Strategy for Optimising German Development Cooperation's Contribution to Greenhouse Gas Mitigation in Developing Countries

Agriculture

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Introduction:

The fourth assessment report of the IPCC (2007) identifies the agriculture sector as having significant potential for greenhouse gas (GHG) emission mitigation. The agriculture sector is responsible for approximately 14% of total global GHG (IPCC 2007), and 80% of the sector's emissions are produced in developing countries. Given the high level of emissions from developing countries, German Development Cooperation is working to identify areas for emissions reductions that could benefit from development assistance. The purpose of this paper is to analyze the agriculture sector in order to identify possible entry-points for German Development Cooperation (DC) with regard to GHG mitigation. A summary of main finding is provided in *Annex 3*.

Throughout the preparation of this paper, a recurring theme has been the significant uncertainty that exists with regard to estimating GHG emissions in the agriculture sector, as emissions come from widely dispersed (non-point) sources such as livestock and soils. The scientific methods for measuring emissions from non-point sources remain relatively weak. Similarly, uncertainty also exists with regard to measuring emissions reductions, which makes the identification of emissions reductions measures and monitoring difficult. However, what is clear from the analysis is that the uncertainties do not preclude the possibility for significant GHG mitigation in the agriculture sector and should, therefore, not be a reason for inaction.

1. Analysis of GHG composition in the agriculture sector

Due to the dispersed sources of emissions in the agriculture sector, it is difficult to measure them; however, annual emission estimates range from 5.1 – 6.8 Gt of CO_2-equivalent (CO_2-eq), with a 6.1 Gt often cited in the literature. The main sources of greenhouse gases in the agriculture sector come from livestock and crop production, which are responsible for the release of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

While agricultural lands also generate very large CO_2 fluxes both to and from the atmosphere via photosynthesis and respiration, this flux is nearly balanced on existing agriculture lands. Significant carbon release, however, results from the conversion of forested land, which is accounted for under the forestry sector. Other agricultural activities also contribute to CO_2 emissions trough energy use and production of fertilizers, which are accounted for in other sectors. CO_2 is thus the smallest contributor to agriculture-related emissions, with just 0.04 Gt (IPCC, 2007a). CH_4, which arises principally from enteric fermentation associated with ruminant livestock, and to a lesser extent from rice cultivation, animal waste and the burning of residues and plant cover, is a major contributor to emissions, with an estimated 3.3 Gt CO_2-eq per annum. N_2O, which is released primarily from agricultural soils through the use of fertilizers, and to a lesser extent from animal waste, contributes 2.8 Gt CO_2-eq (USEPA, 2006a). (See *Annex 4*). In total, the CH_4 and N_2O emissions from agriculture amount to more than half of the total anthropogenic global emissions for these two gases (USEPA, 2006b).

In terms of geographical dispersion of GHG emissions from the agriculture sector, they are highly concentrated in developing countries, with approximately 25% (1.5 Gt CO_2-eq) of emissions arising in the developing countries of East Asia in 2005. By region, particularly high emissions from enteric fermentation are attributable to Latin America, emissions from rice cultivation are associated with South and Southeast Asia, as well as China, and Sub-Sahara Africa and Latin America have the highest emissions from biomass burning (see *Annex 5* and Verchot, 2007). *Annex 6* provides a list of the top 30 emitting countries of non-CO_2 GHG from agriculture.

As development occurs, the GHG emissions from the agriculture sector will change, and all estimates indicate that they are set to increase substantially (Simmons, 2002), yet no widely accepted reference scenario for agricultural GHG emissions is currently available (UNFCCC, 2007)[1]. According to the USEPA (2006a, see *Annex 7*), overall non-CO_2 GHG emissions that are attributable to agriculture will rise by about 20% in 2020 compared to 2005[2]. CH_4 emissions are estimated to increase by 17 % and N_2O emissions by almost 25 % in the same period. Agricultural GHG emissions are particularly predicted to increase in developing countries, with the largest increases occurring in the Middle East and Sub-Saharan Africa, as well as in Latin America as the intensification of agriculture grows and productive areas expand.

2. Leverage Points with the largest cost-efficient mitigation potential

The estimated global mitigation potential for the agriculture sector varies by researcher and ranges from 4.5 Gt CO_2-eq (Caldiera et al, 2004) to 6 Gt CO_2-eq (Smith et al., 2007a), with 5.2 – 5.8 Gt CO_2-eq in the year 2030 used by the IPCC. This is considering the sequestration potential of CO_2 storage in soils and vegetation which is close to current emissions from agriculture.

Thus, despite methane (CH_4) and nitrous oxide (N_2O) accounting for the majority of agriculture-related emissions, the greatest technical mitigation potential in the agriculture sector is related to CO_2 storage in soils and vegetation. The estimated CO_2 emissions mitigation potential is 4.9 Gt, as compared with 0.55 Gt CO_2-eq of CH_4 emissions and approximately 0.15 Gt CO_2-eq for N_2O emissions (see for example, Smith et al., 2007a). Most of the technical mitigation potential lies in developing countries. Around 40 % of the global mitigation potential is located in Asia, including 17% in Southeast Asia and 10% in China. Almost 15% of the global technical mitigation potential lies in Latin America and almost 20% in Africa (see *Annex 8* for mitigation potential by region).

Mitigation potentials can be divided into three mechanisms (IPCC 2007a) which are discussed with respect to their possible contribution to mitigation below:

Reducing agricultural emissions of mainly non-CO_2 GHGs through the following measures:

- rice management
- livestock management
- manure management
- Enhancing removals by mainly sequestering carbon derived from atmospheric CO_2 within an ecosystem through the following measures:
- cropland management
- grassland management
- restoring organic soils
- restoring degraded lands

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[1] Two reference scenarios which are based on national GHG inventories (USEPA, 2006a) respectively model exercises (USEPA, 2006b) are frequently quoted (see, e.g. Verchot, 2007, Smith et al., 2007b).

[2] This is in line with estimates by Smith et al. (2007b), UNFCCC (2007) Vattenfall (2007), and Verchot (2007).

- water management
- agriculture and land-use changes
- Avoiding and displacing fossil-fuel derived emissions through the following measures: bioenergy from energy crops, solid, liquid, biogas, residues

The above estimates represent a technical (biophysical) mitigation potential, as compared with an economic mitigation potential that varies according to the price per ton of carbon-equivalent. Economic potential at different carbon prices, too, has been assessed at a global scale, but estimates are still very rough and do not take into account additional factors determining whether a mitigation option is employed.

The measures that provide the highest economic potential in global terms for the first two mechanisms include cropland management, grassland management and restoring organic soils. The table below provides information about technical and economic potential for the nine measures presented above for mitigating under mechanisms one and two. (See *Annex 9* for a graphic comparison).

Agriculture Mitigation Potential in 2030 for nine measures in Mt CO_2-eq

Measure	Technical Potential	Economic Potential (US$20/ton CO_2-eq)	Economic Potential (US$100/ton CO_2-eq)
Cropland management	1450	750	850
Grassland management	1350	200	800
Restoring organic soils	1250	300	1200
Restoring degraded lands	700	150	650
Rice management	300	150	200
Livestock management	250	150	200
Water Management	100	0	0
Manure management	100	50	~100
Agriculture and land-use	100	50	~100

30% of the technical potential of these options can already be exploited at less than US$20 per t CO_2-eq, 50% can be achieved at US$50 per t CO_2-eq, and almost three-quarters could be realized at US$100 per Mt CO_2-eq, making agriculture an important low cost emission reduction sector (McCarl, 1999). 90% of the mitigation occurs from carbon sequestration.

Estimates on the mitigation potential of bioenergy vary widely and have included different types of bioenergy from agricultural feedstocks, including by-products of agricultural production, and dedicated energy crops. Translation into global mitigation potential has only been done in few studies, and is not straight forward according to IPCC. The IPCC (2007a) presents estimates of the competitive cost-effective mitigation potential of biomass energy (primarily from agriculture) in 2030 ranging between yearly 70 and 1260 $MtCO_2$-eq (0-13 EJ) at prices up to 20 US$/t CO_2-eq, 560-2320 $MtCO_2$-eq (0-21 EJ)at up to 50 US$/t$CO_2$-eq, and 2720 $MtCO_2$-eq (20-45 EJ) at up to 50 US$/t$CO_2$-eq. Organic wastes and residues together are reported to potentially supply 20- 125 EJ/yr by 2050 (IPCC 2007a).[3]

[3] Annex 10 presents a discussion on bioenergy.

The above section demonstrates that the agriculture possesses considerable technical and economic potential to mitigate emissions.

3. Most promising approaches for reducing GHG emissions

The best indicator to identify suitable approaches to mitigation of greenhouse gases in the agriculture sector would be to calculate the amount of CO_2-eq abated per unit produced in agriculture (hectare or head of livestock) at various cost levels and compare it across countries to identify the most promising entry points for mitigation measures. This would ensure that tradeoffs between mitigation and production which might lead to leakage (e.g. higher demand on land) would be captured. However, a lack of data across countries and regions hinders such a comparison. Instead, other proxies have to be used. Available indicators and information to help to guide decisions on were to focus mitigation include the following:

One approach could be an examination of emissions data from the world's top emitting countries. In terms of emission intensity per unit of agricultural GDP produced (*Part A, Annex 6*), developing countries, including countries targeted by German Development Cooperation, are at the top of the list. In terms of absolute emissions from agriculture, 6 Latin American countries, four Asian and five African countries fall into the global top-30-emitters category. If production technologies were to be examined in these top-emitting countries, large mitigation potentials could likely be identified and exploited.

Another approach could be to look at detailed regional data on mitigation options and associated costs per ton of CO2-eq. However, scientific information is particularly weak with regard to this option. For non-CO_2 GHGs, the USEPA (2006b) provides details on the costs of GHG mitigation in three areas: Cropland, rice and livestock management (see *Annex 11*). Despite a potential for greater cost-efficiency from N_2O abatement globally, in most developing countries, particularly in Asia, the percentage mitigation rates of CH_4 have been higher. Some regional studies exist, detailing abatement costs for specific agricultural mitigation options (e.g. ADB 1999).

Thirdly, identifying promising approaches could take into account varying mitigation potential in the agriculture sector by climatic zone (e.g. cool-dry, cool-moist, warm-dry, warm-moist). Absolute technical and economic potential for mitigation is higher in humid areas, but cost-effective mitigation potentials are available in all climatic zones (see *Annex 12*).

This information should, therefore, be considered as one piece of a larger, still incomplete puzzle. More precise information is still needed in order to make decisions about mitigation activities in regional and local settings (Erda, 2003 and see *Annex 13*).

Despite the considerable uncertainties, the integration of agriculture GHG mitigation into Development Cooperation approaches is still relevant and important due to the vast economic mitigation potential that can be achieved in developing countries and that are mostly consistent with existing production methods and production infrastructure. Moreover, several mitigation options have synergies with sustainability and production as will be explained in more detail below. Exploiting these co-benefits may be the most promising approach for mitigation in agriculture.

4. Trade-offs and synergies

The mitigation of GHGs in agriculture may affect agricultural productivity and sustainability, which needs to be carefully analysed. Moreover, the mitigation of one GHG may impact other greenhouse gases, which underlines the need to ensure a net migitating effect.

The trade-offs and synergies of mitigating for agricultural GHGs in a global and/or regional context have been discussed by several authors. (See, for example, DeAngelo (2006); IPCC (2007a); a summary of trade-offs and synergies in *Annex 14* discussion of bioenergy in *Annex 10*). Evidence suggests that using one measure to target the mitigation of a certain GHG can often have positive outcomes for the mitigation of others (e.g. set-aside/headland management), as well. However, in some cases the opposite happens (e.g. restoration of organic soils). The conclusion is, therefore, that mitigation projects and measures need to consider a multi-gas approach (see, for example, Erda, 2003). Mitigation projects and measures should also consider how activities may work with or against other international development objectives. Many of the mitigation approaches described herein are able to create win-win situations (World Bank, 2008; Erda, 2003) - while some are possibly counterproductive. Three examples are given below and discussed in more detail in *Annex 15*:

Mitigation may negatively affect productivity and Millennium Development Goals (MDG) (E.g. in some cases, curtailing supplemental N use could restrict yields, thereby hampering food security. Large-scale biofuels production could further stress the competition for land and water; It could also lead to displacement of smallholder farm households and other rural poor.).

Mitigation goals and sustainable agriculture goals are similar (in particular many C-conserving practices sustain or enhance the future fertility, productivity and resilience of soil resources; Practices that reduce N_2O emission often improve the efficiency of N use, thereby also reducing energy use for fertilizer manufacture avoiding deleterious effects on water and air quality from N pollutants (Smith et al. 2007a)).

Mitigation and adaptation belong together (e.g. agroforestry).

The co-benefits and trade-offs of a practice may vary from place to place because of differences in climate, soil, or the way the practice is adopted. The following statement should serve as a guideline for analysing mitigation activities:

Any mitigation measure that tends to increase agricultural productivity and/or 'saves' resources and at the same time lowers the amount of GHG emitted per unit of agricultural raw material primarily produced and finally consumed should be prioritised (1) if it is available at negative, zero or low costs and (2) only in case its net mitigation effect (taking into account all GHG emission effects occurring as a result of its application) is positive.

5. Conditions for realising the mitigation potential

Cost of Action:

Although generally considered as cost-effective, agricultural mitigation options do come at a price, making proper financing a precondition for success. Investments are needed to implement mitigation measures, and financing is also necessary to maintain new systems. Over the long-term, the UNFCCC (2007) concludes that approximately US$35 billion of financial flows are needed to achieve what is called a 'realistic' mitigation scenario by 2030[4] in agriculture. Two-thirds of this investment is needed in developing countries (UNFCCC, 2007).

Pre-conditions for success:

However, several mitigation options may be achieved at negative costs (see USEPA, 2006b), which means that proper financing is not necessarily a pre-condition for success. The fact that farmers are not adopting mitigation options that should theoretically increase their profitability indicates that there are (a) other costs which have to be covered additionally, and/or (b) barriers that have not been considered in analyses to date (Beach et al., 2008; Paustian et al, 2006) and that will need to be overcome.

The realization of economic mitigation potential in agriculture is limited by a variety of factors, including poverty, infrastructure, markets, institutions, competing land-use, and policy frameworks (Niles 2002). Barriers that have been discussed in greater detail in the literature (see *Annex 16*,,UNFCCC 2007, FAO and GTZ 2001) include (1) lack of information and knowledge, (2) lack of private as well as public awareness, (3) lack of capacity, (4) the need for better institutional arrangements, (5) market distortions, (6) lack of investments and (financial) resources, (7) lack of technology, and (8) insufficient research expenditures.

One precondition of particular interest is market distortions, including the distorting effect of the Clean Development Mechanism (CDM) under the Kyoto Protocol. Soil carbon sequestration is not eligible for CDM financing, and only few methodologies have been developed and approved, including on manure management systems and methane recovery. If GHG mitigation from agriculture in developing countries is to reach its potential, carbon market mechanisms will have to improve. For this to happen within the context of the CDM, carbon trading policy reform would need to take place and post-2012 negotiations would have to include concerns of farmers from developing countries (Yohe et al., 2007; Feng et al., 2000). The incentive structure of the CDM would have to change to promote (1) broader access to CDM for agriculture, (2) reduced transaction costs, (3) comprehensive capacity building, (4) institutional innovations, (5) micro-level orientation for carbon markets, (6) clear property rights, and (7) resolution or minimisation of existing technical problems, such as permanence, additionality, uncertainty, and leakages (FAO, 2008a; Rosegrant, 2007; Smith et al., 2007b).

Questions remain as to how mitigation mechanisms and their inclusion in carbon markets should be designed. Overcoming the aforementioned barriers will be a formidable task.

Despite the uncertainties, it is clear that the resources and capabilities required to establish and manage the conditions for mitigation in the agriculture sector cannot come from developing countries alone. Development cooperation has an important role to play in the future with regard to helping developing countries achieve their significant economic potential for GHG mitigation in the agriculture sector.

6. Role of actors, stakeholders and Development Cooperation

The emissions-reduction potential of the agriculture sector is well-established; however, the task of formulating and implementing proper mitigation strategies is still in its infancy. This is true for both developing and developed countries (von Witzke and Noleppa, 2007). The

4 The additional investment accumulates to more than 70 % of current global agricultural research expenditures. 20 billion USD are needed for non-CO_2 GHG-related measures, 15 billion USD for targeting C sequestration.

establishment of an agriculture mitigation strategy will require collaboration from all stakeholders in a specific region, as well as support from the international community.

Development Cooperation activities can contribute to (1) removing or minimising barriers, and (2) implementing mitigation measures in accordance with the guideline set forth in the framed box at the end of chapter 4[5]. A first step will be to define the roles of the various stakeholders. Domestic stakeholders may include farmers, participants in value chain and markets, local and regional organisations, national policy makers and research. International stakeholders may include multilateral frameworks, development cooperation, and foreign investors, and the roles may be defined in the following way (UNFCCC 2007):

The beneficiary would be responsible for identifying special needs and implementing projects/mitigation measures. Governments will have to facilitate potential (technology and knowledge) transfers, strengthen institutions, and provide the necessary incentives through the regulation or deregulation of markets in order to properly support the beneficiary.

Both domestic and international stakeholders should look for opportunities to establish financing mechanisms, improve technologies, enable farmers to master and manage the new technologies, train personnel, enhance the exchange and dissemination of information, analyse barriers and develop response strategies. Both sides are also responsible for investing more in research and pilot projects in order to gain a better understanding of the mitigation potential and to manage the utilisation of that potential in a local/countrywide/regional setting.

The international community, including donors, should provide funding for pilot/demonstration projects and replication efforts, organise training and consultations, provide initial financing for institutions, such as information centres, advisory services, monitoring units, etc., and help channel direct public and private investments into strategic mitigation programs, including in public private partnerships. In addition, the international community may support policy – especially intergovernmental – dialogue (Schneider, 2007).

7. Synthesis of existing initiatives with strong potential for mitigation

To date, the agriculture sector has not received as much global attention as other sectors when it comes to GHG mitigation potential, which might explain the limited number of agriculture mitigation initiatives. Nevertheless, examples do exist, including in the Tigray province of Ethiopia, where the carbon content of soil on degraded lands was successfully increased through composting measures and the farming of leguminous plants (Edwards, 2007). In Brazil, as of May 2000 the common practice of burning sugar cane in the fields is being gradually phased out. The incorporation of mitigation-friendly technologies for the sugarcane industry is slated to be fully operational by 2030 (Cerri et al., 2007). In Tanzania, the use of rotational woodlots has been successful in moderating the intensity of the agro-forestry sector. Similar rotational practices have been used in central Java (pine-coffee-banana system), and in Indo-Gangetic Plains (Eucalyptus-Poplar-based agro-forestry) with the unintended co-benefit of mitigating for GHGs (Bekele-Tesemma, 2007)[6].

The role of ecosystems in providing mitigation services has resulted in several approaches:

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[5] Both aspects shall not be repeated here. FAO (2008a, b), Simmons (2002), Chandler et al. (2002), Tiwari (2000) and other discuss them in greater detail.

[6] While reflecting these approaches it should be kept in mind that their main motivation was never to contribute to agricultural mitigation. Respective success should rather be considered a by-product.

On the voluntary carbon market, credits from agricultural mitigation can increasingly be traded. The World Bank's BioCarbon Fund demonstrates[7] projects that sequester or preserve carbon in forests and agro-ecosystems. The fund aims at delivering cost-effective emission reductions and seeks opportunities to buy carbon that is sequestered or preserved from a variety of land-use and forestry projects. The portfolio includes incentives to explore innovative approaches that mitigate for agricultural carbon, while the focus is clearly on forestry. The Chicago Climate Exchange (CCX)[8] has operated since 2003 and is an active, voluntary, legally-binding, integrated trading system that seeks opportunities to reduce emissions of all six major GHGs through the financing of projects worldwide that represent all sectors of the economy, including agriculture. CCX has developed simple and standardised rules for issuing carbon contracts for agricultural methane from livestock operations, as well as for carbon from soil sequestration activities in the agriculture sector[9]. The Voluntary Carbon Standard Program provides a global standard for approval of credible voluntary offsets, and agricultural land management is eligible under this program. Such initiatives may play an important role in supporting future processes, especially with respect to the inclusion of agricultural measures into the CDM post-2012. Furthermore, they are considered innovative with regard to the use of simplified rules and easier access (Yohe et al, 2007; Rosegrant, 2007)[10] and it is a very dynamic field.

Several companies, value chains, or initiatives have introduced labels and standards that inform about or regulate the GHG emissions related to products, including agricultural products. Most initiatives address GHG emissions as just one of many sustainability criteria (e.g. Rainforest Alliance), while few are specifically developed to indicate GHG emissions (e.g. Stop Climate Change). Apart from providing market incentives to reduce emissions, such initiatives are also an important source of knowledge on emissions related to production processes as well as possible ways of reducing them. As standards and labels mostly related to sustainability and food hygiene are by now fairly common in agriculture, they may provide readily available certification and monitoring procedures.

Among international development cooperation agencies, USAID is the only major donor to report active participation in agriculture mitigation activities[11] through capacity building with regard to emissions monitoring, however, that may be too narrow of an approach. German development cooperation has limited experience implementing explicit agriculture mitigation projects, but a range of project types and activities have GHG mitigation effects. These include supporting special (or "good") agricultural practices like sustainable agriculture, no tillage practices, sustainable sugar cane production (no burning), sustainable fertilizer use, and agroforestry; improving agricultural productivity and efficient water management; introducing biogas production from residues and manure; combating desertification and soil degradation or rehabilitating degraded land, supporting labelling and standard initiatives and supporting efficiency in value chains.

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[7] See also www.carbonfinance.org.

[8] See also http://www.chicagoclimatex.com.

[9] Eligible systems include, e.g., digesters as well as covered lagoons and continuous conservation tillage as well as grass planting.

[10] World Bank (2008) concludes that these emerging markets for trading C emissions offer new possibilities for agriculture to benefit especially from land use that sequesters C.

[11] See also www.usaid.gov/our_work/environment/climate/field_support.html.

8. Sector-specific recommendations to German Development Cooperation

Based on the findings outlined above, the following recommendations may be made:

In the short term, priority should be given to mitigation strategies which have clear co-benefits in terms of other development objectives and which are already being employed. These include mitigation projects in the context of sustainable agriculture and rural development, combating desertification and land degradation, and producing biogas, among others.

The large technical and economic potential of mitigation strategies based on enhancing removals by sequestering carbon in soils should be exploited. Many of the related mitigating strategies have co-benefits in terms of enhancing soil productivity. From a pure mitigation perspective, questions of permanence of GHG mitigation would have to be addressed as carbon sequestered in soils may be quickly released in case of management practices or land use change. Lessons learned can be derived from the forestry sector. More detailed analysis of costs and mitigation potentials of these options should be conducted, in particular on restoring degraded and organic land.

Projects need to have an adequate analytical component until the science base has improved. This relates to developing and testing concrete mitigation strategies as well as monitoring and measuring emissions, emissions potentials and actual abatement.

Capacity building, technical and financial support can contribute to mitigation in the agricultural sector.

Strategies for improving incentives for farmers to invest in mitigation, including through carbon finance and labels or standards should be developed and supported, if they contribute to enhancing income opportunities of farmers.

The implementation of pilot programs with a large multiplier effect should be prepared for the short- and medium-term. Approaches should be tested in order to gain experiences and to prove successfulness The implementation of concrete mitigation measures should be based on the following criteria:

Minimisation of conflicting goals (i.e. mitigation vs. food security)

Adoption of low-cost or negative-cost measures

Assurance of a net mitigation effect at a regional level

Emissions from agriculture production are directly related to the demand placed on the sector to supply food for human consumption, feed for livestock or feedstock for bioenergy purposes. Therefore, the greatest potential for mitigation actually lies in changes to consumer behaviour.[12] While consumer behavioural issues may go beyond the scope of DC mandates, the issue serves the purpose of emphasizing the importance of not approaching the problem of agriculture-related emissions with too narrow of a focus.

[12] According to Bellarby et al. (2008), ITC (2007), von Witzke and Noleppa (2007), Foster et al. (2006), Flessa et al. (2002) and others the greatest potential for reducing GHG emissions from agriculture lies in changes to consumer behaviour; see *Annex 17*.