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Agricultural innovation
An evidence gap map

December 2017

Evidence Gap Map Report 12

Agriculture

International Initiative for Impact Evaluation

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The International Initiative for Impact Evaluation (3ie) is an international grant-making NGO promoting evidence-informed development policies and programmes. We are the global leader in funding, producing and synthesising high-quality evidence of what works, for whom, how, why and at what cost. We believe that using better and policy-relevant evidence helps to make development more effective and improve people's lives.

3ie evidence gap maps

Evidence gap maps (EGMs) aim to inform funding and research decision-making by compiling existing research accessibly in one place in a way that also shows limitations and gaps. These maps are based on systematic methods to identify and describe completed and ongoing impact evaluations and systematic reviews. EGMs are structured around a framework of interventions and outcomes and include an interactive map that highlights areas with extensive, limited or non-existent evidence. They provide an overview of evidence on the effects of policies and programmes in a particular sector or thematic area. EGMs are available through an online interactive platform on the 3ie website that allows users to explore the full studies and reviews that are included.

About this evidence gap map report

This report provides the supporting documentation for the online EGM map on agricultural innovation developed to inform current 3ie grant-making in this area. The 3ie Agricultural Innovation grant programme is funded by UK aid through the Department for International Development, the Bill & Melinda Gates Foundation, the International Fund for Agricultural Development and the Alliance for a Green Revolution in Africa. All of the content is the sole responsibility of the authors and does not represent the opinions of 3ie, its donors or its Board of Commissioners. Any errors and omissions are the sole responsibility of the authors. Any comments or queries should be directed to the corresponding author, Diana Lopez-Avila at davila@3ieimpact.org.

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Agricultural innovation: an evidence gap map

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Summary

The World Bank's *World development report 2008: agriculture for development* (Byerlee et al. 2008) highlighted the importance of the agriculture sector in international development. Agriculture for development encourages opportunities for economic growth, food security, poverty reduction, sustainable land management, climate change mitigation, and the overall improvement in the livelihoods of smallholder farmers in low- and middle-income countries. Innovations in agricultural production are key in helping determine the best practices and technologies to help improve farmers' livelihoods. Although many agricultural technologies are available, adoption remains low among smallholder farmers in developing economies. The effective dissemination of knowledge remains a challenge to preventing more productive approaches from being adopted by many rural farmers. Farmers also face different constraints along the value chain, including a lack of financial resources and inadequate infrastructures or market inefficiencies, which can restrain farmers' abilities to increase their productivity and subsequent well-being.

This evidence gap map consolidates evidence on impact evaluations referring to agricultural inputs, practices and programmes aimed at improving farmers' productivity and well-being. Specifically, we included impact evaluations and systematic reviews assessing the effects of agricultural training, financial schemes, institutional arrangements and the provision of inputs. Included studies and reviews look at outcomes, such as adoption of inputs and practices, productivity, consumption and sustainable land management, among others. We map the included studies according to the interventions and outcomes that they assess, with the analysis further characterising the studies by geographical location and study design. We also offer a critical appraisal of the included systematic reviews. We identified 308 completed impact evaluations, 6 completed systematic reviews, and 2 systematic review protocols and mapped them on a matrix framework of 16 intervention and 15 outcome types. Included studies were conducted across 58 low- and middle-income countries with the most prominent dispersion being within Sub-Saharan Africa (179 studies), South Asia (46), and Latin America and the Caribbean (35).

Our findings show that the largest grouping of impact evaluations is concentrated across interventions referring to the provision of inputs and practices, and outcomes related to productivity, such as yield and income. Despite the fact that a large number of interventions were planned around activities that involve some form of education or training, few studies measured how knowledge was transferred.

We find gaps in evidence on cost-effectiveness and measurements of spillover effects. We also observe a gap in the use of experimental methods. The vast majority of studies use quasi-experimental methods, particularly propensity score matching (162 studies), as compared with randomised designs (66 studies). Most of the impact evaluations were conducted after completion of the programme being studied. Our findings also show that only one third of the studies included subgroup analyses, with most being done across poverty and sex dimensions, leaving out a dearth of population-related characteristics, such as age, poverty or literacy that could be analysed.

Among the different gaps, three main aspects can be highlighted to help guide future research. First, more evaluations using experimental methods are needed, requiring more evaluations to be designed in parallel with the programme implementation. The vast majority of interventions took place after the programme's completion, leaving aside the possibility of a randomisation and making propensity score matching the most common identification strategy. The results obtained from this type of methodology need to be interpreted under a larger set of assumptions, sometimes reducing their robustness.

Second, more cost-effectiveness analyses need to be conducted alongside impact evaluations. We found very few studies doing it, showing that there is still a dearth of evidence regarding the most effective ways to incentivise farmers to adopt new technologies.

Finally, more evidence is needed in those economies where poverty is not highly concentrated in rural areas, but rather where the food industry is a prominent driver of economic growth. Studies focused in Latin America are limited, as well as studies focused on interventions related to financial and institutional intermediation, and market linkages. Although not exhaustive, these are some key areas towards which impact evaluations related to agricultural innovation could be orientated.

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Abbreviations and acronyms

DID	Differences in differences
EGM	Evidence gap map
FAO	Food and Agriculture Organization (UN)
GDP	Gross domestic product
GHG	Greenhouse gases
IV	Instrumental variable
L&MICs	Low- and middle-income countries
PICOS	Population, interventions, comparators, outcomes, study design
PRISMA	Preferred reporting items for systematic reviews and meta-analyses
PSM	Propensity score matching
RCT	Randomised controlled trial
RDD	Regression discontinuity design

1. Introduction

Agriculture is the main source of income and employment for 70 per cent of the world's rural population (ILO 2016). Despite this, in 2014 there were only 0.19 hectares of arable land per person, thereby failing to provide farmers with sufficient opportunities to increase their productivity and income (Alexandratos and Bruinsma 2012). The depletion and degradation of agricultural land and global water supplies are serious challenges that affect the sustainability of many farmers' livelihoods. In regions such as South Asia, East Asia and Sub-Saharan Africa, the effects of low agricultural production can be seen strongly affecting both food security and household well-being.

The World Bank's *World development report 2008: agriculture for development* highlighted the importance of the agriculture sector in international development, encouraging opportunities for economic growth, food security, poverty reduction, sustainable land management, climate change mitigation, and overall improvement in the livelihoods of smallholder farmers in low- and middle-income countries (L&MICs). The report stated that a developing country's gross domestic product (GDP) growth, if originating from agriculture, is four times more likely to be effective in reducing poverty than other forms of domestic income (Byerlee et al. 2008). Policies that foster higher productivity and encourage climate-smart agriculture[1] can have substantial sustainable impacts on poverty alleviation, food security and improved well-being, particularly for smallholder farmers (Asfaw et al. 2014).

Innovations in the field of agricultural production are key in helping determine best practices and technologies to help improve farmers' livelihoods. Although many agricultural technologies are being created continuously, the effective dissemination of knowledge remains a challenge that inherently affects the productivity of many rural farmers. Farmers' lack of access to resources and infrastructure, as well as a lack of capacity to support local agricultural production, can lead to unstable rural economies and declines in farmers' well-being.

Improving agricultural innovations and technologies in developing countries is of paramount importance, as it offers new opportunities for increased agricultural production and income sustainability (Feder et al. 1985). In an analysis of the intersection between agriculture and development (Dethier and Effenberger 2012), the authors identify two challenges that hamper the sustainable growth of the agriculture sector in developing countries: the need for increased food productivity and the volatility of food prices. Thus, many agricultural innovations aim at targeting factors that contribute to improving production and quelling volatile markets. This includes improving access to credit and market information and land tenure security, encouraging diverse employment, and increasing supplies of complementary inputs (fertilisers and seeds) and infrastructures (irrigation and roads) (Feder et al. 1985).

A report by the Food and Agriculture Organization (FAO 2011) on the role of women in agriculture notes that closing the input gap on the agricultural land held by women would

[1] Climate-smart agricultural practices are defined as those practices that increase adaptive capacity and resilience of farm production in the face of climate shocks, thereby improving food security, and which can also mitigate GHG emissions, mainly through increased carbon sequestration in soils (SOFA Team and Doss 2011).

(assuming a gender yield gap of 20 to 30%) lead to an increase in the agricultural output of developing countries by 2.4 to 5% (FAO 2011). Promoting the usage of gender analyses is important in agricultural impact evaluations, as evidence shows that there are significant gender gaps in the access to credit, extension services and land tenure in many developing countries. More gender-based analyses in the agricultural sector could enhance smallholder productivity and household income, and improve women's status, purchasing power and independence within a community (SOFA Team and Doss 2011). Although women play an important role in agriculture, many evaluations shy away from in-depth gender analyses, limiting to a sex-disaggregated data analysis. In this evidence gap map (EGM), we capture whether the evaluations do a subgroup analysis by the sex of the farmer and whether outcomes related to women's empowerment are measured.

Despite important institutional innovations in agriculture, huge institutional gaps need to be filled to support the competitiveness of smallholder farmer (Byerlee et al. 2008). Important overlaps between a developing country's traditional and'modern sectors have made agricultural growth an important tool for alleviating rural poverty (Dethier and Effenberger 2012). The World Bank has been continuously at the forefront of promoting the agricultural agenda, encouraging international organisations to improve their research systems in order to increase the supply of new knowledge and technologies for adoption.

A large set of interventions in agriculture focus on food insecurity, input and technology adoption, tenure security and community infrastructure (Rajalahti 2012). Recent interventions have homed in on the use of mobile phone and multimedia technologies to enhance agricultural production through direct linkages with markets and timely dissemination of information regarding weather shocks and correct use of inputs. This EGM gathers evidence pertaining to innovative interventions that aim to improve the use of agriculture for the social and economic development of smallholder farmers in L&MICs. The map and the evidence it presents can be used to inform further research, policy and funding decisions in the agriculture for development sector.

1.1 EGM objectives

The International Initiative for Impact Evaluation (3ie) has produced this EGM to provide a platform for policymakers, researchers and donors on what interventions in agriculture exist and which have been evaluated so far in L&MICs.[2] The overall aim of this EGM is to identify, map and describe existing empirical evidence on the effects of agricultural innovations on smallholder economic development and well-being. This EGM has these objectives:

1. Identify and map existing evidence from impact evaluations and systematic reviews on the effects of agricultural innovation interventions, such as extension services, provision of agricultural inputs, financial and institutional intermediation, and market linkages on outcomes related to awareness and adoption of new practices, income and productivity, and farmers' well-being;
2. Identify existing gaps in terms of methodologies, interventions, outcomes, geography and subgroup analysis to guide donors, researchers and policymakers to better direct research and funding; and

[2] World Bank definition of L&MICs.

3. Inform discussions to orient further research and promote the use of impact evaluations in under-evaluated areas in the field of agricultural innovation.

1.2 Methodology

EGMs are a tool developed to support evidence-informed policymaking in particular sectors or thematic areas. They draw on a range of systematic methods for evidence synthesis, and provide an approach for rapid knowledge transfer and capture, combining mapping approaches and data visualisation in an interactive platform. Although this map does not synthesise information, it presents an interactive matrix of interventions and outcomes from existing impact evaluations and systematic reviews (Snilstveit et al. 2017). An impact evaluation is an experimental or quasi-experimental study assessing the causal effect of a policy or an intervention on outcomes of interest, showing the distribution and sustainability of impact (Gertler et al. 2011). A systematic review is a methodology used to synthesise the results of multiple impact evaluations that aim to answer a similar research question pertaining to the effectiveness of social and economic interventions (Polanin and Pigott 2013).

This EGM is structured using a matrix of intervention and outcome categories informed by a theory of change (see section 2.1), which draws on relevant academic literature and consultations with key stakeholders. In particular, the intervention and outcome categories of this EGM were first informed through an exercise conducted during a stakeholder consultation workshop organised by FAO and the International Fund for Agricultural Development in January 2016. During this workshop, participants were asked to point out three areas (i.e. intersections between interventions and outcomes) where they considered there was a lack of evidence. They were also asked to highlight any outcome or intervention category that may have been missed. The inclusion of the cost-effectiveness analysis came from this exercise.

The relevant outcomes are structured along the causal chain, from outputs to outcomes to impacts. Intervention and outcome categories were organically updated throughout the mapping process, as the authors continually debated the veracity of the categorisations based on the coding process. The authors first developed a comprehensive search and screening strategy, which captured studies from eight online databases (see Appendix B). These results were then complemented by studies and reviews found through hand-searching and snowballing techniques. The financial intervention category was further supplemented by screening studies that were used in a 3ie EGM on agricultural risk (Barooah et al. 2017). The authors also collected information on: whether the included studies carried out heterogeneity or subgroup analyses (see Appendix C for the categories); whether the evaluation was ex post (designed and carried out after the programme was completed) or ex ante (designed before the beginning of the programme and then conducted alongside the programme); and the donor for the evaluation.

At the start of the screening process, the authors had 34,060 articles pertaining broadly to the category of agriculture for development. A preliminary duplication search expelled 4,811 articles, leaving 29,249 to undergo title and abstract screening whereby studies were either included or excluded on the basis of a PICOS framework (population, interventions, comparators, outcomes, study design; see Table A3 in Appendix A). At

this stage, 28,278 articles were excluded by the authors, leaving 771 for full-text assessment; after this, 394 articles remained and were coded using the matrix framework. Upon a second screening and manual cross-referencing, 12 articles were additionally excluded and 67 duplicates were found. The final result yielded 316 articles that are included in this EGM: 308 impact evaluations, 6 systematic reviews, and 2 systematic review protocols (see Figure A1 in Appendix A). While this EGM critically appraised systematic reviews using a standardised checklist, the quality of the impact evaluations was not assessed.

The six completed systematic reviews were assessed for confidence in the quality of their reporting using a standardised critical appraisal tool by 3ie's Systems Reviews Office (Snilstveit et al. 2014). Based on this, two reviews were rated as having a high level of confidence, one as having a medium level of confidence, and the remaining three as having a low level of confidence in their findings. The three low-level systematic reviews were classified as such due to major limitations, ranging from unclear inclusion criteria (Marr et al. 2016) to issues concerning the risk of biased appraisal of included studies (Ton et al. 2013; IOB 2011).

The EGM identifies key gaps in evaluations conducted within the agricultural sector, specifically looking at: interventions, outcomes, geographical location, donors, study type and targeted population groups. The results from this EGM aim to inform policy decisions and strategic approaches to building the evidence base within agriculture for development. This report summarises the evidence captured by an interactive, online EGM.[3] The online EGM highlights the following:

- Evidence showing the combination of interventions and their corresponding outcomes;
- Gaps in evidence (cells with no or few studies or reviews); and
- Cells where there are enough impact evaluations to support a systematic review.

Appendix D (available online) contains a list of included studies and reviews.

1.3 Limitations

This EGM covers the broad categories of interventions and outcomes identified through the theory of change we developed for this mapping exercise (see section 2.1). Agricultural innovation is a wide area, and hence including all possible interventions throughout the production and value chain phase was not possible. We balanced relevance with feasibility when defining the interventions and outcomes we would include in the map, including their value within the 3ie agricultural innovations thematic grant programme.

The first limitation refers to the population of interest. The population of interest in the EGM is farmers living in L&MICs, excluding all forms of non-crop-based farming (see also section 2). This definition focuses on interventions and outcomes relating specifically to agricultural innovations within the framework of crops. Although this EGM is limited to crop-based farmers, it allows for a nuanced approach to mapping the interventions and outcomes that pertain to crop production. It allows for the presentation

[3] http://gapmaps.3ieimpact.org/evidence-maps/agricultural-innovation

of evidence on how farmers can move from a subsistence-based existence to one that generates income and interacts with the environment in a sustainable way.

The second main limitation is the exclusion of 'market mechanisms and linkages' from the types of interventions that were coded. The linking of farmers to market mechanisms allows for the commercialisation and expansion of smallholder production into local, national and international markets (Ferris et al. 2014). While the market is an important part of the agricultural value chain, the EGM scope is limited to agricultural processes that end at the point of production.

The market, however, was not entirely ignored, as many of the studies within the EGM offer smallholders marketing-intensive interventions,[4] coupled with financial incentives to boost household income and promote farm sustainability. The presence of market linkages and mechanisms is an integral part of this map's theory of change (see section 2.1), which acknowledges its importance in creating sustainable mechanisms for smallholder farmers to generate income and grow their agrarian businesses. Through limiting the scope of agricultural interventions to those that pertain primarily to production and pre-production activities, this EGM is able to identify potential gaps in research areas more precisely.

The third limitation is that this EGM does not appraise the quality of included impact evaluations. In the screening process, studies were coded against the PICOS matrix in order to tease out relevant categories for mapping. While this matrix provides stringent guidelines regarding the types of interventions, outcomes, populations, study groups and methodologies that must be present for the study to become included, it does not provide a scale for quality judgements. In this EGM, only the systematic reviews have been quality assured, and their main results have been summarised in section 3.4. Regarding the way in which the reviews were coded, it is important to point out that some studies included in the systematic reviews may also have been included as separate studies. However, we do not have the data disaggregated in such a way to point to these studies.

The final limitation is that the mapping process did not include any information or synthesis regarding the validity of the studies or the robustness of the resuls. As this map is mainly to be used to assist policy and funding recommendations, it primarily provides information on what evidence exists in the field of agricultural innovations (using the map), rather than giving indication as to the quality or veracity of the studies. Only studies that attempted to measure causal impacts through experimental or quasi-experimental methods were included in the EGM.

1.4 Report structure

This report is structured as follows: section 2 presents the scope of the EGM. Section 3 presents the findings, including the search and screening results, an analysis of the trends seen from the EGM, and a synthesis of findings from medium- and high-quality systematic reviews. Section 4 concludes and discusses implications for policy, programming and research. Appendix A includes the methodology definitions; Appendix

[4] Such as: Cole et al. 2012; Crépon et al. 2015; Field and Field 2006; Gilligan et al. 2009; Hill et al. 2016; Kleeman et al. 2014; Munongo 2012; Paolisso et al. 2002; and Rozo et al. 2015.

B includes the search strategy; Appendix C contains the coding sheet and subgroups; Appendix D (available online only) has a list of all included studies in the EGM; and Appendix E includes the heat map generated by the EGM.

2. Scope of the EGM

The scope of the EGM is defined by the matrix of intervention and outcome categories included in the framework. The theory of change (see section 2.1) was used, along with stakeholder consultations and a literature review, to develop the intervention and outcome categories used in the mapping matrix. Section 2.1 describes the theory of change for this EGM, while sections 2.2 and 2.3 outline the development of the interventions and outcomes categories, respectively.

2.1 Theory of change

Important investments in agricultural innovations have taken place to develop new technologies and practices. Yet, inputs and best practices adoption remain challenging for most smallholder farmers. This lack of adoption has lowered farmers' competitive potential to make profits from their participation in the agricultural sector. The lag in innovation has submerged smallholder farmers and their families into poverty and food insecurity, making them more prone to adverse situations and less capable of coping with them (Byerlee et al. 2008).

Many agricultural development programmes have been initiated to help combat the decline in conditions for smallholder farmers. These programmes have covered a wide spectrum of interventions and activities along the whole of the production process and value chain. These activities include provision of inputs, dissemination of knowledge, financial inclusion and market linkages, among others. The main goal of these interventions is to improve the well-being of farmers and their families. This goal will be reached through an increase in farmer productivity, which is expected to occur if farmers adopt new technologies and practices.

Figure 1 shows the causal path through which we expect agricultural innovation interventions will lead to expected impacts. New practices and technologies are given to farmers either through the simple provision of inputs or through extension services. Extension services aim at transferring knowledge on agricultural inputs and practices to farmers. Assuming an adequate dissemination of information, we expect that farmers will know what the available practices and inputs are, along with their advantages and disadvantages. This will lead to an impact on intermediate outcomes such as yield, income, household consumption, water and land management, access to markets and rural employment. An impact on these outcomes is facilitated by adequate financial and institutional intermediation and market linkages, as well as good rural infrastructure and support from key stakeholders and governmental actors.

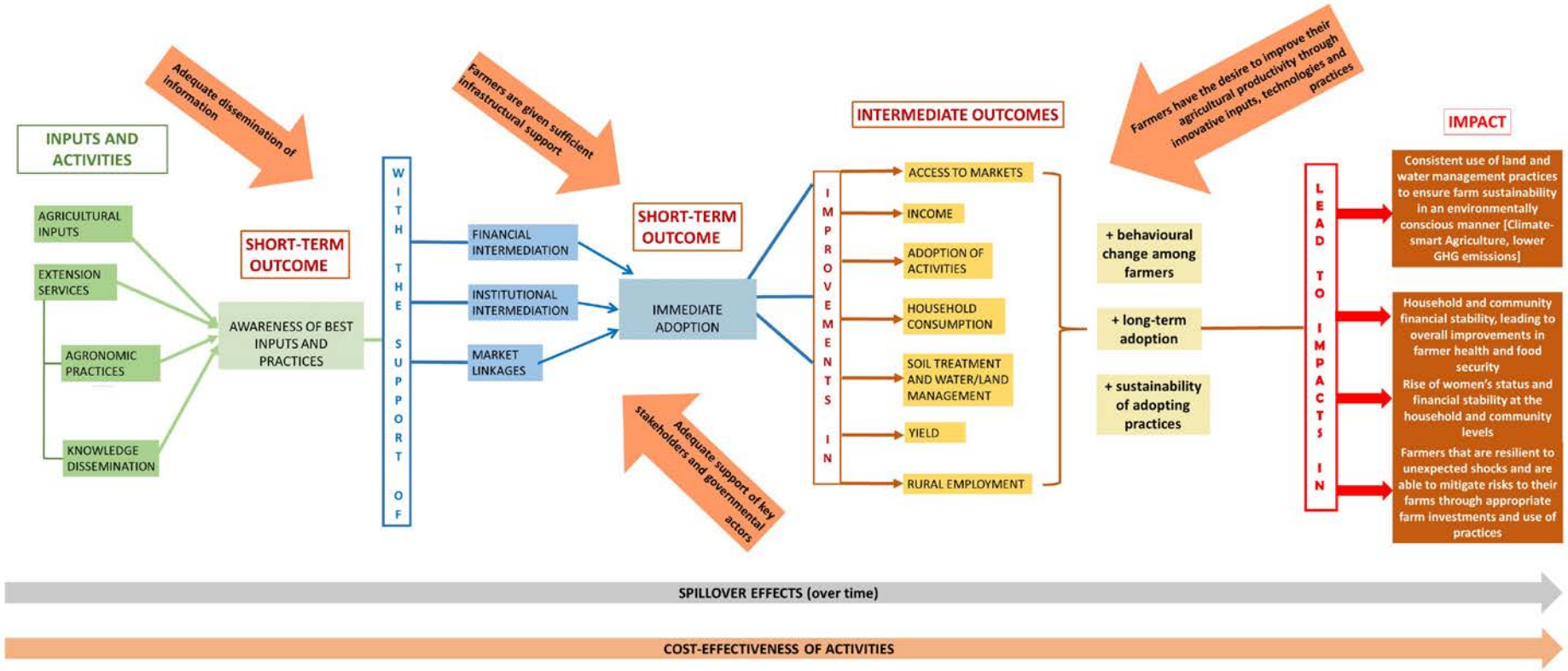
A change in these intermediate outcomes can lead to long-term impacts, such as: sustainable land and water management practices; improvements in household welfare, including better health, education and food security for the farmers and their families; a rise in women's status at the household and community level; financial stability; and

farmers' resilience. These long-term impacts will be achieved if it is possible to generate a behavioural change among farmers that leads to long-term adoption and continuous use of the new practices.

Through the provision of agricultural innovations (knowledge, inputs) and infrastructural support (institutional and financial provisions), farmers will gain knowledge of how to utilise inputs and best practices in effective and sustainable ways. This, in turn, will lead to improvements not only in farm production, but also in financial returns, farmer well-being and environmental effects. The adoption of knowledge, inputs and provisions are important factors that contribute to the necessary changes in farmers' behaviour and the ability for smallholders to lead sustainable and resilient lives.

Additionally, throughout this causal path, spillover effects can be measured to better understand how information is shared among farmers. Cost-effectiveness analyses can be conducted in order to understand not only whether a programme works, but also at what cost.

Figure 1: Theory of change



2.2 Interventions

Our theory of change shows that the type of interventions that can contribute to encouraging farmer adoption of improved inputs and practices to increase productivity are those around the provision of inputs, extension services, financial and institutional intermediation, and market linkages. The large number of interventions that fall under this wide spectrum can be narrowed by selecting interventions covering different aspects of agriculture up to the production phase. The selection of the interventions was done in light of the theory of change previously described, together with a preliminary literature review. As mentioned in the methodology section of this report (see section 1.2), the intervention categories were continuously updated to reflect additional evidence accrued through the screening process in order to capture the most relevant categories for classification.

The interventions were classified into four main categories:

- knowledge dissemination
- finance
- institutional arrangements
- inputs and practices.

This classification captured what interventions are provided to farmers and how.

Knowledge dissemination corresponds to the different means in which information and knowledge is transferred to farmers. Finance refers to the schemes put in place to try to overcome the shortcomings of the rural financial markets. The institutional arrangements category corresponds to arrangements established between farmers and another party or parties in order to facilitate agricultural production and innovation, and help farmers cope with risk. Lastly, the inputs and practices category refers to the provision of packages of inputs (such as seeds) and the presentation of new agricultural practices (such as irrigation) to farmers. Table 1 provides a description of each of the subcategories used.

Table 1: Interventions

Subcategories	Description	Example
Knowledge dissemination		
Social networking and peer learning	Interventions that transfer information through farmers' social networks	Participatory approaches like involving local champions, peer-to-peer
Information and communication technologies	Interventions that transfer information through communication devices and/or applications. This can be phone, radio, television, or other computer-related software or hardware pathways	SMS alerts
Demonstration plots and training	Set of agricultural extension interventions that aim at	Demonstration plots, farmers' field days, public extension services

	transferring knowledge to farmers through training schemes	
Finance		
Transfers, credit and incentives	Interventions that provide farmers with access to financial instruments	Credit cooperatives, matching grants, vouchers and cash transfers
Insurance	Interventions put in place to help farmers cope with shocks	Weather insurance or crop damage schemes
Financial literacy and advice on risk management	Interventions that help farmers mitigate risk or that facilitate farmers' financial inclusion	
Institutional arrangements		
Farming certifications	Interventions that provide quality or process certifications to farmers	Certification schemes, organic certification
Cooperatives and farmer federations	Arrangements that facilitate agricultural production and innovation through farmers' organisations	Farmer-based organisations, particularly market-orientated ones
Contract farming	Agreements between a buyer and the farmers that establish conditions for the production and marketing of the farm products	Contract farming, subleasing, market demand schedules
Land titling and property rights	Interventions involving provision of title or rights that guide land ownership or acquisition	Land titling
Community infrastructure	This refers to public works aiming at facilitation of agricultural productivity and innovations	Irrigation, watershed development, rural electrification and roads
Inputs and practices		
Seeds	Interventions that involve provision of seeds with the intended purpose of boosting production, increasing efficiency or mitigating risk	High-yield seeds, hybrids, genetically modified, weather resistant
Fertilisers and chemicals	Interventions that involve provision of fertilisers or other chemicals with the intended purpose of boosting production, increasing efficiency or mitigating risk	Organic fertilisers, pesticides
Agricultural tools and livestock	Interventions that involve utilising or upgrading tools or livestock with the intended purpose of boosting production, increasing efficiency or mitigating risk	Machinery, sickle, better breed of livestock

Planting techniques and practices	New planting techniques or practices presented to the farmers with the purpose of achieving greater efficiency or boosting production	Row planting, crop rotation, crop diversification
Land management practices	Practices presented to the farmers that promote sustainable land use (help enhance soil quality or avoid degradation)	Nutrients, soil fertility, soil erosion, water management, crop diversification, agroforestry

2.3 Outcomes

Table 2 represents the broad set of outcomes and their definitions. These are taken from the measured effects generally reported in studies falling in this thematic area and are organisationally grouped under categories that are conceptually similar. Each outcome category reflects our theory of change and covers a range of subcategories linked to the intervention activities. Like the intervention categories, the outcome categories were also established in an organic way that allowed for the revision and development of classifications based on relevant literature.

The outcomes cover five broad categories:

- knowledge and behaviour
- productivity
- social outcomes
- environmental outcomes
- cost-effectiveness analysis.

Our theory of change is predicated on the knowledge that strengthening the outcome areas will provide holistic and sustainable improvements to the lives of smallholder farmers and agrarian economies. While the category of ‘cost-effectiveness’ and the subcategory of ‘spillover effects’ are not necessarily linked to activities, outcomes or impacts, they do provide information on relevant analysis in an impact evaluation.

Table 2: Outcomes

Subcategories	Description
Knowledge and behaviour	
Knowledge	Farmer acquisition of information about best practices, inputs and market conditions through programmes, interventions, personal experiences, schemes or market linkages. Knowledge garnered is utilised to inform farming and financial decisions
Adoption of inputs, practices and financial instruments	Acquisition and use of agricultural inputs, practices, infrastructural services and financial instruments aimed at boosting production and/or mitigating farm risk
Spillover effects	Positive or negative influence of an intervention occurring in communities or households that are not part of the target beneficiaries

Productivity	
Yield	Agricultural outputs, measured as returns per hectare or units of production
Employment	Employment status of farmers and household members in both farm- and non-farm-related activities. This includes all changes in labour demands of the farm household (excluding those who have migrated for employment) and changes in the use of child labour
Time use/efficiency	Measurement of time used by farmers and household members on activities that are farm related as well as on those other than agriculture (paid and unpaid), such as working in a family business, contributing to household chores, school activities and education, and opportunities for leisure
Income	Agricultural and non-agricultural income of the household, including any profits that may be made from agriculture-related engagement
Farm investment	Agricultural expenses and farmer initiatives to invest in inputs, tools and livestock, and to engage in best practices (both for farm productivity and sustainability of the land)
Social outcomes	
Household assets	Ownership of assets within household, including livestock
Consumption and food security	Amount of food consumed by household members. Access to sufficient, safe and nutritious food
Savings	Income not spent or saved
Women's empowerment (status)	Measurements of a woman or female child's agency within the household and/or community. Indicators include: household decision-making, educational opportunities, financial independence and decision-making, contraceptive agency, social capital and assets ownership
Environmental outcomes	
Sustainable land management	Use of practices and technologies that aim to integrate the management of land, water, biodiversity and other environmental resources to meet human needs while ensuring the long-term sustainability of ecosystem services and livelihoods. Sustainability in agriculture in this context is defined as the production of crops and use of animals in a manner that does not rely on chemical pesticides, synthetic fertilisers, genetically modified seeds or other practices that may degrade the soil, water or other natural resources. Examples of sustainable agriculture include practices such as crop rotation and conservation tillage
Greenhouse gas (GHG) emissions	Measurement of GHG emissions attributable to agricultural activity. This includes the measurement of carbon, nitrogen and potassium percentages as well as soil pH
Cost-effectiveness	
Cost-effectiveness analysis	Studies that include cost-effective analysis of the programme

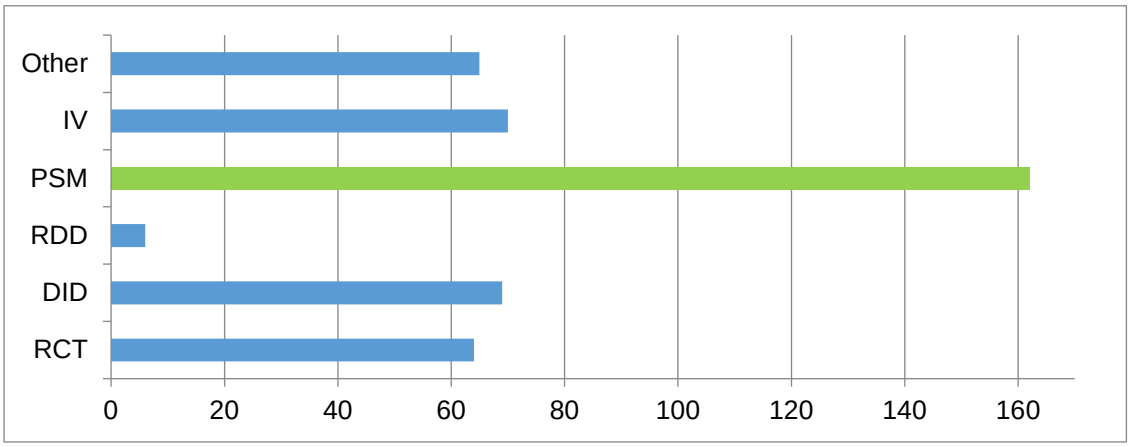
3. Findings

In order to illustrate the trends and findings of this EGM, we provide an analysis of the methodologies used and the outcomes and interventions addressed. We also analyse additional information, such as donor, impact heterogeneity, publication year of the study, geographical location and timing of the impact evaluation (i.e. ex ante or ex post). Sections 3.1 to 3.3 present findings from the 308 included impact evaluations, while section 3.4 only presents findings from the three high- and medium-quality 3ie-assured systematic reviews. Systematic review protocols, of which this map has two, are not used to feed the results of this report. Section 3.5 presents the major evidence gaps derived from the analysis of the impact evaluation studies and systematic reviews. In order to inform the findings across included impact evaluations, the authors generated a heat map (Appendix E) to identify preliminary gaps and overlaps.

3.1 Main results on methodology, outcomes and interventions

Figure 2 shows the number of studies divided by the methodology used to establish the impact of the programme studied. The most used methodology is propensity score matching (PSM), with 162 studies. In second place are methodologies such as randomised controlled trial (RCT), differences in differences (DID) and instrumental variable (IV), with approximately 65 studies each. The least used methodology is regression discontinuity design (RDD), with only six studies. There are 65 studies coded under the category 'Other', which encompasses fixed effects and endogenous switching regression; fixed effects are mostly used in conjunction with an IV, while endogenous switching regression estimations are usually made either alone to address endogeneity or along with PSM.

Figure 2: Number of studies by methodology



Note: The total number of studies reported in the tables and figures can be greater than the total number of studies included in the EGM, as some studies fall into multiple intervention, outcome or methodology categories.

These figures show that the number of studies using a PSM is more than double the number of studies using an RCT. This is in contrast to other EGMs, which show the proportion of RCT usage to be five times higher, on average, than that of PSM. In 3ie's EGM on adolescent sexual and reproductive health, only 16 studies use PSM, compared with 101 using RCTs (Rankin et al. 2016). Similarly, an EGM on science and technology innovations identified 44 studies using PSM, compared with 238 using RCTs (Sabet et

al. 2017). A possible reason driving these differences could be that a large part of the evaluations of agricultural interventions are carried out after completion of the programmes studied, not allowing for the use of experimental methods.

The use of quasi-experimental methods relies on a larger set of assumptions than would be needed for experimental methods. In the case of PSM, treatment and control are matched based on observable characteristics, with a main assumption being that selection into the programme is only based on observable characteristics. In the case of interventions aiming at encouraging farmers to adopt new practices or inputs, different unobserved characteristics can affect the choice to participate in the programme, making the matching on observable characteristics subject to selection bias. For example, if a programme is channelled through a farmer-based organisation but it is not possible to randomly allocate it for its evaluation, it would be difficult to guarantee unbiased results. Farmers who belong to a farmer-based organisation are different from those who do not belong, with different observable and unobservable characteristics. Besides this, in some cases the existing data may not be exhaustive enough to guarantee a good matching on observables. Going deeper into the quality of the impact evaluations included in this EGM is beyond our objectives and scope; however, the number of studies using PSM, as opposed to RCT, gives a hint on how robust the evidence could be.

In several cases, more than one method was used to estimate the impact of the programme. Table 3 shows various common combinations of methods used, with the most common being PSM and DID (31 studies), followed by RCT and IV (21 studies). In the absence of a random allocation of the programme, the combination of PSM and DID is commonly used as a way to increase the robustness of the results. However, lack of data can make it difficult to provide support for the common trend assumption, which can lead to questioning the robustness of the results. The second most common combination of RCT and IV is usually used when there has not been full compliance with the randomisation and the authors want to distinguish the average treatment on the treated estimator from the intention to treat estimator. In these cases, the instrument used is the initial allocation to treatment and control, which usually accurately satisfies the two conditions for an instrumental variable (IV) to work: it is a good predictor of the actual participation in the programme and meets the exclusion restriction. However, when the measuring of the impact of the programme relies solely on an IVs approach, it is usually hard to find an instrument that satisfies the exclusion criteria.

Table 3: Number of studies by combined methodology

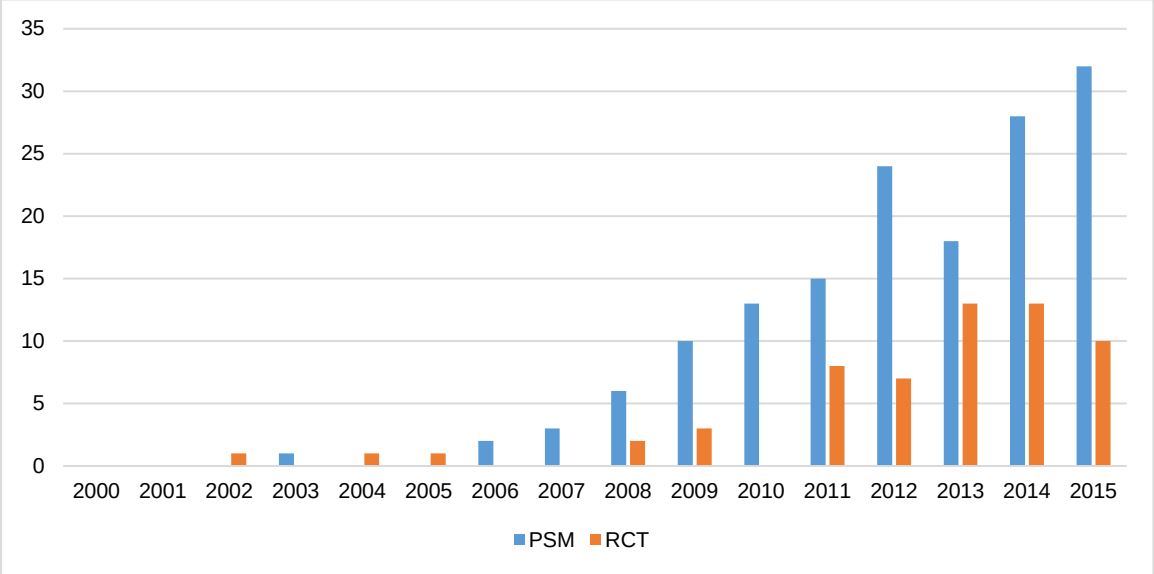
Combined methodologies	Number of studies
IV + PSM	10
PSM + DID	31
DID + IV	5
RCT + PSM	2
RCT + DID	10
RCT + IV	21

Note 1: For this table we focus on the combined methods based only on the five main methodologies: PSM, DID, RDD, RCT and IV.

Note 2: In some cases, these methods are combined with a third method, so there may be some overlap between the categories in the table.

Figure 3 shows the number of studies by year and methodology (either PSM or RCT). There was an important jump in the number of studies in 2008, increasing from 5 studies in 2006 to 14 studies in 2008. From 2009 onwards, there has been a progressive increase in the number of studies, reaching 55 studies in 2014. The number of RCTs increased from 2011 to 2014, going from 7 in 2012 to 13 in 2014. On average, 20 studies per year used PSM. This shows that, despite the number of studies using RCTs having increased in recent years, the large majority of evidence being produced still comes from PSM. Our search took place in the last quarter of 2016, the reason why some studies published later in the year may have been missed. However, we have incorporated, through hand search, two studies published in 2017.

Figure 3: Number of studies by year and methodology (PSM or RCT)



Note: The total number of studies reported in the tables and figures can be greater than the total number of studies included in the EGM, as some studies fall into multiple intervention, outcome or methodology categories.

Table 4 presents the number of studies per main intervention and outcome category. The most-studied intervention category is inputs and practices with 134 studies, while the least-studied intervention category is knowledge dissemination with 67 studies. This first set of results shows us that, although a large set of studies tells us about whether the provision of inputs and practices works, few studies tell us about the different means in which information is transmitted. Following our theory of change, we observe a similar number of studies addressing financial provisions and institutional arrangements, with 103 and 101 studies, respectively (see Table 4).

Table 4: Number of studies by main intervention and outcome category

Intervention category	Number of studies
Knowledge dissemination	67
Finance	103
Institutional arrangements	101
Inputs and practices	134
Outcome category	
Knowledge and behaviour	144
Productivity	256
Social	109
Environmental	30
Cost-effectiveness	7

Note: The total number of studies reported in the tables and figures can be greater than the total number of studies included in the EGM, as some studies fall into multiple intervention, outcome or methodology categories.

Figure 4 presents the number of studies by intervention category and subcategory. Under the category of knowledge dissemination, the most-studied subcategory is demonstration plots and training, with 48 studies; followed by social networking and peer learning, with 15 studies; and information and communication technologies, with 14. The low number of studies addressing social networking is not necessarily surprising; measuring social networks can be highly interesting but also costly and not easy to implement. The relevance of addressing social networks would depend on the type of questions that the evaluation aims to answer. The low number of studies evaluating information and communication technologies suggests that there is scope to examine other media with which to transfer information to farmers besides the usual demonstration plots and field days.

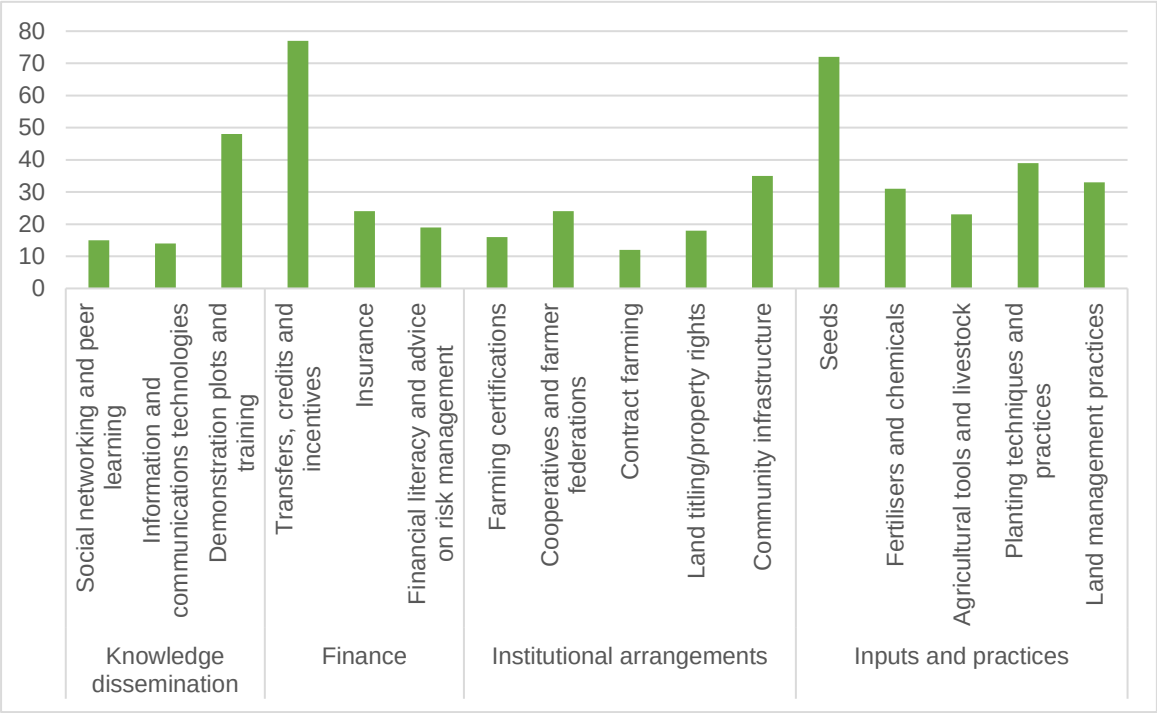
In the case of the inputs and practices category, the most common subcategory is seeds, with 72 studies. Interventions aimed at providing planting and farming techniques are studied to a lesser extent, with 39 studies for the subcategory planting techniques and practices, and 34 studies for land management practices. These figures, together with the ones for knowledge dissemination, suggest that there is still scope to know more about interventions that do not only transfer inputs but also knowledge and practices, and what the best channels for transferring that knowledge are. If we refer to our theory of change, the provision of inputs, together with the transfer of knowledge, is the first link to generate a change in farming practices and, subsequently, in farming productivity.

In light of our theory of change, financial intermediation may be an important factor in improving farmer productivity. In the finance category, we aim to capture schemes put in place to try to overcome the shortcomings of the rural financial markets. The provision of transfers, credit and incentives is the most common way to overcome those shortcomings, and hence, this subcategory is where most of the evidence lies (77 studies). Studies referring to financial literacy, risk management and insurance are less common. Financial literacy and advice on risk management is a subcategory that could be explored further. Making farmers aware of the financial tools that are available and

teaching them how to manage financial resources effectively can potentially contribute to improving farmers' productivity.

Finally, in the category of institutional arrangements, the most common subcategory of intervention is community infrastructure, with 35 studies. Interventions referring to land titling and/or property rights and contract farming are studied to a lesser extent, with 18 and 12 studies, respectively. Establishing formal land titles, or setting conditions to sell what would be produced, can potentially reduce the uncertainty around production, leading to better and higher farm investments.

Figure 4: Number of studies by intervention category and subcategories



Note: The total number of studies reported in the tables and figures can be greater than the total number of studies included in the EGM, as some studies fall into multiple intervention, outcome or methodology categories.

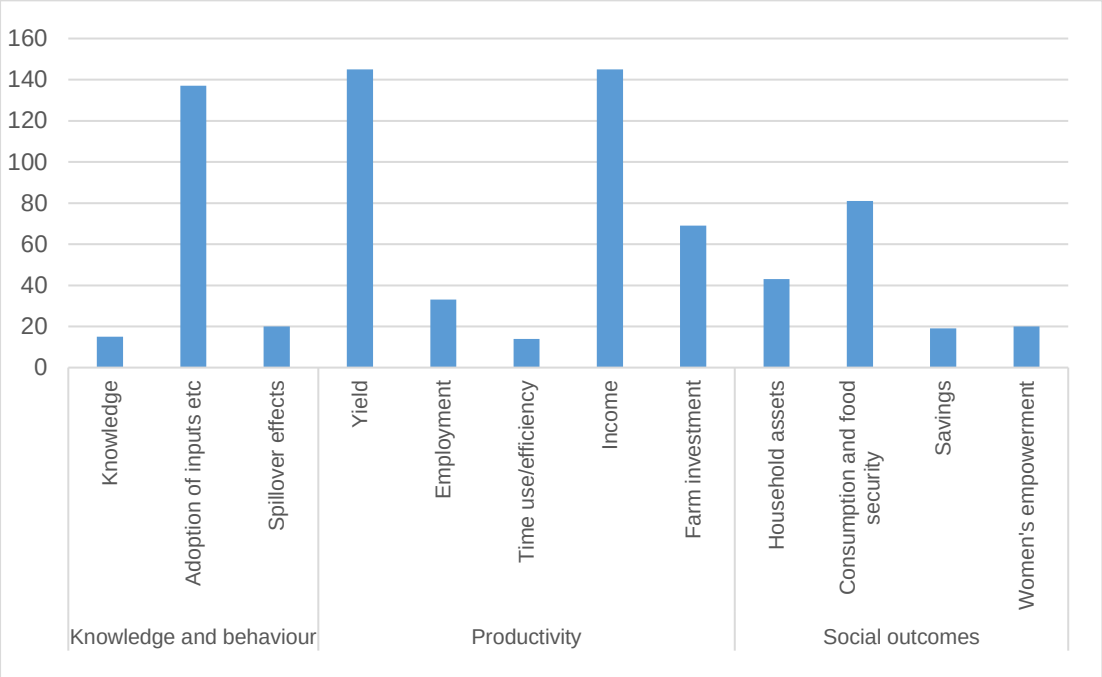
Regarding outcomes, the most-studied outcome category is productivity, with 257 studies, followed by knowledge and behaviour, with 145 studies. The least-studied outcome is cost-effectiveness, with only seven studies (Machila et al. 2015; Hagos et al. 2008; Brune et al. 2011; Duflo and Pande 2007; Hill et al. 2016; Fuchs and Wolff 2014; Khandker and Faruqee 2001). Figure 5 shows the results by outcome category and subcategory, with figures presented for the most common categories: knowledge and behaviour, productivity and social outcomes. In knowledge and behaviour, the most common subcategory is adoption of inputs, practices and financial instruments, with 137 studies, and the least is spillover effects, with 20 studies. This result is related to what was found in the analysis of the intervention subcategories, where there were only a few studies addressing social networks. Studying social networks and measuring spillovers can be seen as second-order questions. For some studies, it is of interest to understand not only whether the programme and the information given has worked, but also how the information has been transmitted across networks. However, although measuring temporal and geographical spillovers remains a gap, the questions these data will help to

answer refer more to how the impact has taken place rather than what the impact is, so this may not necessarily be the first gap that needs to be filled. Within this category, the low number of studies in the knowledge subcategory, measuring the impact on farmer acquisition of information about best practices and inputs, becomes salient. A first step to encouraging technology adoption and subsequently pushing farmer productivity is to generate awareness about what the new practices are; however, not much seems to have been said about this first link in the theory of change.

In productivity, the most common subcategories are yield and income, with 145 studies each, while the least-studied outcome subcategories are employment (33 studies) and time use (14 studies). In light of our theory of change, yield and income are the two main intermediate outcomes related to productivity; hence, large amounts of evidence are expected to be concentrated in these two outcome areas. Evidence referring to how the new techniques and inputs affect the use of other production inputs, such as women's and children's time or non-family labour, remains scarce. However, the appropriateness of this type of analysis will depend on the context that is being studied. Cases in which crop production or farming practices entail the participation of different household members can see changes in farm labour allocation.

Together with improvements in yield and income, farmers are expected to be able to increase their consumption, ingest better-quality food and, consequently, raise their food security. In this line, in the social outcome category, the most common subcategory is consumption and food security, with 81 studies. The least-studied subcategories are savings (19) and women's empowerment (20). A change in these outcomes is expected later in the theory of change, and hence not all studies may have had the sufficient time lapse to observe an impact or the data needed. Similarly, there may not have been salient elements of the programme pointing to a change in these outcomes, particularly those referring to women's empowerment. Although a change in women's empowerment is not necessarily expected from all interventions, given the high share of smallholder female farmers, it would remain important to mention differential impacts by farmer's sex, which will be discussed in section 3.3.1.

Figure 5: Number of studies by outcome category and subcategory



Note: The total number of studies reported in the tables and figures can be greater than the total number of studies included in the EGM, as some studies fall into multiple intervention, outcome or methodology categories.

Table 5 shows the frequency of study design methodologies used across the main intervention categories. In Figure 2 the popularity and use of the PSM methodology is evident; however, Table 5 allows for a more in-depth understanding by linking methods to intervention categories. More than half of the studies addressing the impact of interventions pertaining to the dissemination of inputs and practices use PSM as the main methodology. PSM is also greatly used when it comes to interventions referring to institutional arrangements. In terms of finance and knowledge dissemination, PSM and RCT are equally used. Interventions related to institutional arrangements are usually implemented at a large scale and allocated at a high geographical level, factors that may not necessarily facilitate the implementation of an RCT. The dissemination of inputs and practices may be more suitable for a random allocation; however, for this to happen the evaluation needs to be designed before the rollout of the intervention. As we will see in section 3.3, the large majority of studies evaluating the impact of disseminating inputs and practices came after the programme was completed (i.e. ex post impact evaluations).

Table 5: Main intervention categories across study design methodologies

Methodology	Intervention categories			
	Knowledge dissemination	Finance	Institutional arrangements	Inputs and practices
PSM	29	41	61	82
RCT	20	41	9	21
DID	18	22	24	21
IV	12	29	27	25
RDD	2	3	2	3

Note: The total number of studies reported in the tables and figures may be greater than the total number of studies included in the EGM, as some studies fall into multiple intervention, outcome or methodology categories.

Table 6 shows the relationship between the main categories of interventions and outcomes of the studies included in the EGM. From earlier analysis, it is evident that studies in the inputs and practices intervention category are the most prevalent. Table 6 also highlights that many of the studies based on inputs and practices interventions measured outcomes in the productivity category. This goes in line with the theory of change. We expect that the provision of seeds, fertilisers, agricultural tools and livestock as well as the dissemination of improved agricultural practices will lead primarily to changes in farmers' productivity, measured mainly by yield and income. Interestingly, the majority of studies doing cost-effectiveness analysis are studies corresponding to finance (Brune et al. 2011; Hill et al. 2016; Fuchs and Wolff 2014; Khandker and Faruqee 2001).

Table 6: Main intervention and outcome categories

Intervention categories	Outcome categories				
	Knowledge and behaviour	Productivity	Social outcomes	Environmental outcomes	Cost-effectiveness
Knowledge dissemination	46	52	23	9	2
Finance	56	83	51	2	4
Institutional arrangements	32	91	41	11	1
Inputs and practices	65	118	45	16	1

Note: The total number of studies reported in the tables and figures may be greater than the total number of studies included in the EGM, as some studies fall into multiple intervention, outcome or methodology categories.

In Table 7 we present the results for the subcategories of the most common combination of intervention and outcome category: inputs and practices interventions across productivity outcomes. The most prevalent combination of intervention and outcome

subcategory concerns the provision of seeds with the measurement of agricultural yield (46 studies) and income (34 studies). We observe few studies analysing interventions referring to planting techniques or land management practices and measuring outcomes related to employment and time use. As we have previously mentioned, the appropriateness of this type of analysis will depend on whether farming practices entail the participation of different household members or non-family labour. Although we don't know in detail what practices are taught and what crops are analysed in these studies, we would have expected a larger number of studies investigating these subcategories. If new practices are taught leading to the re-allocation of farming inputs, we would expect that outcomes related to the use of labour are measured. We also observe few studies addressing the impact on farm investment of interventions pertaining to the provision of agricultural tools and livestock. We would expect that interventions utilising or upgrading tools or livestock would encourage farmers to better invest in their farms; however, the time span needed to measure such impacts may not always be achievable.

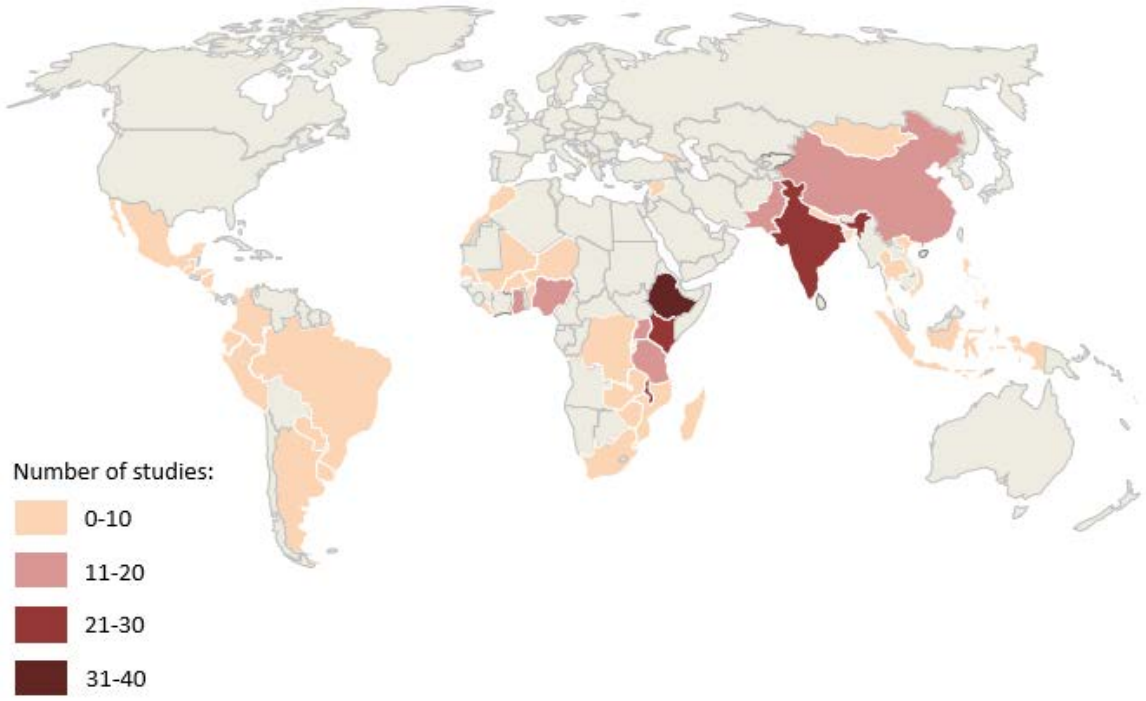
Table 7: Inputs and practices interventions across productivity outcome measures

Inputs and practices intervention subcategories	Productivity outcome subcategories				
	Yield	Employment	Time use/efficiency	Income	Farm investment
Seeds	46	3	3	34	8
Fertilisers and chemicals	19	1	2	10	6
Agricultural tools and livestock	11	2	3	13	4
Planting techniques and practices	26	5	3	20	8
Land management practices	17	3	1	14	5

Note: The total number of studies reported in the tables and figures may be greater than the total number of studies included in the EGM, as some studies fall into multiple intervention, outcome or methodology categories.

3.2 Geographic analysis of the studies

Figure 6: Included impact evaluations by geographical location



Studies included in this EGM were conducted across 58 L&MICs. In total, there are 179 studies in Sub-Saharan Africa, 46 studies in South Asia and 35 studies in Latin America. While the regions of Sub-Saharan Africa and South Asia are the two most populous in terms of total number of impact evaluations, it is important to note that there is little diversity within these regions regarding the countries where evaluations are carried out. For example, in Sub-Saharan Africa, Figure 6 shows that the number of studies in Ethiopia (34) and Kenya (24) is more than double that seen in neighbouring countries such as Zambia (7) or Tanzania (9), despite similar social and economic demographics. This pattern can also be seen in South Asia, where India has almost double the number of impact evaluations (23) than many of its less economically developed neighbouring countries.

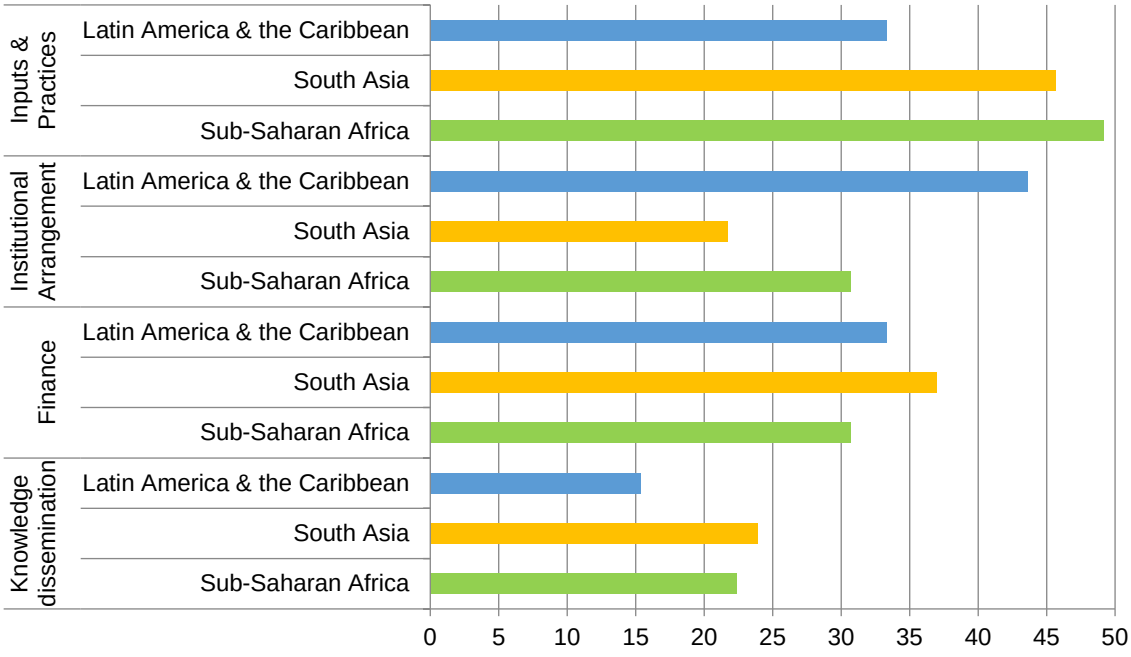
Sub-Saharan Africa and South Asia are regions where rural poverty is concentrated and hasn't decreased over the last decades; in fact, the number of rural poor increased over the period between 1993 and 2002 (Byerlee et al. 2008). In Sub-Saharan Africa, agriculture contributes to approximately 30% of GDP growth, and 70% of the poor live in rural areas. In India, agriculture contributes approximately 7% to GDP growth but nearly 80% of the poor population lives in rural areas.

In Latin America, the contribution of agriculture to GDP growth is less than 5%, and rural poverty accounts for nearly 45% (Byerlee et al. 2008). Despite many Latin American countries falling into the World Bank's L&MIC classification, there is a dearth of evidence

on the effectiveness of agricultural interventions in agriculturally dominant countries such as Bolivia, Ecuador, El Salvador, Gautemala, Honduras, Mexico, and Nicaragua. Enhancing research initiatives and impact evaluations in Latin America and the Caribbean is important in order to increase the stock of available evidence on what works in the specific geopolitical context and why. Although interventions referring to agricultural innovation have a large scope to contribute to poverty alleviation in Sub-Saharan Africa and South Asia, focusing on these regions may limit the evidence of what can work to enhance agricultural production and reduce rural poverty in contexts that rely on agribusiness and the food industry and services for GDP growth, such as Latin America and Central Asia (Byerlee et al. 2008). In these kinds of settings, interventions referring to institutional intermediation, financial intermediation and market linkages may be more relevant.

As can be seen in Figure 7, most studies taking place in Sub-Saharan Africa and South Asia correspond to inputs and practices interventions, while those in Latin America correspond to institutional arrangement interventions. This goes in line with the idea that there is limited evidence on what works in economies where poverty is not highly concentrated in rural areas, but where the food industry is still a prominent driver of economic growth.

Figure 7: Share of studies by intervention in Sub-Saharan Africa, South Asia and Latin America



Note: Shares do not add up to 100 per cent because one study can fall into more than one intervention.

3.3 Additional analyses

In section 3.1, we pointed out that there are a high number of studies using the PSM methodology, particularly for interventions relating to inputs and practices. This large number relates to the fact that well over half of the studies addressing inputs and practices interventions correspond to ex post impact evaluations (see Table 8). This also

holds true for studies analysing interventions related to institutional arrangements, in which case only a quarter of the evaluations are ex ante impact evaluations.

Table 8: Ex ante and ex post evaluations and intervention category

	Knowledge dissemination	Finance	Institutional arrangements	Inputs and practices
Ex ante	31	56	21	41
Ex post	37	50	84	99

Note: The total number of studies reported in the tables and figures may be greater than the total number of studies included in the EGM, as some studies fall into multiple intervention, outcome or methodology categories.

The results presented in Table 8 suggest that the evaluation of the programmes may have come too late in the timeline of programme implementation to allow for the use of an experimental setting. Based on this, we observe a need to plan the impact evaluations hand in hand with the programmes to permit more experimental settings and, hence, more robust results.

3.3.1 Subgroup analysis

Approximately one third of the studies do a subgroup analysis (98 out of 316 studies). The most common categories used for heterogeneity analysis are sex (54 studies), poverty (49 studies) and education (31 studies). Table 9 presents the number of studies by subgroup analysis and intervention category. Farmers' sex is the most common category for subgroup analysis across the different interventions. The difference between farmers' sex and the other categories becomes particularly salient in the case of knowledge dissemination, where there are 15 studies doing a subgroup analysis based on the sex of the farmer, 7 doing an analysis by education and 5 by poverty. In the case of inputs and practices, there are an equal number of studies doing an analysis by farmers' sex and poverty, and half of that number doing an analysis by education. Similar divisions of studies occur for institutional arrangements.

In section 3.1, we observe that very few studies measure women's empowerment as one of their outcomes. We argue that this could be explained by the fact that a change in women's empowerment comes late in the theory of change, and hence not all studies may have had the sufficient time span to observe an impact. Also, not all programmes may be expected to lead to a change in women's empowerment. However, given the large share of women participating in agriculture, it does become relevant to estimate differential impacts by sex of the farmer. Table 9 shows that relevant information is being produced about how the programme impacts differently on male and female farmers; however, if women are a particular group of interest, a gap still remains regarding going further into the theory of change and study outcomes related to women's agency and empowerment.

Table 9: Number of studies by subgroup analysis and intervention category

	Knowledge dissemination	Finance	Institutional arrangements	Inputs and practices
Sex disaggregation*	15	17	16	22
Education/literacy	7	6	6	11
Poverty**	5	11	17	22

* Note: The 'sex' category refers to studies that have looked at programme impacts or effects on the basis of sex disaggregated data.
** Note: The 'poverty' category includes indicators of wealth, household size, land size, consumption amount, income, land ownership or tenure security.

3.3.2 Donors

Table 10 shows the main donors for the impact evaluations. It is important to point out that only 181 out of the 316 impact evaluation studies included reported information on the donor of the study. Based on the information reported in those 181 studies, USAID is the lead donor with 39 studies, followed by the Bill & Melinda Gates Foundation and the World Bank, with 19 studies each. These donors have mainly supported ex ante impact evaluations, particularly in the case of the Gates foundation and the World Bank. The Gates foundation has supported 19 evaluations, 12 of them being ex ante. World Bank has supported 16 impact evaluations, 14 of them being ex ante.

Table 10: Main donors of the impact evaluations

MAIN DONORS	Number of studies
International Initiative for Impact Evaluation (3ie)	7
United Kingdom's Department for International Development (DFID)	10
United States Agency for International Development (USAID)	32
International Labour Organization (ILO)	5
Bill & Melinda Gates Foundation	19
International Food Policy Research Institute (IFPRI)	16
World Bank	19
Deutsche Forschungsgemeinschaft (DFG), German development fund	7
Swedish International Development Cooperation Agency (SIDA)	9
United States National Science Foundation (NSF)	3

3.4 Main findings from the systematic reviews

The EGM platform covers the coding of six systematic reviews and two systematic review protocols. In this section, we first look at an overview of the systematic reviews and protocols and then present the primary results of medium- and high-quality reviews. The methodology of coding and screening the reviews and protocols was identical to that used for the impact evaluations in this EGM.

3.4.1 Overview of the systematic reviews and systematic review protocols

The information for ongoing reviews is limited by what was provided in publicly available protocols. The systematic review protocol by Rosenstock and others (2016) focuses on

the agricultural training practices that promote climate-smart agriculture, while the protocol by Hall and others (2012) looks at the impact of land property rights interventions on agricultural productivity in Latin America and Sub-Saharan Africa.

Three of the included systematic reviews focused on the impacts of financial incentives on aspects of agricultural production: Cole and others (2012) looked into the provision of index-based micro-insurance for combatting weather-related risks; Marr and others (2016) looked into bundling index insurance with credit, and Ton and others (2013) looked into different modalities of disbursing agricultural innovation grants to smallholder farmers. All three of these systematic reviews track outcomes related to agricultural productivity and farmer knowledge and behaviour. Two other reviews, Waddington and others (2014) and Stewart and others (2015), concentrated on the effects of learning interventions on a wide array of knowledge transfers, agricultural productivity, and environmental and social outcomes. Finally, IOB (2011) looked into the impact of agriculture-related interventions on food security in L&MICs.

3.4.2 Findings from high- and medium-quality systematic reviews

3ie's Systematic Review Office classified two reviews (Waddington et al. 2014; Stewart et al. 2015) as having a high level of confidence, one as having a medium level of confidence (Cole et al. 2012) and the remaining three (Ton et al. 2013; Marr et al. 2016; IOB 2011) as having a low level of confidence in their findings. The three low-level systematic reviews were classified as such due to major limitations ranging from unclear inclusion criteria (Marr et al. 2016), to issues with the risk of biased appraisal of included studies (Ton et al. 2013; IOB 2011).

Waddington and colleagues (2014) included 92 impact evaluation studies and 20 qualitative studies that look into farmer field schools as a discovery-based learning programme to promote sustainable and effective agricultural skills. The study found that, although farmer field schools have been shown to be beneficial in changing practices and yields during pilot phases, they are difficult to sustain when scaled up. Major components of the programme, such as promoting better use of pesticides, involve active encouragement and buildup of experience and are therefore not readily diffused to other non-participating farmers and groups (Waddington et al. 2014).

Stewart and colleagues (2015) assessed 19 impact evaluations looking into programmes that support African smallholder agriculture by implementing training programmes and introducing new technologies and agricultural innovations and their effect on economic and food-related outcomes. The study highlights the limited capacity of rigorous evidence available in this area and suggests that agricultural input innovations might increase the nutritional status of farming households but could not conclude that training programmes increase farmers' harvests in general (Stewart et al. 2015).

Finally, Cole and colleagues (2012) conducted an analysis of research on take-up and impact of index-based micro-insurance. The study is also limited by the availability of rigorous evidence and includes just 13 studies in its analysis. The evidence suggests that certain factors, such as financial literacy and trust and liquidity, affect the demand for insurance products and that there is mixed evidence on increased use of agricultural inputs as a result of access to index-based insurance (Cole et al. 2012).

3.5 Major evidence gaps

Based on the descriptive analysis previously presented, we can identify some important gaps in the evidence of studies addressing agricultural innovation. Regarding methodology, we still see a vast majority of studies using PSM, which is related to the fact that for 205 studies the evaluation came after the completion of the programme (i.e. ex post impact evaluations). Although the number of studies using RCTs has increased since 2011, there is still room to use experimental methods to evaluate the impact of agriculture-related interventions. Running RCTs requires good coordination between the researchers and implementing agencies, meaning that they are not always feasible. However, RCTs allow for the establishment of a counterfactual with the least restrictive set of assumptions, leading to more robust estimations. Increasing the number of studies using RCTs will also require planning the impact evaluations alongside the implementation of the programme. If the evaluation begins when the programme has already started or when the programme has been completed, it is not possible to use anything other than quasi-experimental methods.

In the case of the interventions addressed, we observe that the least-studied intervention category is knowledge dissemination, with most studies focused on inputs and practices. Within knowledge dissemination, the subcategory 'information and communication technologies' is the most scantly addressed. When the adoption of new practices is analysed, it is important to understand how the new knowledge is transmitted and acquired. We expect to see that the acquisition of this new knowledge is translated into a more frequent use of the inputs and practices taught; hence, understanding how that knowledge is transmitted and adapted becomes key for policy design. Although inputs and practices is a well-studied intervention category, within it we observe some important gaps. The subcategories 'land management practices' and 'planting techniques and practices' represent interventions that are minimally analysed across impact evaluations. If the evidence is concentrated in the adoption of seeds but little is known about how farmers use those seeds, a significant gap arises; thus, generating evidence on this particular area becomes important.

For outcomes, there are also important gaps to highlight. A major gap observed is related to the small number of studies including a cost-effectiveness analysis. Only seven studies include a cost-effectiveness analysis. This is a major gap: we may have evidence to know what works to increase farmers' technology adoption, but we have limited evidence on what the most cost-effective policies are. There is also limited evidence when it comes to the measurement of spillover effects. As we mentioned earlier, how information is transmitted across the farmer's network can be seen as a second-order question in the theory of change, and hence, it may not be a priority for all studies. Collecting the appropriate data to measure spillover effects can be costly, both in terms of budget and time. Also, it requires planning to identify the farmer's network properly and to take into account the geographical expansion of the programme. This is not necessarily feasible when it comes to ex post impact evaluations.[5]

The results presented in this report also highlight a gap in terms of measuring outcomes related to employment and time use. Although these outcomes come later in the theory

[5] Out of the 20 studies measuring spillover effects, 14 correspond to ex ante impact evaluations.

of change, it is important for studies that evaluate interventions teaching new techniques to address outcomes related to the use of labour.

Given the high participation of women in agriculture in developing countries,[6] it is important to introduce a gender perspective to the evaluations. Although this gap map does not account for studies that engage in a gender analysis, we did code for studies that disaggregated data by sex. What has become increasingly clear through this mapping and coding process is that very few studies consider gender to be a type of analysis that should be undertaken. As women often play a crucial role in agricultural production, it is important for future impact evaluations to focus part of their analyses on how interventions affect gendered roles and perceptions, and whether women in particular benefit from programmes. The previous results show that, among the studies doing a subgroup analysis, a fair number undertake analysis by sex disaggregation; yet many more studies could be doing a subgroup analysis. While understanding how interventions impact on male and female farmers differently can help programmes to be better adapted to female farmers' needs and behaviour, it is still important for donors and impact evaluation commissioners to encourage gender-based impact evaluations.

Geographically, it is clear that evidence is highly concentrated in Sub-Saharan Africa, where most of the interventions refer to inputs and practices. Although rural poverty is highly predominant in Sub-Saharan Africa and interventions aiming to encourage adoption of new technologies will contribute to poverty reduction, there is still a gap on what interventions work to encourage agricultural productivity in those settings where agribusinesses and food industry are drivers of economic development.

This EGM shows that sufficient evidence and impact evaluations exist in certain areas to warrant syntheses. One of the main reasons that more systematic reviews were not included in this EGM was a lack of methodological rigour – many reviews in agriculture have low standards regarding the quality of the impact evaluations admitted into their review, causing overall implications for the quality of the findings presented by the review. This result can be related to the low number of impact evaluation studies using experimental methods. Given the large number of impact evaluation studies related to interventions linked to the provision of inputs and practices (particularly seeds), and to schemes put in place to try to overcome the shortcomings of the rural financial markets, such as transfers and credit, systematic reviews in these areas are recommended.

4. Conclusion

Agriculture represents an important area and instrument for poverty alleviation and sustainable development. A large part of the world's poor population lives in rural areas, with rural poverty particularly widespread in South Asia and Sub-Saharan Africa. Smallholder farmers often lag in their access to agricultural innovation and, consequently, their ability to engage in effective technology adoption. This EGM draws upon a systematic search and plots the available literature on a selection of interventions that fall broadly under the agricultural innovation umbrella. The map consists of 308 completed impact evaluations, 6 completed systematic reviews, and 2 systematic review

[6] Aggregate data shows that women comprise about 43 per cent of the agricultural labour force globally and in developing countries (SOFA Team and Doss 2011).

protocols across 16 intervention and 15 outcome categories made available to access between 2000 and 2017.[7]

Some limitations need to be taken into account when reading the results presented in this report. As we explain earlier, we do not include studies of interventions that refer solely to the market process; the population of interest is farmers living in L&MICs, excluding all forms of non-crop-based farming; and lastly, information or any synthesis regarding the validity of the studies or the robustness of the results was not part of the mapping process.

The evidence collected in this study includes a large number of impact evaluations that look into provision of inputs, agricultural training and financial intermediation, among other things. Adoption of inputs or practices, yield and income are the three most commonly measured outcome categories. Despite most interventions being planned around activities that involve some form of education or training, very few studies measure knowledge transfer as an outcome. If we refer to our theory of change, a key step to generate adoption of the new inputs and practices is to generate awareness of what those inputs and practices are. If we do not know whether the intervention is generating awareness among the targeted population, it will be difficult to understand the path in which a change in adoption can be achieved.

Other gaps can be seen in outcome categories referring to the use of labour inputs, such as employment and time use and/or efficiency, as well as savings or women's empowerment. As we described above, not all programmes are designed to generate a change in labour allocation or women's empowerment; however, given that new practices are taught, we expect more studies to analyse changes in labour and time allocation. Similarly, given the relevance of the role of women in agriculture, we would expect a much more thorough gender analysis in which several outcomes related to women's agency and empowerment were analysed.

By region, Sub-Saharan Africa and South Asia account for more than half of the included studies. This can be explained, in part, by the agrarian nature of these economies, as well as the high rural poverty rates. Latin America is studied to a much lesser degree, which reflects that there is still a gap on what interventions work to encourage agricultural productivity in those settings where rural poverty is not as high as in Sub-Saharan Africa, but where economic development still relies on agriculture-related industry.

When it comes to systematic reviews, there are several areas with adequate evidence that can be used to provide important policy recommendations. These include areas such as the provision of inputs and practices (particularly seeds), and schemes related to financial intermediation such as transfers and credit. Other areas of interest are subsidies and concessions, property rights and farming certifications. However, some of these reviews need to be updated, and others are low in confidence when it comes to their findings, which suggests that there is room for more robust impact evaluations in these areas as well.

[7] Our search took place in the last quarter of 2016; however, while writing the report, we have included two studies published in 2017.

Based on the trends and gaps found, forthcoming impact evaluations should include cost-effectiveness analyses and measurement of spillover effects. As we are interested in knowing what the best ways of transferring information and knowledge are, it is essential to understand how that information is disseminated. Connected to this, there is a need for evaluations focused on interventions relating to the use of information and communication technologies. Another important gap observed corresponds to impact heterogeneity analysis – only one third of the studies do a subgroup analysis, mainly along farmers' gender, leaving room for a more in-depth analysis across different subpopulation groups. These gaps can be addressed as long as impact evaluations are planned and accounted for alongside the implementation of the programme; if the evaluation comes when the programme has been completed it is much more difficult to address these points. Future impact evaluations should be planned hand in hand with programme implementation to allow for experimental approaches and the most rigorous quasi-experimental designs. By planning for impact evaluation from the outset, implementers and researchers can better explore opportunities for random allocation of treatments and, in cases where this is not feasible, collect good baseline data that would allow the implementation of more robust quasi-experimental methods.

Appendix A: Detailed methodology

An area was chosen by the team based on the current thematic window on agricultural innovation. We felt that an EGM would complement this thematic window by assessing where the evidence exists and where the gaps are, leading and motivating future research in the area. The first step in developing an EGM was to build the scope. The scope was developed by doing an extensive literature review and by defining key areas of interest in accordance with the agricultural innovation thematic window. The scope was defined by an inclusion-exclusion criterion based on population, interventions, comparators, outcomes and study design (PICOS). To provide a clear thematic focus and ensure the map's scope was adaptable, the focus chosen was on agricultural innovation interventions up to the production phase.

The intervention categories were designed to avoid significant overlap and to allow for studies to be coded discretely with multiple interventions. The outcome categories were designed to follow a causal chain and go from short- to medium- and long-term outcomes.

After the framework was built, it was internally reviewed by specialists on agriculture, systematic reviews and impact evaluations. A stakeholder exercise was conducted during a workshop co-organised with the International Fund for Agricultural Development in May 2016. The workshop brought together a fairly diverse group of participants: researchers, implementing agencies and donors involved in impact evaluations of development programmes related to agriculture and rural development. During the last day of the workshop, 3ie conducted an exercise in which participants were asked to point out where, according to them, evidence was missing. The interventions and outcomes were displayed in a big chart, and participants were given the opportunity to identify up to five cells where they considered evidence was missing.

The second step in developing the EGM was to run the search strategy. We developed a search word list (see Appendix B) with a search specialist who ran the search strategy in August 2016 for eight academic databases (see Table A1), which generated 33,801 results. We limited our search to studies dated from 2000 onwards. We conducted targeted searches of organisations' databases, online repositories of impact evaluations and systematic reviews. Table A2 provides a list of the websites that we visited for hand searches. We snowballed systematic reviews and books to obtain the relevant impact evaluations.

After removing duplicates and screening, all studies were coded (see Appendix C) in Microsoft Excel® and populated into the 3ie online platform. The included systematic reviews were also quality-assessed using 3ie's tool[8] to assign their findings a rating of low, medium or high confidence. This was then highlighted on the 3ie EGM online platform. Each study was screened and verified by a second reviewer.

[8]3ie's systematic review assessment tool:
http://www.3ieimpact.org/sites/default/files/2019-01/quality_appraisal_checklist_srdatabase.pdf

Figure A1 shows the preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow diagram for this EGM.

Figure A1: PRISMA flow diagram

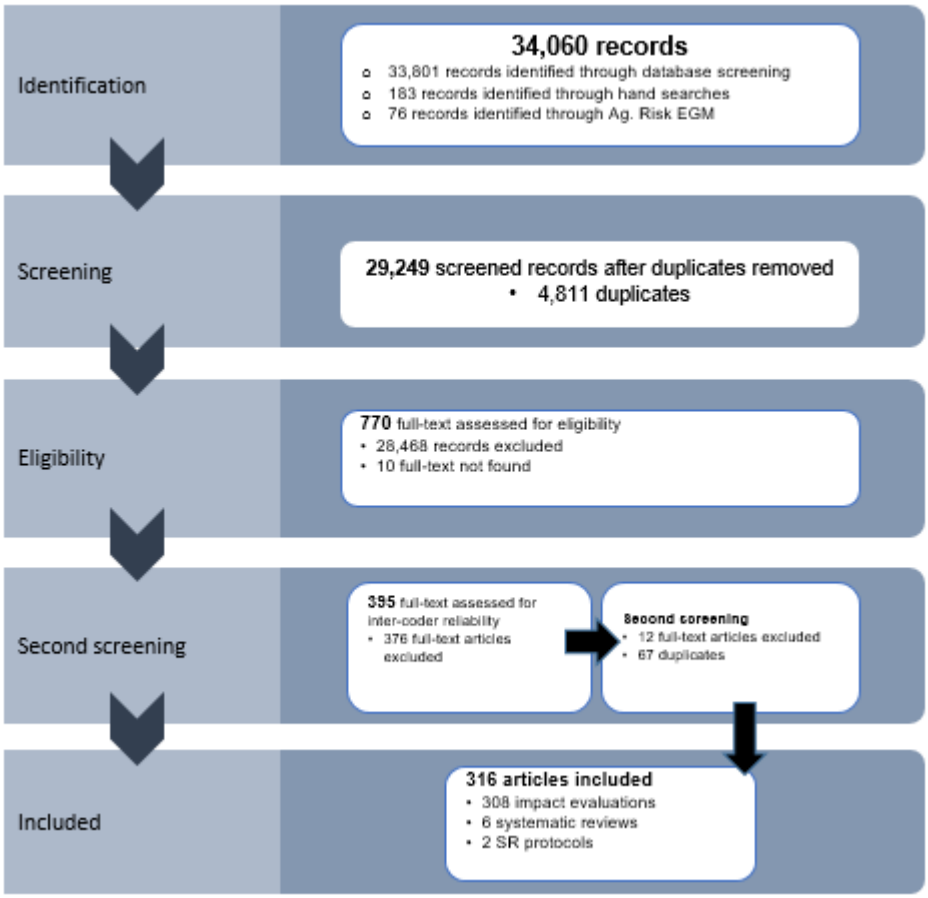


Table A1: List of databases

Database	Date the database was searched
CAB Abstracts (Ovid)	2 August 2016
Agris – EBSCO Discovery	4 August 2016
Africa – Wide & Repec – EBSCO Discovery	4 August 2016
Econlit – EBSCO Discovery	4 August 2016
GreenFILE (EBSCO)	8 August 2016
ERIC (Ovid)	9 August 2016
Web of Science (SCI/SSCI)	10 August 2016
IBSS (Proquest)	16 August 2016

Table A2: Hand search

Organisations	Websites
FAO	http://www.fao.org/home/en/
World Bank	http://www.worldbank.org/
AGRIS	http://agris.fao.org/agris-search/index.do
Proquest	http://www.proquest.com/
Inter-American Development Bank	http://www.iadb.org/en/inter-american-development-bank,2837.html
United States Department of Agriculture	https://www.usda.gov/
International Development Statistics	http://www.oecd.org/development/stats/idsonline.htm
J-PAL	https://www.povertyactionlab.org/
3ie	http://www.3ieimpact.org/
International Development Research Centre	https://www.idrc.ca/
Japan International Cooperation Agency	https://www.jica.go.jp/english/
CGIAR	http://www.icarda.org/ http://ciat.cgiar.org/ http://www.iita.org/ http://www.ifpri.org/ http://www.irri.org/ http://www.icrisat.org/ http://www.cimmyt.org/ http://www.africarice.org/
Center for Effective Global Action (CEGA)	http://cega.berkeley.edu/
IDEAS/RePEc	https://ideas.repec.org/
BIOSIS	http://www.library.ethz.ch/en/Resources/Databases/BIOSIS-Previews
Agricola	https://www.ebscohost.com/academic/agricola

Table A3: PICOS

Population	***Include*** • **Rural farmers and households in low- and middle-income countries (L&MICs)** ***Exclude*** • **Non-rural population (urban farming)** • **Agricultural experiments**
Interventions	Knowledge dissemination Finance Institutional arrangements Inputs and practices *These are further divided into subcategories and detailed in section 2.2*
Comparators	Studies that use a comparison group to measure the causal effect of programmes
Outcomes	Knowledge and behaviour Productivity Social outcomes Environmental outcomes Cost-effectiveness *These are further divided into subcategories and detailed in section 2.3*
Study designs	Experimental (RCT) Quasi-experimental (DID, RDD, PSM, IV) Systematic reviews (including systematic review protocols and meta-analysis) *We only include systematic reviews that describe search, data collection and synthesis methods according to the 3ie database of systematic review protocols (Snilstveit et al. 2014). These are also assessed on confidence in their methods according to 3ie's systematic review assessment tool*
Language	Articles in English language only
Time frame	Year 2000 onwards

Appendix B: Detailed search strategy

Sample Search Strategy

1. CAB Abstracts (Ovid) <1990 to 2016 Week 29> – Searched 2 August 2016

1 (agricultur* or farm* or smallhold* or "small hold*" or small-hold* or horticultur* or ((vegetable* or fruit or dairy or milk or flower* or cereal or tea or soybean* or rice or coffee or potato* or sugarcane or mushroom* or maize or millet or pepper* or crop or crops or land) adj3 (produc* or grow*)) or floriculture or eco-agricultur* or agroforest* or agro-forest* or "agro forest*").ti,ab. (783697)

2 agriculture/ or aquaculture/ or exp crop husbandry/ or exp crop production/ or exp farming/ or exp food production/ or exp horticulture/ or exp market gardens/ or cooperatives/ or dairy cooperatives/ or food cooperatives/ or producer cooperatives/ or rice/ or maize/ or soyabeans/ or potatoes/ or private farms/ or large farms/ or medium sized farms/ or dairy farms/ or small farms/ or marginal farms/ or cooperative farms/ or family farms/ or collective farms/ or farms/ or farming systems/ or pastures/ or "agricultural sector"/ or "agricultural trade"/ or floriculture/ or "agricultural products"/ or agricultural land/ or agricultural society/ or farm inputs/ or farming systems research/ or grazing systems/ or exp cropping systems/ or arable farming/ or mixed farming/ or soil fertility/ or land productivity/ or soil degradation/ or soil quality/ or soil conservation/ or agricultural land/ (733418)

3 1 or 2 (1210343)

4 practical education/ or extension education/ or extension agents/ or education programmes/ or community education/ or agricultural education/ or in-service training/ or innovation adoption/ or on-farm training/ or extension courses/ or extension/ or educational courses/ or continuing education/ or information needs/ (26820)

5 ("farm* field school*" or "farm* school*" or "advisory service*" or "training and visit*" or extension or (capacity adj2 build*) or capacity-building or "technology transfer" or (innovat* adj2 adopt*) or (skill* adj3 (develop* or train*)) or ((agricultur* or crop or crops or farm*) adj2 (knowledge or information or outreach or training or education)) or (in-service or vocational or "training or technical or on-site or on site or on field or on-field) adj2 training) or ((mobile* or cell*) adj (phone*" or telephone*) or ICT or "information campaign*" or (information adj2 (disseminat* or diffus* or need*))).ti,ab. (80955)

6 ((peer* adj2 (learn* or tutor* or information or knowledge)) or "local champion*").ti,ab. (165)

7 peer tutoring/ (62)

8 demonstration farms/ or pilot farms/ (294)

9 (demonstrat* adj2 (plot or plots or farm* or frontline or front-line)).ti,ab. (1986)

10 "mobile telephones"/ or "information technology"/ or "information services"/ or "diffusion of information"/ or "digital technology"/ or telecommunications/ or internet/ (20314)

11 (Laptop* or computer* or PC or Internet or landline* or telephone* or mobile* or phone* or cell or cellphone* or smartphone* or CSCs or telecenter* or telecentre* or Wifi or WLAN or GDPRS or messaging or digital or ipad* or iphone* or android or windows or broadband or wireless or wireline or CDMA or SMS or text* or MMS or facebook or linkedin or network* or Intranet or "discussion list*" or contacts or "online forum" or "discussion thread*" or "online feedback" or ICT or ICTs or ((communication or digital or information) adj (technolog* or systems))).ti,ab. (639785)

12 "weather forecasting"/ or global information systems/ or global positioning systems/ or precision agriculture/ or remote sensing/ or agricultural meteorology/ or agroclimatology/ or climatic factors/ or climate change/ or global warming/ or greenhouse effect/ or seasonal variation/ or methane/ or biogas/ or greenhouse gases/ or carbon/ or net ecosystem carbon balance/ or biomass/ or fuel crops/ (308102)

13 (((weather or rain* or monsoon* or climat* or season*) adj2 (forecast* or forewarn* or alert* or predict* or report*)) or "climate change*" or "greenhouse effect*" or "global warming" or gps or "remote sensing" or "global positioning" or gis or "global information system*" or "greenhouse gas*" or carbon or methane or biomass or biogas).ti,ab. (410727)

14 (innovat* or sustainab* or resilien*).ti. (49257)

15 innovations/ or sustainability/ (75745)

16 farmers' associations/ or self help/ (3067)

17 ((farm* adj (association* or group* or federation* or societ* or organisation* or organization*)) or self-help or "self help").ti,ab. (5017)

18 certification/ or quality standards/ or quality labelling/ (9621)

19 ((fair* or ethic* or alternative or sustainab* or responsib* or specialty or eco or ecologic or ecological or organic) adj3 (certifi* or standard* or label* or seal* or scheme* or trad* or market* or "value chain*" or commodit* or product*)).ti,ab. (43073)

20 agricultural credit/ or farm indebtedness/ or credit policy/ or long term credit/ or cooperative credit/ or short term credit/ or credit/ or agricultural banks/ or savings/ or savings banks/ or loans/ or bank loans/ or private loans/ or public loans/ or support measures/ or subsidies/ or grants/ or investment/ (27451)

21 (subsid* or credit* or saving* or loan* or grant or grants or invest* or (financ* adj3 instrument*) or ((financial or cash or pay$ or monetary or money) adj3 (transfer$ or measure$ or incentive$ or reward* or allowance$ or exclu$ or reform$ or gain$ or credit$1 or benefit$1))).ti,ab. (999727)

22 taxes/ or tax credits/ or tax incentives/ (3822)

23 ((tax or taxes) adj2 (concession* or incentiv* or credit* or allowance*)).ti,ab. (575)

24 risk assessment/ or risk reduction/ or insurance/ or agricultural insurance/ or crop insurance/ or animal insurance/ or cooperative insurance/ or agricultural disasters/ or compensation/ (47762)

25 (insurance or microinsurance or micro-insurance or "micro insurance" or "financial literacy" or compensation or (money adj manag*) or ((risk or risks or disaster* or flood* or drought* or shock*) adj3 (interven* or prevent* or pooling or assess* or stop* or reduc* or manag* or mitigat* or moderat* or diminish* or lessen* or ameliorat* or decreas* or limit* or curb* or minimis* or minimiz* or restrict* or counteract* or inhibit* or discourage* or imped* or avert* or deter or deterr* or suppress* or constrain* or curtail*))).ti,ab. (113720)

26 contract farming/ or vertical integration/ (2137)

27 (Contract* or "nucleus estate*" or cooperative* or "producer* association*" or (embedded adj3 service*) or (pre-harvest adj2 (agreement* or sales)) or "value chain*" or farm-firm* or outgrow* or (vertical adj3 (integration or coordination or linkage*))).ti,ab,sh. (55740)

28 land ownership/ or land reform/ or "property rights"/ or "land use"/ or tenure systems/ or "land use planning"/ or land policy/ or land markets/ (67928)

29 ((land or lands or landowner* or "land owner*") adj3 (tenure or right* or conversion or freehold* or titl* or codif* or recognition or customary or certification)).ti,ab. (7606)

30 infrastructure/ or public investment/ or investment policy/ or irrigation systems/ or development projects/ or rural roads/ or transport/ or development policy/ (37948)

31 (infrastructur* or irrigat* or road or roads or transport* or (development adj2 (invest* or policy or policies or plan or plans or planning or project or projects))).ti,ab. (314536)

32 (seed or seeds or sowing or sowed or (sow not pig*)).ti,ab. (348021)

33 seeds/ or seed banks/ or sowing/ or seed quality/ or hybrid seed production/ or "hybrid varieties"/ (175066)

34 ((manur* or fertilis* or fertiliz*) adj2 (use* or apply or applied or application or adopt* or introduc*)).ti,ab. (50497)

35 exp fertilizers/ or manures/ (170917)

36 or/4-35 (2662352)

37 ((match* adj3 (propensity or coarsened or covariate)) or "propensity score" or ("difference in difference*" or "difference-in-difference*" or "differences in difference*" or "differences-in-difference*" or "double difference*") or ("quasi-experimental" or "quasi experimental" or "quasi-experiment" or "quasi experiment") or ((estimator or counterfactual) and evaluation*) or ("instrumental variable*" or (IV adj2 (estimation or approach))) or "regression discontinuity").ti,ab,sh. (3166)

38 (((experiment or experimental or phase-in or "phase in" or cluster) adj2 (design or study or research or evaluation or evidence or field)) or (random* adj4 (trial or assignment or treatment or control or intervention* or allocat*))).ti,ab,sh. (129780)

39 ((impact adj2 (evaluat* or assess* or analy* or estimat* or measure)) or (effectiveness adj2 (evaluat* or assess* or analy* or estimat* or measure))).ti,ab,sh. (44268)

40 ("program* evaluation" or "project evaluation" or "evaluation research" or "natural experiment*" or "program* effectiveness").ti,ab,sh. (2197)

41 ((systematic* adj2 review*) or "meta-analy*" or "meta analy*").ti,ab,sh. (16691)

42 or/37-41 (190739)

43 (Afghanistan or Angola or Albania or "American Samoa" or Armenia or Armenian or Azerbaijan or Bangladesh or Belarus or Belize or Benin or Bolivia or Bosnia or Herzegovina or Botswana or Brazil or Bulgaria or Burkina Faso or Burkina Fasso or Burundi or Urundi or Cabo Verde or Cape Verde or Cambodia or Cameroon or Cameroons or Cameron or Camerons or Central African Republic or Chad or China or Colombia or Comoros or Comoro Islands or Comores or Congo or Costa Rica or Cuba or Zaire or Cote d'Ivoire or Ivory Coast or Djibouti or Dominica* or East Timor or East Timur or Timor Leste or Ecuador or Egypt or United Arab Republic or El Salvador or Eritrea or Ethiopia or Fiji or Gabon or Gambia or Gaza or Georgia Republic or Georgian Republic or Ghana or Grenada or Guatemala or Guinea or Guiana or Guyana or Haiti or Honduras or India or Indonesia or Iran or Iraq or Kazakhstan or Kenya or Kiribati or Korea or Kosovo or Kyrgyzstan or Kirghizia or Kyrgyz Republic or Kirghiz or Kirgizstan or Lao PDR or Laos or Lebanon or Lesotho or Liberia or Libya or Macedonia or Madagascar or Malagasy Republic or Malawi or Malaysia or Maldives or Marshall Islands or Mali or Mauritania or Mauritius or Agalega Islands or Mexico or Micronesia or Moldova or Moldovia or Moldovian or Mongolia or Montenegro or Morocco or Ifni or Mozambique or Myanmar or Myanma or Burma or Namibia or Nepal or Nicaragua or Niger or Nigeria or Pakistan or Palau or Palestine or Panama or Paraguay or Peru or Philippines or Philipines or Phillipines or Phillippines or Romania or Rwanda or Ruanda or Samoa or Samoan Islands or Sao Tome or Senegal or Serbia or Sierra Leone or Sri Lanka or Solomon Islands or Somalia or South Africa or St Lucia or St Vincent or Grenadines or Sudan or Suriname or Swaziland or Syria or Tajikistan or Tadzhikistan or Tadjikistan or Tadzhik or Tanzania or Thailand or Tonga or Togo or Togolese Republic or Tunisia or Turkey or Turkmenistan or Tuvalu or Uganda or Ukraine or Uzbekistan or Uzbek or Vanuatu or New Hebrides or Vietnam or Viet Nam or West Bank or Yemen or Zambia or Zimbabwe).hw,ti,ab,gl. (1529586)

44 ((developing or less* developed or under developed or underdeveloped or middle income or low* income or underserved or under served or deprived or poor*) adj (countr* or nation? or population? or world)).ti,ab. (47851)

45 ((developing or less* developed or under developed or underdeveloped or middle income or low* income) adj (economy or economies)).ti,ab. (770)

46 (low* adj (gdp or gnp or gross domestic or gross national)).ti,ab. (46)

47 (low adj3 middle adj3 countr*).ti,ab. (2400)

48 (lmic or lmics or third world or lami countr*).ti,ab. (2425)

49 transitional countr*.ti,ab. (83)

50 exp developing countries/ (1439969)

51 or/43-50 (1639161)

52 3 and 36 and 42 and 51 (24587)

53 limit 52 to yr="2000-Current" (**21205**)

Appendix C: Coding sheet

	ID	Question	Description/codes
Publication details	ID	Unique identifier	Unique ID number generated
	Year	Publication date	Year
Intervention details	Region	Region where the programme was implemented	East Asia and Pacific Latin America and the Caribbean Middle East and North Africa South Asia Sub-Saharan Africa Europe
	Country	Country/ies where the programme was implemented	Write down the country/ies
Study design	Study design	The design or method used to establish causality in the study	Randomised controlled trial Difference in difference Instrumental variables Regression discontinuity design Multiple regressions with fixed effect Propensity score matching Other quasi-experimental design/method Other (e.g. fixed effects) Systematic review Meta-analysis
Interventions	Intervention	The product or service on which the study provides evidence	Knowledge dissemination Finance Institutional arrangements Inputs and practices

	Intervention subcategory	Specific intervention description and classification	Social networking and peer learning Information and communication technologies Demonstration plots and training Transfers, credit and incentives Insurance Financial literacy and advice on risk management Farming certifications Cooperatives and farmer federations Contract farming Land titling/property rights Community infrastructure Seeds Fertilisers and chemicals Agricultural tools and livestock Planting techniques and practices Land management practices
Evaluation timing	Evaluation timing	The time at which the evaluation was conducted	Ex ante Ex post NA
Outcomes	Outcome	The measured impacts that the study addresses	Knowledge and behaviour Productivity Social outcomes Environmental outcomes Cost-effectiveness
	Outcome subtype	Specific outcome description and classification	Knowledge Adoption of inputs, practices and financial instruments Spillover effects Yield Employment Time use/efficiency Income Farm investment Household assets Consumption and food security Savings Women's empowerment (status) Sustainable land management GHG emissions Cost-effectiveness analysis

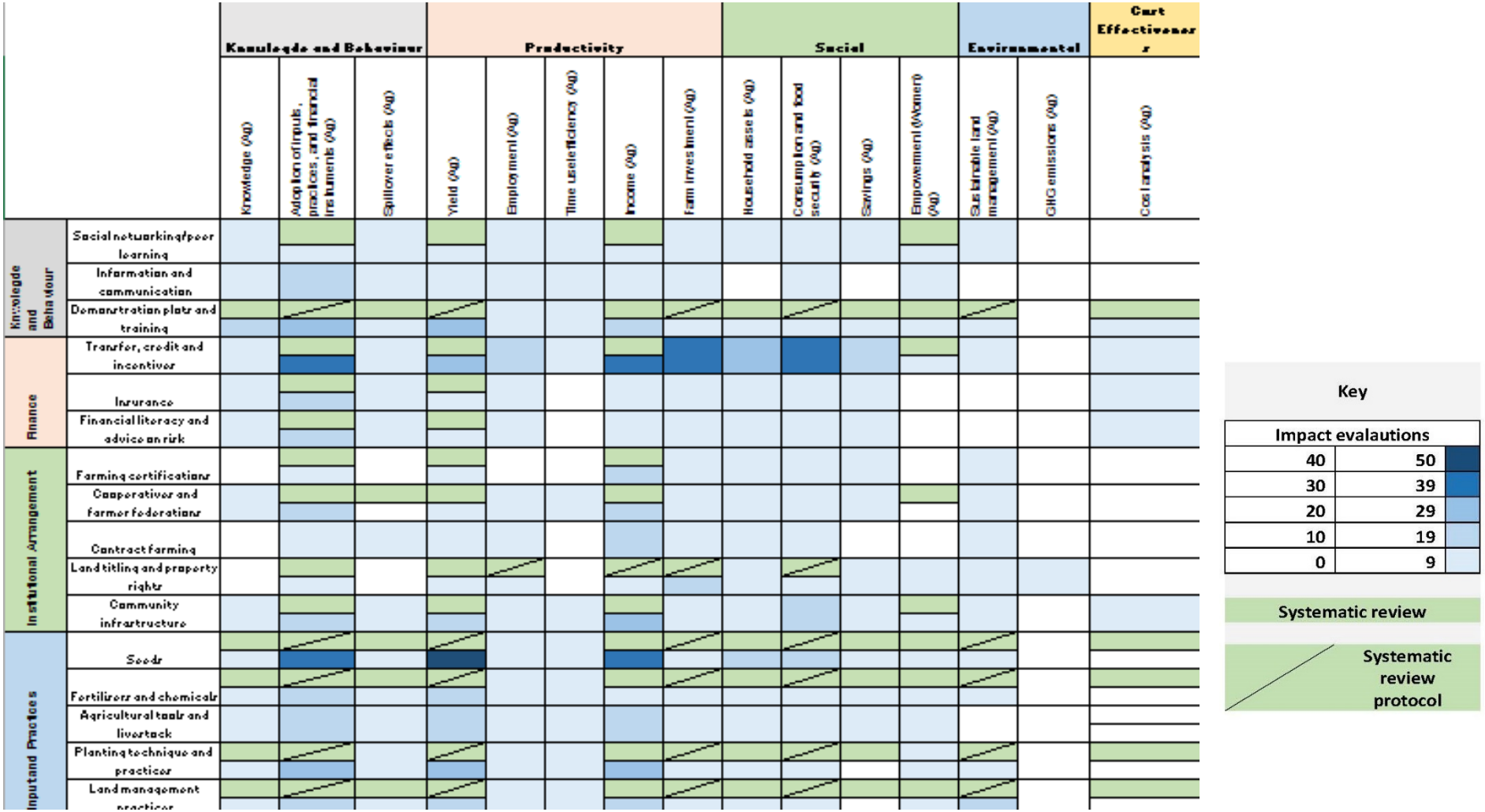
Heterogeneity	Heterogeneity analysis in outcomes	Whether there was heterogeneity in the outcomes category	Yes No
	Heterogeneity category	Basis of heterogeneity	Farmer sex Education/literacy Poverty (wealth, household size, land size, consumption, income) Minority populations (e.g. indigenous peoples, sexual minorities, ethnic minorities) Differently abled Migrant workers Elderly Vulnerable children
Digital data	Use of digital data	Use and type of digital data/technology	Yes No Type of digital data used (e.g. GIS/remote sensing)
Donors/funder	Donor information	Donor organisation of the evaluation	Names of donor organisations (e.g. World Bank, Gates Foundation or 3ie)

Online appendix D: Included studies

This appendix is only available online and can be accessed from:

http://www.3ieimpact.org//sites/default/files/2019-01/egm12-appendix-d.pdf

Appendix E: Heat map



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This evidence gap map by Lopez-Avila and colleagues consolidates evidence on impact evaluations and systematic reviews referring to agricultural inputs, practices and programmes aimed at improving farmers' productivity and well-being. The largest grouping of impact evaluations is concentrated around the intersection of interventions focused on the provision of inputs and practices and outcomes related to productivity, such as yield and income. The map highlights prominent gaps in evidence on cost-effectiveness, measurements of spillover effects and the use of experimental methods. Only one-third of the studies included subgroup analyses, with most done across poverty and sex dimensions, leaving out a number of population characteristics, such as age, poverty or literacy that could be analysed.

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