewer (FB) and all extracted data were checked by a second reviewer (AP). Information on the study location, design, target population, intervention type, comparison group, study length and outcomes was extracted for each included study.

Included studies were assessed for quality using a checklist adapted from the Critical Appraisal Skills Programme (CASP) for randomised control trials (Critical Appraisal Skills Programme, 2018) (Appendix 1).

Table 1
Search concepts and key terms.

Search concept	Search terms
South Asia	"South Asia", Asia, Pakistan, Afghanistan, India, Bangladesh, Nepal
Agriculture	agricultur*, "farming system" "nutrition sensitive", nutrition-sensitive, "home garden", "homestead production", "kitchen garden", "household production", livestock, "animal husbandry", biofortifi*, bio-fortifi*, aquaculture, "cash crop"
Intervention	intervention, program*, strateg*, RCT, "randomi$ed control* trial", trial
Nutrition outcomes	nutrition, "nutritional status", "nutritional outcomes", malnutrition, "diet* diversity", micronutrient*, growth, anthropometr*, "women's empowerment", WEAI, empowerment

Blinding was rarely used in these interventions so the criterion was removed from the checklist. Study quality was assessed independently in duplicate (FB, ADD) and studies were scored against four criteria: (1) clear study description; (2) appropriate comparison group/situation; (3) clear methods description; and (4) rigorous and clearly described analysis. Studies scoring 4/4 (i.e. studies that were deemed to meet all four criteria) were labelled "good" quality (Appendix 2). No relevant studies were excluded from the review based on reporting quality.

2.3. Data synthesis

Due to the diversity of study settings, designs, interventions and reported outcomes, no formal meta-analysis was possible. We provide a narrative report of the identified studies with a focus on their impact on intermediate and final nutrition outcomes.

3. Results

The initial database search identified a total of 4429 papers. After removal of duplicates and screening of titles and abstracts, 48 papers remained. Full text screening led to the exclusion of 40 of these papers and one additional relevant paper was identified through hand-searching of reference lists. In total we identified nine relevant papers for this review that reported on six intervention studies (Fig. 2).

The intervention studies were conducted in Bangladesh (2 studies; 3 papers), India (2 studies; 2 papers), and Nepal (2 studies; 4 papers). No published papers were identified for intervention studies conducted in either Pakistan or Afghanistan. Many of the studies included multiple interventions and the primary interventions included in studies were: provision of seeds, plants and training to increase home garden production of vegetables and fruit (4 studies; 5 papers); provision of poultry in combination with home garden training (2studies; 2 papers); provision of training in livestock management and access to livestock (1 study; 3 papers); and provision of training and inputs for village aquaculture (1 study; 1 paper). Interventions typically targeted lower income, smallholder farming communities and often specifically women and young children. Summary details of the nine included papers are provided in Table 2.

Studies reported a variety of nutrition outcomes (Table 3). Of the intermediate nutritional outcomes included in this review, all six studies (seven of nine included papers) collected information on reported individual or household dietary intake or indicators of individual or household dietary diversity; nutrition-related knowledge and behaviour was reported in four studies (four papers). Of the final nutritional outcomes included in the review, anthropometric measurements were reported in three studies (four papers) and biochemical indicators of nutrient status (specifically haemoglobin status) was reported in one study (one paper).

Three study designs were used in the included studies: randomised controlled trials (Miller et al., 2014, Miller et al., 2016, Darrouzet-Nardi et al., 2016, Osei et al., 2017); before and after studies (Birdi and Shah, 2015, Murty et al., 2016, Pant et al., 2014); and quasi-experimental designs with a non-randomised comparison group and long-term follow-up (Schreinemachers et al., 2014, Schreinemachers et al., 2016).

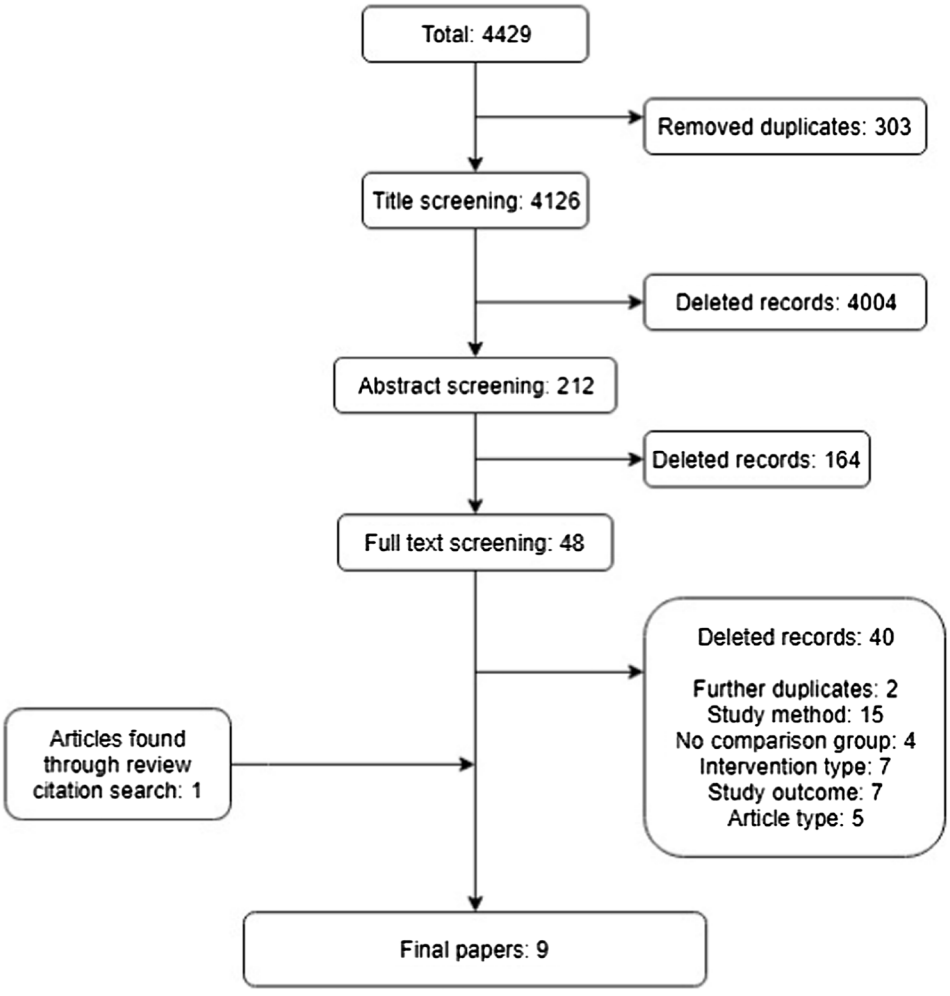

Fig. 2. PRISMA flow chart following the systematic screening process.

Table 2
Details of the study designs of included nutrition-sensitive agriculture intervention studies.

Author, year, study location	Type of intervention	Intervention details	Comparison details	Study design	Sample size	Duration
Birdi and Shah (2015) India	Home garden	Distribution of 18 nutrient-dense plants accompanied by information, education and communication activities.	Baseline vs. end-line	Before-and-after design. Village selection based on geographical representation of the study area. Household selection based on voluntary participation and having at least one child < 6 years old.	396 households	2 years
Miller et al. (2014) Nepal	Livestock provision and agricultural training	Donation of two meat-type goats accompanied by community-level development activities including sustainable agricultural practices, animal management, gender awareness, kitchen gardens, and pest control.	Matched pairs	Randomised Controlled Trial. Three matched pairs of non-adjacent communities in three districts randomly assigned to receive intervention immediately (Group 1) or after 12 months (Group 2).	415 households	2 years
Miller et al. (2016) Nepal	Livestock provision and agricultural training	As in Miller et al. (2014)	Matched pairs	As in Miller et al. (2014)	415 households	4 years
Darrouzet-Nardi et al. (2016) Nepal	Livestock provision and agricultural training	As in Miller et al. (2014)	Matched pairs	As in Miller et al. (2014)	415 households	2 years
Murty et al. (2016) India	Home garden, poultry provision and nutrition education	Distribution of vegetable seeds, fruit plants and high egg-yielding backyard poultry accompanied by focus group discussions, cooking demonstrations and educational pamphlets.	Baseline vs end-line	Before-and-after design. Eleven Integrated Child Development Services centres in eight villages identified and selected registered mothers included.	142 mothers	3 years
Osei et al. (2017) Nepal	Home garden, nutrition behaviour change communication, agricultural training, poultry provision	Enhanced Homestead Food Production (EHFP) program: distribution of seeds, saplings and chicks; monthly agricultural and nutrition lessons; cooking demonstrations; monthly home visits from trained staff.	Intervention vs control	Prospective multistage cluster-randomised controlled trial.	2106 mother-child pairs	3 years
Pant et al. (2014) Bangladesh	Aquaculture production	Household-specific aquaculture interventions and training using the farmer field school approach.	Baseline vs end-line	Before-and-after design. Randomly selected resource-poor households registered within the Adivasi Fisheries Project.	657 households	2 years
Schreinemachers et al. (2014) Bangladesh	Home garden	Home garden and nutrition training, demonstrations, and distribution of vegetables to grow.	Intervention vs comparison	Quasi-experimental design. Small land-owning households randomly selected from purposively selected districts.	582 women	2 years
Schreinemachers et al. (2016) Bangladesh	Home garden	As in Schreinemachers et al. (2014)	Intervention vs comparison	As in Schreinemachers et al. (2014)	582 women	2 years

Table 3
Summary of nutritional outcomes reported in nutrition-sensitive agriculture intervention studies included in this review.

Study	Dietary assessment	Anthropometric measures	Biochemical measures	Nutrition awareness and behavioural changes
Birdi and Shah (2015)	• Dietary intake survey	–	–	• Complementary feeding practices • Home garden practices
Miller et al. (2014)	–	• MUAC • HAZ • WAZ • WHZ	–	• Household health practices
Miller et al. (2016)	–	As in Miller et al. (2014)	–	–
Darrouzet-Nardi et al. (2016)	• 24 h recall	–	–	–
Murty et al. (2016)	• Food frequency questionnaire	• Birth weight • WAZ	–	• Knowledge, attitude and practice regarding health and nutrition • Knowledge of balanced diet • Sanitation & hygiene practices
Osei et al. (2017)	–	• WAZ • HAZ • WHZ	• Haemoglobin concentration	• Maternal breastfeeding • Complementary feeding practices
Pant et al. (2014)	• Not specified	–	–	–
Schreinemachers et al. (2014)	• 24 h recall	–	–	–
Schreinemachers et al. (2016)	• Food frequency questionnaire	–	–	–

MUAC, mid-upper-arm circumference; HAZ, height-for-age z-score; WAZ, weight-for-age z-score; WHZ, weight-for-height z-score.

Table 4
Summary of key findings reported in nutrition-sensitive agriculture intervention studies included in this review.

Study	Main findings
Birdi and Shah (2015)	Marginal increase in the consumption frequency and diversity of green leafy and root vegetables.39% decline in household pulse consumption (70.2 g/person/day), and no change in cereal consumption.
Miller et al. (2014)	Longer participation in the programme led to better height-for-age z-scores.In the Terai (fertile plain) subgroup there was a marginal significant positive effect of the intervention on child weight, height, number of sick days, increased income and animal ownership.
Miller et al. (2016)	Child nutritional outcomes remained relatively unchanged in the first 24 months in both groups.After 48 months, there were significant decreases in children underweight (from ~50% to ~31%), wasting (from ~24% to 9%), and stunting (from 32 to 25%).
Darrouzet-Nardi et al. (2016)	Children receiving the intervention for 2 years vs. 1 year were more likely to consume an additional food group [OR:1.52, 95% CI: n.d.], achieve minimum dietary diversity [OR:1.15, 95% CI: ND], and consume animal source foods [OR: 1.18, 95% CI:n.d.].The intervention was more effective at improving child diets in agro-ecologically vulnerable regions.The intervention had a stronger effect during the hungry season.
Murty et al. (2016)	In comparison to baseline, the intervention increased the number and cultivated area of home gardens, increased mean weekly household consumption frequency of cooked leafy vegetables and eggs, and improved knowledge of balanced diets. There was a significant decline in child weight-for-age z-scores.There was no change in mean birth weight.
Osei et al. (2017)	The intervention reduced the odds of anaemia in children [OR: 0.76, 95% CI: 0.59–0.98] and mothers [OR: 0.62, 95% CI: 0.48–0.82], reduced the odds of underweight in mothers [OR: 0.61, 95% CI: 0.46–0.82], and improved reported breastfeeding and complementary feeding practices.There was no evidence of an impact of the intervention on child anthropometry.
Pant et al. (2014)	In comparison to baseline, the intervention increased household monthly consumption of fish, meat and eggs, and increased annual household income.
Schreinemachers et al. (2014)	In comparison to the control group, the intervention increased reported vegetable yields from home gardens by 86%, and improved dietary diversity.
Schreinemachers et al. (2016)	In comparison to the control group, the intervention increased vegetable yields from home gardens by31kg, and increased consumption of fruit and vegetables by 19.3 g/per capita/day.

OR, odds ratio; CI, confidence interval; n.d., no data.

Study duration ranged from one year to four years. Sample sizes ranged from 142 (Murty et al., 2016) to 2106 (Osei et al., 2017). A summary of the main findings from the included studies is provided in Table 4.

3.1. Impact of nutrition-sensitive interventions on intermediate outcomes

Of the seven papers reporting changes in dietary outcomes resulting from nutrition specific agricultural interventions, all seven reported improvements in the selected intermediate outcomes. In a good quality quasi-experimental study in Bangladesh, one year of seed and plant provision, home garden training and nutrition education resulted in a significantly higher reported vegetable harvest (mainly leafy vegetables) and a marginally higher reported dietary diversity compared to the comparison group (Schreinemachers et al., 2014). After two further years of intervention, reported household consumption of fruit and vegetables and the reported number of different vegetables consumed was higher in the intervention group (Schreinemachers et al., 2016). In a good quality cluster randomised controlled trial over three years in Nepal, distribution of seeds, and poultry, as well as home garden training and nutrition education increased reported household production of nutrient-rich foods such as vegetables and eggs, overall food security and Infant and Young Child Feeding (IYCF) practices (Osei et al., 2017). In a good quality randomised controlled trial over two years in Nepal, provision of training in livestock management and access to livestock resulted in greater reported diversity of food group consumption including animal source foods and a greater likelihood of achieving a minimum dietary diversity (Darrouzet-Nardi et al., 2016). In a before and after study in India, distribution of plants resulted after two years in a small reported increase in the diversity and frequency of consumption of green leafy and root vegetables (Birdi and Shah, 2015). Measurement of the impact of the intervention on childcare practices was limited to the reported inclusion of fruit and vegetables into complementary foods and a difference was observed (Birdi and Shah, 2015). In a before and after study in India, distribution of seeds and poultry, as well as home garden training and nutrition education resulted after three years in a reported increase in household consumption of cooked leafy vegetables and eggs (Murty et al., 2016). After three years, households that received the intervention were more likely

to have a home garden (than at baseline) and there was an overall improved knowledge in households of nutrition (Murty et al., 2016). Finally, in a before and after study in Bangladesh, provision of training and inputs for village aquaculture increased the reported consumption of animal-sourced foods, especially fish (Pant et al., 2014).

3.2. Impact of nutrition-sensitive agriculture interventions on final outcomes

Measurement of final nutrition outcomes was conducted in three studies (four papers). In a good quality cluster randomised controlled trial over three years in Nepal, distribution of seeds and poultry, as well as home garden training and nutrition education resulted in reduced odds of anaemia among mothers and children in the intervention arm compared with the control arm, and a reduced odds of maternal underweight. The intervention had no impact on child anthropometry (Osei et al., 2017). In a good quality randomised controlled trial over two years in Nepal, provision of training in livestock management and access to livestock did not improve overall growth in height, weight or middle-upper arm circumference among children (Miller et al., 2014). In sub-group analysis there was some evidence that the intervention improved growth among children living in the Terai (fertile plains of Nepal) but not among children living in hill regions (Miller et al., 2014). The children in this study were followed-up for 48 months (in a randomised design for 0–24 months and a longitudinal before and after design for 25–48 months) by which time households had received the intervention for at least three years (Miller et al., 2016). Overall there were declines in the prevalence of underweight, wasting and stunting with some evidence that longer exposure to the intervention was associated with better nutritional outcomes for participating children (Miller et al., 2016). In a before and after study in India, the effect of distribution of seeds and poultry, as well as home garden training and nutrition education was estimated based on routinely collected clinic data. The authors report a decline over two years in the unadjusted prevalence of low weight-for-age (underweight) (Murty et al., 2016).

4. Discussion

4.1. Key findings

We identified six studies (nine papers) published between 2012 and 2017 on the impact of interventions in agriculture on nutrition outcomes in South Asia. The majority of interventions aimed to facilitate and encourage the cultivation of fruits and vegetables in home garden, a few studies included training in the management and provision of small animals (poultry and goats). Study quality was mixed and only six of the nine papers were graded as good quality. Studies that failed to be graded as good quality typically failed to describe their methods and their data analysis clearly. Study duration ranged from one to four years and study designs ranged from before and after studies to randomised controlled trials.

The small number and heterogeneity of included studies precluded formal meta-analysis but some common themes emerged across the studies. Home garden interventions had a positive impact on intermediate nutritional outcomes (typically self-reported) such as dietary diversity and the consumption of nutrient-rich crops. Integration of livestock into the home garden programmes also encouraged the consumption of animal-sourced foods. Final nutrition outcomes such as biochemically assessed nutrient status and anthropometric status appear less amenable to change through nutrition-sensitive agriculture interventions. One study reduced the odds of anaemia in the intervention arm, but the evidence from this review that agricultural interventions are able to improve child growth is extremely limited.

A common concern amongst the studies identified in this review relates to study design. Before and after studies and quasi-experimental designs while relatively straightforward and attractive to deliver provide relatively low quality evidence on the impact of interventions. The quality of reporting of studies is another area of concern, with sample size calculations, clearly specified methods and data analysis, and appropriate reporting of data urgently requiring improvement and standardisation. Finally, many of the studies were relatively small (only one study included more than 1000 participants) and many of the samples were not randomly selected. The reported study findings are therefore likely to be hard to generalise to other populations either within the LANSA focus countries or the rest of South Asia. Large well designed studies including randomly selected samples are needed to strengthen the external validity of the evidence base on nutrition-sensitive agricultural interventions.

4.2. Comparison with past reviews

Our systematic review provides the most recent summary of evidence on the effect of nutrition-sensitive agricultural interventions in South Asia, updating from work by Pandey et al (2016) that included 25 studies from five countries published before 2014 (Pandey et al., 2016). We similarly concluded that the evidence base supporting the link between interventions in agriculture and nutrition outcomes in South Asian population is limited. This reflects findings in other global reviews (Masset et al., 2012, Ruel et al., 2017), where evidence to support an association was weak; frequently due to poor study designs and study quality. However, the findings from South Asia and elsewhere consistently show that there is a potential for agricultural interventions to improve intermediate nutritional outcomes (such as dietary diversity and the consumption of animal-source foods) at least during the life-time of the intervention. Improving the quality of diets at the individual and household level is a critical step to improving population nutritional status.

4.3. Gender and sustainability considerations

The potential impact of nutrition-sensitive agriculture interventions on women working in agriculture requires significant attention. Although there is a growing evidence base that supporting women's empowerment in agriculture leads to improved maternal and child nutritional status, there are still potential implications to consider. Interventions that increase women's involvement in agricultural work need to balance the time demands of agriculture with the time demands of other household duties such as child-caring (Rao and Raju, 2017). Other important gender-relevant factors include the level of expected labour-demand for women and intra-household decision dynamics. The paper by Rao et al. (this issue) examines gender in agriculture in detail.

A focus is also needed on long-term programme sustainability with a particular emphasis on cost. Many of the interventions found within this systematic review provided agricultural inputs and training typically using the existing cadre of extension workers. It is difficult to assess whether after the intervention period ends, households have the financial capacity or willingness to purchase further agricultural inputs, maintain their home garden or livestock and also whether they retain the nutritional and agricultural education received. Further research is required better to understand start-up and maintenance costs of nutrition-sensitive agricultural interventions as well as longer-term issues of programmatic sustainability.

Furthermore, the South Asian region is facing a wide range of challenges that threaten the sustainability of agriculture and food production; population growth, urbanisation, dietary transition, climate change and associated environmental changes. It is therefore increasingly important that future interventions promote sustainable and resilient farming systems and consider the environmental impacts of their programmes. In India for instance, these stressors are coinciding with depleting groundwater resources and therefore challenging the agricultural system's ability to meet population dietary requirements (Milner et al., 2017). Interventions in agriculture aiming to improve nutrition outcomes therefore need to consider the implications of reduced groundwater availability, climate change scenarios and projected dietary transitions to both inform the design and adaptation of

Table 5
Details of LANSA supported nutrition-sensitive agricultural interventions.

Lead institution	Study name	Location and Period	Intervention type	Measured outcomes
M.S Swaminathan Research Foundation (MSSRF)	Farming System for Nutrition (FSN) (feasibility study across 12 villages in two locations)	India 2013–2018	Biofortification	Farm and home garden yield and household consumption of orange-fleshed sweet potato
				Yield and consumption of household production
			Livestock and Poultry	Production, consumption and sale of poultry and eggs
			Home garden	Frequency and quantity of consumption of vegetables
			Aquaculture	Production, consumption and sale of fish
			Agriculture Technology	Finger millet productivity, labour requirement, cost of cultivation and household consumption
International Food Policy Research Institute (IFPRI)	Using agricultural platforms to disseminate nutrition education videos	India 2013–2014	Innovative Technology	Comprehension and retention of nutrition messages
University of Queensland	Household duck rearing in rural communities	Bangladesh 2016–2017	Livestock and Poultry	Household duck meat and egg consumption, income generated from these outputs
BRAC Afghanistan	Vegetable gardening for adolescent girls	Afghanistan 2016–2017	Homegarden	Nutritional knowledge and frequency of vegetable consumption
ACF Pakistan	Feasibility of setting up kitchen gardens in different environmental regions	Pakistan 2016–2017	Homegarden	Identify context-specific barriers and facilitators for scaling up kitchen gardens in different representative regions
University of Heidelberg	Biochar Urine Nutrient Cycling for Health (BUNCH) for homestead food production	Bangladesh 2016–2017	Agriculture Technology	Yield differences between trial and traditional practice. Identification of barriers.
Institute for Financial Management and Research (IFMR)	Subsidising farm-machinery to reduce time-demands of female agricultural labourers	India 2016–2017	Agriculture Technology	Identify constraints to adoption of the rental of farm machinery. Female farmer's time spent on agricultural labour
Collective for Social Science Research (CSSR)	Transferring agricultural assets to women	Pakistan 2014–2018	Asset transfer	Feasibility or otherwise of targeted interventions for women agricultural workers, particularly agricultural asset transfer programmes
BRAC Bangladesh	Farming Systems for Improved Nutrition	Bangladesh 2013–2014	Interviews and focus group discussions	Understanding of nutrition and nutrition-sensitive agriculture
University of Sydney	Integrated agriculture and nutrition behaviour change intervention to improve maternal and child nutrition	Bangladesh 2016–2018	Innovative Technology	Community acceptance of the approach
Vaagdhara	Designing Suitable Approaches for Nutrition-sensitive Farming Systems	India 2016–2017	Participative Learning and Action (PLA) tool	PLA as a tool for promoting nutrition-sensitive farming systems

agricultural policies and the potential mitigation of further preventable impact on planetary health. A recent LANSA FAO online consultation (FAO, 2017) highlighted that the environmental sustainability of farming systems is often overlooked and methods to measure environmental impacts are not widely known.

4.4. Formative and feasibility research under LANSA

The design and delivery of novel formative and feasibility studies was a core component of LANSA. Data from these studies, that are typically small-scale and rapid, are critical to support the design and implementation of high quality large scale intervention studies capable of generating the robust evidence required for policy makers. One LANSA study in India (Farming Systems for Nutrition) set out to examine the feasibility of a farming systems approach to improve nutrition among rural communities (Bhaskar et al., 2017) and emerging evidence suggests that the approach is feasible and improves household dietary diversity (Pradhan et al., 2018). Another study in India examined the feasibility of using a digitally-enabled agriculture platform for disseminating nutrition messages (Kadiyala et al., 2016)and has resulted in the development of a large intervention study (Kadiyala et al., 2018). In addition to these studies led by LANSA consortium members, LANSA supported research and development partners in the region, through a competitive funding call in 2015, to conduct a suite of household-level formative and feasibility studies. The studies (outputs from which are forthcoming) address critical gaps in knowledge such as the development of nutrition-sensitive farming systems that deliver context-specific nutrition solutions, the engagement of adolescent girls in home gardens, the use of innovative fertilizers in agriculture, and increasing women's access to farm machinery to reduce demand on their time for labour (Table 5). Through this competitive call, LANSA expanded the geographic evidence base to include Pakistan and Afghanistan (Abdul and Anowar, 2018), from which no studies were identified in the current systematic review (Appendix 3 and Appendix 4).

4.5. Implications for future research and policy engagement

The South Asian region suffers a significant burden of malnutrition in all its forms and has the highest prevalence of childhood stunting and wasting in Asia (UNICEF et al., 2017). Close to half (44%) of the region's population is employed in agriculture and are at least in-part dependent on farming for their livelihoods (World Bank Group, 2017). Substantial transformations are required to ensure that agricultural practices and food systems can support nutrition outcomes now and into the future. This review suggests that interventions in agriculture certainly have the potential to be part of the solutions to improve population nutritional status. Further improved research and engagement is required before they can generate an adequate evidence base to be integrated into policy.

Intervention studies in this area have frequently relied on limited funding that has resulted in short intervention time frames with limited capacity to influence important nutrition outcomes thereby restricting the potential for scaling up findings. Further engagement from governments and other funding stakeholders is vital to develop a favourable and financially supportive policy environment to encourage larger and higher quality intervention research studies. Agricultural interventions *per se* have the potential for large impact; the Green Revolution was able to help address India's food security crisis in the last century primarily because of this connected interface of research and policy to encourage the necessary input and price support to farmers that led to large scale uptake (Swaminathan, 2008). Following the success of biofortification programmes in Africa (Bouis and Saltzman, 2017), South Asian governments' and public acceptability of biofortified crops are growing and more interventions are testing micronutrient enriched crops, such as zinc fortified rice and iron fortified pearl millet (Yadava et al., 2017). If such interventions are to lead to uptake and demonstrable impact on nutrition and health in South Asia, more effective evaluations are needed that understand the pathways of impact, as well as consideration of costs, gender and sustainability, and are more engaged with local stakeholders and policy-makers.

5. Conclusion

The interventions identified in this systematic review as well as LANSA supported studies cover a wide variety of target groups, especially those considered to be the most nutritionally vulnerable including adolescents, women, children and landless households. The systematic review revealed a focus for interventions in India, Nepal and Bangladesh, and more recently LANSA has broadened the research focus to design and support interventions in Afghanistan and Pakistan.

In line with previous systematic reviews, we do not find strong evidence that the agricultural interventions so far tested have had an impact on final measures of nutritional status such as child growth. However, the demonstrated potential of these interventions to influence and improve intermediate outcomes such as dietary diversity, and the consumption of animal-sourced foods, identifies the need to continue supporting and conducting research in this critical area to support efforts to meet the globally agreed sustainable development goals.

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Competing interests

All authors state that they have no competing interests to declare.

Appendix 1. Modified checklist derived from the critical Appraisal Skills programme for randomised controlled trials (Critical Appraisal Skills Programme, 2018)

	Criterion description	Issues considered
1.	Clear study description	• Did the authors provide a clear description of the study design of the intervention? • Was a clear description given of the participants and the justification of the intervention? • Did they give a clear justification of study in particular area? • Did they give a clear justification of the nutrition outcome/s for the chosen intervention?
2.	Appropriate comparison group/situation	• Were the intervention group compared to an appropriate and comparable control situation? I.e. baseline/endline comparison or separate control group.
3.	Clear methods description	• Were the methods of implementing the intervention clearly described? • Were the methods of measuring outcome clearly described?
4.	Rigorous and clearly described analysis	• Are sufficient data presented to support the findings? • Were analyses described in detail? (Could they be repeated by someone not involved in the study) • Did the researchers critically examine their potential biases during measurement, analysis and selection of data for presentation?

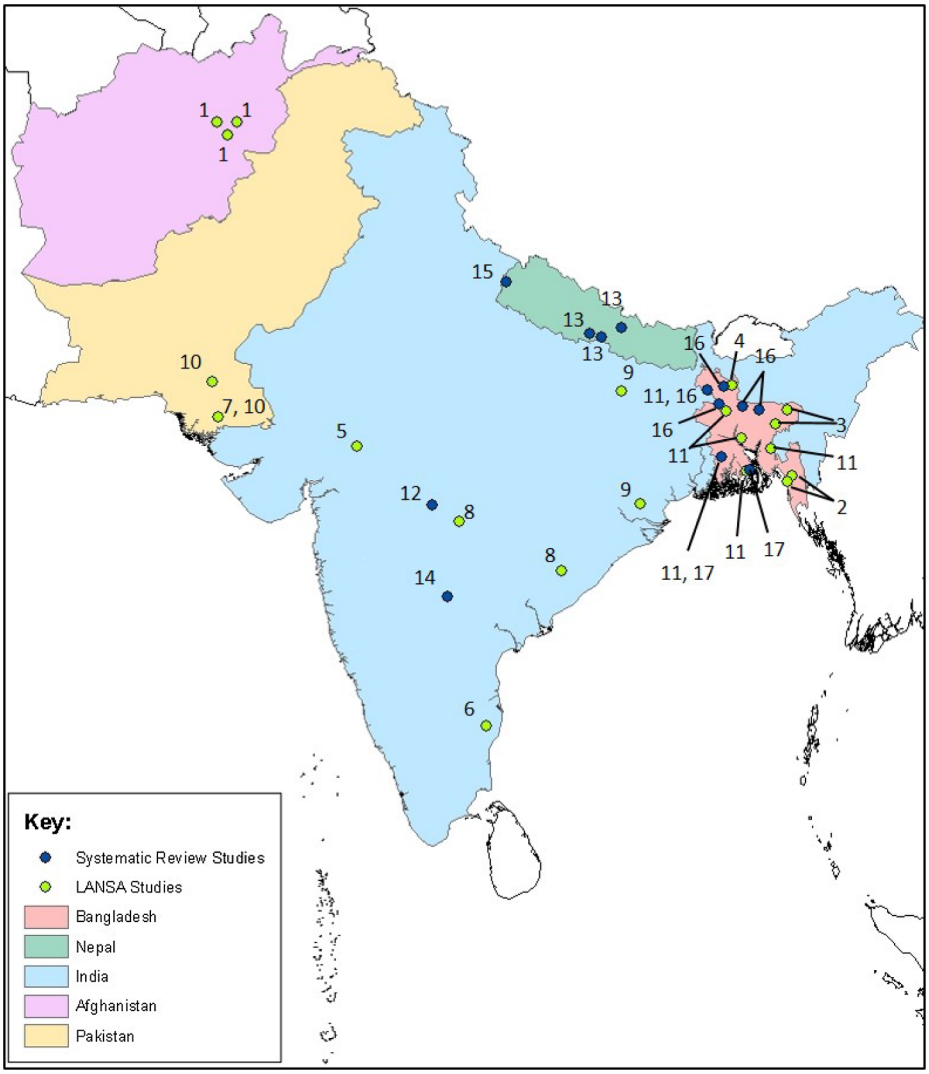
Appendix 2. Quality scores of the nine included studies

Study	Quality criteria				
	Clear study description	Appropriate comparison group/situation	Clear methods description	Rigorous and clearly described analysis	Total quality score
Birdi and Shah (2015)	1	1	0	0	2
Miller et al, 2014	1	1	1	1	4
Miller et al, 2016	1	1	1	1	4
Darrouzet-Nardi et al, 2016	1	1	1	1	4
Murty et al, 2016	1	1	0	0	2
Osei et al, 2017	1	1	1	1	4
Pant et al, 2014	1	1	0	0	2
Schreinemachers et al, 2014	1	1	1	1	4
Schreinemachers et al, 2016	1	1	1	1	4

Appendix 3. Details and location of nutrition-sensitive agriculture interventions

Point No.	Intervention type		Location
LANSA supported Nutrition-sensitive Agriculture (NSA) Interventions			
	Lead Institution		
1	BRAC Afghanistan	Homestead vegetable gardens for female adolescents	Kabul, Parwan and Kapisa - Afghanistan
2	University of Queensland	Household duck rearing	Rangunia and Anwara – Bangladesh
3	University of Heidelberg	Agricultural technology - Biochar fertiliser	Habiganj and Sylhet – Bangladesh
4	University of Sydney	Agriculture and nutrition behaviour change and communication	Kurigram – Bangladesh
5	Vaagdhara	Nutrition-sensitive farming system in Tribal communities	Banswara – India
6	Institute for Financial Management and Research (IFMR)	Women, agriculture and time constraints	Kanchipuram – India
7	ACF Pakistan	Kitchen gardens	Badin, Dadu and Hyderabad – Pakistan
8	M.S Swaminathan Research Foundation (MSSRF) (Das et al., 2014)	Farming System for Nutrition (FSN)	Wardha and Koraput – India
9	International Food Policy Research institute (IFPRI) (Kadiyala et al., 2016)	Agricultural technology	Keonjhar – India
10	Collective for Social Science Research (CSSR)	Women's access to agricultural assets	Shahdadpur and Badin – Pakistan
11	BRAC Bangladesh	Farming Systems for improved Nutrition	Manikganj, Comilla, Dinajpur, Bogra, Jessore and Jhalokati – Bangladesh
NSA Interventions in South Asia identified in current systematic review			
	Reference		
12	Birdi and Shah (2015)	Home garden	Melghat – India
13	Miller et al. (2014), Miller et al. (2016), Darrouzet-Nardi et al. (2016)	Livestock	Chitwan, Nawalparasi and Nuwakot - Nepal
14	Murty et al. (2016)	Home garden and poultry	Medak – India
15	Osei et al. (2017)	Home garden and poultry	Baitadi – Nepal
16	Pant et al. (2014).	Aquaculture	Dinajpur, Rangpur, Joypurhat, Sherpur and Netrakona – Bangladesh
17	Schreinemachers et al. (2014), Schreinemachers et al. (2016)	Home garden	Barisal and Jessore – Bangladesh

Appendix 4. Map of the South Asia region showing the location of the interventions found in the systematic search and those led by LANSA



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