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Financing sustainable agriculture under climate change with a specific focus on foreign aid

Jikun Huang*

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Abstract

Agricultural development is facing great challenges in meeting global food security and is expected to face even greater difficulties under climate change. The overall goal of this paper is to examine how foreign aid in particular can be used to achieve the joint objectives of development, mitigation of and adaptation to climate change in agriculture in the developing world. The results show that agriculture is underinvested and foreign aid has not increased sufficiently to assist developing countries achieve sustainable agriculture; substantial funds are needed to finance the wide range of measures for mitigating and adapting to climate change. The paper attempts to examine the successful cases where agricultural mitigation of and adaption to climate change have worked in the developing countries. In this respect, we pose four main questions: What works? What could work? What can be scaled? And what can be transferred?

Keywords: climate change, finance, foreign aid, agriculture, mitigation, adaption
JEL classification: F35, G32, H87, Q54

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* Center for Chinese Agricultural Policy, Chinese Academy of Sciences, Beijing, email: jkhuang.ccap@igsnrr.ac.cn

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Acronyms

ADCs	agro-technical demonstration centres
CAD	Comprehensive Agricultural Development
CCAP	Center for Chinese Agricultural Policy
CGIAR	Consultative Group on International Agricultural Research
GEF	Global Environment Facility
GHG	greenhouse gases
HARITA	Horn of Africa Risk Transfer for Adaptation
IDRC	International Development Research Centre
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
IRRI	International Rice Research Institute
LDCF	the Least Developed Countries Fund
NapaS	national adaptation programmes of action
SAIN	Sustainable Agriculture Innovation Network
SCCF	Special Climate Change Fund
SSC	South-South cooperation
SSNM	Site Specific Nutrient Management
UNFCCC	United Nations Framework Convention on Climate Change
WRI	World Resources Institute

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UNU World Institute for Development Economics Research (UNU-WIDER)
Katajanokanlaituri 6 B, 00160 Helsinki, Finland

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1 Introduction

Hundreds of millions of people suffer from hunger and food insecurity. According to estimates, the total number of undernourished people in the world in 2009 was 1.023 billion, although this was expected to decline by 2010 to 925 million (FAO 2010a). But in 2010, the actual number of hungry people was higher than the level which had existed when world leaders at the World Food Summit in 1996 had agreed to reduce these numbers by half (ibid.). Most of the world's hungry live in the developing countries.

Global food security is likely to face even greater challenges in the coming decades. According to FAO's estimates (2009a), global food production must increase by at least 70 per cent to meet the growing food demands of a world population that is expected to surpass nine billion by 2050 (ibid.). Furthermore, the growth rate of agricultural productivity has been falling; for example, average annual growth rate of cereal yields has decreased from about 2-3 per cent in the 1970s and1980s to 1-2 per cent in the 1990s and early 2000s (World Bank 2007).

Agriculture and food security may face even greater difficulties under climate change. Despite some existing uncertainties, increasing evidence indicates that the earth's climate is experiencing significant changes. According to projections (FAO 2009a), due to continued and rising global warming, by 2050 developing countries may experience a decline of between 9 and 21 per cent in overall agricultural productivity. In addition to long-term effects, global and regional weather conditions are also expected to become more varied, with increases in the frequency and severity of extreme events such as cyclones, floods, hailstorms, and droughts (Easterling et al. 2000; IPCC 2007a, 2012). Such extreme weather conditions will bring larger fluctuations to crop yields and local food supplies as well as higher risks of food insecurity (FAO 2008a, 2009a; IPCC 2012).

How severely climate change will affect agriculture depends on whether these impacts can be countered by investments in agriculture. The amount of investment needed for sustainable agriculture in the developing countries is tremendous even without taking climate change into consideration and must be greatly increased to address food insecurity issues (FAO 2009a). When climate change is included in the equation, even greater efforts will be necessary in the coming decades. However, investment and foreign aid in agriculture have either fallen or not grown appropriately. Current investments and commitments fall far short of the requirements necessary to meet the growing needs, especially in the developing world (Islam 2011). In addition, there has been a decline in the share targeted to the agricultural sector in aggregate foreign aid. For example, while the share of aid to agriculture in total aid increased from 13.0 per cent in 1973-75 to 23 per cent in 1979-81, it has declined since the mid-1980s (Table 1).

The international community has called for measures for climate change adaptation to be incorporated into national development plans (World Bank 2010). Climate change adaptation is defined by IPCC (2001) 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'. This would mean learning to manage new risks by preparing to deal with shocks and by strengthening resilience in the face of change. In the food and agriculture sector, FAO (2007a) has already highlighted some measures for climate change adaptation but these need large amounts of investment for implementation in the developing countries.

While agriculture is the most sensitive and vulnerable sector to climate change, it is also one of the major contributors of greenhouse gas (GHG) emissions (IPCC 2007b; FAO 2008b). Projections indicate that these emissions will increase if agricultural development is continued under the 'business-as-usual' model. According to recent data by IPCC (ibid.), agriculture accounts for 13.5 per cent of global GHGs or about 6.8 Gt of CO_2 equivalent (e) in 2004. The World Resources Institute (Herzog 2006) indicates that the energy sector's emissions attributable to the use of fossil fuels by agricultural and food processing account for another 2.4 per cent of GHG emissions. Agriculture is also the largest producer of both methane and nitrous oxide (N_2O), which together make up about 22 per cent of global emissions (Baumert, Herzog and Pershing 2005). Agricultural nitrous oxide (N_2O) emissions are projected to grow by 35-60 per cent by 2030 due to increases in both nitrogen fertilizer use and animal manure production (IPCC 2007b). As about 74 per cent of total agricultural GHG emissions originate in the developing countries, their mitigation is also important for slowing down climate change.

Obviously, however, mitigation and adaptation need investment. With the recently rising awareness of the consequences of climate change, it is likely to find its way into international and national action climate change plans, but the design and implementation of effective mitigation and adaptation strategies in agriculture are still in its infancy. It is still not clear what measures are needed to ensure the implementation of such plans or action. A series of questions exists that need to be investigated:

- How can agricultural mitigation and adaptation plans be funded?
- What is the role of foreign aid?
- How can the funds be used most effectively?
- What measures work?
- What evidence exists on the foreign aid effectiveness for agriculture?
- What projects could work? What types of foreign aid practices have the potential to work for agriculture?
- What measures are scalable? What types of foreign aid (projects) that have delivered on a small scale can be scaled up and what needs to be done to deliver foreign aid on a bigger scale?
- What is transferable? What aid experiences can successfully be transferred from one region to another?

The overall goal of this paper is to examine how finance, particularly foreign aid, can be used to achieve the joint objectives of development, mitigation and adaptation in agriculture in the developing world. The analysis is based on existing literature and case studies. The paper is organized as the follow. The following section provides an overview of the financing needed for sustainable agriculture under climate change, with a specific focus on foreign aid. Sections 3-6 examine the role of foreign aid in financing the mitigation of and adaptation to climate change in agriculture by examining each of the following four questions, respectively: what works, what could work, what is scalable, and what is transferable. The last section concludes and discusses policy implications.

2 Financing and aid to agriculture under climate change

2.1 Overall financing and aid to agriculture

Agriculture has been largely underinvested. A global assessment of agricultural development by the World Bank (2007) concludes that insufficient investment in agriculture was one of primary causes of falling agricultural productivity since the 1980s. The lack of incentive, largely due to low agricultural prices and market failure, is apparent in the both public and private sectors.

Over the past two decades, investment in agriculture through foreign aid also experienced a falling trend until the recent global food crisis. According to OECD statistics, while average annual foreign aid to agriculture, including bilateral and multilateral aid measured in constant 2007 prices, increased from US$5.5 billion in 1973-75 to US$11.4 billion in 1979-81, it decreased to US$7.8 billion in 1991-93 and US$5.5 billion in 2006-08 (Table 1). Measured in relative terms, the fall in agricultural aid was even larger. Table 1 shows that aid to agriculture accounted for 22.5 per cent of total aid to all sectors in 1979-81, declining to 11.2 per cent in 1991-93 and 5.4 per cent in 2003-05. Despite a slight recovery when aid to agriculture increased during the global food crisis (2006-08), its share in total aid was still only 6 per cent (Table 1). Financing agriculture is going to face much greater challenges in the future. To increase global production by 70 per cent to feed the world's forecasted 9.1 billion people in 2050, it is estimated that net investments to agriculture must top US$83 billion per year. This is about 50 per cent more than current levels (FAO 2009a).

Table 1: Average annual bilateral and multilateral agricultural and total aid

	1973-75	1979-81	1991-93	2000-02	2003-05	2006-08
Agriculture commitments:	In US$ billion (constant 2007 price)					
- Bilateral	3.4	6.7	5.4	3.0	4.0	3.4
- Multilateral	2.1	4.7	2.4	2.0	2.3	2.1
Bilateral plus multilateral	5.5	11.4	7.8	5.1	6.3	5.5
Total aid to all sectors	42.5	50.5	69.7	92.9	104.8	42.5
Agriculture commitments:	In percentage (%)					
- Bilateral	7.9	13.2	7.8	5.4	3.3	3.8
- Multilateral	5.0	9.3	3.4	2.8	2.2	2.2
- Bilateral plus multilateral	12.9	22.5	11.2	8.1	5.4	6.0
Total aid to all sectors	100.0	100.0	100.0	100.0	100.0	100.0

Source: Based on OECD/DAC and OECD/CRS (various years) and Islam (2011).

2.2 Overall climate change funds

In facing the challenges of climate change, international communities have initiated several global-wide funds raised through both bilateral and multilateral channels for 'climate finance' for the developing countries (OECD 2009). Under the UNFCCC, three multilateral funds address climate-related needs and are managed by the Global Environment Facility (GEF). They are the Adaptation Fund, the Least Developed Countries Fund (LDCF), and the Special Climate Change Fund (SCCF) (Oxfam 2009; OECD 2009). The Special Climate Change Fund was created to fund projects in capacity building, adaptation, technology transfer and climate change mitigation. The Least Developed Countries Fund is designed to help the

Table 2: Multilateral adaptation funding channels

Funding stream	Institution	Pledged US$ million	Received US$ million	Disbursed US$ million
Least Developed Countries Fund (LDCF)	GEF	176.5	135.0	31.4
Special Climate Change Fund (SCCF)	GEF	121.0	100.5	46.9
GEF Trust Fund's Strategic Priority for Adaptation	GEF	N/A	50.0	50.0
Kyoto Protocol Adaptation Fund	Adaptation Fund Board	Increasing to 300 pa	18.5	
Pilot Programme for Climate Resilience (PPCR)	World Bank	546.0	95.8	N/A
Total		843.5	399.8	128.3

Source: Compiled from Oxfam (2009).

Table 3: Summary of existing climate change funding initiatives outside UNFCCC (non-convention funds)

Fund	Pledged amount, US$	Administrator	Short description
CIF Climate Investment Fund that encompasses SCF Strategic Climate Fund	6.3 billion	World Bank	Piloting new approaches or scaling-up activities in developing: (i) the SFC for increasing climate resiliency; reducing emissions from deforestation and forest degradation (under consideration); and scaling-up renewable energy. (ii) the CIF for demonstrating and transferring low-carbon technologies.
FCPF Forest Carbon Partnership Facility	165 million	World Bank	Focusing on mitigation through REDD.
CPF Carbon Partnership Facility	470 million	World Bank	Supporting developing countries towards lower carbon development paths. Components of the Investment Framework for Clean Energy and Development (CEIF).
CBFF Congo Basin Forest Fund	200 million	FFDB	Promoting biodiversity conservation, natural resource management and mitigation through REDD.
SPA Strategic Priority on Adaptation	50 million	GEF	A 3-year pilot programme for adaptation planning.
UN-REDD Programme	35 million	UNDP	Focusing on mitigation through REDD.
MDG Achievement Fund: Environment and Climate Change window	90 million	UNDP	Focusing on adaptation and general mitigation.
GCCA EU-Global Climate Change Alliance	300 million (€220m)	UN	Focusing on adaptation, general mitigation and REDD.
Cool Earth Initiative (Japan)	10 billion	Japan	Focusing on adaptation and mitigation activities.
Environmental Transformation Fund (UK)	1.2 billion (£800m)	UK	Focusing on adaptation and mitigation with some components administered by World Bank and AFDB (Congo Basin Forest Fund).
International Climate Initiative (Germany)	170 million (€120 m)	Germany	Focusing on adaptation and general mitigation.
International Forest Carbon Initiative (Australia)	180 million (AUD 200m)	Australia	Focusing on mitigation through REDD.

Source: Adapted from a report prepared for the Financing for Development Conference on Climate Change, Kigali, 21-22 May 2009.

poorest countries cover the costs of preparing and implementing their national adaptation programmes of action (NAPAs). The newest fund, the Adaptation Fund, was established to finance adaptation projects and programmes in developing countries that are parties to the Kyoto Protocol in order to protect vulnerable communities from the impacts of climate change. A summary of the multilateral adaptation funding channels is provided in Table 2.

Moreover, climate change funding initiatives outside the UNFCCC (non-convention funds) are also rising. These funds are used either in general or specific areas (e.g., forests) to address both adaptation and mitigation issues. The total of these funds, if the sums can be raised in full, is indeed impressive (Table 3).

Despite the recent funds that have emerged, they are still far from the amounts needed to effectively mitigate and adapt to climate change. As of 2010, the combined climate finance from the UNFCCC, multilateral and bilateral sources including the CDM, GEF Trust Fund, Adaptation Fund, World Bank Climate Investment Funders and others amounted to US$8 billion per annum (UN-HAGCCF 2010). In addition, by November 2011, approximately US$450 million had been pledged to the LDCF and US$250 million to the SCCF (Schalatek et al. 2011) but are nevertheless much less than the estimated additional investment needed to finance climate change (Table 4; World Bank 2009b).

Table 4: Estimated additional investment and financial flows needed for adaptation in 2030 (US$).

Sector	Investment flow, US$/year	In developing countries, US$/year		Africa, US$/year	
Agriculture, forestry & fisheries	14 billion	7 billion	(50%)	1,000–2,000 million	
Water resources	11 billion	9 billion	(80%)	2,788–2,913 million	
Coastal zones	11 billion	5 billion	(45%)	528–612 million 1,197–1,319 million	(2030) (2080)
Human health	5 billion	5 billion	(all)	2,166–3,328 million	
Infrastructure	8–130 billion	2–41 billion		22–371 million	
Total	49–171 billion	28–67 billion	(57–39%)	7,173–9,931 million	

Source: UNFCCC (2007).

2.3 Climate-change funds for agriculture

Climate finance offers an opportunity to strengthen food security and promote climate change mitigation and adaptation in the developing countries. However, current climate-related financial flows specifically targeted to agriculture in the developing nations cover only a tiny fraction of the total climate-change funds (Climate Focus 2011). By 2008, the average total aid on agriculture was less than US$6 billion (Table 1), yet when considering the annual investment needs for agricultural adaptation are about US$7 billion (Nelson et al. 2010), climate finance is unlikely to meet most of the developing countries requirements for mitigation and adaptation. On the other hand, it is estimated that the potential increase in global investment flows to agriculture, forestry and fishery sectors will reach US$14 billion per year by 2030, of which US$7 billion/year is assumed to go developing countries (SEI 2008). However, according to projections, mitigation costs in agriculture will reach about US$20 billion by 2030 (Table 5). The amount of investment flows on agriculture will be significantly less than the expected costs for agricultural mitigation and adaptation (Louis 2007).

Table 5: Estimate of the reductions of emissions from non-CO_2 and soil carbon GHGs ($MtCO_2e$) and the investment needed to achieve these reductions (US$ billion) between 2000-30 at a cost of US$30 tCO_2e (2000$)

	2000		2010		2020		2030	
Subsector	Reductions	Cost	Reductions	Cost	Reductions	Cost	Reductions	Cost
Cropland	172	7.74	183	5.48	168	5.04	180	5.39
Rice	200	6.0	226	6.79	238	7.14	243	7.3
Livestock	131	3.93	143	4.28	158	4.73	175	5.26
Total	529	15.88	596	17.89	631	18.92	684	20.5

Source: Based on Verchot (2007).

2.4 Financing measures to battle climate change in agriculture

Financing sustainable agriculture under climate change includes financing both the mitigation of and adaptation to climate change. The extent of reduction in agricultural GHG emissions depends on the potential and marginal cost of limiting emissions. Table 6 summarizes four major areas of potential support to mitigate the effects of climate change in agriculture. Based on a review of literature and various adaptation programmes and practices, we summarize additional four broad categories for agricultural adaptation to climate change in Table 7. In the following sections, we base our analysis on four questions: What measures work? What could work? What procedures are scalable? And what are transferable?

3 What will work?

Financing mitigation of and adaptation to climate change in agriculture through foreign aid is an international movement that has been in existence only for a short period, but a number of successful experiences have emerged. This section discusses some of the foreign aid projects in developing countries that have worked well in terms of areas financed and successful outcomes.

3.1 Major areas of involvement

In financing the mitigation of climate change in agriculture, foreign aid-supported measures have worked well in locations where GHG emissions are significant but relatively easy to reduce with appropriate technologies. Agricultural GHG are caused by nitrous oxide emissions from soils, methane from ruminants and paddy fields, CO_2 emissions from soils, and from the energy used in agricultural production (IPCC 2007b; Table 6). The two major areas where foreign aid has worked well (Table 6: column 1) are reductions in paddy field methane emissions and in CO_2 soil emissions such as soil carbon sequestration through land-use conversions or from changes in farm practices (e.g., less or zero tillage, alternative periods of fallow and tillage, etc.). An example from the Philippines is presented later to show how foreign aid has worked to reduce paddy field methane emissions, and a grassland carbon sequestration project for controlling CO_2 emissions is presented in Section 6.

With regard to agricultural adaptation to climate change, foreign aid has been present to finance nearly every area listed in Table 7 (column 1). These include investments: (i) in water conservation infrastructure; (ii) in agricultural science and technology, (iii) in capacity-building programmes, and (iv) in risk management. The wide coverage of the finances for climate change adaptation in agriculture may be due to the fact that the aim of many of these measures is to further enhance agricultural and rural development. Irrigation is a priority area that has received considerable attention from foreign financing. This is not surprising, given that irrigation infrastructural development has been targeted by many international development and financing agents. In the next subsection, to illustrate the importance of mainstreaming climate change adaptation into agricultural development, we examine the role of foreign aid in China with respect to irrigation and its successful outcome.

Table 6: Potential areas for financing mitigation of climate change in agriculture in developing world through foreign aid

		Foreign aid			
	Potential areas	Works	Could work	Scalable	Transferable
1	Reducing nitrous oxide emissions from soils:				
	For example, by improving efficiency of fertilizer use through better technology extension service and training		***	***	**
2	Reducing methane from ruminants and paddy fields:				
	Reducing emissions from ruminants by reducing animal number in degraded grassland		*	*	*
	Reducing emissions from paddy fields through better farm management	**		***	**
3	Reducing CO_2 emission from soil:				
	Soil carbon sequestration through injection		**	*	*
	Soil carbon sequestration through land-use conversion or conservation	**		**	*
	Reducing CO_2 emissions by changing farming practices such as less or zero tillage, alternative fallow and tillage periods, etc.	**		**	**
4	Reducing CO_2 emissions through energy-saving technology:				
	For example, saving energy use through water-saving technology, less land preparation, etc.		**	**	**

Note: *, ** and *** indicate the level of probability (minimal, normal, or high, respectively) for 'what works', 'what could work', 'what is scalable' and 'what is transferable'

Source: Author's analysis.

Table 7: Potential areas for financing adaptation to climate change in agriculture in developing world through foreign aid

		Foreign aid			
	Potential areas	Works	Could work	Scalable	Transferable
1	Investment in water conservation infrastructure				
	Develop/improve irrigation infrastructure	***		***	***
	Water transfer or diversion projects within a country	*		*	*
	Land contouring, terracing, water storage, etc.	**		**	**
	Development of integrated drainage systems	**		***	***
2	Investment in agricultural science and technology				
	Investing in research for a better understanding of climate change impacts and vulnerability	**		***	***
	Developing new crop varieties, e.g., drought-resistant or flood-tolerant varieties	**		***	***
	Facilitating international technology transfer and local technology extension service	**		***	***
	Others (e.g., biotech, water saving technology, ecological and organic agriculture in some areas, etc.)	**		***	***

Table 7 (con't)

Table 7 continues

	Potential areas	Foreign aid			
		Works	Could work	Scalable	Transferable
3	Investment in capacity-building programme				
	Capacity to develop/implement adaption plans by national and local government	**		***	***
	Community planning and management capacity		**	**	**
	Improving farmers' capacity through farmers' associations (e.g., water users associations and cooperatives) and training	**		***	**
4	Investment in risk management				
	Subsidized agricultural insurance		**	**	**
	Natural disaster release and food aid programme	***		***	*
	Early warning and information systems to provide timely weather predictions and forecasts	**		***	***
	Restore the natural capacity to buffer climate impacts	**		**	**

Notes and source: as given in Table 6:

3.2 Successful experiences

In this subsection, we examine several cases where foreign aid has had a prominent role in the successful financing of sustainable agriculture under climate change.

Box 1: Mitigating methane emissions through new irrigation schemes in rice production in the Philippines

Methane emission is a major component of overall GHG emissions and has been rising over time (Oberthür and Ott 1999; Tyler et al. 1999). Paddy fields are a primary source of methane emissions and are also one of the few anthropogenic sources where management of methane is possible (Wassmann et al. 2009). A more integrated approach to rice paddy irrigation and fertilizer application can substantially reduce methane emissions but it requires modifications to farm management such as changes in the mid-season drainage of rice paddies and intermittent irrigation.

This box summarizes measures to mitigate methane emissions in rice production in Bohol Island (the Philippines) based on the report by Wassmann et al. (2009) and FAO (2010b). Bohol Island, one of the country's biggest rice-growing areas in the Visayas region, has experienced declining productivity because of defective existing irrigation systems. Before completion of the Bohol Integrated Irrigation System (BIIS) in 2007, two older reservoirs (Malinao and Capayas Dam) were beset by problems, unable to ensure sufficient water for the second crop (November to April), especially for farmers farthest downstream from the dam. The problem was aggravated by unfair water distribution practices and water wastage through continuous flooding to irrigate rice crops.

In the face of declining rice production and ineffective water management, the National Irrigation Administration (NIA) created the BIIS action plan in 2007, with the overall goal to improve the efficiency of water management, which would also achieve simultaneous benefits of mitigating methane emissions, and increasing rice productivity in Bohol. The project included construction of a new dam (Bayongan Dam; funded by a loan from the Japan Bank for International Cooperation) and implementation of a water-saving technology known as Alternate-Wetting and Drying (AWD) which was developed by the International Rice Research Institute (IRRI) in cooperation with national research institutes. The visible success achieved with AWD in pilot farms as well as specific training programmes for farmers dispelled the widely held perception of possible yield losses from non-flooded rice fields.

Wide adoption of AWD improved irrigation water usage, so that crop intensity could be increased from ca. 119 per cent to ca. 160 per cent (compared to the 200 per cent maximum of double-cropping systems). Moreover, based the revised IPCC methodology (IPCC 2006), modifications to the water regime have the potential to reduce methane emissions by 48 per cent over the traditional method of continuous flooding of rice fields.

The AWD project therefore generated multiple benefits with regard to methane emission reductions (mitigation), decreased water use (adaptation where water is scarce), and increased productivity, thereby contributing to food security (author, based on Bouman et al. 2007).

A project for reducing methane emissions in the Philippines

Methane emission constitutes an important component of global GHG emissions. The general consensus is that the potential to reduce methane emissions at its major source—rice fields—is high (FAO 2010b) but the problem is how to incorporate a methane emission reduction objective into farming practices while also maintaining or even improving agricultural productivity.

Box 1 describes one such case of successful foreign aid intervention in the Philippines where emission reductions were achieved through new irrigation schemes. Investment also benefitted the farmers who participated in the programme in Bohol Island, one of the biggest rice-growing areas of the Philippines. As this case indicates, a programme aimed at reducing GHG emissions can be successful if it is incorporated into the agricultural development agenda, provides incentives for farmers to participate and attracts the interest of major stakeholders.

A project for financing measures for climate change adaptation in agriculture

Faced with the reality of global warming, adaptation to climate change through appropriate measures and investment is essential. As Table 7 shows, four major categories of investment in the agricultural sector for adaptation to climate change could produce successful outcomes. Here, we introduce a foreign aid scheme in China that underlines importance of mainstreaming climate change adaptation into national development programme (Box 2).

Box 2: Mainstreaming climate change adaptation in irrigated agriculture in 3H Basin

The Huang-Huai-Hai River Basin (3H Basin), a region with a population of 425 million is beset with challenging climatic risks. Primarily an agricultural region, producing about 50 per cent of China's grain, it is heavily dependent on irrigation water. But the region's per capita water availability is only one-third of the country's average and available resources are already fully allocated and often overexploited, making the region highly vulnerable to climate change. Higher temperatures and higher crop evapotranspiration further aggravate the problem.

To ease the water shortage, the World Bank, supported by the SCCF of the Global Environment Facility, implemented a project in 2008-10 on mainstreaming climate change adaptation measures in irrigated agriculture. The project consisted of three phases, each with a specific target. The first phase identified and prioritized different adaptation measures; the second phase constituted demonstration and implementation of the measures while the third component was to mainstream adaptation into the national comprehensive agricultural development (CAD) programme and institutional strengthening.

The activities included a series of measures to promote capacity building, technical assistance, knowledge sharing, public awareness, and the preparation of a national climate change adaptation plan for CAD. The procedure for integrating and mainstreaming climate change adaptations into the national plan also engaged officials from the National Development and Reform Commission, the Ministry of Finance, and provincial government, and scholars from the Chinese Academy of Sciences and the Chinese Academy of Agricultural Sciences.

Through the efforts of SCCF and IAIL3 projects, communities are currently better informed about climate threats but, more importantly, their ability to sustain and perhaps even improve that knowledge and use it to guide future coping choices has increased. Equipped with a toolkit of immediate instruments, the communities are better prepared to protect their livelihoods, and to expand the toolkit in accordance with changing climatic circumstances and increased knowledge. This represents the beginning of an adaptive capacity that rural communities across the developing world will need to safeguard their livelihoods against the effects of global warming.

The project created the first line of defence in five provinces across the 3H Basin by exploring and demonstrating how the achievements of IAIL3 and other CAD initiatives can be used to safeguard against climate change. More detailed information on the project is given in World Bank (2012) and Conrad and Li (2012).

Source: Author, based on reports by World Bank (2012) and Conrad and Li (2012)

The Mainstreaming Climate Change Adaptation in Irrigated Agriculture is a project supported by the GEF-managed SCCF and focused on the Huang-Huai-Hai River Basin (3H Basin) in the northern plains of China. All project objectives were fulfilled: to introduce, demonstrate and implement specific adaptation measures in selected demonstration areas, adjust and integrate appropriate adaptation measures into the implementation of the Third Irrigated Agriculture Intensification Project (IAIL3), and to reduce vulnerability to climate change in the 3H Basin (Conrad and Li 2012). The project was successful in increasing local ability to react to changing circumstances. For example, more than 1,000 water users associations, 209 farmer associations, and 20 specialized farmer cooperatives were established under the overall IAIL3 project. According to interviews with national officials, the project also generated a general framework and approach for the Office of the National Comprehensive Agricultural Development (CAD), the Ministry of Finance on integrating and mainstreaming climate change adaptation into the national CAD programme.

A project to invest in agricultural technology

Box 3 illustrates the successful results of an investment in the research for drought-tolerant maize for Africa. This case shows that investment in research to develop relevant technology is a priority area for financing agriculture under climate change.

Within a short period, this project has demonstrated high investment returns in science and technology by the international public research organizations and the importance of agricultural technology in mitigating the impacts of climate change in developing countries. Maize productivity is increasing, and the adoption rate of drought-tolerant maize varieties can be expected to be high. Should wide adoption of drought-tolerant varieties materialize, it is estimated that over four million people will 'escape poverty and many millions more will be able to improve their livelihoods' (La Rovere et al. 2010). Moreover, the impacts of the project are expected to continue after the conclusion of the first phase in 2016, as non-participating countries can also benefit from technology spillovers.

Box 3: The DTMA project for drought-tolerant maize

A typical programme of foreign aid research and development, the Drought Tolerant Maize for Africa (DTMA) project was launched in 2006 and was jointly funded by the Bill and Melinda Gates Foundation, the Howard G. Buffett Foundation, USAID, and the UK Department for International Development. Coordinated by the International Maize and Wheat Improvement Center and the International Institute for Tropical Agriculture, the current 10-year phase of DTMA covers the period 2006-16 and focuses on 'expanded use by farmers of certified, drought-tolerant maize seed, and should enable delivery of enough seed to benefit 30-40 million people in sub-Saharan Africa and provide added grain worth US$160-200 million each year in drought-affected areas' (DTMA 2012).

Recent studies suggest that the return to investment is impressively high. Farmers in the 15 participating countries had access already by 2012 to 34 drought-tolerant seed varieties and hybrids (DTMA 2012). Yields of drought-tolerant maize over normal varieties, depending on the seriousness of actual drought conditions, have improved between 3-34 per cent, which has significantly increased farmer income, household food security and local food supply. An impact assessment reported by La Rovere et al. (2010) shows that 'at the most likely rates of adoption, based on several recent studies and expert advice, drought tolerant maize can generate US$0.53 billion from increased maize grain harvests and reduced risk over the study period, assuming conservative yield improvements'. The report also estimated the likely impacts of the project under a more optimistic yield-gain scenario, and concluded that the economic benefit could reach as high as US$0.88 billion in the 15 African countries covered in this project.

Sources: Author based on La Rovere et al. (2010).

Other schemes for investing in agricultural technology

Other major foreign aid investment areas in agricultural technology include biotechnology, water saving technology, and technologies supporting ecological agriculture (Table 7). Recent investment in biotechnology by the Bill and Melinda Gates Foundation in Consultative Group on International Agricultural Research (CGIAR), Africa and South Asia for improving food security and poverty reduction in the less developed countries has been impressive. Kostandini et al. (2009) document the ex ante impact of transgenic research for mitigating drought in rain-reliant production areas for maize, rice, and wheat in Asia and Africa.[1] Their results show that the biotech drought-tolerant crops are 'very promising for the millions of poor in the more marginal rain-fed agricultural areas of developing countries'. Water saving technology is also an area that has often attracted foreign aid from the World Bank and several regional development banks worldwide, particularly in Africa and Asia (World Bank 2009a, 2010; Howden and Meinke 2003). In Senegal, in responding to increasing desertification from climate change, IFAD supported a successful project on drip irrigation (World Bank 2010). Some programmes are also aimed at developing ecological farming and organic agriculture (EU focus 2010; Tirado and Cotter 2010). For example, the EU-supported small projects facility has helped Philippines farmers adopt organic agriculture, thereby increasing their export potential for to European markets (EU focus 2010). In Burkina Faso, the IFAD-supported sustainable rural development programme is encouraging the adoption of more environmentally friendly technologies such as soil and water conservation techniques and agroforestry (IFAD 2010).

4 What measures could work

In this section, we present an examination of foreign aid-supported measures 'which could work', but where foreign aid is underrepresented, yet where it has the potential to product results (column 2 of Tables 6 and 7). We also highlight a few examples to show how foreign aid could work in these areas.

4.1 Major areas

Foreign aid can do more to mitigate the effects of climate change on the agricultural sector. As was mentioned earlier, primary areas where foreign financing has been used for this specific purpose include the reduction of methane emissions from paddy fields, increased carbon sequestration through land use changes, and limiting CO_2 emissions from the soil. But there are other areas that are also potential targets for foreign finance in developing countries. These concern the control of nitrous oxide emissions from crop production or limiting CO_2 emissions through energy-saving technology.

In financing agricultural adaptation to climate change, most areas identified in Table 7 have often involved foreign aid projects that have produced good results (column 1). Two additional areas should also be considered as possible target areas where foreign aid could work or work better: investment in community planning and management capacity as well as subsidized agricultural insurance. Capacity building covers a wide range of activities as the lack of capacity is a compelling problem in developing countries in their fight against climate

[1] E.g., India, Indonesia, Bangladesh, The Philippines, Kenya, Ethiopia, Nigeria, and South Africa.

change; this includes improving community capacity to adapt to global warming (NFCCC 2012). So far, little experience has been gained from this type of financing because community capacity building is a complicated task. There are a lot of open questions with respect to the impacts of climate change at the local level, and large diversity exists among local communities. The performance of a foreign aid project in this field could be improved with more information and understanding of the consequences of climate change at the local level and actual needs of specific communities in their adaptation approach. With respect to subsidized agricultural insurance, creating an enabling environment for foreign investment in agricultural insurance and closely working with the local government are critical for the success of foreign aid project, as is indicated by the study-case presented in later in this section.

4.2 Examples of potential areas for foreign aid investment

In this subsection, we review three schemes to illustrate possible areas of foreign aid financing to achieve sustainable agriculture under climate change.

Project to control nitrous oxide emissions from soils: China

Nitrous oxide emissions can be effectively reduced through increased efficiency in the use of nitrogen, thus limiting its application. While this major transition of nitrogen use is common in many developed countries, it has not occurred in the developing world. For example, the overuse of synthetic nitrogen fertilizers was common in the UK in the 1970s and early 1980s with significant nitrous oxide emissions and other serious environmental consequences. Since then regulatory changes and investment have brought about improvements in nutrient management and agricultural technology that have allowed the increase in application rates to stop or decline slightly whilst crop yields have risen (SAIN 2010). In the developing countries a typical problem is that farmers are credit constrained, which limits sufficient use of synthetic nitrogen fertilizer. But nitrogen fertilizer overuse is common in many emerging countries such as China (Huang et al. 2008)

China has considerable potential for reducing nitrous oxide emissions in crop production. The manufacture and use of synthetic nitrogen (N) fertilizer is estimated to account for about 10 per cent of the fossil energy used by the industrial sector, contributing to nearly 5 per cent of China’s total GHG emissions (SAIN 2010). While chemical fertilizers play an important role in increasing agricultural production and ensuring food security, farmers in China use at least 30 per cent more per hectare than farmers in many other countries (Huang et al. 2012; SAIN 2010). If appropriate technology for improved N fertilizer use could be adopted, the resulting decrease of overuse could reduce China’s total GHG emissions by more than 1 per cent and nitrous oxide emissions by 30 per cent or more (SAIN 2010).

While little foreign aid has been aimed at measures to reduce the overuse of N fertilizer in developing countries, several pilot experiments in China funded by both the Chinese government and international donors show that this could be an area where more financing, foreign aid included, is needed. For example, a series of training programmes shows that delivering information and knowledge on the efficiency of N fertilizer can significantly lower its use in grain production by 15–30 without adverse effects on crop yields (Hu et al. 2007; Huang et al. 2008, 2012; Peng et al. 2010). Improved N fertilizer management is a clear win-win situation with economic and environmental benefits. However, to reduce nitrous oxide emissions through more efficient use of fertilizer implies better capacity building and training programmes for the farmers. Consequently, substantial investment, including foreign aid, in agricultural extension is needed to educate hundreds of millions of small farmers in the developing countries. A brief discussion on this topic is provided in Box 4.

Box 4: Reducing nitrogen fertilizer use in China through training programmes

Low carbon agriculture can make a significant contribution to the overall reduction of GHG emissions. There is indisputable evidence from recent studies that the overuse of nitrogen fertilizer in China is serious and that application rates could be cut 20 to 30 per cent (Hu et al. 2007; Huang et al. 2008, 2012; Peng et al. 2010) or even more in grain production with no loss in crop yields or national food security (Zhang et al. 2008; Zhao et al. 2010). Such a decrease in overuse could reduce China's total GHG emissions by 1-2 per cent and nitrous oxide emissions by 30 per cent or more (SAIN 2010).

Two pilot experiments (rice and maize) aimed at cutting N fertilizer use without affecting crop yields were conducted China. The rice pilot experiment was conducted by CCAP and International Rice Research Institute (IRRI) and funded by International Development Research Center (IDRC) in 2003-05. The maize pilot project was also conducted by CCAP with its collaborators from China Agricultural University in 2009 and jointly funded by the Sino-German Research Project and the China-UK Sustainable Agriculture Innovation Network (SAIN).

Rice production: The technology being transferred to farmers to reduce N fertilizer use is the site-specific nutrient management (SSNM) programme developed by IRRI. Experiments were implemented in six rice-growing villages in four provinces (Guangdong, Hunan, Hubei and Jiangsu). A half-day training course by the local extension agent outlined the details of efficient fertilizer application to the farmers. After training, some of the farmers were randomly selected for field trials (Hu et al. 2007; Huang et al. 2008). Farmers who had attended the training session reduced N fertilizer use by 18 per cent compared to the control group of non-participating farmers, while the field trial participants decreased their usage of N fertilizer up to 35 per cent with no difference in yields. The study also indicated that the scheme's advantages needed first to be convincingly conveyed to the extension agents and that intensive training should be provided. Although 'getting the message right' does help, intensive efforts to promote technology were needed in order to secure maximum benefits from the increased efficiency of N fertilizer use.

Maize production: Experiments were implemented in two counties in Shandong province in 2009. A training course of one to two hours was offered to farmers on nitrogen fertilizer use in maize production by trained extension staff. The study results show that the training was instrumental in reducing overall N fertilizer use by 22 per cent but they also pointed out that training China's 200 million smallholders is a challenge and despite significant reductions in N fertilizer usage by trained farmers, its use still exceeded recommended levels. Whether China's current agricultural extension system can deliver appropriate information and knowledge on the efficiency of N fertilizer to millions of farmers is an issue that requires further study because the current agricultural extension system also faces great difficulties in providing technology services to farmers.

Source: Author's analysis.

Investments for reducing CO_2 emissions from direct energy use in farm operations

Although the role of direct investment through foreign aid in farm operations is limited, foreign aid could assist developing countries generate energy-saving technologies in agricultural production. But as the technology has to be adopted by the farmers, cost effective technologies are the prerequisite of a successful project.

CO_2 emissions can be reduced by saving energy in farm operations (e.g., mechanization, land preparation and irrigation). Energy-saving machinery and limiting the use of machinery in land preparation by changing farm practices (e.g., zero tillage) have often been discussed in the literature. Water pumps for irrigation also consume vast amounts of energy (Lal 2004; Mushtaq et al. 2009), but this source of GHG emissions has been largely neglected to date. Yet a recent empirical study from China shows that emissions from groundwater irrigation pumps totalled 33.1 $MtCO_2e$ in the late 2000s, which was about 0.5 per cent of the country's total emissions (Wang et al. 2012). Direct savings resulting from the controlled use of such energy sources as gasoline, diesel and the electricity used in farm operations could be achieved through investment in energy-saving technologies in land preparation, irrigation, harvesting, storage and transportation.

Investment in risk management: subsidized agricultural insurance

Agricultural insurance is an area that has not attracted significant investment from foreign aid but which could produce benefits. Currently, crop and livestock insurance programmes are government subsidized and are implemented mainly in the developed countries (OECD 2011; Smithers 1998). In the developing countries farmers are normally more vulnerable to natural disasters but often receive little subsidized agricultural insurance from the government because of financial constraints. Market-based private agricultural insurance is rare in the developing world because small-scale farmers lack the resources to pay for insurance premiums, and private insurance companies are not interested in operating costly schemes for millions of small farmers. Thus, financial mechanisms and public policy should be deployed strategically to leverage foreign aid and private capital and exploit opportunities to create enabling conditions for investment in agricultural insurance.

Box 5 presents one innovative insurance mechanism implemented in Ethiopia to show how foreign aid can work to promote agricultural insurance in the developing countries.

Box 5: Insurance mechanism in Ethiopia: the HARITA model

The Horn of Africa Risk Transfer for Adaptation (HARITA) is an innovative climate change resilience project launched jointly by several international donors, NGOs and one insurance company. Between November 2007 and December 2009, a pilot climate risk management package was designed for poor farmers in the village of Adi Ha which consisted of a mix of risk reduction, drought insurance, and credit. The approach consisted of three main components:

- Risk reduction and minimizing vulnerability: Farmers participating in the HARITA learned how to use compost, which is important for rebuilding soil nutrients and improving soil moisture retention. They also built small-scale water harvesting structures and planted trees and grasses to promote soil and water conservation;
- Risk transfer and weather index insurance: Introduced micro-insurance to strengthen Ethiopia's productive safety net programme by addressing the non-chronic, 'unpredictable' needs not covered under the programme;
- Prudent risk taking and credit: Supported poor producers in making optimal production decisions even in the face of uncertainty for livelihood diversification, technology adoption and entry into more profitable lines of business.

HARITA was innovative in the sense that it allowed very vulnerable farmers to pay their premiums and benefit through risk reduction measures.

Sources: Oxfam America (2009).

5 What can be scaled up?

Currently, most of the foreign aid projects that are known to work (see columns 1 and 2 of Tables 6 and 7) are normally implemented on a small scale. These could be scaled-up to bring additional benefits, but greater efforts may be needed to deliver foreign aid on a bigger scale. In this section, we introduce several examples of projects for climate change mitigation or adaptation and review the results of the scaling-up experiences in these cases.

5.1 Expanding pilot projects for reducing CO_2 emissions through soil carbon sequestration

The Kyoto Protocol recognizes that it is possible to reduce net emissions either by decreasing the rate at which GHGs are emitted to the atmosphere or by increasing the rate at which GHGs are removed from the atmosphere through sinks. Agricultural soils are among the planet's largest reservoirs of carbon and hold the potential for expanded carbon sequestration, and thus provide the possibility of mitigating the growing atmospheric concentration of GHGs (FAO 2001). It is estimated that soils can sequester around 20 Pg C in 25 years, more than 10 per cent of the anthropogenic emissions.

While cost effective technologies for soil carbon sequestration are still to be developed, there are a number of efforts and pilot projects in effect. Some of the successful pilot projects could be scaled-up in the future. For example, an international network was created in 2000—the DMC (Direct sowing, Mulch based systems and Conservation tillage)—which already includes 60 international and national institutions. The German government established a partnership with the African tillage network. CIRAD joined this network and with a French cooperation funding set up a plan of action in Brazil, Madagascar, Mali, Laos and Tunisia, where different agricultural practices are tested and assessed with measurements of stocks and fluxes of CO_2 and N_2O emissions at benchmark sites.

Box 6: The Three Rivers Grassland Carbon Sequestration project in Qinghai, China

The potential of grasslands to sequester carbon is being increasingly recognized. With low levels of plant biomass compared with forests or shrub land ecosystems, grasslands form a major terrestrial carbon stock that can be increased though appropriate management (UECC 2010). Nevertheless, grassland soil carbon sequestration is significant, and its effects with respect to climate mitigation are measurable and verifiable.

The pilot stage of the Three Rivers Grassland Carbon Sequestration project was launched in 2009 in Qinghai (China) where overgrazing was a serious problem. Utilizing carbon financing, the pilot project was aimed at increasing carbon stocks through restoration of degraded grasslands and enhancing livestock productivity. The project introduced better grassland management practices such as improving summer-winter pasture rotation of grazing, limiting the timing and number of animals on degraded pastures, and restoring severely degraded lands by replanting perennial grasses and ensuring appropriate long-term management. Replacing the low-input, low-output, degradation-inducing livestock system with a high-productivity, sustainable land management system can contribute to carbon sequestration.

Herders were offered a menu of options designed to fit their specific land use. These included a combination of grassland restoration zoning and stocking rate management within an incentive-based system. Given the 45 per cent rate of overstocking prior to project implementation, considerable reductions in animal numbers, and therefore in incomes, could be expected during the first years of implementation, for which herders were to be compensated. In subsequent years, as incomes grow in response to increased livestock productivity—and possibly from small additional business support measures—compensation decreases progressively until year ten, when it will cease altogether.

Overall, during the project's first ten years, households will have fewer but more productive livestock after which herds can be increased beyond the initial 10-year level without risk of overgrazing. Increased availability of forage will ensure higher incomes and higher levels of production over the long run, providing a financial incentive for long-term sustainable management. In addition, the project envisions developing a number of activities aimed at enhancing the profitability of livestock rearing for improved herder livelihoods. In addition to improvements in animal production (e.g., feeding, winter housing and breeding), the project includes the development of processing activities and marketing associations.

This project hopes to break the vicious cycle of overstocking and degradation, thus demonstrating sustainable management options while generating a reduction of approximately 500,000 tCO_2e, over a 10-year period. It also aims to address some of the key barriers to smallholder access to carbon finance, which include the lack of appropriate methodologies for accessing credit, and cost effective monitoring, reporting and verification.

Source: Author, based on FAO (2010b).

Box 6 provides a pilot case which demonstrates that a carbon sequestration project can be successfully scaled-up if the mitigation objectives of foreign aid are formulated in partnership with short-run compensation and the need to increase long-run agricultural productivity. The Qinghai (China) carbon sequestration project is aimed at promoting livestock productivity while at the same time increasing carbon stocks through the restoration of degraded grasslands. This is an interesting case because there are few operational examples of carbon finance projects that are targeted to grasslands anywhere in the developing world. The project introduces improved grassland management practices, while concurrently providing compensation to herders during the initial years of project implementation. As the livestock system changes from degradation-inducing methods to sustainable land management systems, it can contribute to carbon sequestration. Based on the experience gained from the project area, the government of China and international donors are planning to scale-up this pilot project, which could also be transferred to other regions of the country and the rest of world.

5.2 Scaling-up existing conservative management practices aimed at sequestrating and reducing CO_2 emissions

Many conservative management practices aimed at sequestrating and reducing CO_2 emissions from the soil can be easily scaled-up. For example, alternative fallow and tillage practices can address climate change-related moisture and nutrient deficiencies. These measures have been significantly scaled-up and are now widely used in Missouri, Iowa, Nebraska and Kansas (Easterling et al. 1993). Other examples of successful scaling-up experiments include crop rotation with legumes or grass-clover leys, application of organic fertilizers, and less or zero tillage practices in many developing countries. In recent years, the World Bank has been strongly involved in the diffusion and extension programmes on direct sowing and associated practices in developing countries, particularly in Brazil (FAO 2009b). Conservation tillage in crop production has expanded rapidly also in many parts of China (Wang et. al 2010a).

5.3 Scaling-up climate change adaptation with regard to agricultural irrigation

As climate change adaptation in water conservation is strongly related to agricultural productivity growth and sustainable agriculture, foreign aid can play an important role in scaling-up existing successful pilot projects. Here we examine the mainstreaming of climate change adaptation within agricultural irrigation in the 3H Basin discussed earlier. But it is worth noting that there are many schemes related to irrigation and drainage infrastructure related to climate change (World Bank 2010; FAO 2010b) which could be scaled-up with foreign aid.

Recently, a decision was made by the government of China and the World Bank to scale-up a project on mainstreaming climate change adaptation into irrigated agriculture in China due to its successful pilot stage. The World Bank approved a loan of US$80 million (Water Conservation Project II) to China for 2012-17 to help improve water management and to increase water productivity within agriculture, and to boost the incomes of 1.3 million farmers in the Ningxia, Hebei and Shanxi provinces. In addition to enhancing adaptation to climate change in agriculture and irrigation water management practices in 3H Basin and northwest China, the project includes activities in awareness and capacity building, and adaptation measures. Within the 3H Basin, in Anhui alone provincial level investment projects on climate change adaptation activities will be increased from 16 to 93 counties, bringing the number of farmers who gain to benefit from one million to 31 million. The

SCCF project has also made great efforts to reduce uncertainty through comprehensive analysis carried out by national and international scientists and supported by a World Bank Analytical and Advisory Activity during the pilot and scaling-up stages.

The discussions above highlight several points that need to be recognized in efforts to scale-up climate change financing. These include recognition of, but not limited only to, such factors as (i) investment should be targeted to a significant specific issue which either mitigates climate change in agriculture or improves agricultural adaptation to climate change; (ii) investment should be relevant to agricultural development and incorporated within regular development programmes; (iii) that problems are similar in both the pilot area and the scaled-up area in terms of climate change and agricultural development issues; and (iv) scaled-up projects must take into the interests of all major stakeholders, particularly farmers.

6 What experiences and concepts are transferrable?

This section presents evidence from four experiments to show that successful intervention through foreign aid in one country can be transferred to others. These were summarized in the last column in Tables 6 and 7.

6.1 Foreign aid to reduce methane emissions through the provision of appropriate technologies and integration with development goals

Measures to reduce methane from rice production, as exemplified by the investments made in Bohol Island in the Philippines (section 3), are potentially transferrable to other Asian countries. Rice is fundamental for food security, involving approximately three billion people and approximately 144 million ha of land under cultivation each year (IRRI 2010). The waterlogged, warm soils of rice paddies make this production system a large producer of methane (Corton et al. 2000). According to recent studies, methane emissions in 2000 reached 625 million metric tons (mt) of carbon dioxide equivalent (CO_2e) (Wassmann et al. 2009).

The Bohol project shows that the design of appropriate technologies and incorporation of the emission reduction objective into a development programme are key elements that can be transferred to other regions or countries. However, as technologies need to adapted to local conditions, participation of local farmers, extension agents, and research institutions in technology design and dissemination is critical. The above observations are also supported by a FAO report (2010b), which emphasizes that with appropriate irrigation and other farm management practices, paddy field methane emissions could be significantly reduced. Moreover, if foreign aid is to succeed in this respect, methane reduction must be fully integrated into local development goals so that farmers become interested in participating and gaining from the programme.

6.2 Foreign aid assisting agricultural adaptation by mainstreaming climate change adaptation into national development programmes and emphasizing local capacity building

Investment in irrigation and other water conservation infrastructure is one of the primary instruments to improve agricultural productivity and a priority area for financing its adaptation to climate change. If measures for climate change adaptation are to be successfully integrated into existing national development programmes, it is important that the demand and interest originates with the beneficiary country, and that close cooperation with local government is maintained. This was clearly highlighted by the 3H Basin project (Box 2). In the case of China, the interest in mainstreaming climate change adaptation into the nation's agricultural development programme originated with the Chinese state office of CAD, who considered this a new development concept that should be explored through a pilot project and then extend to other major projects. But for such local involvement, capacity building and technical assistance are needed, and here foreign aid can play a unique role by bringing together both international and local experts to help design adaptation measures and improve local capacity.

Investments in agricultural technology

Technology will have to be the primary driver for agricultural growth in the future, as it is anticipated that in the coming decades, the world will have fewer natural resources to produce much more food. According to an FAO report (2009b), 80 per cent of the production increases are projected to come from better yields and greater cropping intensity in the first half of twenty-first century, while in land-scarce developing countries, almost the entire production growth must be achieved through improved yields. Global food security, particularly in developing countries, is expected to face an even greater challenge under climate change. Furthermore, the average growth rate of agricultural productivity has been falling (World Bank 2007).

Agricultural productivity in the developing world can be improved through technology that has been developed locally or transferred from abroad. One successful case of improving research capacity and facilitating technology transfer in developing countries is the programme to develop drought-resistant grain varieties in Asia. Recognizing the special difficulties of generating varieties for the poor and of distributing technology to these people in unfavourable environments, the Rockefeller Foundation initiated in 1998 a multi-year, multi-country programme to support research and technology transfers of drought-tolerant rice in Asia. The Foundation supported research by China, India, and Thailand as well as by the International Rice Research Institute, and to promote technology transfer, it helped to provide training and networks for scientists, capital for improved screening facilities at experiment stations, and invested in the diffusion of drought-tolerant rice. The programme generated significant improvement in both the research and technological capacity of the countries involved, and experiences from the project have been transferred to countries engaged in the network. Pray et al. (2011) show that the programme generated drought-tolerant varieties which have already been adapted by farmers in the target countries. New varieties of drought-tolerant rice are being tested in other Asian countries. If these varieties could be widely adopted by Asian producers, they could help mitigate the risks to farmers of climate change, particularly during extreme drought conditions.

Examples of international collaboration in agriculture: enhancing South-South cooperative and learning experiences among developing countries

The patterns of international collaboration in agricultural development have been changing. Traditionally, most agricultural development programmes, including technology transfers and capacity building, have followed a north-south cooperative framework. Agricultural technological transfers have also been arranged by international organizations such as FAO, World Bank, and the CGIAR. While these channels of investment are important and should be enhanced in the future, the recent experiences of south-south cooperative programmes in technology transfer are encouraging.

In recent years, emerging countries such as Brazil, China and India have strived to develop agricultural collaboration with other countries in Africa and Asia. One of these south-south cooperative programmes worth mentioning is the China-Africa agricultural technology scheme. Under this endeavour, China has established 14 agro-technical demonstration centres (ADCs); six other ADCs are being constructed in Africa. More than 100 senior agricultural experts were dispatched in 2002 to 33 African countries (including, among others, Morocco, Sierra Leone, Namibia). Moreover, more than 4,200 agricultural officers and experts from Africa have been trained in China over the period 2004-11. While the impact of the China-Africa agricultural technology programme is yet to be evaluated, south-south cooperation does provide a new avenue of foreign aid for improving food security in the developing world and mitigating the adverse impacts of climate change.

To facilitate this cooperation, FAO launched the South-South Cooperation (SSC) Initiative in 1996. This Initiative has played important role in the transfer of technology and development experiences within the developing world through numerous SSC agreements, the implementation of which have supported country- and regional-level action to increase food production, reduce poverty, and improve local capacity to manage climate-related disasters. By 2012 FAO had facilitated the dispatch of more than 1,500 SSC experts and technicians to demonstrate how hunger and malnutrition can be alleviated and productivity improved through the adoption of new technologies, and how to reduce year-to-year production variability due to extreme weather events.

7 Conclusions

While agriculture is one of the major contributors to GHG emissions, it is also the most sensitive and vulnerable sector to climate change. Agricultural development is going to face great challenges in meeting global food security and can be expected to face even greater difficulties due to climate change. Mitigating and adapting to climate change in order to achieve sustainable agriculture needs substantial investment.

This paper has examined how finance, with a particular focus on foreign aid, can be used to fund climate change mitigation and adaptation in agriculture in the developing world. The results showed that agriculture is greatly underinvested and that foreign aid has not increased adequately for maintaining sustainable agriculture. Although climate change funds have recently been emerging, more funding will have to be raised. While additional climate change funds are important, their effective utilization is equally important. Recently, funding agencies and donors have tried to explore innovative approaches to the challenges posed by climate change in agriculture in developing nations.

The review of literature and case analyses showed that there is a wide range of areas where climate change mitigation and adaptation need support from foreign aid. We identified four general categories of mitigation measures that are considered to be potential areas for financing agricultural mitigation with foreign aid. They include the reduction of nitrous oxide emissions from soils (e.g., through greater efficiency in fertilizer uses with better technology extension services and training), limiting methane from ruminants and paddy fields, soil carbon sequestration through land-use conversion or conservation, scaling-down CO_2 emissions through modifications in farming practices (e.g., zero tillage), and through energy-saving technology.

Proposed investments through foreign aid for agricultural adaptation to climate change also cover four major categories. They include investments:

- in water conservation infrastructure (e.g., irrigation, water transfers, land terracing, water storage, and integrated drainage systems);
- in agricultural science and technology (e.g., better understanding of climate change impacts and vulnerability, new crop varieties, international technology transfers and local technology extension services, biotechnology and water-saving technology);
- in the capacity of governments, communities and farmer to adapt to climate change, and
- in risk management (e.g., agricultural insurance, natural disaster release and food aid programme, early warning and information systems, and restoration of natural capacity to buffer climate impacts).

In each category of financial support for either the mitigation of climate change or adaptation, we emphasized four major questions: ‘what works?’ ‘what could work?’ ‘what can be scaled up?’, and ‘what is transferable?’ Reviewing several aid-supported cases that have worked in certain developing countries, this paper shows that for successful investments in agriculture in the fact of climate change, foreign aid needs to consider the multiple objectives related agricultural development, mitigation and adaptation as well as the interests of major stakeholders involved (e.g., government and farmers).

Major requirements for successfully financing sustainable agriculture through foreign aid should include programmes and measures that are mainstreamed into each country’s national action plans on climate change; close collaboration with developing country governments, enhanced local capacity, and consideration of the needs of different stakeholders. This paper also shows that these prerequisites are the key in scaling-up and transferring projects within a country or across countries. Of course, the degree to which foreign aid-funded projects can be scaled-up and replicated depends on the significance and similarity of problems in terms of climate change and agricultural development within the pilot area and other potential locations.

References

Baumert, K. A., T. Herzog, and J. Pershing (2005). 'Navigating the Numbers'. WRI Greenhouse Gas Data and International Climate Policy. Washington, DC: World Resources Institute. Available at: www.pdf.wri.org/navigating_numbers.pdf.

Bouman, B. A. M., R. M. Lampayan, and T. P. Tuong (2007). 'Water Management in Irrigated Rice: Coping with Water Scarcity'. Los Baños, Philippines: IRRI.

Climate Focus (2011). 'Title Carbon Market and Climate Finance for Agriculture in Developing Countries'. Washington, DC: Climate Focus. Available at: www.climatefocus.com/documents/files/title_carbon_market_and_climate_finance_for_agriculture_in_developing_countries.pdf

Conrad, B., and Q. Li (2012). 'Building a Line of Defence against Climate Change: From Reactive Coping to Adaptive Capacity in China's Irrigated Agricultural Development'. Washington, DC: World Bank.

Corton, T. M., J. Bajita, F. Grospe, R. Pamplona, R. Wassmann, and R. S. Lantin (2000). 'Methane Emission from Irrigated and Intensively Managed Rice Fields in Central Luzon (Philippines)'. *Nutrient Cycling Agroecosystems*, 58: 37–53.

DTMA (Drought Tolerant Maize for Africa) (2012). 'Five Years of Addressing the Needs of Smallholder Farmers in Africa'. DTMA Brief. Available at: www.dtma.cimmyt.org/index.php/publications/doc_view/175-dtma-brief-english-revised-

Easterling, W. E., P. R. Crosson, N. J. Rosenberg, and others (1993). 'Agricultural Impacts of and Responses to Climate Change in the Missouri-Iowa-Nebraska-Kansas (MINK) Region'. *Climate Change*, 24: 23–61.

Easterling, D. R., G. A. Meehl, C. Parmesan, S. A. Changnon, T. R. Karl, and L. O. Mearns (2000). 'Climate Extremes: Observations, Modelling, and Impacts'. *Science*, 289: 2068–74.

EU Focus (2010). 'The EU and Food Security'. Washington, DC: EU Focus. Available at: www.eurunion.org/News/eunewsletters/EUFocus/2010/EUFocus-EU&FoodSecur-Mar2010.pdf

FAO (Food and Agriculture Organization) (2001). 'Soil Carbon Sequestration for Improved Land Management'. FAO World Soil Resources Reports 96. Rome: FAO.

FAO (2007). 'Crop and Food Supply Assessment Mission to Ethiopia'. Special Report for Global Information and Early Warning System on Food and Agriculture. World Food Programme. Rome: FAO.

FAO (2007a). 'Adaptation to Climate Change in Agriculture, Forestry and Fisheries: Perspective, Framework and Priorities'. Report of the FAO Interdepartmental Working Group on Climate Change. Rome: FAO.

FAO (2008a). 'Climate Change and Food Security: A Framework Document'. Rome: FAO. Available at: www.fao.org/forestry/15538-079b31d45081fe9c3dbc6ff34de4807e4.pdf

FAO (2008b). 'Enabling Agriculture to Contribute to Climate Change Mitigation'. Rome: FAO. Available at: www.unfccc.int/resource/docs/2008/smsn/igo/036.pdf

FAO (2009a). 'How to Feed the World in 2050'. Rome: FAO. Available at: www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf

FAO (2009b). 'How to Feed the World in 2050: The Technology Challenge'. Rome: FAO. Available at: www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/HLEF2050_Technology.pdf

FAO (2010a). 'The State of Food Insecurity in the World 2010'. Rome: FAO. Available at: www.fao.org/docrep/013/i1683e/i1683e.pdf

FAO (2010b). ' "Climate-Smart" Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation'. FAO: Rome. Available at: www.fao.org/docrep/013/i1881e/i1881e00.htm

UN-HAGCCF (High-Level Advisory Group on Climate Change Financing) (2010). 'Report of the Secretary-General's High-Level Advisory Group on Climate Change Financing'. 5 November 2009. New York: United Nations: Available at: www.un.org/wcm/webdav/site/climatechange/shared/Documents/AGF_reports/AGF%20Report.pdf

Howden, S. M., and H. Meinke (2003). 'Climate Change: Challenges and Opportunities for Australian Agriculture'. In Proceedings of 'Climate Impacts on Australia's Natural Resources: Current and Future Challenges'. Gold Coast, Queensland, pp.53–5.

Hu, R., J. Cao, J. Huang, S. Peng, J. Huang, X. Zhong, Y. Zou, J. Yang and R. J. Buresh (2007). 'Farmer Participatory Testing of Standard and Modified Site-specific Nitrogen Management for Irrigated Rice in China'. *Agricultural Systems*, 94: 331–40.

Huang, J., C. Xiang, X. Jia, and R. Hu (2012). 'Impacts of Training on Farmers' Nitrogen Use in Maize Production in Shandong, China'. *Journal of Soil and Water Conservation*, 67(4): 321–7.

Huang, J., R. Hu, J. Cao, and S. Rozelle (2008). 'Training Programmes and in-the-Field Guidance to Reduce China's Overuse of Fertilizer without Hurting Profitability'. *Journal of Soil and Water Conservation*, 63(5): 165–7.

IFAD (International Fund for Agricultural Development) (2010). 'Climate Change Strategy'. Rome: IFAD.

IPCC (Intergovernmental Panel on Climate Change) (2001). *Climate Change 2001. Impacts, Adaptation, and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of IPCC. Cambridge: Cambridge University Press.

IPCC (2006). 'Revised Guidelines for National Greenhouse Gas Inventories'. IPCC/OECD/IEA/IGES. Vol. 4. Agriculture, Forestry and other land use.

IPCC (2007a). Climate Change 2007. *Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of IPCC. Cambridge: Cambridge University Press.

IPCC (2007b). *Climate Change 2007. Mitigation of Climate Change*. Contribution of Working Group III to the Fourth Assessment Report of IPCC. Cambridge: Cambridge University Press.

IPCC (2012). *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*. Special Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

IRRI (2010). 'Rice in the Global Economy: Strategic Research and Policy Issues for Food Security'. Los Baños: IRRI.

Islam, N. (2011). 'Foreign Aid to Agriculture--Review of Facts and Analysis'. IFPRI Discussion Paper 01053. Washington, DC: IFPRI.

Kostandini. G., B. F. Mills, S. W. Omamo, and S. Wood (2009). 'Ex ante Analysis of the Benefits of Transgenic Drought Tolerance Research on Cereal Crops in Low-income Countries'. *Agricultural Economics*, 40(4): 477–92.

La Rovere, R., G. Kostandini, T. Abdoulaye, J. Dixon, W. Mwangi, Z. Guo, and M. Bänziger (2010). 'Potential Impact of Investments in Drought Tolerant Maize in Africa'. Addis Ababa: CIMMYT.

Lal, R. (2004). 'Carbon Emission from Farm Operations'. *Environment International*, 30 981–90.

Louis, V. V. (2007). 'Opportunities for Climate Change Mitigation in Agriculture and Investment Requirements to Take Advantage of These Opportunities'. A report to the UNFCCC Secretariat. Nairobi: ICRAF. Available at: www.icraf.com/downloads/publications/PDFs/rp15435.pdf

Mushtaq, S., T. N. Maraseni, J. Maroulis, and M. Hafeez (2009). 'Energy and Water Tradeoffs in Enhancing Food Security: A Selective International Assessment'. *Energy Policy*, 37: 3635–44.

Nelson, G .C., M. W. Rosegrant, J. Koo, R. Robertson, T. Sulser, T. Zhu, C. Ringler et al. (2010). 'The Costs of Agricultural Adaptation to Climate Change'. WB Discussion Paper 4: Development and Climate Change. Washington, DC: World Bank.

Oberthür, S., and H. E. Ott (1999). The Kyoto Protocol: International Climate Policy for the 21st Century. Berlin: Springer Verlag.

OECD (Organization for Economic Co-operation and Development) (2009). 'Financial Resources and Investment for Climate Change'. Paper prepared for the Special Session of the Africa Partnership Forum on Climate Change, 3 September. Addis Ababa. Available at: www.oecd.org/site/africapartnershipforum/meetingdocuments/43551000.pdf

OECD (2011). *Managing Risk in Agriculture: Policy Assessment and Design*. Paris: OECD.

Oxfam America (2009). 'Horn of Africa Risk Transfer for Adaptation'. HARITA Project Brief. Washington, DC: Oxfam America.

Oxfam (2009). 'Beyond Aid: Ensuring Adaptation to Climate Change Works for the Poor'. Oxfam Briefing Paper. Available at: www.preventionweb.net/files/11158_oxfam beyondaidsep09.pdf.

Peng, S., R. J. Buresh, J. Huang, X. Zhong, Y. Zou, J. Yang, G. Wang, Y. Liu, R. Hu, et al. (2010). 'Improving Nitrogen Fertilization in Rice by Site-Specific N Management. A Review'. *Agronomy for Sustainable Development*, 30: 649–56.

Pray, C., L. Nagarajan, L. Li, J. Huang, R. Hu, K. N. Selvaraj, O. Napasintuwong, and R. Chandra Babu (2011). 'Potential Impact of Biotechnology on Adaption of Agriculture to Climate Change: The Case of Drought Tolerant Rice Breeding in Asia'. *Sustainability*, 3: 1723–41.

SAIN (the China-UK Sustainable Agriculture Network) (2010). 'Improved Nutrient Management in Agriculture: A Neglected Opportunity for China's Low Carbon Growth Path'. SAIN Policy Brief 1. Beijing: SAIN.

Schalatek, L., M. Cook, S. Alboher, and E. Eggerts (2011). 'The Least Developed Countries Fund and the Special Climate Change Fund'. New York: UNDP. Available at: www.gender-climate.org/Content/Docs/Publications/UNDP_LDCF_SCCF.pdf

SEI (2008). 'Scoping Paper for Climate Change Adaptation in Africa for the Ministerial Session and Expert Group: Segments of the Dialogue on Climate Adaptation. Lead authors: Downing (SEI) and YoubaSokona (OSS). African Ministerial Conference on Environment. Expert consultation on adaptation: 8 June 2008. Ministerial session: 12 June 2008.

Smithers, C. (1998). 'Crop Insurance and Farm Management'. Guelph: Department of Geography, University of Guelph. MA thesis.

Tirado, R., and J. Cotter (2010). 'Ecological Farming: Drought-Resistant Agriculture' Greenpeace Research Laboratories GRL-TN 02/2010. Available at: www.greenpeace.org/international/en/publications/reports/Ecological-farming-Drought-resistant-agriculture/

Tyler, S. C., H. O. Ajie, M. L. Gupta, R. J. Cicerone, D. R. Blake, and E. J. Dlugokencky (1999). 'Stable Carbon Isotopic Composition of atmospheric Methane: A Comparison of Surface Level and Free Tropospheric Air'. *Journal of Geophysical Research*, 104(D11): 13895–910.

UECC (2010). 'Carbon Sequestration & Biodiversity'. Coastal & Marine Union (EUCC). Available at: www.eeconet.org/eaf/climate-biodiversity/Carbon-Sequestration-Biodiversity-FINAL-REPORT.pdf.

UNDP (United Nations Development Programme) (2004). *Reducing Disaster Risk: A Challenge for Development*. A Global Report. New York: UNDP. Available at: www.undp.org/cpr/whats_new/rdr_english.pdf.

UNFCCC (United Nations Framework Convention on Climate Change) (2007). 'Investment and Financial Flows Relevant to the Development of an Effective and Appropriate International Response to Climate Change'. Bonn: UNFCCC.

Verchot, L. V. (2007). 'Opportunities for Climate Change Mitigation in Agriculture'. A report to the UNFCCC Secretariat. Financial and Technical Support Programme. Available at: unfccc.int/files/cooperation_and_support/financial_mechanism/application/pdf/verchot.pdf

Wang, J., J. Huang, L. Zhang, S. Rozelle, and H. F. Farnsworth (2010a). 'Why Is China's Blue Revolution so "Blue"? The Determinants of Conservation Tillage in China'. *Journal of Soil and Water Conservation*, 65(2): 113–29**.**

Wang, J., S. Rothausen, D. Conway, L. Zhang, W. Xiong, I. P Holman, and Y. Li (2012). 'China's Water–Energy Nexus: Greenhouse Gas Emissions from Groundwater Use for Agriculture'. *Environmental Research Letters*, 7(1).

Wassmann, R, S. V. K. Jagadish, S. Heuer, A. Ismail, E. Redoña, R. Serraj, et al. (2009). 'Climate Change Affecting Rice Production: The Physiological and Agronomic Basis for Possible Adaptation Strategies'. In D. L. Sparks (ed.), Advances in Agronomy, vol. 101. Burlington: Academic Press, pp. 59-122.

World Bank (2007). *World Development Report*. 2008. Washington, DC: World Bank.

World Bank (2009a). 'Monitoring and Reporting on Financial Flows Related to Climate Change'. Discussion Draft. Washington, DC: World Bank. Available at: www.climatechange.worldbank.org/sites/default/files/documents/ClimateFin-Monitoring-122909.pdf

World Bank (2009b). *World Development Report*, 2010. Washington, DC: World Bank.

World Bank (2009c). 'Morocco—Country Partnership Strategy for the period FY2010–13'. Washington, DC: Maghreb Department, World Bank.

World Bank (2010). *Economics of Adaptation to Climate Change: Synthesis Report*. Washington, DC: World Bank. Available at: www.climatechange.worldbank.org/sites/ default/files/documents /EACCSynthesisReport.pdf.

World Bank (2011). *World Development Report*, 2011. Washington, DC: World Bank.

World Bank (2012). 'China: Third Irrigated Agriculture Intensification Project and Mainstreaming Climate Change Adaptation in Irrigated Agriculture Project'. Report No: ICR500. Washington, DC: World Bank.

Herzog, T. (2006). 'Greenhouse Gases and Where They Come From.'. Washington, DC: WRI. Available at: www.wri.org/climate/topic_content.cfm?cid=4177.

Zhang, F. S., J. Q, Wang, W. F. Zhang, Z. L. Cui, W. Q. Ma, X. P. Chen and R. F. Jiang(2008). 'Nutrient Use Efficiencies of Major Cereal Crops in China and Measures for Improvement'. *Acta Pedologica Sinica*, 45: 915–24 (in Chinese with English abstract).

Zhao, B., X. Li, X. Shi, S. Huang, B. Wang, P. Zhu, et al. (2010). 'Long-Term Fertilizer Experiment Network in China: Crop Yields and Soil Nutrient Trends'. *Agronomy*, 102(1): 216–30.