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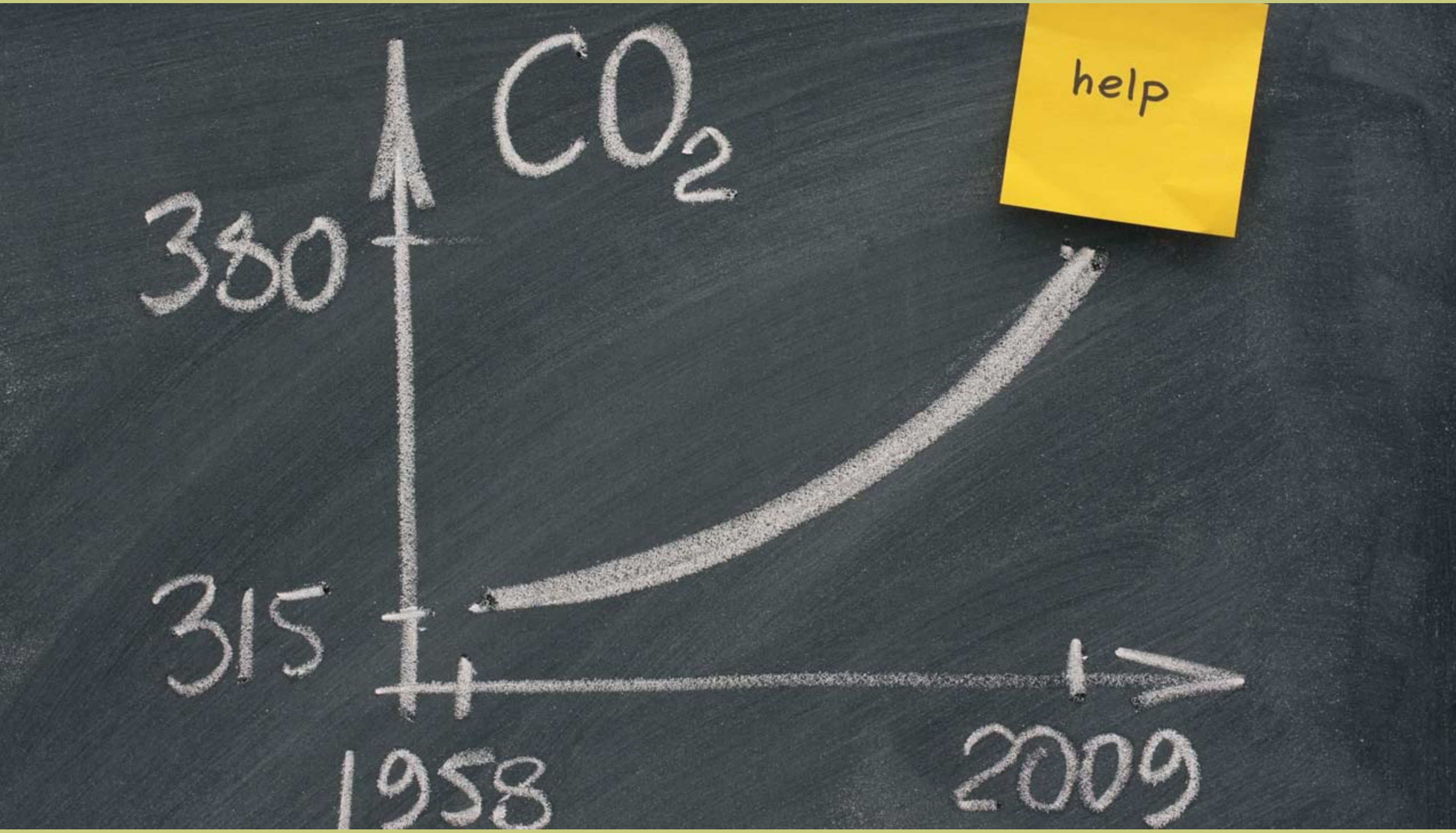

Impact Evaluation and Interventions to Address Climate Change: A scoping study

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Foreword

Substantial and increasing amounts of money are available for countries to undertake climate change interventions. This paper argues that to ensure effective allocation of these resources, the selection and design of climate change mitigation and adaptation interventions should be based on evidence of what works, what doesn't work, under what circumstances and at what cost. Currently the evidence base on the impact of climate change interventions is almost non-existent and there is a need for wider application of rigorous impact evaluation in the field. Climate change interventions have much to learn from experiences in related fields, notably international development and conservation. The paper highlights some of the challenges faced when conducting impact evaluations of climate change interventions and discuss how these can be tackled. It argues that despite the limited experience so far there are ample opportunities to conduct impact evaluation of climate change interventions. Increased financing of climate change interventions is urgently needed to mitigate global warming and enable countries and communities to adapt to its impact. However, if calls for increasing financing of climate change mitigation and adaptation by hundreds of billions of dollars a year are to remain credible and gain support, evidence of the effectiveness of current spending is essential. Donors will likely remain hesitant to provide additional funding unless it is clear that interventions are reaching their environmental and developmental objectives.

Howard White
Executive Director
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Acronyms

CDM	Clean Development Mechanism
FAO	Food and Agriculture Organization
GDN	Global Development Network
GEF	Global Environment Facility
GHG	Greenhouse gas
HFC-23	Fluoroform
IBRD	International Bank for Reconstruction and Development
IDA	International Development Association
IDS	Institute for Development Studies
IE	Impact evaluation
IEG	Independent Evaluation Group
IETA	Internationa Emissions Trading Association
IIED	International Institute for Environment and Development
IPCC	Intergovernmental Panel on Climate Change
LDCF	Least Developed Countries Fund
LULUCF	Land use, land-use change and forestry
MDBs	Multilateral development banks
NASFAM	National Smallholder Farmer's Association of Malawi
NGO	Nongovernmental Organisation
ODA	Official Development Assistance
OECD	Organisation for Economic Co-Operation and Development
ORCHID	Opportunities and Risks of Climate Change and Disasters
PRA	Participatory rural appraisal
PES	Payment for environmental services
RCT	Randomised controlled trial
REDD	Reduced Emissions from Deforestation and Degradation
SCC	Social cost of carbon
SCCF	Special Climate Change Fund
SPA	Strategic Priority on Adaptation
TBIE	Theory based impact evaluation
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

1. Introduction and background to study

Climate change is a major challenge and has been at the top of the international policy agenda for a number of years. While differences in interests and negotiating positions makes the ongoing international negotiations challenging, there is broad agreement on the need for a new global climate change treaty. This widespread acknowledgement of the need to take action on climate change has been triggered by the accumulation of evidence on the causes and likely consequences of climate change. However, while there is a substantial evidence base on the science of climate change, what do we know about the effectiveness of policies and interventions designed for mitigation and adaptation? Calls for better development effectiveness and more evidence-based policy have led to increased interest and resources for rigorous impact evaluation (IE). While there has been growth in the literature analysing the impacts of climate change (see for instance Dell et al., 2009; Guiteras, 2009), much less work has been done to assess the effectiveness of interventions designed to deal with its causes and consequences. So far few rigorous impact evaluations of climate change mitigation and adaptation interventions have been undertaken and the evidence to guide policymakers in the allocation of resources is lacking.

Substantial and increasing amounts of money are available for countries to undertake climate change interventions. This paper argues that to ensure effective allocation of these resources, the selection and design of climate change mitigation and adaptation interventions should be based on evidence of what works, what doesn't work, under what circumstances and at what cost. In doing so the paper attempts to be of relevance to climate change professionals on the one hand, and impact evaluators on the other. As the applicability of IE techniques to climate change interventions has not been widely considered, the paper does not purport to be comprehensive or exhaustive. Instead, it sketches out the terrain on which future studies might build.

The following three sections of the paper provide an extended introduction to climate change and sources of funding for interventions, and may therefore already be familiar to those in the field of climate change. Section 2 summarises current thinking on the science of climate change and its physical impacts. Section 3 provides a background on what is meant by climate change adaptation and mitigation and highlights the sectors most relevant for these interventions. Section 4 provides a brief overview of the main financial resources available through the United Nations Framework Convention on Climate Change (UNFCCC) and other multilateral and bilateral sources. The remaining sections discuss impact evaluation in relation to climate change interventions. Section 5 provides a brief introduction to IE, before looking at how it has been applied to climate change and related environmental interventions in developing countries to date, followed by a discussion of the limits and opportunities to applying rigorous IE to climate change interventions. The sixth and seventh sections focus on some of the key areas relevant for adaptation and mitigation interventions, respectively, and suggest ways in which IEs could be implemented, using evaluations in other policy fields as examples. The final section concludes.

2. Physical and human impacts of climate change

Climate change is shorthand for anthropogenic global warming, caused by higher concentrations of greenhouse gases, especially carbon dioxide from the combustion of fossil fuels, in the atmosphere. These gases insulate and warm the earth by preventing radiation from escaping into space. The evidence that the earth's climate is warming is overwhelming. Nine of the ten warmest years on record occurred between 1995 and 2004 (van Aalst, 2006). Such increases in temperature are having a profound effect on environmental systems, increasing sea levels, thawing glaciers and permafrost, and changing the spatial distribution of plant and animal species (and their reproductive cycles).

In addition to the impact on environmental systems, climate change has become one of the most pressing international development issues. Anthropogenic global warming threatens, *inter alia*, to radically alter crop yields and the area of arable land and to increase the frequency and severity of natural hazards in the poorest and least developed countries in sub-Saharan Africa and Asia.[1] A recent Human Development Report thus states that climate change is "the defining human development issue of our generation" (UNDP, 2007). These sentiments were recently echoed by the President of the World Bank, Robert Zoellick, who argues: "Climate change is a development, economic, and investment challenge, not just an environmental issue. . . . Addressing climate change is a critical pillar of the development agenda" (World Bank, 2008a: 1). Climate change is also the theme for the 2010 World Development Report, 'Development in a Changing Climate' (World Bank, 2009e). The remainder of this section discusses the consequences of climate change for developing countries.[2]

Changing temperatures are likely to lead to changes in the global pattern of agricultural production (FAO, 2008). For instance, small increases in temperature are expected to contribute to an aggregate decrease of 9 per cent in potential

[1] Further physical impacts include: Seas and Oceans: increased salinity of oceans; sea temperature rises affecting fish stock locations.
Health: weather-related mortality; infectious diseases; air-quality respiratory illnesses.
Water resources: water supply; water quality; competition for water.
Coastal areas: erosion of beaches; inundation of coastal areas; additional costs to protect.
Sources: FAO (2007); Scott (2007).
[2] See also Prowse and Braunholtz-Speight (2007) for an overview.

agricultural land in sub-Saharan Africa by the 2080s. By 2050 it is expected that cereal yields will decline by up to 18 per cent, while the decline of maize yields is estimated to be up to 10 per cent (Cline, 2007; Fischer *et al.*, 2002). However, while the projections indicate that climate change will have a negative impact on agricultural production in tropical zones, models project greater agricultural productivity in temperate regions of the northern hemisphere (through longer and more intense growing seasons), thus suggesting that trade in staple food crops between the temperate north and tropical south might increase (Ludi *et al.*, 2007).

A recent report from the FAO suggests the implications of changing production patterns for food security are twofold (FAO, 2008). Firstly, low income countries with limited financial resources and ability to trade might be unable to substitute declining domestic food production without having to depend on food aid. Secondly, people's livelihoods and access to food will be affected, with serious implications for the security and welfare of the large share of people in developing countries who depend on agriculture for their livelihood. If such scenarios do unfold, these changing patterns of food production pose a serious challenge to the future food security of the poorest. One estimate suggests that by 2080 an additional 600 million people could be at risk of hunger if global temperatures increase by over three degrees Celsius from 1990 levels (Warren *et al.*, 2006).

In the short term it is projected that episodes of heavy rainfall and drought are likely to become more frequent and severe, though prediction of these events will remain difficult. According to the Intergovernmental Panel on Climate Change (IPCC) it is 'likely' (> 66% probability) that there has been an increasing trend in such events in the latter half of the 20th Century and 'very likely' (> 90% probability of occurrence) that the frequency and severity of such natural hazards will increase in the mid to late 21st Century.[3]

Developing countries are most vulnerable to natural hazards. Vulnerability has two components: exposure to risk, and ability to cope with shocks. The tropical location of many developing countries makes them more exposed and developing countries often lack the capacity to cope with such extreme events. This is clearly seen in the recent history of hazards and disasters. Between 1970 and 1985 over 97 per cent of all the world's major disasters triggered by natural hazards and 99 per cent of all disaster-related deaths occurred in the developing world (Abbott, 1991). More recent evidence suggests countries in sub-Saharan Africa and countries recovering from conflict are the most vulnerable to future droughts and floods (Brooks *et al.,* 2005). An analysis of data on natural disasters in 73 countries for the period between 1980 and 2000 found that while poorer nations do not experience more natural disasters they suffer a higher

[3] See http://www.ipcc-wg2.org/

number of deaths per disaster (Kahn, 2005). Additionally, a recent paper analysing the relationship between climate shocks and economic growth found that increasing temperatures reduced economic growth, but only in poor countries (Dell et al., 2009).

The major impacts of rising sea levels are projected to be experienced in areas of Asia. Although the range of estimates for sea level rise varies widely, Dasgupta *et al.* (2007) suggest that the greatest impacts will be felt in Asia and the Pacific, followed by the Middle East and North Africa. Such findings are supported by Nicholls *et al.* (2007) in their study of port cities at risk from sea level rise. They find that Asian cities, such as Calcutta, Mumbai, Dhaka, Guangzhou, Ho Chi Minh City, Shanghai, Bangkok and Rangoon have the greatest number of people at risk of coastal flooding. If temperatures increase by 3 or 4 degrees Celsius it is predicted that rising sea levels will lead additional annual flooding affecting tens to hundreds of millions of people (Stern, 2007).

Whether we look at the projected impacts of climate change on crop yields, areas of arable land, natural hazards, or sea-level rise, it is clear that consequences of climate change will be distributed unequally, affecting the poorest countries disproportionately. Developing countries and poor people living within them are more likely to rely on natural resources and economic sectors that are vulnerable to climate change, such as agriculture, fisheries and forestry (Reid and Swiderska, 2008). Moreover, climate change related natural disasters are likely to have the largest impact on the poorest people, with subgroups among the poor, such as women, the elderly, ethnic minorities being particularly vulnerable. Ibarrarán *et al.* (2009) argue that while the occurrence of extreme natural events are determined by natural processes, the impact on people and societies is mediated by existing structures and human activities. They conclude that, as poor people are more vulnerable to natural disasters, “climate change has the potential to create a vicious cycle of poverty and vulnerability” (Ibarrarán *et al.*, 2009, p. 563).

Despite rapid urbanisation in Latin America and the Caribbean, and parts of Asia, absolute poverty remains a resolutely rural phenomenon. The vast majority of the rural poor are reliant on agriculture, or agriculturally-derived incomes, for their livelihood. For example, the World Bank (2009e) states that around 85 per cent of rural people (which equates to around 2.5 billion people) depend on agriculture either directly or indirectly. Due to the severe threat posed to agriculture in the poorest countries, especially in marginal locations, climate change poses a direct threat to livelihoods, food security and health for a large number of poor people (Reid and Swiderska, 2008).

Furthermore, poor people may be more likely to reside in areas that are more exposed to the impacts of climate change, such as flood plains and areas affected by landslides (Reid and Swiderska, 2008). Buttenheim (2006) shows how those suffering from the 1998 floods in Bangladesh were disproportionately poor. Many of the rural poor live in peripheral locations, which tend to be far from the centres of economic and political activity, in terms of both time and distance. They also generally have poor natural resource endowments: poor-quality agricultural potential or natural resources limit income-earning opportunities. Additionally, they are generally not well-connected in terms of physical, communication and market infrastructure (Bird and Higgins, 2007).

In sum, the risks from climate change are greatest for the poorest countries – in South Asia and sub-Saharan Africa[4] – and for the poorest sections of societies. Poor people and countries tend to rely more on natural resources and have less resources and capacity to draw on when faced with an unpredictable and changing climate (Christoplos et *al.*, 2009; Reid and Swiderska, 2008).

As Huq and Ayers (2007) note, the countries which face the greatest dangers from the physical impacts of climate change have contributed least to greenhouse gas emissions. There is a profound sense of injustice if the poorest are forced to suffer most from the physical impacts of climate change (see Paavola and Adger, 2006; Thomas and Twyman, 2005). There is thus both a moral as well as an economic case for global interventions to finance climate change interventions in developing countries, and a need for rigorous IE to ensure optimal use of those funds.

3. Climate change mitigation and adaptation

Climate change interventions are often divided into two broad categories: mitigation and adaptation. Mitigation interventions are designed to tackle the causes of climate change, while adaptation refers to interventions designed to assist people and countries to tackle the effects of climate change.[5] This section will provide a brief discussion of these two broad categories of interventions, with reference to developing countries.

[4] As of 2004, the greatest numbers of poor people were found in South Asia, totalling some 450 million people, mainly in India, while the greatest incidence of poverty was found in sub-Saharan Africa, where 47.2% (300 million) of the population was estimated to be in absolute poverty (Chen and Ravallion, 2007).
[5] In practice there will be some overlaps between these two types of interventions, notably in sectors like agriculture and forestry (Dodman et al., 2009). As the expected outcomes of mitigation and adaptation interventions are different it makes sense to order a discussion on impact evaluation of climate change interventions accordingly.

3.1. Mitigation

Climate change *mitigation* refers to policies that tackle the causes of climate change, through reducing green house gas (GHG) emissions and preserving/expanding carbon sinks.[6] Because of the large number of human activities that contribute to GHG emissions, interventions to mitigate climate change will have to be implemented across a range of sectors, such as agriculture, energy, transport, industrial production, waste management, technology research and development, and forestry (UNFCCC, 2008b). Barker *et al.* (2007) estimate that in 2004 the most important sources of GHG emissions were energy supply (26%), industry (19%) and forestry (17%). In addition, current GHG emissions from agriculture are estimated at around 14 per cent, with high emission increases expected for the future (UNFCCC, 2009b).

In contrast to previous decades where developed countries emitted the vast bulk of carbon emissions, in future decades developing countries may account for a substantial share of total carbon emissions. Due to the global shift in manufacturing and rapid industrialisation to parts of Asia, the majority of energy-intensive industry is now based in developing countries. For instance, in 2003 around 55 per cent of nitrogen fertiliser production, 78 per cent of global cement manufacture, and half of global aluminium production came from the developing world (Barker *et al.*, 2007). Developing countries now account for a greater proportion of final energy use by industry than the developed world, and this proportion is set to increase (Barker *et al.*, 2007).

Concomitant with structural change and industrialisation in some parts of Asia have been higher incomes, increased mobility, and greater use of motorised transport. Transport energy use in the developing world is projected to increase by 3 to 5 per cent per year in the coming decades, bringing its share of total energy use on a par with the developed world by around 2030 (Barker *et al.*, 2007).

Funding and implementation of mitigation activities have been more widespread than adaptation. A large proportion of mitigation activities have so far been focused in the energy and transport sectors (World Bank, 2009d). Mitigation options for energy supply and industry include energy efficiency measures, fuel switching, the use of renewable energy and bio-fuels (IIED, 2007). For transport, mitigation options are relatively limited because of dependence on oil as a fuel, although possibilities for motorised transport include the use of bio-fuels, fuel-cell vehicles, and hydrogen power. Agriculture is another sector

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[6] The UNFCCC defines a sink as ‘any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere’ (United Nations, 1992, p. 4). Examples of sinks include the forests, ocean, peat, permafrost and soil (IETA, n.d). Sinks can be preserved or enhanced to increase their role in reducing GHG emissions to the atmosphere.

receiving increased attention for its potential to mitigate climate change through carbon sequestration, reducing GHG emissions and reducing its role as a driver of environmental degradation through deforestation and biodiversity loss (de Boer, 2009; Muller, 2009; World Bank, 2009d)

In addition to reducing carbon emissions, climate change mitigation can also take the form of preserving and expanding carbon sinks such as forests. Global forest cover equates to around 30 per cent of global land area, but is shrinking rapidly due to the pressures of agriculture, infrastructure and urbanisation. Such carbon sinks can be preserved and expanded, not only through increasing forest areas, but increasing the carbon density of such locations (Barker *et al.*, 2007).

In common with adaptation, many mitigation interventions share similarities with development activities. Examples include the introduction of new technologies, sustainable agriculture, bio-fuel production and payment for environmental services (PES), all of which it is hoped can provide new sources of income in addition to reducing GHGs.

3.2. Adaptation

The science suggests the climate is already changing and that some further changes in the future are likely to be unavoidable (Rosenzweig *et al.*, 2007). Consequently, adaptation has received increased attention in both international policy debates and in the academic literature on climate change (see for instance Adger *et al.*, 2007; Huq and Reid, 2004; McGray *et al.*, 2006; Parry *et al.*, 2007; Smit and Wandel, 2006). As Smit and Wandel (2006) note, while there are countless definitions of adaptation in the conceptual literature, most definitions refer to a common theme, namely the adjustment of individual groups, systems and institutions to a changing climate, including an increase in external shocks, in order to reduce vulnerability and thus improve the capacity to cope with and reduce the negative impacts of climate change. For instance, the IPCC (2001, p. 982) defines adaptation as*:* "Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities."

There is an extensive literature focusing on conceptualising different types of adaptation. For example, distinctions are made between *ex ante* (anticipatory) or *ex post* (reactive) adaptation, and *planned* and *autonomous* adaptation (Mitchell and Tanner, 2007). However, the purpose of this paper is to discuss practical aspects of interventions and not to go into detail on the conceptual debate; readers are advised to consult the wider literature for further discussions on this.

While initial attempts at adaptation appear to have been planned using large-scale modelling to inform policy choices, more recently the approach appears to be shifting towards community-based approaches which place greater emphasis on existing risk coping strategies of communities and individuals (Huq and Reid, 2007). Calls for increasing the focus on autonomous adaptation is echoed by a recent paper (Christoplos, *et al.*, 2009) which argues "approaches to adaptation must be turned upside down to focus on local adaptation strategies as the point of departure for engagement" (p. 31).

So far adaptation has received relatively little funding (see section 4) and Burton *et al.* (2006) describe the international adaptation effort as "more an irregularly funded patchwork of multilateral and bilateral initiatives than a fully conceived and functioning regime" (p. 13). The low level of funding for adaptation is arguably one of the main reasons for the relatively small number of adaptation activities implemented to date. Moreover, the adaptation activities that have been undertaken have mainly focused on preparing for adaptation through capacity building and assessments of vulnerability and options for adaptation (Burton *et al.*, 2006; GEF, 2007b).

While there is still a lack of knowledge of climate data and data processing skills the GEF suggests "all countries, including [least developed countries] have enough information to start implementing adaptation actions" (GEF, 2007b, p. 7). Hence, there are signs of a slow move towards actual implementation of adaptation activities on the ground and a number of GEF funded projects are now underway, focusing on enhancing food security, access to water, public health and coastal infrastructure (GEF, 2007b).[7] Other examples of current or suggested adaptation activities include crop and livelihood diversification, seasonal climate forecasting, community-based disaster risk reduction, famine early warning systems, insurance, natural resource management, water storage and supplementary irrigation (Adger *et al.*, 2007; Hedger *et al.*, 2008; Huq and Reid, 2004; World Bank, 2009d).

A recent review study identified and gathered data on 135 activities labelled adaptation (McGray *et al.*, 2007). The results suggest the majority of interventions were implemented in rural areas, at the village or community level, with few national level interventions being identified. In terms of sectoral distribution, the review found that agriculture and disaster risk management dominate, followed by water resources management and coastal resources, with very few interventions undertaken in the human health and energy sectors.

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[7] Examples of specific adaptation interventions in the GEF portfolio include sustainable management of water resources in Argentina, market-led small holder development in Mozambique, adaptation using agro-biodiversity in Yemen, participatory coastal zone restoration in Sri Lanka, and piloting of community-based adaptation in ten different countries (GEF, 2007b).

White (2009c) argues that the distinction between ‘environment’ and ‘development’ is rather artificial. This is especially the case with adaptation interventions.[8] There are increasingly calls for including adaptation in the mainstream of development efforts (OECD, 2006). In terms of the strategies used and being considered for adaptation interventions, there is much in common with the methods used in the development field. Examples of this overlap and potential for using strategies from the ‘development toolbox’ include calls for the use of microfinance services (Hamhill *et al.*, 2008), social protection (Commission on Climate Change and Development, 2009; Oswald, 2009) and agricultural extension services (Commission on Climate Change and Development, 2009) to assist poor people adapt to climate change. For instance, Oswald (2009) argues social protection in the form of weather indexed crop insurance, asset restocking and cash transfers should be considered, while the Commission on Climate Change and Development (2009) suggests the use of social protection mechanisms like cash transfers.

Furthermore, the close links between the policy fields of climate change adaptation, development and disaster risk reduction are also increasingly recognised (Commission on Climate Change and Development, 2009; O’Brien et al., 2008; Thomalla et al., 2006; ISDR, 2009a; Yamin et al., 2005). For instance, the recent Global Report on Disaster Risk Reduction (ISDR, 2009a) suggests the current lack of integration between the policy fields of adaptation, disaster risk reduction and poverty reduction “is the missing link that is holding back progress in addressing the disaster risk-poverty nexus in the context of climate change” (p. 15). These policy, practitioner and academic communities have long operated in isolation, but it is clear that there are a range of overlaps between the activities and concerns dealt with in these fields. This is highlighted by the report of the Commission on Climate Change and Development (2009), which argues that in poor countries adaptation is inseparable from development, as assets, health, education and governance are key components of adaptive capacity, and further, that risk management is an important determinant of progress. While risk factors and longstanding development challenges such as chronic poverty, HIV/AIDS, lack of market access and social safety nets cannot be attributed to climate change, dealing with these underlying drivers of risk are essential to both disaster risk reduction and climate change adaptation (ISDR, 2009a).

[8] The methodological overlap between adaptation and development activities is confirmed by the adaptation strategies identified in two reviews (Hedger et al., 2008; McGray et al., 2007). McGray et al. (2007) identify 12 different strategies in their data set, but climate change awareness is the only activity unique to adaptation. Thus they suggest “if there are uniquely ‘adaptive’ elements to these efforts, they are those involved in defining problems, selecting strategies, and setting priorities, not in implementing solutions” (p. 15).

4. Financing of climate change interventions [9]

Adaptation and mitigation interventions require substantial financial resources. Indeed, both the UNFCCC (United Nations, 1992) and the Kyoto Protocol (United Nations, 1998) acknowledge adequate financial flows and investments as an important component of a successful global strategy for climate change mitigation and adaptation. Strengthening efforts on finance and investments in support of climate change mitigation, adaptation and technology transfer is one of the four key issues of the Bali Action Plan, which is guiding the current negotiations for a new global treaty on climate change (UNFCCC, 2008a). Recognising the 'common but differentiated responsibilities' of the Parties, the UNFCCC and the Kyoto Protocol commit Developed Country Parties (Annex II)[10] to provide new and additional funding to support Developing Country Parties in their efforts to mitigate and adapt to climate change (United Nations 1992; United Nations 1998). In addition to the financial mechanisms designated for this purpose under the UNFCCC and the Kyoto Protocol, provisions are also made for Annex II countries to distribute financial resources through other bilateral, regional and multilateral channels (United Nations, 1998, Article 11, paragraph 3).

As climate change has moved up the policy agenda the sources of finance directed at climate change interventions have multiplied into a mixture of bilateral and multilateral funding initiatives. In 2007 alone, 14 new climate change related financing initiatives were announced (Porter *et al.*, 2008). Financial resources now come from a range of sources, including national government spending, national private sector spending, foreign direct investment, international lending, official development assistance (ODA), carbon markets and the financial mechanisms of the Convention (Porter *et al.*, 2008; UNFCCC, 2008c).

The proliferation of new financing initiatives has raised concerns over the lack of a coherent global financial architecture to avoid duplication of efforts and inefficient allocation of resources. The extent to which new funds are actually additional funding and not merely a re-branding of existing ODA is also a key

[9] Note on the currency amounts quoted in this section: UNFCCC (2007a), UNFCCC (2008), UNDP (2007) are quoted in 2005 US$; Carbon Finance (2009) appears to be quoted in December 2008 US$; GEF (2007a) appears to be quoted in 2006-07 US$; Porter (2008) appears to be quoted in April 2008 US$; World Bank (2009a) is in 2008 US$.

[10] The UNFCCC divides parties to the Convention into three groupings, depending on their commitments under the Convention. Annex I parties include industrialised countries who were members of OECD in 1992 and economies in transition, such as Russia and the Baltic states. Annex II parties are the Annex I states that are members of OECD and these countries are obliged to provide financial assistance to support developing countries to undertake climate change mitigation and adaptation interventions, in addition to promoting the development and transfer of environmentally friendly technologies to developing and transition economies. The last group is Non-Annex I parties and it largely includes developing countries (UNFCCC, n.d).

concern.[11] It remains difficult to provide an exact estimate of funding required for the future, but a 2007 report from the UNFCCC suggested around $200-210 billion in annual global investment will be needed for mitigation by 2030, while the 2007/2008 Human Development Report suggests $86 billion will be needed for adaptation by 2015 (UNDP, 2007). The shortfall in current funding is enormous. However, the current negotiating text for a new global treaty on climate change (UNFCCC, 2009a) includes a number of proposals for increased funding and it seems likely that financial flows for mitigation and adaptation will increase substantially in the future. High quality impact evaluations are essential to ensure these funds are allocated effectively and efficiently. Table 1 below provides an overview of international sources of funding for climate change mitigation and adaptation activities in developing countries.[12]

Table 1 - International funding sources for climate change mitigation and adaptation activities in developing countries (not including FDI)

Funding source	Period	Amount (US$)
GEF Trust Fund	June 2005-July 2007	432 million
Least Developed Countries Fund (managed by GEF)	2002-2008	172 million
Special Climate Change Fund (managed by GEF)	2002-2008	90 million
Adaptation Fund	Estimated available funding at the end of 2008	90 million
	Estimated available funding for 2008-2012	400 million – 1.5 billion
Clean Development Mechanism	Value of transactions in 2008	6.5 billion
World Bank funding for renewable energy and energy efficiency	2008	>2.6 billion
Carbon Finance Unit (managed by World Bank)	Value of carbon offset portfolio at the end of 2008 (value of emissions purchase agreements at the end of 2008)	2.3 billion (1.8 billion)
Total funding from six new multilateral funds[13]	2008-2012	<2 billion

[11] Levina (2007) conducts an analysis of existing ODA flows reported in the OECD Creditor Reporting System (CRS) database. Assuming that activities in a wide range of sectors, including education, health, water resource management, governance, agriculture, infrastructure and energy are potentially relevant to adaptation, she suggests the share of ODA funding relevant to adaptation and adaptive capacity is more than 60 per cent. However, this includes both activities that contribute to climate change and activities that are vulnerable to climate change.

[12] According to a major review on financial flows to address climate change for the year 2000 (UNFCCC, 2007a) the major share of funding addressing climate change comes from domestic funds (60%), followed by 22 per cent from FDI and 18 per cent from foreign debt. The estimated ODA of US$ 16 billion is too small to show up in the overall distribution of the total of US$ 7,750 billion invested.

[13] The World Bank Forest Carbon Partnership Fund (FCPF), the GEF Tropical Forest Account (TFA), the World Bank Clean Technology Fund (CTF), the GEF-IFC Earth Fund, the World Bank Strategic Climate Fund (SCF) and Pilot Program for Climate Resilience (PPCR), the Kyoto Protocol Adaptation Fund (Porter et al., 2008)

Funding source	Period	Amount (US$)
Bilateral contributions to mitigation from Annex II countries	2001-2003	1.4 billion
Bilateral contributions to adaptation from Annex II countries	2001-2003	345 million
Total funding from recent bilateral initiatives[14]	Estimated total annual contribution up until end of commitment period in 2012	3 billion

Sources: Carbon Finance 2009; GEF 2007a; Porter *et al.*, 2008; UNFCCC 2007; UNFCCC 2008c; World Bank 2009a; World Bank 2009b.

5. Impact evaluation and climate change interventions

The Paris agenda of harmonisation and alignment has focused attention on improving the effectiveness of the international aid system, an important component of which is the use of rigorous impact evaluation (IE) designs to assess the impact of development programs on people's well-being (Bamberger and White, 2007; Banerjee *et al.*, 2007). This contrasts with conventional evaluation procedures which have tended to focus almost exclusively on institutional processes. This section provides a background to IE and discusses its application to climate change interventions.

5.1. What is impact evaluation?

While there is agreement on the importance of impact evaluations, impact evaluation has also been subject to widespread debate in recent years (see White 2009a for an overview). This paper follows the International Initiative for Impact Evaluation (3ie) in defining rigorous impact evaluations as: ”analyses that measure the net change in outcomes for a particular group of people that can be attributed to a specific program using the best methodology available, feasible and appropriate to the evaluation question that is being investigated and to the specific context” (3ie, 2008, p. 2).

Broadly speaking, IE is therefore structured to answer the question: how would participants' welfare have altered if the intervention had not taken place? This counterfactual analysis involves “a comparison between what actually happened

[14] Global Climate Change Alliance (GCCA) of the European Commission, the International Window of the Environmental Transformation Fund (ETF-IW) of the United Kingdom, the Spanish Millennium Development Goals (MDG) Fund, the Japanese Cool Earth Partnership, the German International Climate Initiative, the Norwegian Agency for Development Cooperation's (NORAD) Rainforest Initiative, the Australian Global Initiative on Forests and Climate (GIFC) and the German Life Web Initiative

and what would have happened in the absence of the intervention" (White, 2006, p. 3). Since it is not possible to collect data on what would have happened if the intervention was not implemented, IE uses different methods to create a robust comparison group who is not directly exposed to the intervention, and whose outcomes would have been similar to participants if the intervention had not taken place (White, 2006). Such counterfactual analysis enables researchers to attribute the changes in outcome to particular interventions. Methods for establishing a valid counterfactual include experimental (randomisation), and quasi-experimental approaches; there may also be opportunities to exploit 'natural experiments'. See Box 1 for a brief description of these methods.

Box 1 - Impact evaluation methodology

IE assesses impact of an intervention using counterfactual analysis. The estimated impact of the intervention is calculated as the difference in mean outcomes between a 'treatment group' (those receiving the intervention) and a 'control group' (those who don't). The single difference estimator compares mean outcomes at end-line and is valid where treatment and control groups have the same outcome values at baseline. The difference-in-difference (or double difference) estimator uses baseline and end-line data to calculate the change in outcomes over time across the two groups. There are various approaches to determining an appropriate control group for counterfactual analysis.

Randomisation: the experimental approach to impact evaluation involves the random selection of participants into the intervention and control groups. When this method is well implemented over a sufficiently large sample the only difference between the two groups is that the control group does not receive the intervention. The experimental approach is often held up as the 'gold standard' of evaluation, but is not applicable to all interventions. See for instance Skoufias (2001) for an example.

Pipeline: This approach uses people, households, communities or businesses already chosen to participate in a project at a later stage as the comparison group. The assumption is that as they have been selected to receive the intervention in the future they are similar to the treatment group, and therefore comparable in terms of outcome variables of interest. See for instance Edmonds (2002) for an example.

Matching: This approach involves matching programme participants to non-participants based on a number of observed criteria. One such approach is that of propensity score matching (PSM), which uses a statistical model to calculate propensity of participation on the basis of the set of observable characteristics. Participants and non-participants are then matched on the basis of similar propensity scores. A second approach is regression discontinuity design, which exploits a decision rule as to who does and does not get the intervention to compare outcomes for those just either side of this cut-off. See for instance Kassie et al. (2009) for an example of a study using matching.

Other techniques of IE include interrupted time-series and regression-based designs.

For a discussion of IE approaches see White (2006). Additionally, 3ie has recently launched an online database with a range of impact evaluations conducted in low- and middle income countries. Available from www.3ieimpact.org

As with all social research methods, there are of course numerous possible problems and limitations to experimental and quasi-experimental impact evaluation approaches. Examples include sampling issues, spill over effects, and the precision of survey data (for a discussion of some of the pitfalls see Ravallion 2001, 2005; and Chen *et al.*, 2006). Two common problems related to establishing a valid counterfactual for the impact analysis are contamination and sample selection bias, however, there are a number of ways to deal with or minimise these problems (see White 2006 for a discussion of this).

Moreover, discussing the use of strong evaluation designs in developing countries Bamberger and White (2007) highlight some of the limitations to applying randomised controlled trials (RCTs) to development interventions. These include the often heterogeneous and changing contexts of interventions, logistical and practical challenges, difficulties with monitoring service delivery, access to the intervention by the comparison group and changes in selection criteria and/or intervention over time. Thus, it is commonly estimated that RCTs are only applicable to five per cent of development finance (Bamberger and White, 2007). However, a range of quasi-experimental approaches are applicable to a greater number of interventions and these can provide valid impact estimates when applied rigorously.

Impact evaluation as defined here has thus far been dominated by (quasi-) experimental analysis of the counterfactual, often based on random sample survey data. These methods are ideally suited to generate evidence of what works (Ellis, 2000), but on their own they do not improve our understanding of why interventions work or not, and under which circumstances. Moreover, evidence on the effectiveness of an intervention in achieving its intended outcomes "does not tell us enough to inform program improvement or policy revision" (Weiss, 2007, p. 77). Most interventions within the realm of public policy are of a voluntary, rather than coercive nature, and will therefore be successful to the extent that people are incentivised to change their behaviour favourably.

The concept of a theory-based approach to evaluation is not new and it has received increased attention in recent years (for instance Birkmayer and Weiss, 2000; Cook, 2000; Rogers, 2007; White, 2009b). For instance, in the context of improving development effectiveness, White (2009b) advocates more widespread application of a theory-based approach to impact evaluation as a means to improve understanding of why an intervention is successful or not, and to increase the policy relevance of IEs. This approach combines rigorous counterfactual impact analysis, as outlined above, with other methods, emphasising analysis of the 'factual' using both quantitative and qualitative methods, to examine the causal chain and shed light on the 'why' and 'how' questions (Leeuw and Vaessen, 2009; White, 2009b). In the case of climate change interventions, if the reduction of carbon-emitting behaviours is known one can to some extent rely on technical coefficients to calculate carbon reductions, for instance from practices like kerosene consumption and air travel. As behavioural changes and take up of new technologies are difficult to assess, data from impact evaluations are normally required. The body of evidence provided by theory based impact evaluations can improve our understanding of these processes. Box 2 outlines six key principles of the theory-based approach as set out by White (2009b).

Box 2 - Principles of theory-based impact evaluation

Map out the causal chain (programme theory): This involves outlining the theory of how the intervention is expected to lead to the intended impact, enabling the evaluation to test the underlying assumptions along the causal chain. The theory should be flexible and ready to adapt to changing circumstances in the field, unforeseen consequences and surprises in the data.

Understand context: The context of the intervention, including the social, political and economic setting, is critical for understanding the impact of the intervention and designing the evaluation. Doing so would involve reading project documents and the broader literature before designing the evaluation.

Anticipate heterogeneity: This would assist in identifying sub-groups and adjusting the sample size to account for the levels of disaggregation to be used in the analysis. Examples of sources of impact heterogeneity are socio-economic status and the timing of impact measurement. Understanding context can assist in anticipating possible impact heterogeneity.

Rigorous evaluation of impact using a credible counterfactual: This is a key component of the TBIE and is discussed above.

Rigorous factual analysis: Many of the links in the causal chain call for factual analysis to supplement the counterfactual analysis. Examples that would require such analysis is targeting and output analyses, for instance; did the training lead to improved knowledge and was the knowledge put into practice?

Use mixed methods: A combination of quantitative and qualitative methods in the same evaluation to provide information on the environmental, political or social context of interventions and provide essential insights into 'why' or 'how' an intervention succeeded or failed. The qualitative data can be generated through a range of activities, including focus groups, in-depth interviews, reading of anthropological and political literature, PRA and field visits.

Source: White (2009b).

Thus, a theory based approach to IE includes collecting data at different points along the causal chain to test the underlying assumptions of the program theory. This provides information about the intervening mechanisms between activities and outcomes, enabling evaluators to use this evidence to draw conclusions about the points in the causal chain that contributed to the outcomes found in the evaluation (Birkmayer and Weiss, 2000). Moreover, as Birkmayer and Weiss (2000) highlight, the theory-based approach to IE also has advantages for the planning of the evaluation; mapping out the program theory can act as 'the scaffolding of the study' and assist the researcher in deciding which key assumptions in the program theory warrants testing and data collection.

To ensure effective allocation of global resources, White (2009c) calls for thorough cost-effectiveness assessments of climate change interventions based on rigorous IE evidence. Climate change mitigation projects are designed to produce benefits in the form of reduced carbon emissions or increased carbon sequestration. To calculate the cost-effectiveness of the reduction of emissions resulting from different interventions, one needs to designate a value to all the costs and benefits resulting from the interventions. White (2009c) suggests that if the impact of the project on carbon emissions is known it is quite straightforward to calculate the cost per ton of avoided emission. Furthermore, to know if the benefits of the avoided carbon justify the costs an estimate of the value of the avoided emissions is required. It has been argued that "the correct approach is to calculate the social cost of carbon [SCC], which is the cost (lost output) resulting from <u>not</u> reducing emissions" (White, 2009c). However, this approach is not followed by everyone and is also complicated by the wide range of estimates of SCC: a recent meta-analysis (Tol, 2008) includes 211 different such estimates. However, Tol (2008) suggests even conservative estimates justify climate change policies to reduce GHG emissions.[15] Many climate change interventions are likely to have (positive or negative) developmental impacts which should also be taken into account in cost-benefit analysis of climate change interventions.

5.2. Applying impact evaluation to climate change interventions

In this sub-section we examine how approaches to impact evaluation have been applied to climate change interventions and environmental interventions more broadly. Climate change has attracted increasing attention in recent years and this has led to an abundance of publications on the issue. However, most of this literature deals with the physical science of climate change and conceptual issues, potential policies and frameworks related to climate change mitigation and adaptation. We searched a range of databases and websites in an effort to identify any rigorous IEs of climate change interventions undertaken in developing countries. [16] We limited our inclusion to studies estimating impact using counterfactual analysis, based on the techniques discussed in Box 1 above, and did not review studies using structural modelling techniques.

Apart from a few recent impact evaluations in the conservation literature, the results of our searches were disappointing and it seems the application of rigorous IE techniques to assess the effectiveness of climate change interventions has so far been limited. This is confirmed by a number of recent publications. For instance, Jones *et al.* (2008) find that there are significant gaps in the application of IE and they particularly highlight the lack of studies on environmental protection, agriculture, health and gender issues. Likewise, a recent desk review (Hedger *et al.*, 2008) assessed the current state of climate change adaptation evaluations and found high quality impact evaluations lacking. Reviewing the 11 evaluations of adaptation interventions in the GEF database Hedger *et al.* (2008) note that the evaluations generally depend on qualitative methods such as stakeholder interviews, tend to lack baselines, and are not integrated into projects. The authors draw attention to some of the challenges associated with evaluating adaptation interventions, including the lack of baselines, long time scales, the diversity of interventions and the lack of agreement on indicators and the definition of adaptation success. An assessment of the evaluations of mitigation interventions included in the GEF database leads

[15] See White (2009c) for a longer discussion of this point.

[16] Using key word combinations such as climate change AND evaluation, clean development mechanism AND evaluation, climate change AND mitigation, climate change AND adaptation, 'payment for environmental services', 'risk management' AND environment AND evaluation, 'disaster risk reduction' AND evaluation, 'crop insurance' AND evaluation, we searched the web, including Google and Google scholar, Science Direct, JOLIS, IDEAS and BLDS. The Cochrane and Campbell Collaboration libraries were searched using the keywords climate change OR clean development mechanism and all results including any of these keywords were scanned. The websites of various organisations, such as the Global Environment Facility, IIED, UNEP and J-PAL were also searched and screened for any relevant results.

to similar conclusions as those drawn by Hedger *et al.* (2008); the evaluation methodologies are largely based on desk review, interviews and short field visits. Moreover, noting the scarcity of counterfactual analysis in the related fields of biodiversity conservation and environmental economics more broadly, both Ferraro and Pattanayak (2006) and Greenstone and Gayer (2007) call for more widespread application of IE in these fields.

While there is a clear lack of rigorous IEs of climate change interventions, a few notable examples of IE of related conservation interventions stand out. These studies are focused on three types of interventions, namely: protected areas, payment for environmental services and decentralised forest management. In the past these strategies have been applied to biodiversity and forest conservation, but they are also highly relevant for climate change interventions, most notably mitigation interventions such as Reduced Emissions from Deforestation and Degradation (REDD).

Protected areas have long been used for environmental conservation and Andam *et al.* (2008), Gaveau *et al.* (2009) and Sims (2008) are recent examples of rigorous impact evaluations of these policies in Costa Rica, Indonesia and Thailand respectively. All three studies use matching techniques to construct a counterfactual and evaluate the impact of the protected area on avoided deforestation. While Gaveau *et al.* (2009) found the protected areas policy has not led to a complete halt in logging and deforestation in the intervention areas in Sumatra, all the three studies suggest a reduction in deforestation due to the protected areas. Moreover, the importance of using rigorous methods and controlling for potential sources of bias to avoid distorted estimates of impact is highlighted by a comparison with results obtained from other methods (Andam *et al.*, 2008). Andam *et al.* (2008) estimate a substantially lower impact of protected areas on avoided deforestation in Costa Rica than what has been estimated by conventional approaches and suggest the lack of random allocation of protected areas, in addition to lack of control for spillovers, are potential sources of bias in studies using conventional methods. In addition to evaluating the environmental impact of protected areas, Sims (2008) is a rare example of a study assessing impact on both environmental and development outcomes. Combining new consumption, poverty and inequality estimates from the sub-district level and remote sensing data on forest cover, Sims uses matching and regression techniques to estimate the impact of the protected areas on socio-economic outcomes and land use. The results suggest that there are no causal links between the protected areas and the high poverty levels found in the communities nearby. Indeed, the analysis shows an increase in consumption and a reduction in poverty for those with land in national parks, although the distributional impacts of the protected areas may have been uneven.

Payment for environmental services (PES) programs is another conservation policy where rigorous IEs are starting to emerge. Arriagada (2008), Pfaff *et al.* (2008) and Robalino *et al.* (2008) all evaluate the impact of Costa Rica's payment for environmental services (PES) program, while Uchida *et al.* (2007) evaluate China's land conservation program, 'Grain for Green'. The PES program in Costa Rica is an attempt to deal with the problem of deforestation by providing forest owners with financial compensation for the services their forests provide, while the 'Grain for Green' PES program in China provide farmers with compensation in the form of grain, cash and seedlings if they set aside all or parts of their land to grow trees. The program's primary objective is to avoid soil erosion by increasing forest cover, but poverty alleviation and more sustainable agricultural production are also among its objectives.

To control for the non-random allocation of the program Pfaff *et al.* (2008) and Robalino *et al.* (2008) use both covariate and propensity score matching techniques to estimate the program's impact on avoided deforestation, while Arriagada (2008) uses multivariate and propensity score matching. Similarly, Uchida *et al.* (2007) collected survey data on a randomly selected sample of 359 households, matching participants with non-participants using difference-in-difference estimation. While Robalino *et al.* (2008) suggest there was a small increase in the avoided deforestation resulting from the PES program in the 2000-2005 period, compared to 1997-2000, both the studies of the PES program in Costa Rica suggest it has failed to have much impact on deforestation and it is suggested this limited effect could be due to a significant reduction in deforestation across the whole country as a result of current and previous policies aimed at reducing deforestation. Hence, both studies argue better targeting of the payments to areas with the highest risks of deforestation has the potential to improve the effectiveness of the program (Pfaff *et al.,* 2008; Robalino *et al.*, 2008). Arriagada (2008) found little impact on forest loss, but found a small positive impact on forest re-growth and net deforestation. The evaluation of 'Grain for Green' in China concluded the programme had been successful both in providing environmental services in the form of reduced soil erosion and in increasing the wealth of the mostly poor participants.

Lastly, decentralised forest management has become a widespread approach to forest conservation and there are a couple of IEs of interventions that come under this category. Edmonds (2002) employed a pipeline approach and instrumental variable analysis to evaluate the impact of forest management by forest user groups in Nepal. National forest management was abandoned by the government in 1993 and field staff was instructed to start building forest user groups who could manage the forests without outside intervention. Three years later over 4000 forest user groups had been established. As this included less than 10 per cent of Nepal's forests it enabled a comparison between areas with and without forest user groups. Thus, Edmonds (2002) matched data from a census of forest user groups in the Arun Valley with the location of communities included in a Living Standards survey from the same area and estimated impact on fuel wood collection, as this is one of two major drivers of deforestation in Nepal. The results from the study showed that forest user groups reduced fuel wood extraction by around 14 per cent. Similarly, Somanathan *et al.* (2009) also employ a quasi-experimental design to evaluate the impact of decentralised forest management. They use multiple regression analysis and propensity score matching to compare the impact and cost-effectiveness of devolution of forest management to village councils to that of state management. The results suggest that village councils were at least as effective as the state in conserving the forests. However, the expenditures for state forest management are more than nine times as high as that of council managed forests, leading the authors to conclude that 'substantial savings could be realized by decentralizing management' (Somanathan *et al.*, 2009, p. 4146)

While this brief review of existing IEs of environmental protection interventions in developing countries found some good examples of the application of quasi-experimental methodologies to evaluate conservation interventions, it is perhaps surprising that the application of rigorous IE techniques to climate change interventions has not become more widespread. With the substantial volumes of finance estimated as necessary for climate change interventions in the coming decades, impact evaluation will need to become a key component in promoting the efficient use of these resources.

5.3. Future opportunities for impact evaluation

It is quite evident that environmental policy is behind other policy areas in relation to impact evaluation (Ferraro, 2009). This is especially the case for climate change policy. There are many reasons for the lack of rigorous IEs, but it appears one factor, especially in relation to adaptation, is that implementation is still at a relatively early stage. Additionally, for a long time many of the interventions related to climate change focused on activities where IEs are not easily applied, such as governance and institutional processes, including activities such as consultation, capacity building, needs assessment and policy development. Moreover, Ferraro (2009) also suggests a lack of experience in IE designs and methods among environmental practitioners and scientists as a reason for the scarcity of rigorous evaluations of environmental policies.

In addition to the common challenges researchers face when undertaking IEs, a number of problems that are especially pronounced when attempting to evaluate environmental programs have been noted in the literature. For instance, environmental programs often lack a theory of change that includes causal relationships (Ferraro, 2009), there is often a long time lag between the intervention and a measurable impact and, moreover, there is commonly no baseline data (Chomitz, 2008; Ferraro, 2009, Hedger *et al.*, 2008), in addition to a general lack of information on actual events (Todd and Brann, 2007), lack of control group or appropriate counterfactual for attribution (Chomitz, 2008; Hedger *et al.,* 2008), the presence of contemporaneous confounding factors and selection bias (Ferraro, 2009).

Discussing the possible use of experimental methods based on counterfactual analysis in the context of GEF activities, Todd and Brann (2007) argue IEs are not well-suited to evaluate climate change interventions: "In the context of impact evaluations of GEF projects, it is clear that the rigorous impact evaluation model is neither appropriate nor affordable" (p.9). Nevertheless, the examples of quasi-experimental evaluations of conservation programs cited above illustrate that, while not widespread, rigorous evaluation of environmental programs are possible. As Ferraro argues:

> *"Counterfactual thinking is critical to building the evidence base in environmental policy about what types of interventions work and under what conditions... Despite the barriers and paucity of examples, there are substantial opportunities to elucidate causal relationships through experimental and quasi-experimental designs"* (Ferraro, 2009: 76).[17]

It is clear that IEs of climate change interventions can be a challenging undertaking, but that is not a compelling argument for not doing so. As Greenstone and Gayer (2007, p. 42) note, estimating the costs and benefits of emissions reductions on the basis of associational evidence "can be highly misleading and can therefore lead to poor policies".

In addition to challenges relating to research design, IEs of climate change interventions are complicated by difficulties related to the methods used to establish baselines and measure environmental and adaptation outcomes. For instance, according to de Boer (2009) lack of sufficient scientific capacity to measure the carbon sequestration in land use, Land-Use Change and Forestry (LULUCF) was one of the reasons for the exclusion of these sectors from the Kyoto Protocol. While progress has been made on this issue, more work is needed, such as improving the measurement of carbon sequestration and

[17] Ferraro (2008) suggests four elements are required for a study of the impact of protected areas on welfare to be credible in attributing effects to the intervention: 1) Indicators of human welfare at a relevant unit of analysis (for example, individual, household, community and region) that can be objectively measured; 2) Data on applicable indicators before and after establishment of the protected area (if baseline observations are not available another way of controlling for the initial situation and trends in social welfare has to be established); 3) Observations of the relevant indicators from treatment and control groups with similar characteristics; 4) Observations of characteristics affecting location of protected areas and human welfare trends in both groups before the establishment of the protected areas.

emissions from various agricultural production methods (Muller, 2009). A Systematic Review entitled 'Comparison of methods for the measurement and assessment of carbon stocks and carbon stock changes in terrestrial carbon pools' (Petrokovsky *et al.*, 2009) is under preparation and its findings will likely provide an important resource to evaluators of LULUCF interventions.

For some interventions, especially mitigation interventions in the agriculture and forestry sectors, the environmental outcomes will be highly dependent on the local environmental context. For instance, soil carbon sequestration can be improved by agricultural management practices, but the amount of carbon in the soil depends on climatic zone, local climatic condition, characteristics of the soil, type of crop and cultivation practices (Muller, 2009). In such cases evaluators could consider measuring environmental outcomes in a smaller sub-sample of plots and then use observation or survey data on behavioural outcomes, or modelling, to extrapolate the environmental outcomes for the larger sample (Conant and Paustian, 2002; Ogle *et al.*, 2007).

Similarly, Ferraro (2009) suggests measuring other intermediate outcomes as a way of overcoming the barriers associated with estimating impact on environmental outcomes. Noting that many interventions are essentially aimed at changing human behaviour in relation to environmental resource use, he points out that measuring the intermediate impact on behavioural changes might be a more feasible approach when direct measurement of environmental outcomes is difficult. This approach could potentially be used for a wide range of mitigation interventions, especially those involving a shift away from carbon intensive technologies to alternative, tried and tested low carbon technologies.

Additionally, depending on the objectives of the intervention under evaluation, one might need to consider different measures of success and include ecological, economic, attitudinal and behavioural outcomes "with the recognition that there may be a temporal aspect to their emergence; for example, positive behavioural outcomes might occur prior to the observation of positive ecological outcomes" (Brooks *et al.*, 2006, p. 1529). Moreover, IEs of interventions aiming to have an impact on climate change by reducing GHG emissions should ideally also assess impact on welfare outcomes for the affected population to avoid widespread implementation of climate change mitigation interventions with negative developmental impacts. Only two of the IEs reviewed in this paper measured both environmental and welfare outcomes (Sims, 2008, Uchida *et al.*, 2007). The announcement that the World Bank intends to assess the carbon footprint of future projects and that it is working together with other multilateral development banks to develop a common methodology for doing this improves the prospects of more widespread measurement of GHG emissions from development projects (Block, 2009).

IEs of adaptation interventions will not always face the challenges associated with measuring and establishing a counterfactual for environmental outcomes. Nevertheless, establishing a counterfactual for measuring people's capacity to adapt to and cope with the consequences of a changing climate can be problematic, especially if the intervention aims to reduce the risks associated with natural hazard events predicted to occur in the future (Dodman *et al.*, 2009). However, the similarities between adaptation and traditional development activities means there is more experience to draw on and in many cases evaluators can use similar methodologies as those used in development evaluations (Hedger *et al.*, 2008). Indeed, research by Adger *et al.* (2007 cited in Commission on Climate Change and Development) suggests indicators commonly used to measure human development have a statistically strong relationship with ability to deal with climate related events.[18] Similarly, Hedger et al. (2008) suggest that many of the indicators used for measuring development effectiveness will also be related to adaptation and can be used to assess impact on adaptive capacity. They highlight the importance of building on existing indicator frameworks to avoid duplication of efforts and 'indicator overload'. The Disaster Risk Index (UNDP, 2004) and the Indicators of Disaster Risk and Risk Management (Cardona, 2007) are examples of other existing tools evaluators can draw on when evaluating adaptation.

Lastly, IE of climate change interventions can benefit from adopting a theory-based approach to evaluation. Setting out the theory of change underlying the program, collecting data on indicators related to key theoretical assumptions and outcomes, and considering the potential impact of confounding factors on outcomes are among Ferraro's (2009) suggested minimum criteria for evaluation of environmental programs. As mentioned in section 5, the theory-based approach can assist researchers in determining which key assumptions need testing and suggest indicators for data collection (Birkmayer and Weiss, 2000). IE of both climate change mitigation and adaptation interventions will often include measuring intermediate outcomes and in such cases a theory-based approach can improve validity. Moreover, as theory-based IEs will provide insights into how and why interventions are effective or not, including evidence on causal mechanisms and contextual factors, this approach can improve the external validity and thus wider policy relevance of evaluations. The multi-tier framework presented by Ostrom (2007) can provide a useful starting point for theory-based IEs of climate change interventions and suggests a range of different variables researchers might want to consider when designing IEs.

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[18] Adger et al. (2007, cited in Commission on Climate Change and Development) identify the following 18 indicators: population with access to sanitation; literacy rate, 5-14 year olds; maternal mortality; literacy rate, over 15 years; calorific intake; voice and accountability; civil liberties; political rights; life expectancy at birth; government effectiveness; literacy ratio (female to male ratio); GDP per capita; Gini coefficient; regulatory quality; rule of law; health expenditure per capita; educational expenditure as a percentage of GDP; percentage of population employed in agriculture.

As this discussion has illustrated, there is a lack of examples of IEs of both mitigation and adaptation interventions for evaluators to draw on when attempting to deal with the challenges faced in evaluating climate change interventions. Evaluators will have to work with environmental practitioners and scientists (Ferraro, 2009) to form creative solutions, while maintaining the rigour required for constructing a valid counterfactual. Some of the strategies used in climate change interventions will be similar to those used to achieve other objectives and the increasing number of IEs in other policy fields can provide useful guidance for the design of IEs of climate change interventions.

A number of smaller projects and pilots are being implemented or are under preparation (see for instance UNDP or GEF project databases). This presents an opportunity for evaluations to be planned and integrated into these interventions from the start, contributing to the empirical evidence in this emerging field. The policy relevance of such evaluations will continue to increase as mitigation becomes more urgent and the need for adaptation more apparent.

We now turn to examples of key mitigation and adaptation interventions. For each area of intervention, the potential for implementing IE is briefly discussed, and, in most cases, an example of a relevant completed IE study is described.

6. Mitigation interventions

6.1. Green growth strategies

International pressure to control carbon emissions is growing, with countries being encouraged to adopt 'greener growth paths' – in other words, to find ways to grow while controlling the associated increase in carbon emissions. Such policies are less likely to affect sub-Saharan African countries than countries such as China and India. Nevertheless, even countries with substantial 'ecological space' may still implement policies such as carbon taxes, tighter environmental standards and regulation. It is vital to ensure that these approaches do not undermine economic growth, but stimulate it through improved energy efficiency and productivity. In terms of poverty, green growth strategies could be beneficial to the poor as well as to the environment if they support a shift to low-polluting, labour-intensive production methods, and if they improve energy efficiency and stimulate growth.

In the past decade, reducing the carbon emissions associated with GDP growth has mainly stemmed from reducing the energy intensity of growth (World Bank, 2008a). Of particular concern are inefficient production equipment in many industries in Eastern Europe and parts of Asia, for example China and India (World Bank, 2008a). A recent report from the World Bank's IEG (2008a) argued that rural electrification shifts energy use to more efficient and usually more sustainable sources, and suggested there is great scope for investments to reduce system losses which will greatly reduce the energy intensity of growth. World Bank supported off-grid energy supply contributes to carbon emissions reductions as the majority of the projects rely on renewable energy technologies and replace non-renewable energy sources. However, as the report highlighted, there is a need for further analyses of the environmental impacts of grid extensions.

There is also potential to use IE approaches to assess energy efficiency mechanisms, but as the following example illustrates, not integrating the evaluation into the project from the beginning can pose difficulties. A set of studies assessed the extent to which energy efficiency measures reduced electricity consumption and GHG emissions (Todd and Brann, 2007, Annex A). However, the studies suffered from a number of shortcomings: IE was not integrated into the project, so the development of a control group was *ex post* and 'highly speculative', and the evaluation encountered resistance from project staff. Taking these shortcomings into consideration, the study still produced some interesting, albeit contestable, findings. Energy efficiency measures resulted in major changes in the residential market for lighting, refrigeration and air conditioning, especially in Thailand. However, there was a lack of impact in institutional, commercial or industrial markets in all countries. Overall, the measures were found to make a modest contribution to the integration of energy efficiency objectives into energy policies.

Importantly, the studies also made some estimates of the costs and environmental benefits of the projects. Annual reductions of electricity sector emissions were estimated at around 0.5 per cent, with the exception of around 3.5 per cent reductions in the case of Thailand. Costs of around US$ 1 to US$ 5 per ton of carbon reduction were found in Thailand, Poland and Mexico, while at around US$ 40 per ton, costs were much higher in Jamaica. Thus, in three of the four countries in the study, the benefits were estimated to exceed costs by a factor of between 2 and 5. In Jamaica, the benefits were found to be only 40 per cent of costs.

Despite the considerable deficiencies of this project (including the difficulties of obtaining good data), it does illustrate that IE can be employed, especially when qualitative forms of enquiry are included to provide some estimates of the impact of energy efficiency measures which are at the core of green growth strategies.

6.2. Clean Development Mechanism

An important policy tool with potential to promote green growth strategies across a number of sectors is the Clean Development Mechanism (CDM). The CDM was established by the Kyoto Protocol as a means to assist Annex I countries in achieving their emission reduction commitments and to contribute to the sustainable development of non-Annex I countries (United Nations, 1998). However, the Kyoto Protocol stipulates that emissions reductions from CDM project activities must provide '[r]eal, measurable and long-term benefits related to the mitigation of climate change' and '[r]eductions in emissions that are additional to any that would occur in the absence of the certified project activity (United Nations, 1998, p.12). In short, the CDM enables Annex I countries to purchase certified emission reductions (CERs) from projects in developing countries on the condition that the reductions are additional to any GHG reductions that would have occurred without the CDM project.

Since becoming operational in 2006 CDM has grown to become the world's largest offset market and there are currently 1,873 registered projects, with another 2,581 and 280 at the validation and registration stages respectively (Fenhann, 2009). In terms of total numbers of CDM projects, the majority are in the renewable energy sector (60%), followed by methane (CH_4) reduction and cement and coal mine/bed (20%), and the energy efficiency sector (15%), while HFCs, PFCs and N_2O reductions have made up the major share (76%) of CERs issued thus far (Fenhann, 2009). Because of restrictions on the inclusion of forestry and agricultural projects under the CDM there are very few projects in these sectors, but the UN CDM Executive Board recently approved a second land-use, land-use change and forestry (LULUCF) project, raising hopes that this sector will play a larger role in the CDM in the future (World Bank, 2009c). The geographical concentration of projects remains uneven and as of November 1, 2009 78 per cent of projects in the CDM pipeline are in Asia and the Pacific, the majority of these being in China and India (almost 70%) followed by 17 per cent of projects in Latin America and Caribbean, 2.4 per cent in Africa, 1 per cent in Europe and Central Asia and 1 per cent in the Middle East (Fenhann, 2009).

We did not succeed in identifying any IEs of CDM projects, indicating that rigorous evaluation of the impact of the CDM has so far been limited and this is likely due to some of the difficulties such an undertaking would involve. This is particularly worrying as the effectiveness of the CDM in achieving its twin objectives of sustainable development and emissions reductions has been questioned in a number of recent publications (Michaelowa and Purohit, 2007; Paulsson, 2009; Schneider, 2007; Wara and Victor, 2008). For instance, a recent study (Schneider, 2007) based on a literature survey, interviews and a systematic evaluation of 93 randomly selected CDM projects conclude that while the CDM has been successful in developing a global market for GHG emissions, it has not been very effective in achieving its sustainable development and environmental objectives. Nevertheless, a recent paper (Huang and Barker, 2009) purports to provide strong evidence that CDM projects have had a significant effect on emissions reductions in a sample of 34 CDM host countries. The authors reach this conclusion after estimating an environmental Kuznets curve by applying VAR modelling to panel data from 34 host countries for the period 1990-2007. However, as no method is used to control for selection bias it is possible that this study provides evidence of an associational, rather than causal, nature.

The effectiveness of the CDM in achieving *additional* emissions reductions has received widespread attention in the literature on CDM (Paulsson, 2009), with some authors questioning the current approach[19] to assessing additionality (Michaelowa and Purohit, 2007; Wara and Victor, 2008). As the CDM is an offset mechanism, the issue of additionality is of the outmost importance if it is to contribute to mitigation. As Michaelowa and Purohit (2007) highlight, failure to assure additionality has serious implications:

> *"The Clean Development Mechanism (CDM) as such does not reduce net global greenhouse gas emissions. For every tonne of emissions reduced in a host country, an investor is allowed to emit one tonne more at home. If a CDM project does not reduce emissions compared to what would happen anyway…then the net effect is an increase of global emissions."* (p. 2)

Wara and Victor (2008) argue that many of the GHG reductions registered under CDM could have been achieved by other means at a much lower cost and that because of the difficulty of ensuring additionality, it is likely that many of the CERs are not based on actual reductions in GHG emissions (p. 10). They focus their discussion on China and the sector experiencing the fastest growth of Chinese CDM projects in the pipeline, namely energy. Increasing dependence on imported coal, in addition to the environmental and health impacts associated with its use, has led the Chinese government to make changes to its energy policy to promote investment in alternative sources of energy, such as wind, hydro, nuclear and natural gas. Examples of this include a growth in dam construction and a Renewable Energy Law. Concurrent with this, nearly all new wind, hydro and natural gas power plants are applying to get their projects credited by the CDM. Wara and Victor suggest that while individually some of these plants may satisfy the criteria of additionality, the situation is different when assessing additionality at the national level. They argue:

[19] There are different ways of assessing additionality under the CDM. The CDM's methodological tool for assessing additionality includes a four step approach for identifying alternatives to the project that are consistent with current regulation, investment analysis, barrier analysis and common practice analysis. See CDM Executive Board (2008) for details.

"Taken collectively however, these individual applications for credit amount to a claim that the hydro, wind, and natural gas elements of the power sector would not be growing at all without help from CDM. This broader implication is simply implausible in light of the state policies described above" (p. 14)

In addition to critiques relating to the CDM's contribution to emissions reductions, a number of studies have also questioned its effectiveness in achieving the sustainable development objectives (Olsen, 2007; Schneider, 2007; Sutter and Parreño, 2007). Assessing the sustainable development objective does not involve the same difficulties of assessing additionality and standard IE techniques like propensity score matching could arguably be more easily applied.

IE of CDM projects must deal with the issue of additionality and while this clearly presents a challenge for evaluators, the current debate on this issue highlights the urgency of developing a rigorous methodology for doing so. Failure to do so runs the risk of scaling up an approach that actually contributes to a net increase in global emissions by enabling Annex I countries to increase their emissions on the back of emissions reductions that would have happened anyway. While establishing a valid counterfactual will clearly be challenging for many CDM projects, a theory based approach to IE could greatly improve the reliability of estimates by alerting evaluators to issues such as the changes in energy policy in China highlighted by Wara and Victor (2008).

It is clear that it might be difficult to use the impact evaluation methods outlined in this paper to estimate the effectiveness of CDM in achieving its environmental objective of *additional* emissions reductions in host countries and contribute to climate change mitigation over time. Structural modelling approaches such as computable general equilibrium (CGE) models have been widely applied to analyses of major policy initiatives such as trade policies (Harrison and List, 2004) and such methods might be the most appropriate for evaluating the effectiveness of major policy interventions such as the CDM. A review and discussion of the methodological and applied literature on structural modelling approaches to evaluation is beyond the scope of this paper, but it is worth noting that a number of recent studies of climate change policies use this technique. Kallbekken (2006) and Sue Wing and Kolodziej (2009) are examples of recent papers using CGE to provide ex-ante estimates of the impact of CDM and the Regional Greenhouse Gas Initiative (RGGI) in the United States respectively. Interestingly, Kalbekken's (2006) study of CDM suggests the CDM can potentially lead to a significant reduction of carbon leakage,[20] mainly through lowering the

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[20] According to Sue Wing and Kolodziej (2009) "the phenomenon of emission 'leakage' arises where there are multiple sources of greenhouse gases (GHGs), and limits on the GHGs emitted by a subset of these

cost of abatement by Annex I countries by reducing the price of emissions permits.

6.3. Agriculture

Agriculture is a major contributor of GHG emissions, with further increases projected for the future due to increased food production (de Boer, 2009). There is therefore increasing attention to the potential of mitigation in this sector (FAO 2009a; FAO, 2009b; Smith *et al.*, 2007; World Bank, 2007). It has been estimated that around 74 per cent of emissions from agriculture originate in developing countries and much of the potential for climate change mitigation in the sector can be achieved in developing countries (FAO, 2009c). Thus, there have been calls to include incentives for emissions reductions in agriculture in a future climate change treaty (FAO, 2009b, World Bank, 2007).

Mitigation options in agriculture include interventions that contribute to the reduction, removal and avoidance or displacement of emissions (Smith *et al.*, 2007). A range of practices have the potential to mitigate climate change, including organic and low input agriculture, agro-forestry, restoration of degraded land, crop rotation, improved land and natural resource management, more efficient livestock production and capture and storage technologies for manure (FAO, 2009c; Kranjac-Berisavljevic *et al.*, 2009; Smith *et al.*, 2007; World Bank, 2007). By increasing productivity and resilience many of these practices have potential additional benefits for food security, sustainable development and adaptation (FAO, 2009b).

It has been suggested that so far mitigation in agriculture has been held back by the lack of appropriate financial mechanisms[21] and the perception that issues related to leakage, additionality, measurement, monitoring, reporting and verification makes agriculture a difficult sector for climate change mitigation (FAO, 2009c). However, according to the FAO (2009c) there are methodologies to deal with these problems and it is suggested making agricultural mitigation projects eligible for inclusion in an emissions reduction market will trigger more extensive field testing and capacity building. While there is a lack of data on the environmental impact of agriculture interventions, according to the FAO (2009c) it is possible to achieve a high degree of accuracy when measuring the carbon content of a soil sample and the ”fundamental issue with respect to direct measurement of soil carbon stocks and stock changes is not so much an issue of

entities causes emissions from uncontrolled sources to increase, wholly or partially offsetting the former’s intended abatement" (p. 2).

[21] For instance, the very limited inclusion of agricultural mitigation in the Clean Development Mechanism (FAO, 2009c; World Bank, 2007).

measurement capabilities per se, but rather a question of applying efficient sampling designs and rigorous protocols" (pp. 3-4).

Climate change mitigation in the agricultural sector is still in the early stages and as there are limited data to construct performance based measurements, IEs would have to include direct measurements (FAO, 2009c). This could be done by combining intensive sampling of benchmark sites to evaluate the impact of different practices, with more diffuse sampling to assess the aggregate impact of the intervention on carbon stocks in the soil (Conant and Paustian, 2002). The FAO (2009c) propose that a combination of field measurements and model-based approaches could become an alternative to more intensive and expensive direct measurements. For instance, using a simulation model developed for ecosystem processes and data from 47 agricultural experiments Ogle *et al.* (2007) test the relationship between modelled and measured carbon stock values under different production systems. They found a significant relationship between modelled and measured results, but as the relationship was imperfect they developed a statistical model to adjust for biases and quantify the precision of the results.

Such an approach would require establishing a database with empirical data on carbon content in the soil from a range of pilots across agro-ecological zones, with information on soil, climate, land use and management. FAO (2009c) suggest a coordinated effort to conduct and 'pool' direct measurements obtained following a rigorous protocol so that in the future practice-based performance standards can be used instead of the more expensive direct measurements.

While we are not aware of any impact evaluations that assess the impact of agricultural mitigation strategies on wellbeing and environmental outcomes, there are a number of evaluations of interventions in agriculture which illustrate the possibilities for IE in this sector (for example Feder *et al.*, 2003).[22] For instance, a recent study evaluates the impact of the adoption of sustainable agricultural practices, with special focus on reduced tillage (Kassie *et al.*, 2009). The study also compares the productivity gains from reduced tillage to those resulting from chemical fertiliser use. Kassie *et al.* (2009) use propensity score matching and a switching regression framework to analyse plot level survey data from two different agro-ecological zones in Ethiopia, a low rainfall area of the Tigray region and high rainfall area of the Amhara region. They estimate the impact of fertiliser under different tillage regimes and the impact of tillage practices under different fertiliser regimes. The results from this analysis suggest reduced tillage had a significant positive impact on crop productivity in areas with lower rainfall, while chemical fertiliser had a higher significant positive impact in high rainfall areas. Thus, Kassie *et al.* (2009) conclude that in a dry

[22] Impact evaluation of related interventions, such as protected areas and payment for environmental services also provide useful examples that evaluations of mitigation interventions in agriculture can draw on.

land environment sustainable agricultural practices like reduced tillage can have multiple benefits for resource poor farmers by increasing yields, reducing production costs and promoting environmental benefits.

6.4. Bio-fuel production

Global demand for liquid bio-fuels more than tripled between 2000 and 2007 (Sims, *et al.*, 2008). With the sustained rise in fossil fuel prices and related developed country targets for bio-fuels in transport energy supply,[23] these trends are set to magnify. While 90 per cent of global bio-fuel production is currently based in the US, Brazil and the EU, mainly from cereals, maize, rape seed and sugarcane, booming demand is leading to the expansion in production of bio-fuel crops across the world, including second generation bio-fuels produced from non-food materials such as wood, energy grass and other cellulosic biomass.

There will be both winners and losers from the expansion in bio-fuel cultivation in developing countries. Benefits are likely to accrue to developing country bio-fuel crop producers, including smallholder farmers by generating employment and increasing rural incomes. But major concerns are being raised relating to potentially negative environmental and social consequences (World Bank 2008a). Firstly, some bio-fuels are not economically viable at current oil prices in the absence of subsidies, which means costs to tax-payers. Second, bio-fuel production may not provide savings in greenhouse gas reduction; for example, in Indonesia the clearance of peat swamp forests for oil palm production is estimated to have been a major contributor to making Indonesia the third largest emitter of GHGs in 2006 (PEACE, 2007). Third, bio-fuel crop cultivation may have serious costs in terms of loss of natural habitats; for example, many species being promoted for bio-fuel production (including *jatropha curcas* discussed below) have become invasive in countries where they have been introduced (World Bank, 2008a, p. 44).

The intensified competition for land and water associated with increasing bio-fuel production is also likely to impact negatively on global food availability and affordability. Mitchell (2008) estimates the most important factor behind the increase in global food prices between 2002 and 2008 to be expanding bio-fuel production in the US and EU. Recent OECD/FAO projections suggest that between 2005/2006 and 2016/2017 the price of maize will rise by 40 per cent, wheat by 20 per cent and rice by 14 per cent (Wiggins and Levy, 2008). The prices of other foods may also rise as they are either potential feedstock for bio-fuels, or close substitutes in consumption. Price rises will, in the first instance,

[23] For example, the EU has targeted 10 per cent of transport fuels to come from bio-fuels by 2020, from the 3 per cent which is currently met through domestic production.

harm the poor who are net-food buyers (and this is probably most of the world's poor).

A number of studies examining environmental implications of bio-fuels have been conducted (see Rajagopal and Zilberman, 2007, for a review). Unfortunately, the impacts of bio-fuel production need to be evaluated on a case-by-case basis. The net impact on GHGs associated with bio-fuel production depends on a number of context-specific factors, including the emissions associated with feed-stock cultivation, the bio-fuel production process, transport of bio-fuels to markets and, importantly, changes in land use. The net social implications of bio-fuels will depend on the proportions of winners and losers from expanding bio-fuel production, but there are serious concerns about the negative distributional impacts since the likely losers are poor net-food buyers. As noted in a recent review, very little is known about these impacts in developing countries (Rajagopal and Zilberman, 2007). What is clear is that bio-fuels as a mitigation strategy are in urgent need of impact evaluation.

The potential for IE in assessing potential social gains from smallholder bio-fuel production is illustrated in Malawi (NASFAM, personal communication). NASFAM, the largest producer organisation in Malawi, is in the process of designing, monitoring and evaluating the pilot phase of a five-year project to promote smallholder *jatropha curcas* production. *Jatropha Curcas* thrives on poor and eroded soils and is now being increasingly used in reforestation programs in tropical countries. It also has great potential as a second generation bio-fuel. NASFAM is a farmer-directed business system based on the individual participation of close to 100,000 Malawian smallholders, most of them farming less than a hectare of land. Through its network of smallholder-owned business organisations, it develops the commercial capacity of its members and delivers programmes that enhance their productivity. NASFAM is considering using IE during the pilot *jatropha* project.[24] Around 400 randomly selected 'grower' households (in around 20 farming clubs) will be compared with a further 400 'non grower' households acting as a control group. The primary purpose of the three-year evaluation is to assess the extent to which *jatropha* production will increase and stabilise the incomes of smallholder farmers in Malawi. Of particular concern in this evaluation will be the food security impacts of *jatropha* adoption, and the relationship between *jatropha* production and hybrid maize production. If successful, *jatropha* production could be expanded to NASFAM's 100,000-plus smallholder farmers.

[24] NASFAM, personal communication.

6.5. Forest carbon

Climate change is leading to initiatives to preserve carbon held in tropical forests. High on the agenda and a key theme in current climate change negotiations is the proposal to include payments from developed to developing countries for Reduced Emissions from Deforestation and Degradation (REDD) within carbon trading mechanisms (UNFCCC, 2009a). This could generate annual revenue flows of US$ 2.2 to 13.5 billion (Ebeling and Yasue, 2008), rivalling ODA flows in the forest sector. REDD promoters argue that it could offer 'co-benefits' for the poor, but a key question is how financial flows can be engineered to directly benefit the poor, especially forest dwellers. Experience with forest carbon markets indicates that can result in few benefits for the poor and in some cases can have negative impacts (Luttrell *et al.*, 2007; Peskett *et al.*, 2007).

While the details of designing forest carbon schemes that provide co-benefits for the poor are complex, three issues stand out (Luttrell *et al.*, 2007; Peskett *et al.*, 2007; see also Peskett and Harkin, 2007).

- The complexity of engaging in carbon markets means poor communities will often need to work through intermediaries, or brokers, such as NGOs, co-operatives and social movements.
- The land, and therefore carbon rights of the poor need to be assured if they are not going to be dispossessed.
- Carbon market contracts need to be designed in a clear, transparent and equitable fashion. Experiences of contract farming – where a firm lends inputs such as credit, fertiliser, seed and extension to a farmer, in exchange for exclusive purchase rights over the contracted crop – are instructive. Here, it is essential that state or non-state actors offer accessible, transparent and legally-binding mechanisms for dispute resolution between firms and farmers, if such contracts are going to work for both parties (see Prowse, 2007).

In a broadly similar way to assessing the well-being outcomes from bio-fuel production, IE could be used to investigate the impact of carbon markets on poor forest dwellers, and whether co-benefits do exist. For example, at a very early stage in carbon market formation, it might be possible to randomise villages/clubs/groups of poor forest dwellers using the information held by NGOs, advocacy organisations, or local government. Doing so at a pilot stage could be the first step in trying to estimate the benefits which might accrue to those in the scheme (and how these are differentiated in terms of income, gender, ethnicity), and how such benefits compare to benefits of avoided deforestation. In addition to the evaluations of PES interventions cited above there are a number of planned and ongoing evaluations which provide examples of how rigorous evaluation designs can be applied to projects relevant to REDD.

For instance, Alix-Garcia *et al.* (2008) are studying the behavioural response of households and communities to the Payments for Hydrological Services program in Mexico. They assess environmental effectiveness by comparing the deforestation rates of the properties enrolled in the program in 2004 with those rejected for administrative reasons and those that applied in the following years, using data from newly interpreted high-resolution satellite images (SPOT). Additionally, the study also measures deforestation spillovers to nearby areas to determine if reduced deforestation on properties participating in the program have displaced the surrounding areas. While this ongoing study is currently focusing on properties that entered the scheme in 2004, the team is hoping to extend the analysis to include multiple years. This proposed project in Mexico offers an illustration of the potential to use an experimental IE design to evaluate REDD interventions.

Moreover, while still in the project preparation phase, a proposed project in Uganda offers an illustration of the potential to use an experimental IE design to evaluate REDD interventions (GEF, 2008). While not strictly speaking a climate change intervention the project, entitled 'Developing an Experimental Methodology for testing the Effectiveness of Payments for Ecosystem Services to Enhance Conservation in Productive Landscapes in Uganda', aims to "test the effectiveness of PES as a viable means for financing and procuring biodiversity conservation outside protected areas using an experimental methodology" (p. 4). To determine the effectiveness of different payment arrangements it is proposed that it will offer payments to individual landowners in one treatment group and payment at the community level or to local institutions in another. In doing so the project seeks to provide both social and environmental benefits by making conservation of the forests a viable livelihood opportunity for local communities, focusing on including low-income landowners and resource users. It is suggested the project will include 12 randomly selected communities from a homogeneous region in Uganda which is identified as at risk of deforestation. In addition to being used by the Government of Uganda when developing a replication strategy in other areas of the country, it is also suggested the evidence from the IE might "help to position Uganda as a credible supplier of carbon credits in a future international scheme focused on avoided deforestation and reduced degradation" (p. 4). The decision to use experimental design is motivated by the need for rigorous evidence of environmental interventions and the project document states that "a major aim of the project will be to successfully demonstrate this methodology to catalyze wider replication in the GEF portfolio" (p. 5).

6.6. Environmental labelling

Responses to climate change have implications for two fast-growing exports – non-traditional agricultural products and tourism. Concerns about 'food miles' are leading to carbon-related labelling schemes. For example, in early 2007 leading UK supermarkets introduced labelling schemes which could discourage the purchase of fruit and vegetables from countries such as Kenya and Ethiopia (see Ellis and Warner, 2007), clearly showing the potential development versus environment trade-off in some climate change interventions.

One scheme, from Marks and Spencer, aimed to reduce the amount of air-freighted produce, and to label such items in stores. Another, by Tesco, aimed at reducing the company's carbon footprint by reducing air-freighted products by over sixty percent, and labelling the remaining air-freighted goods (Garside *et al.,* 2007).

Over one million people in rural Africa rely, directly and indirectly, on fresh fruit and vegetables exports to the UK, and it is estimated that not buying fresh produce air-freighted from Africa would reduce UK emissions by less than 0.1% (Ellis and Warner, 2007). Since late 2007, both supermarkets have become more cautious in their approach to reducing air-freighted goods and to implementing such labelling schemes. Interestingly, both have indicated that such labels have had no discernable impact on sales (Garside *et al.,* 2007). Similar concerns about developed country 'carbon footprint' could discourage holidaymakers from visiting countries such as South Africa, Namibia and The Gambia, from which the poor can accrue up to 15-35 per cent of total expenditure (see Mitchell et al., 2007).

Labelling schemes may be creating non-tariff barriers for exports from developing countries, and could reduce market demand for such exports. In this respect, a more sophisticated labelling scheme, that takes into account the overall environmental impact, not just the air transport component, and that also factors in the development impacts of consumption decisions, could be preferable (see Ellis and Warner, 2007).

But how should this be realised? And what metrics should be used? Garside *et al.*, 2007) suggest that if environmental harm is to be compared against poverty reduction (or broader development goals), then such a scheme needs to consider developing countries' current 'ecological space' for carbon emissions and quantify both the degree of harm from air-freighted produce or tourist flights, and the poverty impact on individuals and households. The extent to which rigorous IE methods could contribute is discussed in Box 3.

Box 3 - Impact evaluation and a 'Good for Development' label

It can be argued that IE techniques can assess both the demand for such labelling schemes, and the impact they have on well-being in developing countries, as well as carbon emissions.

First, by randomising which products within a range of goods in supermarket outlets carry the 'air-freighted' label, it would be very simple to assess the extent to which consumers react to such labels, and whether there is substantial demand for them. As noted above, initial indications suggest that they have little impact on sales.

Second, IE could be used to assess possible impact on producers. Air-freighted goods are often produced on estates. Frequently, estates are contracted by supermarkets (or intermediaries) as they offer increased reliability of supply quantity and quality compared to spot markets, or smallholder producers. Depending on the number of estates engaged, it may be possible to randomise the estates from where air-freighted goods are being labelled.

If it is possible to randomize in this manner, then a 'before and after' double difference IE could be conducted to assess: (i) the possible impact on the profitability of the estate/firm; (ii) possible impact on the well-being of workers or smallholders; (iii) and estimates of the reduction in carbon emission caused by the 'air-freighted' label.

If it is the case that such labels reduce the profitability of firms and the well-being of poor workers, having quantitative data would strengthen the case for some compensatory mechanism (possibly financed by a price premium paid by consumers).

7. Adaptation interventions

Adaptation interventions are undertaken at different scales, across sectors and through different strategies.[25] As with all fields, the type of intervention will have implications for how IEs are designed. This section provides a brief discussion of IE of adaptation interventions in relation to three key sectors relevant for

[25] Hedger *et al.* (2008) and McGray *et al.* (2007) distinguish between three types of adaptation interventions: (1) Serendipitous adaptation - development activities that contribute to adaptation without being designed to do so; (2) Mainstreaming or climate proofing of development efforts - this includes changing the design of ongoing development activities or designing development interventions so that they are also successful in a changing climate (McGray et al., 2007); (3) Discrete adaptation - activities specifically designed to address climate change and where adaptation is the primary objective, although common development strategies might still be applied.

adaptation interventions, in addition to 'mainstreaming' of adaptation and disaster risk reduction.

7.1. Agriculture

Current and predicted climate change means that adaptation in the agricultural sector is urgent (World Bank, 2007). Farmers are already altering their practices in response to changes in the climate (Deressa *et al.*, 2009), but poor people and countries will need outside assistance for adaptation (World Bank, 2007). In the agricultural sector people's ability to cope with stresses induced by climate change depend on their access to knowledge, training, credit, technologies and other agricultural resources (Kranjac-Berisavljevic *et al.*, 2009). Moreover, a recent report from the World Bank outlines three strategic objectives for adaptation efforts in agriculture: (1) Monitor climate change impacts on crops, forests, livestock and fisheries; (2) Support farmers and lenders in managing the risks of climate change impacts; (3) Improve management techniques and crop varieties/livestock breeds to prevent crop and livestock losses due to climate change and increased pest pressures (World Bank, 2009d). Thus, adaptation interventions in agriculture are likely to be wide ranging, but will typically include elements that are similar to existing agricultural interventions.

AADAPT is a recent initiative by the World Bank which is set up to support countries in undertaking rigorous evaluations of agricultural development and adaptation to climate change (World Bank, 2009f). At a recent meeting in Addis Ababa a number of proposed evaluations were presented. Examples include an evaluation of the Rural Capacity Building Project (RCBP) in Ethiopia (Hiluf *et al.*, 2009), Ethiopia Nile Irrigation and Drainage Pjoject (Tessema *et al.*, 2009), the Agricultural Development Program Support Project in Malawi (Musopole *et al.*, 2009), Market-led Smallholder Development in the Zambezi Valley in Mozambique (Banze *et al.*, 2009) and Impact of the Productive Safety Nets Project on Agricultural Productivity in Ghana (Dannson *et al.,* 2009). All of these research projects propose to use experimental or quasi-experimental methods to evaluate agricultural interventions of relevance to climate change mitigation. For instance Dannson et al. (2009) plan to randomly select districts for participation in the Productive Safety Nets Project on Agricultural Productivity in Ghana, and then randomly select four proposals from each district for funding in the first year. They will then compare agricultural productivity and household consumption among beneficiary and pipeline communities in order to evaluate impact. Similarly, Musopole et al. (2009) will use an experimental design to evaluate three different methods of disseminating two different agricultural technologies of relevance to adaptation, namely conservation agriculture and fertiliser management. The evaluation of the RCBP in Ethiopia faces a common problem for evaluators in that the treatment has already been assigned to the intervention units (Hiluf *et al.*, 2009). However, the study utilises quasi-experimental methods to deal with this, using propensity score matching to construct the control group and difference-in-difference to estimate impact. As these evaluations are still in the early stages, there are not yet any results to report on. Nevertheless, they illustrate the feasibility of using IE methods to assess the impact of adaptation intervention in agriculture.

7.2. Water resource management

It is expected that climate change will have detrimental impacts on water resources (World Bank, 2009d). While there is still a lot of uncertainty as to the specific impacts of climate change on water resources it is clear that it will manifest itself differently across regions, with some areas experiencing increases in water availability, including inland flooding, while other areas will suffer from a decrease in the availability of water and increased risks of drought (Kundzewicz *et al.*, 2007). Thus adaptation efforts in the sector will have to take account of the various projected future scenarios in order to secure access to water of sufficient quality and in sufficient quantities.

Options for adaptation interventions to improve water management include increasing storage capacity by building reservoirs and dams, desalination of sea water, prospecting and extraction of sea water, water recycling to improve water use efficiency, changes in agricultural practices to reduce the demand for irrigation, increased use of economic incentives to promote water conservation and protection of natural resources such as forests and watersheds (Kundzewicz *et al.*, 2007; World Bank, 2009d).

As with all interventions, the choice of impact evaluation design would depend on the intervention, but it is likely that both experimental and quasi-experimental approaches could be applicable to a range of adaptation interventions in this sector. A recent study of two irrigation projects in Andhra Pradesh, India provides a useful example of an IE using quasi-experimental design to evaluate the impact of a large scale infrastructure program in the water sector (IEG, 2008b). While there was no baseline data and the project was closed when the evaluation was undertaken, the fact that a number of farmers were yet to be connected to the system and were due to be irrigated in the 2005 and 2006 seasons enabled the study team to adopt the 'pipeline approach', whereby the areas in the final group to be treated were selected as the control group. Impact was estimated by applying difference-in-difference methodology to data from two survey rounds. While some of the predicted benefits failed to materialise and the projects suffered from delays and higher costs than was budgeted, the IE suggests access to irrigation leads to an increase in both yields and farm income. The study also assessed the effectiveness of participatory irrigation management, suggesting that while water user associations can contribute to water management, there is still need for government support, for instance to ensure equitable distribution and resolve disputes.

7.3. Social protection

The consequences of climate change are set to increase the vulnerability and risks faced by poor people. The burden of changing weather patterns will be particularly felt by those without access to insurance, credit or social protection (World Bank, 2008). It has been argued human development and poverty reduction are at the core of effective adaptation (UNDP, 2007) and, as was highlighted earlier in this paper, adaptation efforts often have much in common with traditional development interventions (McGray *et al.*, 2007). Social protection is one such intervention which is increasingly seen by development agencies and some developing country governments as an effective way to increase access to basic services and improve the wellbeing of poor households (Commission on Climate Change and Development, 2009). The spread of conditional cash transfer programs is a testament to this.

There is increasing attention to the potential role of social protection and social transfer programmes as an effective adaptation strategy (Anderson *et al.*, 2009; Commission on Climate Change and Development, 2009; Oswald, 2009; UNDP 2007). For instance, a recent study suggests impact evaluations of social transfer programs in countries like Mexico and Brazil provide analogous evidence that ”the role of social protection in building adaptive capacity among poor and vulnerable groups shows considerable promise” (Anderson *et al.*, 2009, p. 3).

Exposure to shocks, such as floods, droughts, earthquakes and hurricanes can have both immediate and longer term repercussions for people’s income and wellbeing (de Janvry *et al.*, 2006; Vakis, 2006). People respond to such shocks in a variety of ways, including by selling off their productive assets, taking loans, reducing consumption and withdrawing children from school (Andersson *et al.*, 2009; de Javry *et al.*, 2006; UNDP, 2007; Vakis, 2006). These responses can have long term detrimental impacts on poverty and human development. Preventing temporary shocks from leading to long term poverty is one of the central objectives of social protection programmes (UNDP, 2007) and impact evaluations have also shown such programs can promote longer term human development objectives (for example Attanasio *et al.*, 2005; Gertler, 2000; Schultz, 2004). Thus, it is suggested that in the context of climate change, social protection programmes could play an important role as part of a wider adaptation strategy (UNDP, 2007; Vakis, 2006).

A range of different social protection instruments could potentially promote adaptation and increase people’s capacity to cope with shocks. Examples include contributory insurance schemes designed to pool risks, cash transfers targeting vulnerable groups, social funds, service fee waivers, public works programmes and cash transfers for agricultural productive inputs in the aftermath of a shock (UNDP, 2007; Vakis, 2006). Existing social protection programmes include the Productive Safety Net Programme in Ethiopia, conditional cash transfer programmes in Latin America and subsidised productive inputs to small-scale farmers in Malawi after a period of droughts and floods (UNDP, 2007).

While more evidence is needed on the impact of social protection interventions on adaptation, the increasing number of impact evaluations of these existing programs demonstrate both the potential effectiveness of such interventions and the possibilities of using experimental or quasi-experimental approaches to evaluate their impact (for example Attanasio *et al.*, 2005; Gertler, 2000; Schultz, 2004). Indeed, de Janvry *et al.* (2006) and Andersson *et al.* (2009) evaluate two different social protection programs and assess whether they protect the beneficiaries from shocks.[26] De Janvry *et al.* (2006) utilise experimental panel data from the evaluation of the *Progresa* conditional cash transfer program in Mexico to assess whether the program protected children from the impacts of shocks. The results indicate that ”the Progresa transfers largely or completely protected children from the effect of these shocks on school enrolment” (de Janvry *et al.*, 2006, p. 372). While the program was not sufficient to avoid an increase in child work in response to shocks, the analysis suggests the price effect of the conditional cash transfer prevented this increase to be at a cost to schooling. Andersson *et al.* (2009) use a quasi-experimental design to evaluate the impact of the Productive Safety Net Program (PSNP) in Ethiopia, a public works program targeting the food insecure. Employing household survey panel data analysis using matching techniques, they assess whether the program protects household’s livestock and tree holdings in times of shock. While they found the program appeared to contribute to an increase in tree holdings, there was no evidence that it protected household’s livestock holdings.

7.4. “Mainstreaming” adaptation and disaster risk reduction

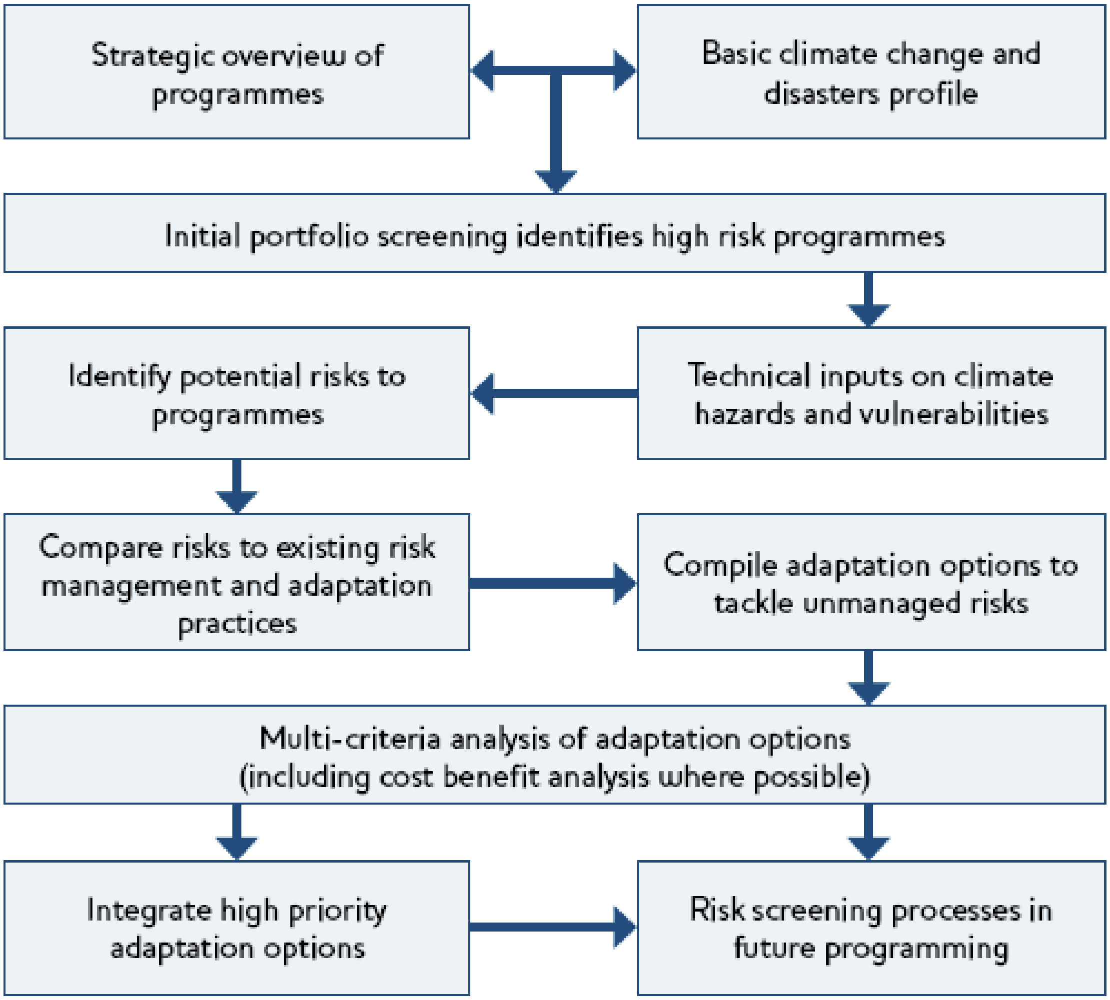
The accumulation of evidence of the potential consequences of climate change is increasingly accompanied by calls for adaptation to be ‘mainstreamed’ into development activities across sectors (OECD 2006; UNDP, 2007; World Bank, 2007). For instance, the OECD suggests that in many cases, instead of requiring new plans, climate change adaptation ”only reinforces the need to implement measures that already are, or should be, environmental or development

[26] An ongoing study by Marta Vicarelli is also using data from PROGRESA in Mexico, and combines this with data on local climatic conditions to assess the impact of local climatic varaiabilities on household consumption and the extent to which PROGRESA reduces vulnerability in the case of climatic shocks (see http://www.hks.harvard.edu/centers/cid/programs/sustsci/people/research-fellows/current-fellows/marta-vicarelli).

priorities…[such as] water or energy conservation, forest protection or afforestation, flood control, building coastal embankments, dredging to improve river flow and protection of mangroves" (OECD, 2006, p. 6). Even where climate change is not yet obvious, including adaptation measures when planning interventions, especially long-lived infrastructure, might prove to be more cost-effective (OECD, 2006). Moreover, as already noted, the need to adopt an integrated approach to adaptation, disaster risk reduction and development are also increasingly recognised (Commission on Climate Change and Development, 2009; O'Brien *et al.*, 2008; Thomalla *et al.*, 2006; ISDR, 2009a; Yamin *et al.*, 2005). So far responses to adaptation have mainly been through project-based approaches, with limited integration of adaptation into national programmes (UNDP, 2007). It has been suggested that part of the reason for the relatively slow progress on adaptation results from this prevalence of project-based assistance, and that in order to scale up adaptation there is a need for a programme-based framework which can be incorporated into broader national strategies (UNDP, 2007). Some developing countries, such as the Maldives, Peru and the Philippines, are already drawing on the experience from disaster risk reduction and have adopted more integrated approaches to climate change adaptation (ISDR, 2009b). For instance, the Philippines recently introduced the Climate Change Act of 2009, which signed the mainstreaming of climate change adaptation and disaster risk reduction into law (Republic of the Philippines, 2009).

ORCHID is an attempt at mainstreaming climate risk management through project and programme appraisal in terms of how climate change will affect their aims and objectives (see Tanner and Conway, 2006). Such appraisals are important as the physical impacts of climate change (such as the increased frequency and severity of natural hazards) can impact on poverty reduction and development through a number of channels (see IDS, 2007; Benson and Clay, 2004): direct physical impacts, such as damage caused by extreme weather events; indirect impacts, such as increased morbidity after a hazard; and fiscal impacts, as hazards create pressures on budgets, often resulting in the reallocation of resources. The ORCHID approach involves applying a country-based screening of projects and programmes, suggesting adaptation opportunities, and prioritising projects that offer substantial risk reduction (Tanner and Conway, 2006). A schematic representation of the methodology used is illustrated in Figure 1.

Figure 1 - ORCHID approach to screening development projects



Source: IDS, 2007

Applying the ORCHID approach to DFID's portfolio of projects in Bangladesh has led to the implementation of a number of adaptation initiatives (Tanner and Conway, 2006). This include improving the structural resilience of infrastructure, including climate change and disaster into education programmes, and conducting further research into the relationship between hazards, vulnerability and disasters.

Taking the first of these measures – improving the resilience of infrastructure – there is certainly potential for IE approaches to assess success. For example, in the urban context, specific projects include those which raise homes in flood-prone locations to above the 20 year flood threshold, improving flood defences and improving the strength of road and water infrastructure. The scale of these measures might appear to militate against using counterfactual analysis, and while it might not be appropriate to randomise the application of this approach there is certainly scope for using quasi-experimental evaluation designs to assess impact.

As the “mainstreaming” of climate change adaptation and disaster risk reduction has yet to become widely implemented more work is needed to identify the best methods for evaluating effectiveness. However, it is likely that IEs of such interventions can draw on the increasing number of IEs assessing effectiveness of interventions across a wide range of sectors. In some cases it might be a matter of including some additional indicators related to adaptation and/or disaster risk reduction to IEs of traditional development interventions. As was discussed in a previous section, there is a range of existing indicator frameworks that can be utilised for IE of adaptation interventions. However, precautionary interventions, designed to manage and reduce the risk from future climate events can be potentially challenging to evaluate (Hedger *et al.*, 2008). Evaluations of such interventions before an event has occurred might have to use process indicators as proxies for potential effectiveness, while disaster response, such as the effectiveness of early warning, evacuation and infrastructure resilience have been suggested to be strong indicators of disaster risk reduction interventions undertaken before the event (Benson and Twigg, 2009).

8. Conclusion

This paper has provided an initial overview of the extent to which IE could be utilised in assessing the impact of climate change interventions in developing countries, with a particular emphasis on evaluating the well-being of the poor. It has also highlighted the lack of rigorous IEs of climate change interventions. Apart from a few quasi-experimental evaluations in the related field of conservation, the application of IE to climate change interventions has been limited. Moreover, only two of these studies include estimates of both environmental and welfare outcomes (Sims, 2008; Uchida *et al.*, 2007). While in many cases evaluating climate change interventions are challenging, this is not a valid argument for not doing so. If calls for increasing financing of climate change mitigation and adaptation by hundreds of billions a year are to remain credible and gain support, evidence of the effectiveness of current spending is essential. Moreover, donors will likely remain hesitant to provide additional funding unless it is clear that interventions are reaching their environmental and developmental objectives. As current funding falls far short of recent estimates of what will be required, evidence from IEs is essential to determine which adaptation and mitigation interventions are the most cost-effective.

The current emphasis on rigorous IE result from debates on development effectiveness and the realisation that reliable evidence is lacking in many areas of development intervention. If a similar situation for climate change interventions is to be avoided there is an urgent need for more IEs in this area. Importantly, new studies should evaluate positive and negative impact of climate change interventions on both environmental and welfare outcomes. A large number of interventions are being planned in developing countries and it is likely this will increase in the aftermath of a new global treaty. Thus, there will be a range of opportunities for programme planners and evaluators to work together to accommodate rigorous impact evaluation from the start. While appropriate outcome indicators will differ between interventions, future evidence syntheses will be improved by work to develop a consensus on a set of common outcome indicators.

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