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Land-use change and forestry programmes

Evidence on the effects on greenhouse gas emissions and food security

November 2016

Evidence Gap Map Report 3

Environment

3ie International Initiative for Impact Evaluation

About 3ie

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, why and at what cost. We believe that high-quality and policy-relevant evidence will 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 accessibily in one place in a way that also shows limitations and gaps. These maps are based on systematic methods to identify and describe the existing evidence base. EGMs are structured around a framework of interventions and outcomes and include a graphic map that highlights areas with extensive, limited or non-existent evidence. EGMs provide an overview of evidence on the effects of policies and programmes in a particular sector or thematic area. They consolidate evidence from impact evaluations and systematic reviews to identify research gaps and provide easy access to existing research. 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 summarises the methods and findings of an EGM on land-use change and forestry programmes, which was developed jointly by 3ie and Conservation International. The online map can be found here.

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Summary

Background

The agriculture, forestry and other land-use (AFOLU) sector contributes around a quarter of global greenhouse gas (GHG) emissions through forest degradation, deforestation and agricultural production. Forest and land are also carbon sinks[1] because they facilitate and enhance the uptake of carbon in soils and biomass. AFOLU, as a sector, provides livelihoods for billions of people. Therefore, the way in which agricultural and forest lands are *managed* is critical for climate change mitigation, global food security and efforts to achieve the Sustainable Development Goals. To reach emissions reduction targets, while avoiding negative effects on food security and other human wellbeing outcomes, there is an urgent need to develop effective policies and programmes in the sector.

This report summarises the findings of an evidence gap map (EGM) produced by the Children's Investment Fund Foundation (CIFF) and the International Initiative for Impact Evaluation (3ie). The EGM consolidates evidence of the effect of land-use change and forest programmes on GHGs and human wellbeing outcomes. Using systematic methods and innovative data-mining and visualisation techniques, the land-use and forestry EGM identifies, displays and categorises 241 impact evaluations and 11 systematic reviews according to 15 interventions and 12 outcome types. The analysis further characterises findings by geographical location and study design, and offers a critical appraisal of the systematic reviews included.

Main findings

A key policy question motivating this study is whether there are trade-offs or potential synergies between programme effects on environmental and human welfare outcomes, as measured by GHG emissions and food security. We did not identify any primary study addressing this question directly by measuring programme effects on both of these outcomes. A few studies examine win–win scenarios or trade-offs by looking at other measures of environmental and human welfare outcomes, but this applies to less than 10 percent of the included studies. This can therefore be considered a more or less 'absolute evidence gap'.

[1]IPPC defines a GHG sink as: 'Any process, activity or mechanism that removes a greenhouse gas (GHG), an aerosol or a precursor of a GHG or aerosol from the atmosphere' (IPCC 2014, p. 127). In the context of the AFOLU sector this typically refers to enhancing the uptake of carbon in soils and biomass (thereby removing CO_2 from the atmosphere). Examples of activities that can enhance carbon sequestration in agricultural and forest lands include planting trees on non-forested agricultural lands (reforestation, afforestation), incorporating trees into agricultural or grazing lands through the use of agroforestry systems and enhancing soil organic content in agricultural and grazing lands through improved soil management.

Moreover, we find almost no evidence of studies directly measuring either carbon storage and sequestration[2] or GHG emissions; studies largely focused on indirect measures of GHG emissions such as forest cover. Most studies assessing human welfare outcomes measure household income and consumption, with very few studies measuring other outcomes such as food security, basic materials or health.[3]

We find that the distribution of evidence is relatively uneven when considering study characteristics according to intervention and geographical location. The interventions with the largest volumes of studies are protected areas (PAs), community and decentralised forest management (C/DFM), payment for environmental services (PES) and agricultural extension and training. Meanwhile, we did not find any studies of dams and civil society interventions, and, very few studies for many other intervention areas, including land rights, information services, and technical and vocational training for farmers. Over half of the identified studies were conducted in only 10 countries: Costa Rica, Brazil, China, Indonesia, Mexico, Uganda, Ethiopia, India, Bolivia and Malawi. Out of the 47 countries that are part of Reducing Emissions from Deforestation and Degradation (REDD/REDD+), we identified evaluations of forestry programmes in only 24.

The available evidence mainly uses quasi-experimental study designs (223 of the 241 studies) such as propensity score matching, instrumental variables and difference-in-differences. Only 18 studies use an experimental study design and all but one of these studies are focused on agricultural interventions. Many of the quasi-experimental study designs rely on weak identification designs and usually use cross-sectional data. However, it is encouraging that more recent studies are increasingly using more robust methods that draw on panel data. Moreover, we identified a small number of ongoing environment-oriented experimental studies, highlighting the possibility of more robust causal identification designs in future research.

Conclusions

The key policy question motivating this study was whether there are trade-offs or potential synergies between programme effects on environmental and human welfare outcomes, as measured by GHG emissions and food security, respectively. Our clearest finding is that the existing evidence base is too limited to guide decision makers on which interventions are likely to be most effective in reaching emissions reductions targets, while avoiding negative effects on food security and other human welfare outcomes. While we identified a relatively large number of studies, few are designed to assess potential trade-offs between climate change mitigation and food

[2] Carbon storage refers to any measure of carbon stocks in biomass and above- and below-ground organic matter. Sequestration is 'the uptake (i.e. the addition of a substance of concern to a reservoir) of carbon containing substances, in particular carbon dioxide (CO_2), in terrestrial or marine reservoirs' (IPCC 2014, p. 127).

[3] Defined in the Millennium Ecosystem Assessment as 'availability and access to physical assets essential for meeting basic needs, such as food, fuel and electricity, clean water and sanitation, and shelter'.

security and poverty reduction. This is an important evidence gap which future studies should address.

The clearest implication of this study is, therefore, the need to generate a body of evidence as new initiatives are rolled out. New programmes, including those implemented under REDD+, should be accompanied by high-quality evaluations assessing potential trade-offs between climate change mitigation and human welfare outcomes. To allow assessment of the potential for win–win solutions and identify potential trade-offs, studies need to measure effects on both GHG emissions and human welfare outcomes, including food security. When feasible, studies should include direct measurement of GHG emissions to test assumptions about the accuracy of using intermediate outcomes such as deforestation rates as proxies for emissions.

Opportunities to use robust identification designs that identify causal relationships, such as randomised designs or quasi-randomised designs, combined with well-informed theories of change should be exploited where possible. Studies should be informed by mixed methods, formative work to inform and validate theories of change, *and* existing randomised or high-quality quasi-experimental studies and process evaluations. Studies combining counterfactual analysis with process evaluation and mixed methods research will allow researchers and decision makers to address questions not just about what works, but how programmes work (or not), for whom and at what cost.

Syntheses of studies assessing PAs, PES, C/DFM and agricultural extension and training are likely to add particular value. Systematic reviews exist for some of these interventions, but these are either out of date and/ or have major weaknesses which reduce confidence in their findings. Coordinated research programmes with studies of similar interventions replicated across settings could enhance the learning from new studies.

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Abbreviations and acronyms

AFOLU	agriculture, forestry and land Uses
CFM	community forest management
CIFF	Children's Investment Fund Foundation
CI	Conservation International
CO_2	carbon dioxide
DFM	decentralised forest management
DID	difference-in-differences
EGM	evidence gap map
FAO	Food and Agriculture Organization
FLEGT	forest law enforcement, governance and trade
GHG	greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
L&MIC	low- and middle-income countries
MEA	Millennium Ecosystem Assessment
PA	protected area
PES	payment for environmental services
PSA-H	PagosporServiciosAmbientales-Hidrologico
PSM	propensity score matching
RCT	randomised controlled trial
REDD+	reduced emissions from deforestation and degradation
UNFCCC	United Nations Framework Convention on Climate Change

1. Introduction

1.1 The issue: balancing climate change mitigation and food production

The agriculture, forestry and other land-use sector (AFOLU) contributes around a quarter of global greenhouse gas (GHG) emissions through forest degradation, deforestation and agricultural production (IPCC 2014; Smith *et al.* 2014). In countries such as Indonesia and Brazil, deforestation and forest degradation are by far the leading sources of emissions over and above industry and the transportation sector. At the same time forests actively remove up to one-third of all carbon dioxide emissions from fossil fuel combustion and land-use change every year (McMullen and Jabbour 2009). Climate change mitigation efforts in the sector must therefore combine policies to conserve existing stocks of carbon in forest biomass, peat lands and soil with efforts to reduce new emissions from unsustainable agricultural practices and from forest and vegetation removal for new agricultural land.

At the same time billions of people globally, especially in low- and middle-income countries (L&MICs), rely on agriculture and forestry for their livelihoods (Beddington *et al.* 2012). The sector is essential for food production and provides critical sources of fibre, fuel and other materials. Land and forests also provide a multitude of ecosystem services, such as provision of clean water, pest regulation, nutrient regulation, soil formation and pollination that are fundamental to human wellbeing (Millennium Ecosystem Assessment 2005). The way in which agricultural and forest lands are managed is therefore also critical for efforts to achieve global food security, alleviate poverty and achieve the Sustainable Development Goals, (Beddington *et al.* 2012; Sachs 2012; Griggs 2013).

International policy discussions under the United Nations Framework Convention for Climate Change (UNFCCC) have recognised the critical importance of reducing emissions from tropical deforestation and degradation for climate mitigation. Reducing Emissions from Deforestation and Degradation (REDD/REDD+) is one specific framework established for addressing this issue (UNFCCC 2010). The UN-REDD programme was established in 2008 and is a framework to support REDD+ by offering positive financial incentives to L&MICs to reduce emissions that result from the conversion of forest land to other land uses. So far, 47 countries have signed up to receive funds from the UN-REDD framework. While there is growing awareness among policymakers of the importance of addressing emissions from agricultural land use, to date there has been less discussion under the UNFCCC on how to effectively reduce emissions from agriculture (Beddington *et al.* 2012).

The concept of ‘climate-smart agriculture’ recognises the importance of agricultural development for both climate change efforts and food security, referring to ‘agricultural systems that increase food security in the face of climate change, enhance adaptive capacity of farmers to the impacts of climate change, and mitigate climate change’ (Rosenstock *et al.* 2016, p. 10). Some potentially important sustainable agricultural practices proposed in the sector include introduction of agroforestry, silvopastoral or integrated crop systems, which combine crops, grazing

lands and trees on agricultural land, improved tillage practices such as conservation agriculture, and reduced use of fire in rangeland management (Liniger *et al.* 2011). Similarly, the idea of sustainable agricultural intensification has also received some attention in the context of climate change mitigation (The Government Office for Science 2011; Tilman *et al.* 2011; Smith *et al.* 2014). This approach suggests that global demands for increasing food production can be met by intensifying production on existing cropland through transfer of high-yield technologies to low-yield areas, reducing pressure to clear forest land for agriculture, reducing nitrogen use and reducing GHG emissions (Tilman *et al.* 2011; Smith *et al.* 2014).

The resources required for actions to balance climate change mitigation and food production are substantial. For example, according to the UNFCCC additional global investments of US$35 billion for the agriculture sector and US$21 billion for the forestry sector will be needed by 2030 to mitigate the effects of climate change (UNFCCC 2009). But there are also concerns that large-scale mitigation activities in the sector could have negative effects on food security, rural livelihoods and other aspects of human wellbeing (e.g., Stickler 2009; Larson 2013; Lawlor *et al.* 2013; Mutabazi 2014), by promoting forest restoration and conservation at the expense of agricultural production. Therefore there is an urgent need to develop policies and programmes that drive more effective action to reach national and global emissions reduction targets, while avoiding negative effects on food security and other human wellbeing outcomes. This evidence gap map (EGM) aims to help inform such efforts by taking stock of the existing evidence on the effects of land-use change and forestry programmes on GHG emissions and human welfare, in particular food security outcomes.

1.2 Study objectives

This EGM is part of a joint programme led by the Children's Investment Fund Foundation (CIFF) and 3ie to understand evidence in the area of land-use and land cover change and welfare. Specifically, CIFF is working on a programme to reconcile agricultural production and forest protection in Brazil. The findings of EGM will inform this work. The overall aim of this EGM is to identify, map and describe existing empirical evidence on the effects of land-use change and forestry programmes and policies on GHG emissions and human wellbeing outcomes. In doing so, it addresses two main objectives:

- Identify, appraise and summarise existing evidence from systematic reviews of the effect of land-use change and forestry programmes on GHG emissions and human welfare outcomes that can be used to inform policy in the AFOLU sector;
- Identify existing evidence gaps where new primary studies and systematic reviews are needed to better inform climate change mitigation and development policies.

1.3 Methodology

3ie EGMs are thematic collections of evidence on the effects of policies and programmes (Snilstveit *et al.* 2013). They provide an innovative approach for rapid knowledge transfer and capture, combining methods from other review and mapping approaches with data visualisation, using an interactive platform. A key feature of an EGM is the use of a framework of interventions and outcomes, based on a review of the policy literature and consultation with stakeholders.

The rows of the framework represent a list of the key interventions of the sector or thematic area of focus, while the columns cover the most relevant outcomes structured along the causal chain, from intermediate outcomes to final outcomes. The framework is designed to capture the universe of important interventions and outcomes in the sector or subsector covered by the map.

This EGM is based on systematic and comprehensive methods to identify impact evaluations and systematic reviews corresponding to the concepts included in the framework. Appendix A describes the methods used in this study in detail. Impact evaluations use counterfactual analysis to measure the net impact of an intervention (3ie, 2012). Systematic reviews of effects use transparent and systematic methods to identify, appraise and synthesise findings from studies addressing a specific issue (Waddington *et al.,* 2012). When using the term ‘evidence’ in this report, we are speaking primarily of these types of primary studies and syntheses of effects.

The remainder of this report is structured as follows. Section 2 outlines the substantive scope of the EGM. In Section 3, we present the findings, describing the size and characteristics of the evidence base. Section 4 provides conclusions and implications.

2. Scope of the evidence gap map

The scope of the EGM is defined by the intervention and outcome categories included in the framework, as well as the type of studies included. We define these concepts for our EGM below.

2.1 Interventions

Options for reducing emissions from forest and agricultural land include: (1) reducing emissions from deforestation and forest degradation by protecting forests and reducing conversion to agriculture; (2) improving forest management, managing fires, and (3) reducing emissions from agricultural land (e.g., by improving use of fertilisers and other inputs, reducing tillage intensity, improving water management, reducing use of machinery), fossil fuels, livestock management (e.g., using appropriate stocking densities, improved grazing management) and alternative rice production methods to reduce methane emissions.

Examples of practices that can enhance carbon sequestration in agricultural and forest lands include planting trees on non-forested agricultural lands (reforestation, afforestation), incorporating trees into agricultural or grazing lands through the use of agroforestry systems and silvopastoral systems, enhancing soil organic content in agricultural and grazing lands through improved soil management (e.g., crop rotation, use of cover crops, reduced tillage, incorporation of tillage) and enhancing above-ground biomass (e.g., through revegetation, conservation of riparian vegetation, natural regeneration, lengthened fallow periods, forest restoration, etc.).

To be eligible for inclusion in the EGM, studies had to assess forestry and land-use programmes or policies likely to have an effect on GHG emissions. Studies which only investigated natural or market-based occurrences, or that reported findings of controlled laboratory experiments or early-stage agricultural research station field trials with no discernible development intervention were excluded (Mishra and Cameron 2014). This means studies comparing differences in outcomes between adopters and non-adopters without any specific intervention were excluded. We separated interventions into the following five broad categories as outlined below. Table 1 presents the specific interventions included under each category and their definitions.

- **Area protection and management**: Interventions in this category involve actions to establish or expand parks, reserves or other legally protected areas (PAs) in which land or resource use is either fully restricted or regulated. They also include programmes with changes to the management regime of a particular area or jurisdiction.
- **Law and policies related to forests and other land**: This category comprise actions to develop, change and implement formal legislation, regulations and voluntary standards related to forestry and other land.

- **Incentives**: This category includes different interventions that use economic and other in-kind incentives provided to individuals or communities to influence land management behaviour.
- **Training, education and information**: Interventions in this category are developed to promote sustainable practices and technology.
- **Infrastructure**: This category includes selected infrastructure interventions (roads, dams) which were included because they could have large effects on land use and be drivers of emissions.

To limit the scope of the EGM and ensure included studies were relevant to the focus of the EGM, we applied additional inclusion criteria to studies of some interventions. Studies of certification, subsidies, grants and concessions, land rights, agricultural extension, technical and vocational training, information services, road construction and dams were only included if they fulfilled at least one of the following criteria: (1) the intervention promoted sustainable agricultural practices, sustainable livestock, agroforestry, aquaculture, sustainable forest management, watershed management or a sustainable technology (e.g., cook stoves, hybrid seeds, organic fertiliser, etc.)[4] *or* (2) the study measured effects on an environmental outcome.

2.2 Outcomes

We searched for studies that measured effects on at least one of the following broad outcomes:

(1) Intermediate outcomes: outcomes measuring the uptake of agricultural practices, land-use management or forest management;
(2) Environmental outcomes: outcomes related to GHG emissions, including proxies such as forest condition and coverage, as well as more direct measures of emissions;
(3) Human welfare outcomes: outcomes related to welfare outcomes for populations living in areas where interventions are implemented and/ or programme beneficiaries.

The outcomes are defined in more detail in Table 2.

[4] By sustainable, we refer to agricultural technologies or practices with a potential for improved agricultural production without an increase in overall emissions, or maintaining current production levels while reducing emissions. However, as there is no agreed list of (evidence-based) practices and technologies that are considered sustainable we adopted an inclusive approach when identifying studies for this map.

Table 1: Intervention categories

Category	Intervention	Definition
Area protection and management	Protected areas	Establishing protected areas such as national parks where access and use of resources is either fully restricted or regulated.
	Community/ decentralised forest management	Interventions 'establishing, improving or monitoring' decentralised forest management. Decentralising forest management typically involves transferring responsibility for forest management, typically from central government to other stakeholders (private sector, forest communities and government). Examples include joint forest management, participatory forest management, community-based forest management.
Law and policies related to forests and other land	Public sector legislation	Actions to develop, change and implement public sector legislation, including federal legislations and regulations implemented by government agencies.
	Private sector codes and legislation	Interventions to develop, change and implement private sector agreements, including standards or business codes.
	Civil society legislation	Interventions to develop, change and implement civil society policies.
	Monitoring and enforcement	Interventions that involves the monitoring and enforcement of forestry and land-use policies
Incentives	Payment for environmental services	Programmes where incentives are offered to individuals or communities for managing land to provide environmental services (such as carbon sequestration or water provision). Conditions for receiving incentives may include either full protection, restoration, reforestation and sustainable land management.
	Certification	Certification schemes promoting sustainable agricultural production or sustainable land management and conservation. To be included studies needed to either (1) assess a programme that promotes sustainable agricultural practices, sustainable livestock, agro-forestry, aquaculture, sustainable forest management, watershed management or a sustainable technology (e.g., cook stoves, seeds, fertiliser, irrigation, etc.) *or* (2) measure effects on an environmental outcome.
	Subsidies, grants and concessions	Subsidies, grants and concessions given to farmers and landowners as a means of reducing the market price of specific inputs used in agricultural production or natural resource management. To be included studies need to either (1) assess a programme that promotes sustainable agricultural practices, sustainable livestock, agroforestry, aquaculture, sustainable forest management, watershed management or a sustainable technology (e.g., cook stoves, seeds, fertiliser, irrigation etc.) *or* (2) measure effects on an environmental outcome.

Training, education and information to promote sustainable practices and technology	Land rights	Formal registration of land rights in an official registry, either through the conversion of communal or non-demarcated rural land to freehold title or statutory recognition and codification of customary or communal rural land rights (Lawry *et al.* 2014). Such programmes may offer farmers incentives to invest in their land in the form of adopting sustainable agricultural management practices, plant trees or refrain from cutting down trees (Kurukulasuriya and Rosenthal 2003).
	Agricultural extension and training	Interventions providing agricultural extension or training, to farmers and landowners to improve knowledge, skills, and influence behaviour. To be included studies needed to either (1) assess a programme that promotes sustainable agricultural practices, sustainable livestock, agroforestry, aqua culture, sustainable forest management, watershed management or a sustainable technology (e.g., cook stoves, hybrid/ improved seeds, fertiliser, small-scale irrigation, etc.) *or* (2) measure effects on an environmental outcome.
	Technical and vocational training	Formal training strategies through degree programmes and technical and vocational training programmes. To be included studies needed to either (1) assess a programme that promotes sustainable agricultural practices, sustainable livestock, agro-forestry, aqua-culture, sustainable forest management, watershed management or a sustainable technology (e.g., cook stoves, seeds, fertiliser, irrigation, etc.) *or* (2) measure effects on an environmental outcome.
	Information services	Information campaigns to promote uptake of technologies and practices. To be included studies needed to either (1) assess a programme that promotes sustainable agricultural practices, sustainable livestock, agroforestry, aqua-culture, sustainable forest management, watershed management or a sustainable technology (e.g., cook stoves, seeds, fertiliser, irrigation, etc.) *or* (2) measure effects on an environmental outcome.
Infrastructure	Road construction	Construction, building, and expansion of paved and unpaved roads for the purpose of transporting goods and people. To be included studies needed to measure effects on an environmental outcome.
	Dams	Construction and management of dams for the production of electrical power through the use of gravitational force of falling or flowing water. To be included studies needed to measure effects on an environmental outcome.

Table 2: Outcome categories

Category	Outcome	Definition
Intermediate outcomes	Acquisition of knowledge/ skills	Improved knowledge of new practices and technology, for or of environmental impact of existing practices/technology.
	Adoption of new practices or technology	Adoption of technology or sustainable agricultural practices such as, use of fertiliser and pesticide, improved crop variety.
	Land and forest management	Measures of the type, frequency, intensity or adoption of land and forest management practices.
	Productivity of land	Crop yield/ productivity.
Environmental outcomes	Forest condition	Measures of characteristics of existing forests, including composition, structure or function of forested land that affects its carbon storage potential.
	Forest cover	Any measures of forest cover, including extent of forest maintained, reforested, regeneration, deforested or converted to another land type. Also includes outcomes related to extraction of wood from forests for fuel (a proxy for deforestation).
	Carbon storage and sequestration	Measures of carbon stocks in biomass and above and below ground organic matter.
	GHG emissions	Any measures of GHG emissions including amount emitted, avoided or leakage to another area.
Human welfare outcomes	Basic materials	Measures of individual and household access to, and availability of materials required to meet basic needs shelter, water, sanitation, electricity, fuel, housing and other resources (MEA 2005).
	Health	Any measures of health status, disease prevalence and access to health care.
	Income and household expenditure	Measures of individual or household monetary income and expenditure, including agricultural/microenterprise-related income and expenditure.
	Food security	Any outcomes measuring food security across the four dimensions included in the Declaration on Food Security (FAO 2009): food availability, access, utilisation and stability. These are typically measured using a range of different indicators, including food consumption, food expenditure, prevalence of undernourishment, nutritional status (FAO 2013).
Infrastructure	Road construction	Construction, building, and expansion of paved and unpaved roads for the purpose of transporting goods and people. To be included studies needed to measure effects on an environmental outcome.
	Dams	Construction and management of dams for the production of electrical power through the use of gravitational force of falling or flowing water. To be included studies needed to measure effects on an environmental outcome.

2.3 Study types

We included both impact evaluations and systematic reviews of effects. Impact evaluations are evaluations that measure the causal change that occurs because of a programme or an intervention. They use experimental or quasi-experimental study designs to conduct a counterfactual analysis, which allows for the attribution of changes in an outcome to a specific intervention, or compare the effects of different types of programmes (3ie 2012). Specifically we included the following types of studies:

- Randomised controlled trial (RCT);
- Regression discontinuity design (RDD);
- Controls before and after study using appropriate methods to control for selection bias and confounding (propensity score matching (PSM) or other matching methods, instrumental variable estimation (or other methods using an instrumental variable such as the Heckman Two step approach), difference-in-differences (DID) or a fixed- or random-effects model with an interaction term between time and intervention for baseline and follow-up observations;
- Cross-sectional or panel studies with an intervention and comparison group using methods to control for selection bias and confounding, as described earlier.
- Studies explicitly described as systematic reviews and reviews that describe methods used for search, data collection and synthesis as per the protocol for the 3ie database of systematic reviews (Snilstveit *et al.* 2014).

2.4 Other inclusion/ exclusion criteria

To be included, studies had to examine existing and degraded forests, grasslands, wetlands, mangroves, coastal or agricultural lands. Studies of marine, tundra or desert ecosystems or urban environments were not eligible for inclusion. Because we anticipated the evidence would be limited, we did not exclude any studies based on geographical location. We did not limit inclusion based on publication status or language of publication. We searched for studies published between January 2000 and April 2016.

3. Results

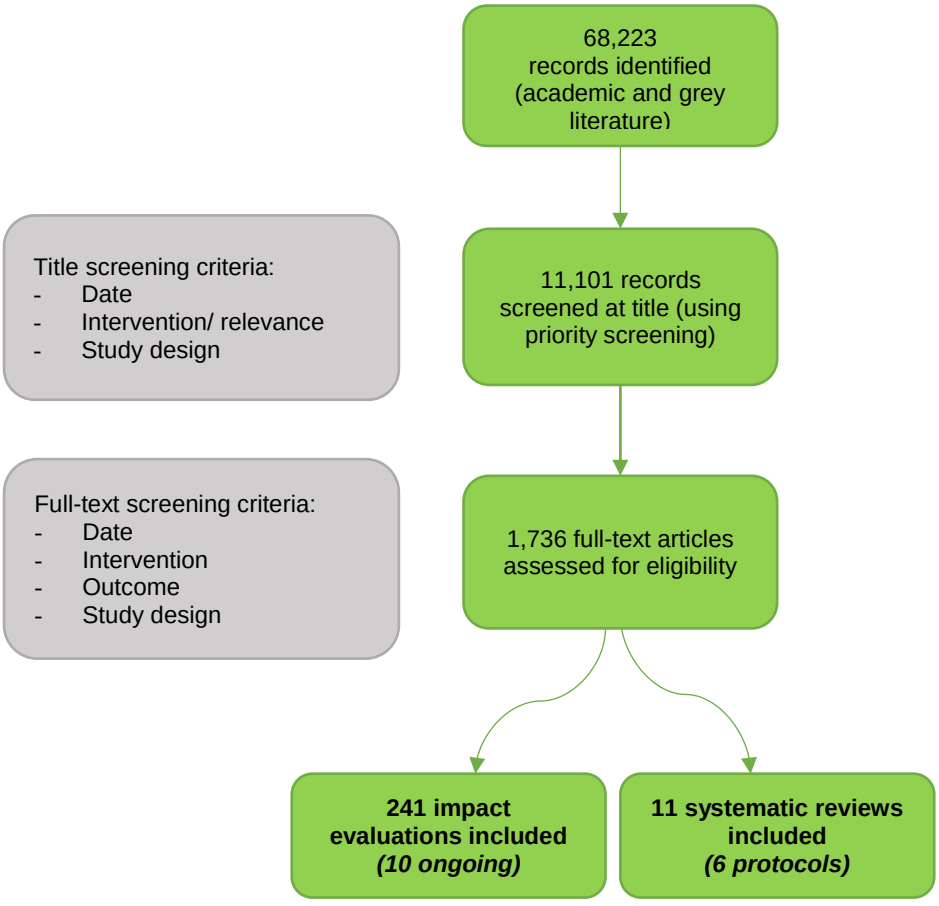
3.1 Volume and characteristics of the evidence base

Figure 1 provides an outline of the search and screening process used to identify included studies. After removing duplicate records, we identified 68,223 citations for screening at title stage. We screened an initial set of 1,500 records to allow us to train a text-mining function which prioritised studies according to relevance. Overall we screened 11,101 records at the title and abstract stage and screened 1,736 papers at full text, resulting in 241 included impact evaluations and 11 systematic

reviews. In addition, through the search we also identified 12 ongoing impact evaluations and 6 ongoing systematic reviews, which were included in the map.

The search returned a large number of records and we also screened a relatively large number of studies at full text. Several factors likely contributed to this. First, the substantive scope of the EGM covers a very broad range of interventions and outcomes, and we did not include any geographical limitations. This meant that the search strategy cast a very wide net to ensure we captured the relevant literature. Second, the literature on interventions in the sector is quite recent, with a lack of common intervention typologies. Thus the search strategy included a large number of keywords, resulting in a larger number of papers being picked up by the search strategy. Finally, as with other areas of social science (Waddington *et al.* 2012), studies often used obscure titles and unstructured abstracts. Because of this, it was often difficult to determine whether a paper met the inclusion criteria and we had to review the full text.

Figure 1: Search results

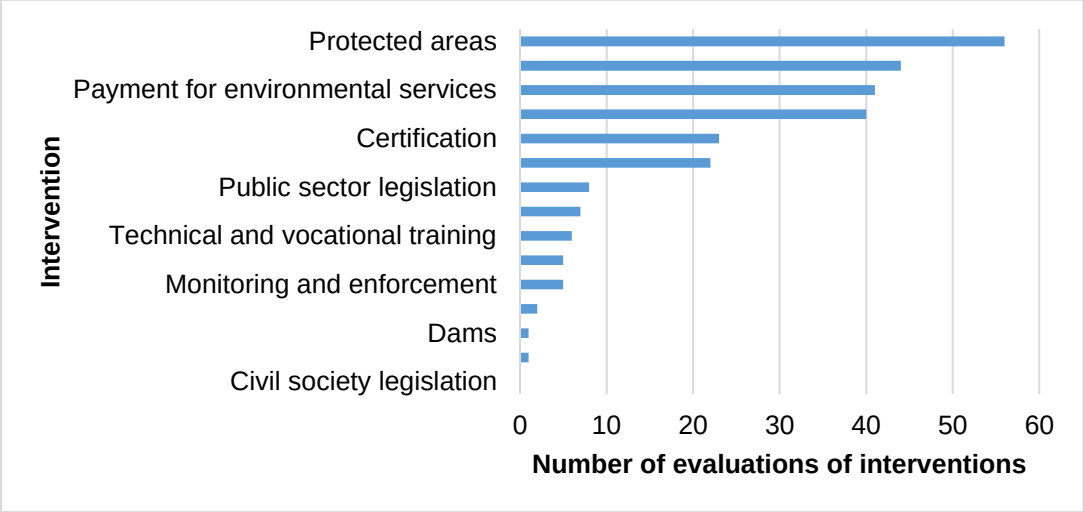


3.2 Descriptive findings: characteristics and trends of the evidence base

Distribution of studies across interventions

Figure 2[5] provides the number of impact evaluations broken down by the 15 different interventions covered by the EGM. The intervention with the highest numbers of impact evaluations (n = 56) is PAs. There are also a large number of studies on payment for environmental services (PES) (n = 41) and community and decentralised forest management (C/DFM) (n = 40). We identified 44 studies that either assessed the impact of a sustainable agricultural extension and training intervention or assessed the impact of any kind of agricultural extension and training intervention on one of the includable environmental outcomes. Environmental certification programmes, such as Rainforest Alliance or Fair trade, are also a relatively well evaluated area, with 23 included studies. Few studies assessed the effect of infrastructure interventions on an environmental outcome, or civil society, private sector and public sector legislation.[6]

Figure 2: Number of impact evaluations that assess the effect on an outcome related to GHG emissions or human wellbeing outcomes, by intervention category (n = 241 studies total)



Outcomes assessed in included studies

The included studies assessed a range of different environmental and human wellbeing outcomes (Figure 3). Forest cover was by far the most evaluated outcome in the included studies, with 103 papers reporting effects on some measure of this outcome. Commonly, studies used a measure of rate of forest loss or, in some cases, forest loss avoided or a local level measure of forest cleared by households. Several studies assessed the effect on a measure of household extraction of wood

[5] Some studies might measure multiple interventions and/or outcomes and therefore the total number in the figures is greater than the total number of impact evaluations included.
[6] This category captured any legislation, policies and codes related to forests and other land use directed at the public, private and third sectors which were not captured by the other intervention categories.

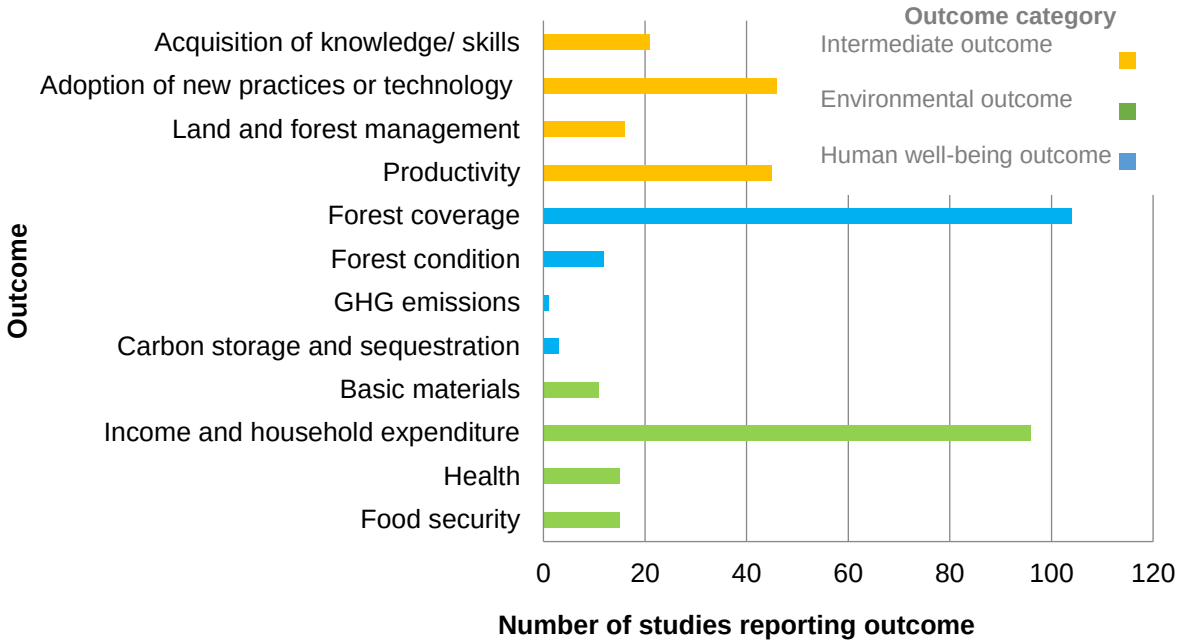
from local forest areas, a measure often used as a proxy measure of the local rate of deforestation. The studies that measured forest condition (n = 11) used a more diverse set of outcomes, including canopy cover, damage to forest sites including extent of lopping, diversity of tree species and measures of biomass.

Among those impact evaluations that measured environmental outcomes, there was a lack of studies measuring carbon storage and sequestration and GHG emissions. Instead they relied on proxies for GHG emissions such as forest cover and forest condition. Just one study reported the effect of an intervention on a measure of GHG emissions. This study[7], which took place in Mongolia (Greene *et al*., 2014), measured the impact of subsidies of energy efficient cook stoves on night-time emissions of CO_2, and $PM_{2.5}$ emissions per kg coal in the home. Measurement of outcomes more directly associated with emissions reduction specifically and climate change mitigation more generally, can be both challenging and costly, so this finding is perhaps not surprising. A lack of sufficient scientific capacity to measure carbon sequestration in land use, land-use change and forestry was one of the reasons for excluding this sector from the Kyoto Protocol (De Boer 2009).

In terms of human welfare outcomes, income and household expenditure were measured in a large number of studies (n = 96). The studies used a diverse set of outcomes, typically income from specific livelihood sources, such as a specific agricultural product or from the forest, total household income or household expenditure. A small number of studies measured some type of poverty rate. Few studies assessed food security (n = 15), basic materials (n = 11) or health outcomes (n = 15). A commonly measured intermediate outcome was adoption of a new practice (n = 46), such as reduced fertiliser use.

[7]Three studies reported on some measure of carbon storage or sequestration. A REDD+ multi-component intervention in Nepal (Sharma *et al.* 2015) that introduced a range of activities to reduce deforestation, forest degradation and improve carbon stock assessed the change in measures of total forest carbon stocks in tons of CO_2 equivalent, which was calculated from an aggregated measure of carbon stocks in tons of carbon per hectare (t C ha). The measure was based on measures of carbon stock in aboveground tree biomass, aboveground biomass, herbs and grass, leaf litter, belowground biomass and soil organic carbon. Similarly, Bluffstone *et al.* (2014) assessed the effect of community forestry in Nepal on forest carbon stocks, calculated as above ground biomass (AGB) multiplied by the IPCC 0.5 conversion factor. Finally, Ferraro *et al.* (2015) estimated the *ex-post* impacts of protected areas in Indonesia, Thailand, Costa Rica and Brazil on stocks of carbon. They used data on the distribution of aboveground woodland biomass and formulae for converting biomass into carbon stocks to assess additional CO_2 storage per hectare.

Figure 3: Number of impact evaluations providing information on outcomes related to GHG emissions and human wellbeing



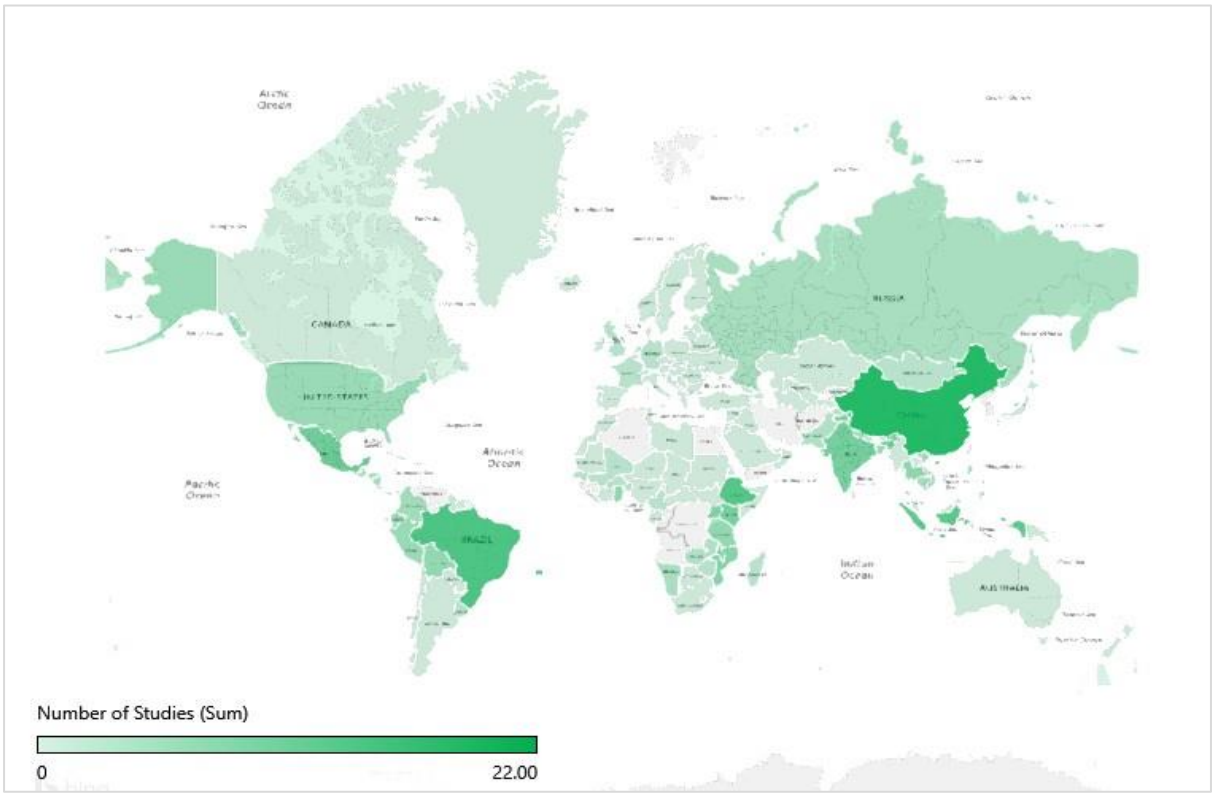
Finally, a key characteristic of the included studies is that they typically either focused on assessing environmental outcomes or socioeconomic outcomes, but few studies measured both. Of the 241 included studies, only 21 impact evaluations measured joint effects of land-use change and forestry programmes on outcomes associated with both GHG emissions and human welfare outcomes. None of these studies included a direct measure of GHG emissions, but used proxies for GHG emissions (such as forest cover and forest condition).[8]

Geographical location

The studies were conducted in 48 different countries (Figure 4). The geographic distribution of studies is relatively uneven. In some regions and countries, there have been a large number of studies conducted, whereas for others there is little or no evidence. The majority of studies were conducted in Latin America and the Caribbean (n = 82), followed by Sub-Saharan Africa (n = 81) and East Asia and the Pacific (n = 53). We identified few studies from high-income countries: only 10 studies in total split between the United States, the United Kingdom, Russia, France and Germany, and there were no studies from the Middle East and North Africa or the Commonwealth of Independent States.

[8]The study of the REDD+ pilot programme in Nepal measured carbon stocks in forests, in addition to human welfare outcomes (Sharma and Pattanayak 2015).

Figure 4: Included impact evaluations by geographical location



The spread of studies across countries is uneven, with over half of the studies originating from only 10 countries (Costa Rica, Brazil, China, Indonesia, Mexico, Uganda, Ethiopia, India, Bolivia and Malawi). This is at least partially due to the existence of long-standing public forest protection programmes and availability of data in these countries.

Across three of the most heavily studied intervention areas, namely PES, C/DFM and PAs, there is a concentration of studies in a relatively small number of countries. Forty-one studies evaluate PES, but these are concentrated in 14 countries, with 27 of the studies from just three countries: namely, Mexico, Costa Rica and China. In many cases there are a number of studies looking at the same programme, using the same or overlapping data sets. For example, eight studies evaluate the PagosporServiciosAmbientales (PSA) PES programme in Costa Rica. Under this system, landowners enrolled in the PES scheme agree to do one of the following: conserve existing forests, establish reforestation, afforestation, or introduce areas of agroforestry. In return, they receive an annual payment from a government national forest fund. All but two of these studies focus on the PES programme nationally. Five studies look at the impact of PSA on deforestation at the national level but over slightly different time periods. Two studies focus on one region only, with one looking at wellbeing outcomes and one at deforestation. One study looks at the PES programme in addition to the Costa Rican National Parks programme. Similarly, five studies evaluate two PES programmes in Mexico (the Pago porServiciosAmbientales-Hidrologico or PSA-H, and FIDECOAGUA) and 13 evaluate

a national PES programmes in China (the Sloping Land Conversion Programme, or 'Grain for Green').[9]

Similarly, while we identified 56 studies of PA programmes, these came from 17 unique countries, with 11 of these 56 studies taking place in Costa Rica, nine in Indonesia and eight in Brazil. As with PES, these studies typically assess effects on different outcomes, over different periods of time or use different methods from previous studies.

Finally, 40 studies covered DFM or CFM cover programmes in 20 countries. For this intervention area, the spread of countries is less heavily concentrated in Latin America and the Caribbean. There are evaluations of nine different decentralised forestry programmes in Sub-Saharan Africa, three programmes in South Asia (Nepal, India and Bhutan) and two in East Asia and Pacific (Indonesia and Cambodia).

To try to explain the uneven spread of studies, we combined data on the number of studies conducted in a country and variables which may explain the level of studies conducted in the sector. Specifically, we analyse the correlation between the number of studies identified and the average annual CO_2 emissions per capita (2000–2015), total size of the population, average per cent annual deforestation (2000–2015) and total size of forest area.[10] The analysis highlights that both the size of the population ($r = 0.53$) and size of the forest area ($r = 0.31$) are moderately correlated with the number of studies identified from a country. Or, more simply put, countries with larger populations and more forest area tend to have more studies. Meanwhile, a weak negative correlation is found between average emissions rates and the number of studies ($r = -0.17$) and no correlation between a country's average annual deforestation rates and the number of studies identified.

Study types

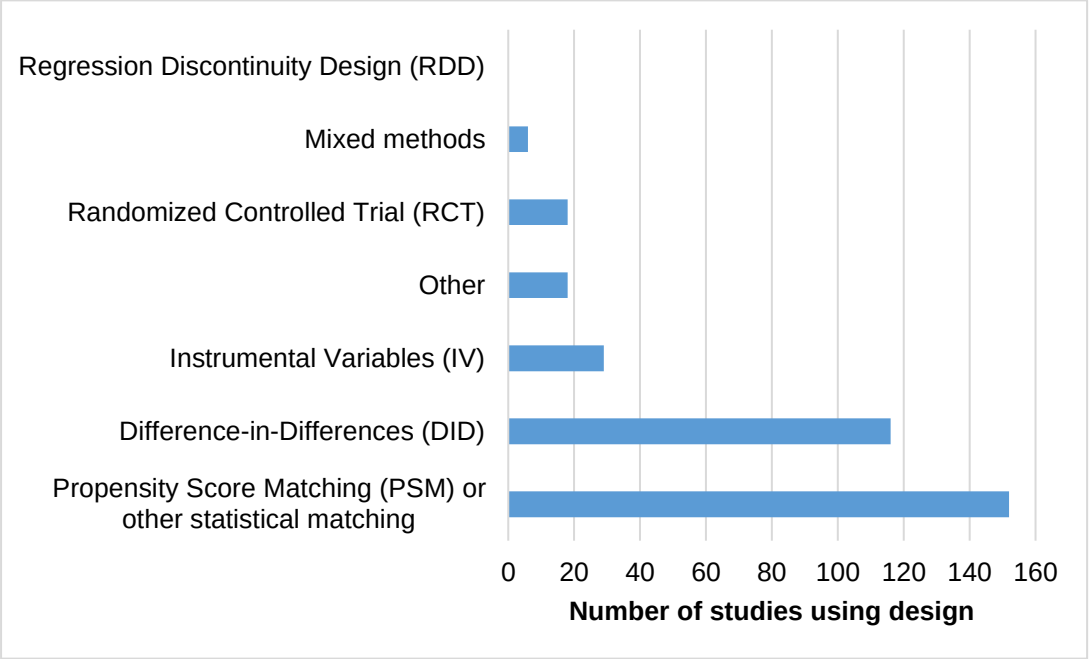
Figure 5 shows the distribution of impact evaluations by study design. Only 18 studies (7 per cent) used a randomised design, with the remaining studies relying on observational and quasi-experimental methods to measure effects (see also Puri and Dhody (2015) that conclude similarly). All studies using a randomised design, except for one that examined a PES trial in Uganda and a cook stove training and dissemination programme in Ethiopia, assessed the effect of subsidies or training, education and information programmes.

The most commonly used evaluation method is PSM or another statistical matching approach (n = 151, 63 per cent), either alone or combined with other methods. Disaggregating this data by intervention further shows that in 9 of the 15 intervention categories more than 50 per cent of the studies feature statistical matching methods. Matching methods have been particularly widespread for assessing the effects of PAs, where 86 per cent of included studies used such techniques. A number of studies also used a DID approach or another type of regression technique relying on

[9] A forthcoming systematic review focus on this programme only (Rodríguez *et al.* 2015).
[10] We used data from World Bank Group, ed. (2015). World Development Indicators 2015.

data from multiple time points. In total, 116 studies (48 per cent) used such techniques, including more than half of studies the studies of PES. Few studies use instrumental variables (n = 29, 12 per cent), although due to the difficulty often found in identifying a valid instrument this is not surprising. Finally, no included studies used RDDs.

Figure 5: Number of impact evaluationsusing different study designs to evaluate the impact of land-use and forestry programmes on GHG emissions and/or human wellbeing



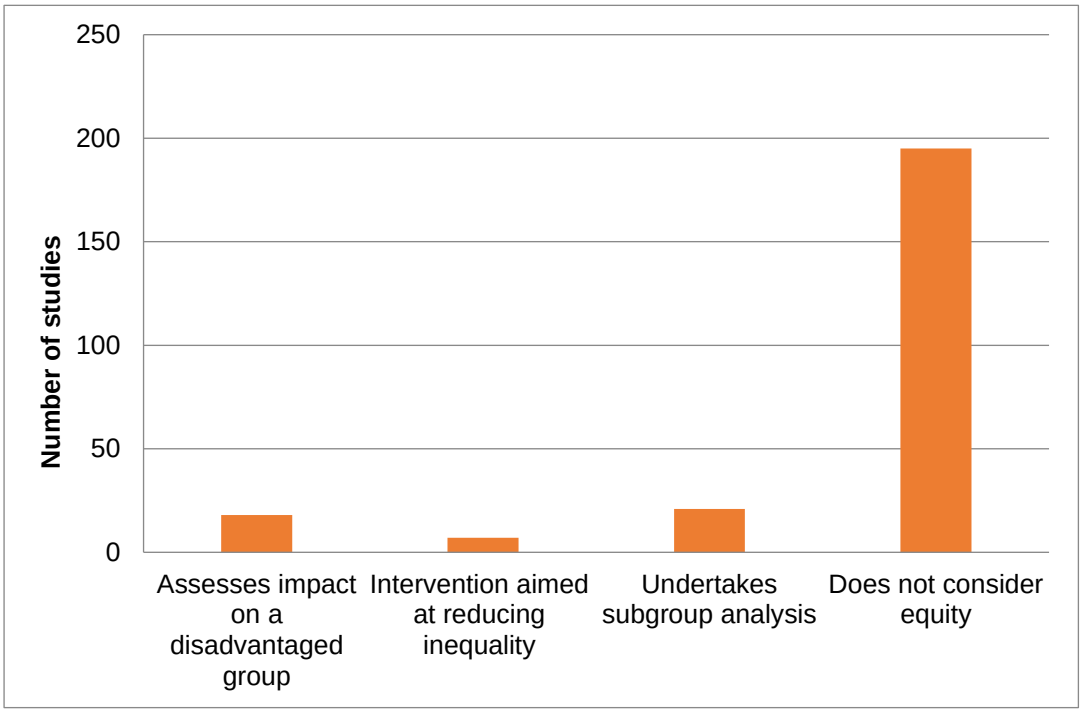
A number of studies combine two or more of these methodologies. The most common combination of methods was PSM or another statistical matching method with DID or a fixed- or random-effects model with an interaction term between time and intervention for two observations over time (n = 76). Of these, 31 are studies of PAs and 20 are studies of PES. A number of the evaluations of PA programmes that combine DID with some kind of matching did not explicitly state that they used a DID approach. However, the authors use panel data on forest cover or a similar measure to calculate a rate of deforestation over time and then match treated areas with comparison areas. This is in contrast to a smaller set of PA studies that use a DID regression technique post-matching. Finally, four studies combine an instrumental variable (IV) approach with DID and three combine an IV approach with some form of statistical matching.

Consideration of equity

We aimed to identify how and to what extent the included studies incorporate equity in their assessment of the intervention. That is, does the paper assess the extent to

which the intervention affects populations or specific groups in different ways.[11] Figure 6 shows the distribution of impact evaluations by consideration of equity. A large majority of the studies do not consider equity in any way (n = 195), either by studying an intervention aiming to reduce inequality, targeting specific groups or by assessing effects on different groups. Twenty-one studies conducted subgroup analysis for one or more potentially vulnerable groups.[12] Of these studies, 13 assessed effects by gender, 10 by socioeconomic status, 3 by educational status, 3 by age, 2 by race, ethnicity, culture or language and 1 by place of residence. In addition, 18 studies assessed the effect of an intervention targeting a specific group, such as socioeconomic status (n = 13), women (n = 5) or place of residence (n = 3). Finally, seven papers assessed the effect of interventions aimed at reducing inequality.

Figure 6: Number of impact evaluations that consider equity impacts of the assessed intervention



[11]We looked for the following three approaches in the included papers (Masset and Snilstveit 2016):
(1) assessment of the effect of an intervention targeting specific groups (for example a study on the impact of a payments for environment services on women); (2) assessment of the effect of interventions aimed at reducing inequality where the outcome of the intervention is inequality in a given domain (e.g., a study on the impact of payments for environment services on income inequality); and (3) assessment of population-level effects of an intervention with subgroup analysis (for example a study on the impact of payment for environmental services that looks at impact of the intervention on female-headed and male-headed families separately).
[12]Sub-group analysis by place of residence, race, ethnicity, culture and language, gender, religion, education, socioeconomic status, social capital, other vulnerable groups, land ownership, age, disability.

Characteristics of systematic reviews

We identified 11 systematic reviews that assessed the effects of one or more land-use change and forestry intervention on an outcome associated with GHG emissions and/or human wellbeing. Five of these reviews synthesised evidence of DFM or CFM interventions. Of these, one looked specifically at CFM only (Bowler *et al.* 2010), one looked at DFM more broadly (Samii *et al.* 2014a) and one focused on community-based conservation, including community-based natural resource management (Brooks *et al.* 2013). Porter-Bolland *et al.* (2012) assessed the evidence on both CFM and PA, while Roe *et al.* (2015) focused on 'alternative-livelihoods programmes', including community-based natural resource management (Roe *et al.* 2015).

Three systematic reviews assessed the evidence on effects of PA on forest coverage (Porter-Bolland *et al.* 2012; Geldmann *et al.* 2013) and human wellbeing outcomes (Pullin *et al.* 2013), while two systematic reviews assessed the effects of PES (Samii *et al.* 2014b; Roe *et al.* 2015). A further two reviews covered some kind of multi-component intervention (Brooks *et al.* 2013; Roe *et al.* 2015). Two systematic reviews focused on agriculture but included environmental outcomes, namely agricultural extension and training (specifically farmer field schools; Waddington *et al.* 2014) and agricultural subsidies, grants and concessions (specifically agricultural innovation grants for farmers; Ton *et al.* 2013). Finally, one systematic review by Lawry *et al.* (2014) looked at the impact of tenure formalisation.

We also included six relevant ongoing systematic reviews (where a protocol is publically available) in the map. These focus on silvicultural interventions, certification for improved agricultural production, property rights regimes, China's conversion of cropland to forest programme, CFM and long-fallow swidden agriculture systems versus alternative land uses and livelihoods and carbon storage in South East Asia.

Results of critical appraisal of systematic reviews

We assessed the confidence in findings of each systematic review using a standardised checklist (Snilstveit *et al.* 2014). Based on this appraisal, five reviews were rated as high confidence (in findings), two reviews were assessed as medium confidence and four were assessed as low confidence. The main limitations of reviews resulting in a downgrading of our confidence in their findings were exclusion of grey literature (Porter-Bolland *et al.* 2011), use of vote counting rather than consideration size and precision of individual study estimates (Brooks *et al.* 2013; Ton *et al.* 2013; Roe *et al.* 2015) and issues with the risk of bias appraisal of included studies (Porter-Bolland *et al.* 2011; Ton *et al.* 2013; Roe *et al.* 2015). We review the findings of the high- and medium-confidence studies in more detail below.

3.3 What are the major evidence gaps?

Figure 7 provides a graphical display of the included studies, with each study mapped according to the intervention/outcome intersection(s) they cover. The size of the bubble indicates the relative size of the evidence base for each intersection. The

grey bubbles show impact evaluations, while the coloured bubbles show systematic reviews, with colours indicating our confidence level in the findings of the reviews. The EGM highlights two types of gaps: absolute evidence gaps, where few or no studies have been conducted, and synthesis gaps, where there is a lack of up-to-date, high-quality systematic reviews. We describe these evidence gaps in more detail below.

Evidence gaps in primary research

There are extensive evidence gaps across most intervention areas. The key policy question motivating this study is whether there are trade-offs or potential synergies between programme effects on environmental and human welfare outcomes, as measured by GHG emissions and food security. We did not identify any primary study that addressed this question directly by measuring programme effects on both of these outcomes. A few studies addressed the question of win–win scenarios or trade-offs by looking at other measures of environmental and human welfare outcomes, but this applies to less than 10 per cent of the included studies. Thus, while we identified a relatively large number of studies, few of them address the important policy question of whether there are trade-offs between climate change mitigation and food security and poverty reduction. This is an 'absolute evidence gap' which future studies should address.

Among the 15 subcategories of interventions within the scope of the map, there is no evidence for the civil society legislation category. For several other subcategories, including training and incentives programmes to encourage sustainable agricultural practices, road and dam construction, land rights programmes that assess impact on environmental outcomes, technical and vocational training and private sector codes and legislation the evidence base is very limited.

Only three areas have been studied relatively extensively, namely PA, PES and C/DFM. These programmes have a relatively long history of implementation, including as part of the REDD/REDD+ mechanism, so this is perhaps not surprising. Only two of the included studies include explicit mention of a programme being undertaken as part of REDD+ (Bluffstone *et al.* 2014; Sharma *et al.* 2015).

Even for these well-studied intervention categories, there are gaps in the evidence base. First, the number of studies is an over estimate as they do not all represent independent samples of different programmes. Some programmes have been studied extensively (such as the PSA PES in Costa Rica, Grain for Green in China and PAs in Costa Rica), using the same or overlapping datasets, but with different methods of analysis. Second, many studies relied on weak quasi-experimental designs, such as cross-sectional surveys without baseline data and used more or less rigorous strategies to control for selection bias. Third, few studies measured GHG emissions, carbon storage and sequestration directly, and relied instead on proxies such as forest cover. Finally, most of these studies measured either environmental or human welfare outcomes, but not both, and hence do not address the important issue of trade-offs.

A relatively large number of studies also assessed the effects of agricultural extension and training, but there are nevertheless gaps in the evidence on programmes falling into this category. It is a broad category of programmes, covering a diverse range of different practices and technologies[13] and the impacts of these practices on GHG emissions and human wellbeing will vary greatly across agricultural systems, agro-ecological regions and socioeconomic contexts. Therefore, both the efficacy of different approaches and effective programmes for promoting uptake of new technologies and practices by farmers under different systems and contexts need to be established, making the evidence needs for sustainable agricultural practices particularly complex. The studies that exist primarily focused on intermediate outcomes such as adoption of new practices or technologies, rather than final outcomes, with no studies assessing changes in environmental outcomes. Therefore, this is an area where there are still major gaps in the available evidence.

Additionally, some key characteristics of the evidence base give rise to the following evidence gaps:

- **Outcomes:** Few studies measured both environmental and human wellbeing outcomes. Most studies typically focused on either effects on the environment or effects on people, which makes it difficult to identify potential trade-offs or synergies. The studies measuring environmental outcomes mainly relied on proxies for GHG emissions, such as deforestation rates. While progress has been made on addressing this issue, more work is needed to improve the measurement of carbon sequestration and emissions from modes of agricultural production (Muller 2009), especially on improving the precision of low-cost methods for measuring biomass and soil carbon. Most studies assessing human welfare outcomes measured household income and consumption. However, we identified very few studies that measured other outcomes, such as food security, basic materials or health.
- **Geographic coverage:** Over half of the identified studies were conducted in only 10 countries: Costa Rica, Brazil, China, Indonesia, Mexico, Uganda, Ethiopia, India, Bolivia and Malawi. This means that for many countries there are no studies. For example, of approximately 50 countries that are designing REDD+ programmes, we found impact evaluations of forestry programmes in only 24.
- **Study design:** There is also an important methodological evidence gap. Only 18 studies (7 per cent) used a randomised evaluation design. The remaining studies used quasi-experimental approaches, such as PSM, instrumental variables and DID. Many studies relied on weak methodological designs based on cross-sectional data. Few studies in the sector have been conducted using

[13] The concept of sustainable or climate smart agriculture covers a broad range of different practices and technologies. Because of the lack of agreement on which technologies and practices can be considered ‘climate smart’ or sustainable we included any study of agricultural programmes that are hypothesised to produce high or improved agricultural production, while leading to reduced emissions or increased sequestration of carbon or other greenhouse gases.

experimental study designs and these are limited to agriculture programmes. Well-conducted quasi-experimental studies can address some of the biases arising from lack of randomised assignment, but there is typically a higher risk of bias in estimates of effects in such studies. We identified a few ongoing studies using randomised designs, demonstrating the feasibility of such studies beyond agriculture (Fundación Natura Bolivia, 2010; Hafashimana *et al.,* 2015).

Synthesis gaps

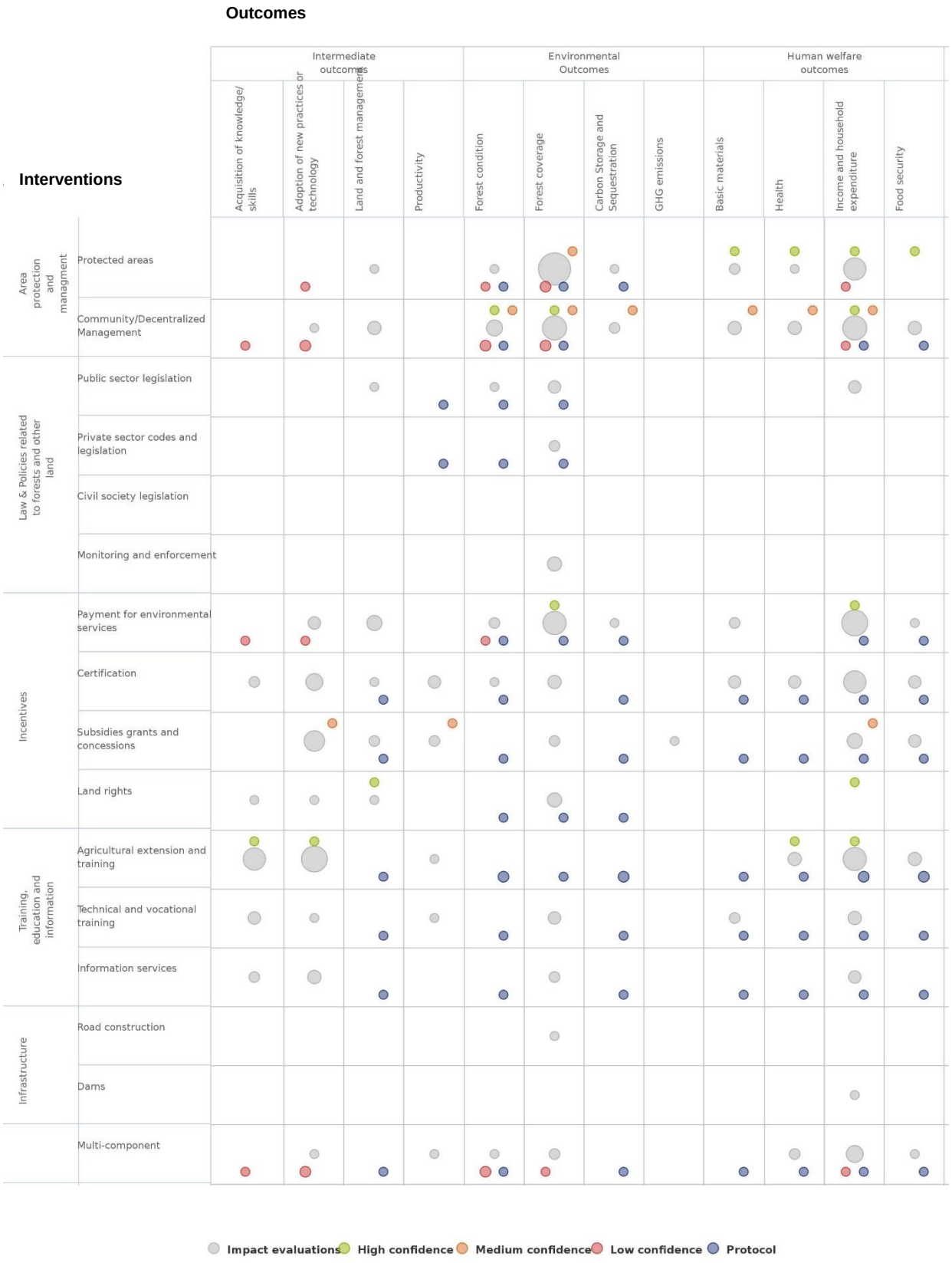
Some programme areas have sufficient primary studies to justify new or updated systematic reviews. Specifically, there is a need for new, updated syntheses of the effects of PA, PES, C/DFM and agricultural extension and training. While systematic reviews exist for some of these interventions, they are either out of date and/or have major weaknesses which reduce confidence in their findings. We did not identify any high-quality systematic review assessing the effect of PAs on environmental outcomes.

For example, Pullin *et al.* (2013) synthesised the effects of PAs on human wellbeing, but this review is now several years old, with at least four new studies published since the research was conducted. Similarly, there are several systematic reviews of PES and C/DFM assessing effects on both environmental and socioeconomic outcomes. However, the research of the most recent review (Samii *et al.* 2014a) was conducted in 2012, and at least six studies have been publishedsince then, suggesting that an update may be warranted.

The number of studies assessing the effects of agricultural extension and training suggest a systematic review focusing on these interventions could add value. As noted above, these studies cover a diverse range of practices and technologies that are either described as sustainable, or that may influence environmental outcomes. The specific practices and technologies promoted for scale-up are likely to differ somewhat between contexts, but a systematic review assessing the effectiveness of strategies or mechanisms for promoting farmer adoption of new practices and technologies (as well as the impacts of adoption on GHG and human wellbeing) could inform the design of future programmes.

Finally, lack of clarity on practices and technologies with climate change mitigation potential highlights the need for systematic reviews to assess the efficacy of different approaches promoted as ‘sustainable’ or ‘climate smart’. It was beyond the scope of this study to map this literature so we are not able to say anything about the scale of the underlying evidence base. However, reviewing such studies could help identify efficacious practices and technologies to be promoted for take up by farmers. Rosenstock *et al.* (2016) is an example of an ongoing systematic review looking at parts of this literature. There may be others, and any future syntheses should start by taking stock of related ongoing and completed systematic reviews assessing the efficacy of ‘sustainable’ or ‘climate-smart’ technologies and practices.

Figure 7: Evidence gap map of land-use change and forestry programmes



3.4 What are the policy relevant findings of existing high-quality systematic reviews?

In this section, we discuss the findings of seven systematic reviews assessed as either high or medium confidence in findings. Two of these reviews assessed the effect of C/DFM. Samii *et al.* (2014a), a high-confidence review, examines the effect of DFM on environmental and human welfare outcomes. Across eight impact evaluations, the review finds some evidence for modest, positive effects of DFM on deforestation rates. However, due to the small size of the evidence base the authors are unable to rule out a negative effect of DFM on poverty. From their review of the accompanying qualitative DFM literature, the authors highlight issues of institutional capacity, finding some DFM programmes were unable to carry out their mandates of achieving reduced deforestation rates.

Similarly, Bowler *et al.* (2011), a medium-confidence review, assessed the impact of CFM on the environment and human welfare at a local level. Across 42 identified studies, they found that CFM had positive effects on measures of forest condition such as basal area of trees and tree density. They suggested some positive effect on forest cover, although the evidence is more mixed. They did not find evidence of an effect on biodiversity outcomes. There was insufficient evidence to evaluate the effect of CFM on measures of livelihoods of those participating in CFM programmes, such as income and social capital.

One high-confidence review examined effects of terrestrial PA on human wellbeing (Pullin *et al.* 2013). Despite being the most frequently used conservation interventions, the authors find that rigorous impact evaluation evidence remains disparate and fragmented. The existing evidence base is insufficient to draw conclusions about the scale of positive or negative impacts of PAs. Impacts of Pas are highly context dependent and the quality and quantity of rigorous evidence restrict their ability to generalise any policy recommendations. Geldman *et al.* (2013), a medium-confidence review of 118 studies assessing the effect of terrestrial PAs on the maintenance of populations of natural species and prevention habitat loss, found generally positive outcomes, particularly for protection of habitat in tropical forested areas, but concluded that there is insufficient evidence to make policy recommendations about PAs.

Another high-confidence review, Samii *et al.* (2014b), found that PES reduce deforestation, but impacts are modest and inefficient, reducing the annual deforestation rate by 0.21 percentage points on average. Two studies suggested modest improvements in household income. The findings come from 11 studies that evaluate the effects of six different PES programmes in four different countries. The authors concluded the evidence base on the effects of PES programmes is limited in both quantity and quality.

One high-confidence review assessed the evidence base on farmer field schools (Waddington *et al.* 2014). Waddington *et al.* (2014) included 92 impact evaluation studies and 20 qualitative studies, mostly covering farmer field schools promoting

integrated pest management and some promoting integrated crop management or integrated soil management. Farmer field schools may improve farmers' knowledge and adoption of more environmentally friendly practices, such as reduced pesticide use, with increased agricultural production and increased income in some contexts (Waddington *et al.* 2014). The positive effects were observed in small-scale or pilot programmes, and, when delivered at scale, farmer field schools appeared less effective. The authors did not find evidence that neighbouring farmers benefit from diffusion of knowledge from farmer field school participants.

Finally, Lawry *et al.* (2014), a high-confidence review, found that land property rights improved tree crop planting in Ethiopia, Nicaragua and Vietnam (Lawry *et al.* 2014). Agricultural productivity also improved in some contexts, with gains being more limited in Africa than other regions. The evidence suggested an improvement of around 15 per cent on average for human welfare outcomes, as measured by income or consumption.

Among the three systematic reviews that included both social and environmental outcomes within their scope, none found impact evaluations that measured joint effects. Many of these reviews were based on few studies, and/or studies with a high risk of bias. Overall, it is clear that the evidence base is insufficient to make generalisations about policy effectiveness or trade-offs between different options.

4. Conclusions and implications

The AFOLU sector is critical for global efforts to mitigate climate change (Eliasch 2008; Agrawal *et al.* 2011). The resources required for actions in the sector to balance climate change mitigation and food production are substantial. This EGM has mapped the evidence on the effects of a range of commonly implemented programmes. The key policy question motivating this study was whether there are trade-offs or potential synergies between programme effects on environmental and human welfare outcomes, as measured by GHG emissions and food security in particular. The clearest finding from this study is that the existing evidence base addressing this question is limited in both quantity and quality. While we identified a relatively large number of studies, few are designed to assess potential trade-offs between climate change mitigation and food security and poverty reduction. This is an important evidence gap which future studies should address.

For some intervention areas, including PA, PES and C/DFM, this evidence gap can partially be addressed in the short term through systematic reviews. Such reviews will still be limited by the trend for primary studies to focus on either environmental or human welfare outcomes, but by including studies looking at either outcome, reviewers would have data on both types of outcomes from several contexts.

The production of impact evaluations in the AFOLU sector has been limited by a number of factors. First, much climate change mitigation programming is still in the early stages of implementation (Prowse and Snilstveit 2010). Second, the environmental outcomes that programmes in the sector are aiming to address are global public goods and may therefore not incentivise private action; this 'tragedy of

the commons' also affects the environmental evaluation discipline. Third, there is an emphasis on monitoring systems (e.g., measuring, reporting and verification that are underscored in REDD/REDD+ and PES programming) that are built for monitoring programme progress and to some extent biophysical 'additionality'. These efforts are often mistaken as a substitute for evaluations of effects.

Fourth, methodological challenges facing evaluators in other sectors are especially prominent, including a lack of baseline data, long time period between intervention and measurable effects (Chomitz 2008; Ferraro 2009; Hedger *et al.* 2008), challenges and cost of outcome measurement and difficulties identifying an appropriate counterfactual (Chomitz 2008; Hedger

et al. 2008). Finally, there is a lack of funding for research assessing the effects of interventions in the sector, and this does not appear to have changed dramatically in recent years. While a large number of studies are ongoing in other sectors, we only identified 10 ongoing studies (that have published a protocol or registration online) that would meet our inclusion criteria.

Overall, the existing evidence base is too limited to guide decision makers on which interventions are likely to be most effective in reaching emissions reductions targets, while avoiding negative effects on food security and human welfare outcomes. The clearest implication of this study is therefore the need to generate a body of evidence as new initiatives are rolled out. While the evidence base is growing for some programme areas, no programme area has yet to reach saturation. New programmes, including those implemented under REDD+, should be accompanied by high-quality evaluations assessing potential trade-offs between climate change mitigation and human welfare outcomes.

The risks associated with investing in climate change mitigation policies that do not work are too high to ignore the lack of evidence. The resources needed to make a significant contribution to our knowledge about the most effective approaches for climate change mitigation and sustainable development represent only a small fraction of the funding dedicated to programme implementation. Identifying effective strategies for climate change mitigation in the land and forestry sector can help assure that limited resources are spent on effective programmes. To ensure that future global investments in the land-use change and forestry sector is used effectively, there is an urgent need for coordinated effort and funding for new studies that consider both the GHG emissions and human wellbeing outcomes of different land and forestry interventions.

Implications for research

Additional research is needed to better understand the potential trade-offs between climate change mitigation in the AFOLU sector and human welfare outcomes. The EGM suggests a few areas with potential for future synthesis to add value, namely PA, PES, C/DFM and agricultural extension and training. While systematic reviews exist for some of these interventions, they are either out of date and/or have major weaknesses which reduce confidence in their findings.

Reviews of PA, PES and C/DFM, in particular, may be able to assess trade-offs by bringing together the evidence on effects on different types of outcomes (e.g., environmental and human) from different studies of the same programme. To enhance the usefulness of findings, authors should consider mixed-methods systematic reviews, which can also help to identify design, implementation and contextual factors that facilitate effective programmes.

Impact evaluations of climate interventions present challenges for both study design and outcome measurement. The nature of many interventions in the sector may prevent randomisation, or even rigorous quasi-experimental designs. However, opportunities exist and these could be better utilised (Ferraro 2009). Moreover, the examples of both experimental and high-quality quasi-experimental evaluations identified in this study highlight that such studies are feasible.

To enhance the value of new research future studies should be informed by existing high-quality experimental and quasi-experimental studies in the sector (Ferraro and Miranda 2014; Samii *et al.* 2014b). Ferraro and Miranda (2014) find that evaluations that use matching methods andpanel data which includes a data point at baseline are most effective at reducing bias. Studies that combine counterfactual analysis with process evaluation and qualitative research would allow results to better inform future programme design and evaluation (White 2009).

To assess the potential for win–win solutions and identify potential trade-offs, future primary studies should measure effects on both GHG emissions and human welfare outcomes, especially food security and poverty. However, evaluating effects on a range of different outcomes introduces issues of multiple hypothesis testing, increasing the risk of making a type I error (a false positive). This issue is, of course, not limited to studies in the agriculture and forestry sectors. Experimental studies are increasingly testing multiple hypotheses, not just by looking at multiple outcomes, but multiple subgroups and different treatment groups (List *et al.* 2015). There are a range of methods available for addressing this issue by making adjustments in the analysis, and researchers should consult existing reviews to identify suitable approaches (Shaffer *et al.* 1995; Austin *et al.* 2014; List *et al.* 2015).

There is also need for direct measurement of GHG emissions to establish effects and test assumptions about the accuracy of using intermediate outcomes as proxies. We encourage researchers to use validated and common outcome measures across outcomes. This will improve the quality of studies, help make more meaningful comparisons across contexts and increase the potential for future syntheses. Future studies should also assess the equity of effects across different groups of people, such as women, marginalised populations, rural and poor populations. Finally, future studies should address the geographical gaps in the evidence base, targeting countries with high potential for climate change mitigation.

Although impact evaluation in the sector presents challenges, there is also opportunity in addressing these challenges. In particular, there are opportunities to innovate, for example in developing new measurement tools, or to conduct relatively

low-cost studies by using existing data. For example, geographic information data systems with high resolution, open source spatially disaggregated data (the digital elevation map of the world and the soil map of the world by FAO (2016) and LP DAAC (2016) are two examples) can be linked with satellite data, administrative and survey data.

Appendix A: Detailed methods

Developing the scope

We started by setting the scope of the EGM. In doing so we developed a framework of interventions and outcomes which represent the main areas of activity in the sector. This was based on documents and materials from major international initiatives focused on sustainability.

We adapted categories from the IUCN's Classification of Conservation Actions (Salafsky *et al.* 2008) as the base typology for interventions. Where possible, categories were designed to be as discrete as possible to avoid significant overlap. However, some studies involved multiple interventions (e.g., a PA with an ecotourism activity) and were therefore recorded in several categories.

A draft framework was shared for review by a small group of external researchers and policy makers to ensure that major categories of interventions or outcomes were not omitted from the framework and that the terms used to describe categories were clearly defined and aligned with existing terminology.

Inclusion criteria

We included impact evaluations meeting the study design/analysis criteria outlined below.

(a) Randomised controlled trial (RCT);

(b) Regression discontinuity design (RDD);

(c) Controlled before and after study using appropriate methods to control for selection bias and confounding (Propensity score matching (PSM) or other matching methods, Instrumental variable estimation (or other methods using an instrumental variable such as the Heckman Two Step approach), difference-in-differences (DID) or a fixed- or random-effects model with an interaction term between time and intervention for baseline and follow-up observations;

(d) Cross-sectional or panel studies with an intervention and comparison group using methods to control for selection bias and confounding as described above.

(e) Studies explicitly described as systematic reviews and reviews that describe methods used for search, data collection and synthesis as per the protocol for the 3ie database of systematic reviews.

We excluded studies that use simulation or forecast models to estimate business as usual versus future scenarios based upon different reference levels. We also excluded studies evaluating the effects of PAs by comparing the outcome achieved within a PA to that of 'nearby land,' without using any statistical techniques to control for confounding factors (Joppa and Pfaff 2010). Non-comparative studies,

observational studies with no control, theoretical studies, editorials and commentaries were also excluded. Literature reviews, which did not describe methods used for search, data collection and synthesis and systematic reviews of efficacy trials (trials undertaken in clinical or laboratory settings) were also excluded.

Search and screening

We worked with an information specialist to develop a systematic and comprehensive search strategy. The search was conducted in August 2015, with a search update conducted in January 2016. We limited our search to studies dated 2000 and later, broadly corresponding with the period when impact evaluations in the sector started to emerge.

Our search strategy included three types of searches, as outlined below:

1. Publication database searches: we searched CAB Abstracts (Ovid), Greenfile (EBSCO), Econlit (Ovid), Scopus (detailed strategy below).
2. Topical databases and organization searches: Targeted searches of specialist websites and databases were conducted, in particular, of established online repositories of impact evaluations and systematic reviews on related topics to our research question. A list of websites is provided in table below.
3. Bibliographic searches: Several relevant systematic reviews (e.g., Bowler & Pullin 2010; Pullin *et al.* 2013; Samii *et al.* 2014a) and evidence gap maps (e.g., Bottrill 2014; Roe *et al.* 2014) address questions of relevance to our scope and we screened these studies for any studies meeting our inclusion criteria.

Table A1: Topical databases and organisation sources

Database or Organization	Web URL
Poverty and Conservation Learning Group	povertyandconservation.info
International Impact Initiative (3ie)	www.3ieimpact.org
Collaboration for Environmental Evidence	www.environmentalevidence.org
Campbell Collaboration	www.campbellcollaboration.org
J-Poverty Action Lab	www.povertyactionlab.org
World Bank Development Impact Evaluation Initiative	web.worldbank.org
DAI Evidence on Demand	www.evidenceondemand.info
International Food Policy Research Institute Library (IFPRI)	library.ifpri.info/
Center for International Forestry Research (CIFOR)	www.cifor.org/library
World Agrofresty Centre (ICRAF)	outputs.worldagroforestry.org/
Environment for Development	http://www.efdinitiative.org/publications
Agricultural Technology Adoption Initiative (ATAI)	http://www.atai-research.org/
Innovations for Poverty Action (IPA)	http://www.poverty-action.org/project-evaluations

All search results were imported into EPPI reviewer (ADD REF). After the search results were cleaned of duplicates, we first screened records at title and abstract. To ensure consistent application of screening criteria all screeners first assessed the same sample of 100 abstracts. Discrepancies were discussed within the team and inclusion criteria were clarified as necessary. We used the priority-screening function in EPPI Reviewer at the title and abstract screening stage to prioritise the items most likely to be 'includes' based on previously included documents. The goal is for the function to 'learn' the characteristics of included and excluded studies and therefore to be able to pull the most relevant studies to the beginning of the screening process and push the irrelevant ones towards the end. It does this based on key-words in the title and abstract of the included and excluded studies during a training screening based on an unbiased, random set of records. This 'learning' process then continues throughout the priority-screening, with accuracy of the predictions made by the machine improving through increased interaction with the screener decisions.

We screened an initial set of 1500 records to allow us to train the priority-screening function. Due to time restraints, we then screened an additional 9.600 studies prioritised by the tool, screening 11,101 in total at title and abstract.

Because of time and resource constraints we did not do independent double screening at full text. To minimise bias and human error all screeners assessed the same set of studies to before starting screening. As with the title/ abstract stage we discussed any discrepancies. Additionally, we had several 'unclear' categories in our screening tool. Any studies where the first screener was uncertain about inclusion/ exclusion were then screened by a second person.

Data extraction

We used a standardised data extraction form to extract descriptive data from all studies meeting our inclusion criteria. Data extracted from each study included bibliographic details, intervention type, outcome type and definition, study design, geographical location and intervention scale. 3ie is piloting 'Equity-sensitive EGMs' which identify to what extent and how current research practice incorporates equity (Masset and Snilstveit 2016). Thus, we also extracted data on the extent to which the existing evidence incorporates groups considered vulnerable in this context, either because they may have less access to services or because programme benefits may be differently distributed. We considered the following groups:

- Place of residence: location of land, including distinctions such those living upstream (hilly forest areas) from those living downstream (normally richer with better land)
- Race, ethnicity, culture and language: Any targeting or subgroup analysis, including for instance ethnic minority communities living in forest areas
- Gender: female and male farmers/ landowners
- Socioeconomic status: this may be measured in different ways, including grouping results by income level, defining people as poor, etc.

- Land ownership status: land may be owned or rented, and vary in size. Landless and farmers with limited land are typically considered more vulnerable.
- Other vulnerable group: Open category, to be used iteratively to record details of any vulnerable groups identified a-priori.

The PROGRESS-Plus checklist suggests a number of other categories of disadvantage, including religion, social capital, education, disability, sex orientation and age. We did not expect programmes in the sector to use any of these as a targeting criteria. During a preliminary screening of the literature we did not identify any studies assessing differential effects on these groups. Therefore we did not include these groups as separate categories in the data extraction form. We did however keep an open category (other vulnerable groups) where we recorded data on any type of vulnerable group not already explicitly mentioned. The full coding tool is provided in Annex B. We used the 3ie systematic review database protocol for appraisal of systematic reviews (Snilstveit *et al.* 2014).

Visualisation and analysis

We uploaded the data onto 3ie's EGM platform to create a graphical display of the existing evidence in terms of types of studies and the interventions and outcomes assessed in the current literature. We used this to identify 'absolute' evidence gaps (where there are no impact evaluations or systematic reviews) and synthesis gaps (where there are impact evaluations but a lack of high-quality systematic reviews). We provide a narrative description summarising this information in addition to the graphical display.

To allow us to describe the characteristics of the evidence base in more detail we used descriptive statistics to describe the population, interventions, study designs and outcomes covered in the included studies. We also provide a descriptive overview of the main findings of all systematic reviews assessed as high confidence.

Table A2: Data extraction form

	Category	Answer
Descriptive information	ID	Open answer
	Title	Open answer
	Full title	Open answer
	Author citation	Open answer
	Publication date	Open answer
	Maps	Land Use Change and Forestry
	Study design	○ Randomized Controlled Trial (RCT) ○ Difference-in-Differences (DID) ○ Instrumental Variables (IV) ○ Regression Discontinuity Design (RDD)

		○ Propensity Score Matching (PSM) ○ Mixed Methods ○ Other
	Further comments on study design	Open answer
	Regions	○ East Asia and Pacific ○ South Asia ○ Europe ○ CIS ○ Middle East and North Africa ○ Sub-Saharan Africa ○ Latin America and the Caribbean ○ North America
	Countries	See list of countries
Equity Data	How does this study consider equity	○ Assesses impact on a disadvantaged group ○ Intervention aimed at reducing inequality ○ Undertakes subgroup analysis ○ Not applicable
	Dimension of equity/Population group	○ Place of residence ○ Race, ethnicity, culture and language ○ Gender ○ Religion ○ Education ○ Socioeconomic status ○ Social capital ○ Other vulnerable groups ○ Land ownership ○ Age ○ Disability
	Dimension of equity/Population description	Open answer
	Sample size of population subgroup	Open answer
Intervention/ outcome	Category of Intervention	○ Area protection and management ○ Law & Policies related to forests and other land ○ Incentives ○ Training, education and information to promote

		sustainable practices and technology o Infrastructure o Multiple category o Other
	Interventions	o Protected areas o Community/Decentralized Management o Public sector legislation o Private sector codes and legislation o Civil society legislation o Monitoring and enforcement o Payment for environmental services o Certification o Subsidies, grants and concessions o Land rights o Agricultural extension and training o Technical and vocational training o Information services o Road construction o Dams o Multi-component
	Intervention description	Open answer
	Outcomes	o Acquisition of knowledge/skills o Adoption of new practices or technology o Land and forest management o Forest condition o Forest cover o Carbon Storage and Sequestration o GHG emissions o Basic materials o Health o Income and household expenditure o Food security o Productivity
Definitions of Intermediate	Acquisition of knowledge/skills	Open answer

Outcome Measures	Adoption of new practices or technology	Open answer
	Land and forest management	Open answer
Definitions of Environmental Outcome Measures	Forest condition	Open answer
	Forest cover	Open answer
	Carbon Storage and Sequestration	Open answer
	GHG emissions	Open answer
Definitions of Human Welfare Outcome Measures	Basic materials	Open answer
	Health	Open answer
	Income and household expenditure	Open answer
	Food security	Open answer
	Intervention scale (local, regional, national, global)	○ Local/Regional ○ National ○ Global ○ Not Known
	Land Type Description (e.g. Forest, Agroforest, Cropland etc.)	
	Link	
	On 3ie database?	Yes/No

Appendix B: Detailed search strategy

Sample search strategy - CAB abstracts

1 (REDD+ or REDD or "Reduced Emissions from Deforestation and Degradation" or FLEGT or CITES or "forest code*" or FSC or "Forest Stewardship Council" or JFM or ((joint or sustainab* or community or participatory or decentrali*) adj2 (forest adjmanag*)) or SFM or "community forestry" or "community agroforestry" or CBFM or CBNRM or "community-based natural resource manag*" or easement* or "conservation agreement*" or "national park*" or conservanc* or "biosphere reserve*" or "nature reserve*" or "natural resource*" or "conservation area*" or "protected area*" or (payment* adj "environmental services") or (payment* adj "ecosystem services") or PES or Grain-for-green).ti,xc,hw. (46591).

2 ((agricultur* or farm* or land or forest* or agro-forest* or agroforest* or rainforest* or rain-forest* or ("natural resource*" adjmanag*)) and (subsidy or subsidies or subsidis* or subsidiz* or voucher* or "co-payment*" or copayment* or reimburs* or "tariff removal" or "tax exempt*" or "tax relief" or "social franchis*" or "price ceiling*" or "price control*" or "social marketing" or ("demand side" adjfinanc*) or "price support*" or concession*)).ti,ab,xc,hw. (14348).

3 (land adj3 (tenure or right* or conversion or freehold* or titl* or codification or recognition or customary or certification)).ti,ab,xc,hw. (9017)

4 ("fair trade" or fairtrade or fair-trade or transfair or "fair for life" or "Rainforest Alliance" or "Sustainable Agriculture Network" or "UTZ Certified" or "UTZ" or "Global Partnership for Good Agricultural Practice" or "Global GAP" or "GlobalGAP" or "4C Association" or "Better Cotton Initiative" or BCI or "Cotton made in Africa" or Bonsucro or "Ethical Tea Partnership" or Trustea or "International Federation of Organic Agriculture Movements" or IFOAM or "soil association" or IOAS or LEAF or "Linking Environment and Farming" or "Union for Ethical BioTrade" or UEBT or "Roundtable on Sustainable Palm Oil" or RSPO or ((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 scheme* or trad* or market*))).ti,xc,hw. (132045)

5 ("farmer field school*" or "agricultural advisory service*" or "training and visit*" or extension or ((agricultur* or crop or crops) adj (knowledge or information or outreach or training or education)) or "in-service training" or "vocational training" or "technical training" or "mobile phone*" or ICT or "information campaign" or "information dissemination").ti,ab,xc,hw. (57850).

6 (road* or dam or dams or reservoir* or hydropower or hydroelectric* or irrigation).ti,xc,hw. (122145).

7 (reserve or policy or policies or incentive* or regulat* or agreement* or contract* or moratori* or standard or legislati* or contract or payment or strategy* or plan or program* or subsid* or tax or penalt* or "capacity building" or "capacity-building" or

"technology transfer" or (skill* adj3 (develop* or train*)) or education).ti,xc,hw. (499118).

8 ((reserve or policy or policies or incentive* or regulat* or agreement* or contract* or moratori* or standard or legislati* or contract or payment or strategy* or plan or program* or subsid* or tax or penalt* or "capacity building" or "capacity-building" or "technology transfer" or (skill* adj3 (develop* or train*)) or education) adj3 (afforest* or reforest* or restor* or "natural regenerat*" or forest* or rainforest* or rain-forest* or agroforest* or agro-forest* or "natural resource*" or biofuel* or silvopastor* or "land use" or "land cover" or "land-cover" or "land-use" or (sustainable adj3 (agricultur* or livestock or "forest management" or "land management" or technology)) or agroforestry or aquaculture or fishpond* or fish-pond* or "fish pond*" or "fish technolog*" or conservation or "environmental protection" or "watershed management" or organic or "integrated pest management" or "integrated nutrient management" or "integrated production and pest management" or "integrated crop management" or "soil conservation" or "soil and crop improvement" or "conservation agriculture" or "conservation farm*" or "pest management" or irrigation or fertiliser* or manure or "organic farming" or "soil conservation" or tillage or biofortification or "Fertilizer Nutrient Management" or "conservation agriculture" or silvicultur* or "eco-agriculture" or "eco-agriculture" or "climate smart landscap*" or "climate smart")).ti,xc,hw. (15513).

9 (afforest* or reforest* or restor* or "natural regenerat*" or forest* or rainforest* or rain-forest* or agroforest* or agro-forest* or "natural resource*" or biofuel* or silvopastor* or "land use" or "land cover" or "land-cover" or "land-use" or (sustainable adj3 (agricultur* or livestock or "forest management" or "land management" or technology)) or agroforestry or aquaculture or fishpond* or fish-pond* or "fish pond*" or "fish technolog*" or conservation or "environmental protection" or "watershed management" or organic or "integrated pest management" or "integrated nutrient management" or "integrated production and pest management" or "integrated crop management" or "soil conservation" or "soil and crop improvement" or "conservation agriculture" or "conservation farm*" or "pest management" or irrigation or fertiliser* or manure or "organic farming" or "soil conservation" or tillage or biofortification or "Fertilizer Nutrient Management" or "conservation agriculture" or silvicultur* or "eco-agriculture" or "eco-agriculture" or "climate smart landscap*" or "climate smart").ti,xc,hw. (896113).

10 ("quasi experiment*" or quasi-experiment* or "random* control* trial*" or "random* trial*" or RCT or matching or "propensity score" or PSM or "regression discontinuity design" or "discontinuous design" or RDD or "difference in difference*" or difference-in-difference* or "diff in diff" or DID or "interrupted time series" or "random* allocation*" or "systematic literature review" or "Systematic review" or "Meta-analy*" or Metaanaly* or "meta analy*" or "Control* evaluation" or "Control treatment" or (random* adj3 allocat*) or "instrumental variable*" or heckman or IV or evaluation or assessment or ((quantitative or "comparison group*" or counterfactual or "counter

factual" or counter-factual or experiment*) adj3 (design or study or analysis)) or QED).ti,ab,hw. (1085740)

11 1 and 9 and 10 (6336)

12 2 and 9 (5224)

13 3 and 9 (5137)

14 5 and 9 (11519)

15 6 and 9 and 10 (19026)

16 8 and 10 (2489)

17 11 or 12 or 13 or 14 or 15 or 16 (47257)

18 limit 17 to (english language and yr="1995 -Current") (34627)

19 limit 17 to (english language and yr="2000 -Current") (29704)

20 11 or 12 or 13 or 14 or 16 (29079)

21 limit 20 to (english language and yr="2000 -Current") (18385) – Main result without infrastructure

22 limit 15 to (english language and yr="2000 -Current") (11881) – Infrastructure only

Appendix C: Included studies

Included studies: Impact evaluations

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