Food and Agriculture Organization of the United Nations

POLICY BRIEF No.3

EPIC | Economics and Policy Innovations for Climate-Smart Agriculture

Climate change mitigation and smallholder agriculture in Zambia

August 2015

Executive summary

This policy brief summarizes the main points of the mitigation analysis of the EPIC programme for Zambia. It identifies the principal sources of greenhouse gas (GHG) emissions and highlights that the Agriculture, Forestry and Land Use (AFOLU) sector contributes the bulk of national emissions. It then examines GHG mitigation potential and the role of smallholder agriculture, analysing the impact of sustainable land management practices, agroforestry and improvements in livestock production. The brief concludes that sector development strategies targeting productivity increases, as well as resilience to climate variability through specific sustainable land management practices and smallholder livestock development options, can also benefit climate change mitigation in Zambia.

Introduction

While agriculture in Zambia is strongly affected by increasing climate variability and overall climate change, the AFOLU sector is itself an important source of (GHG) emissions in the country. Climate-Smart Agriculture (CSA) is predominantly concerned with the impacts of climate change on food security, as well as the sustainable transformation and development of the agricultural sector. As a secondary objective, CSA also analyses the role of agriculture as a GHG emission source by estimating the potential for mitigating climate change through actions within the AFOLU sector that benefit food security and productivity goals in an integrated manner.

According to the FAO Statistics Division (FAOSTAT), Africa had the highest growth rates in GHG emissions from agriculture in the 1990-2012 period, a trend that is expected to accelerate in the near future. While agriculture in Africa is thus also established as a relevant emission source, emissions from land use, including deforestation, are still the largest emission source on the continent.

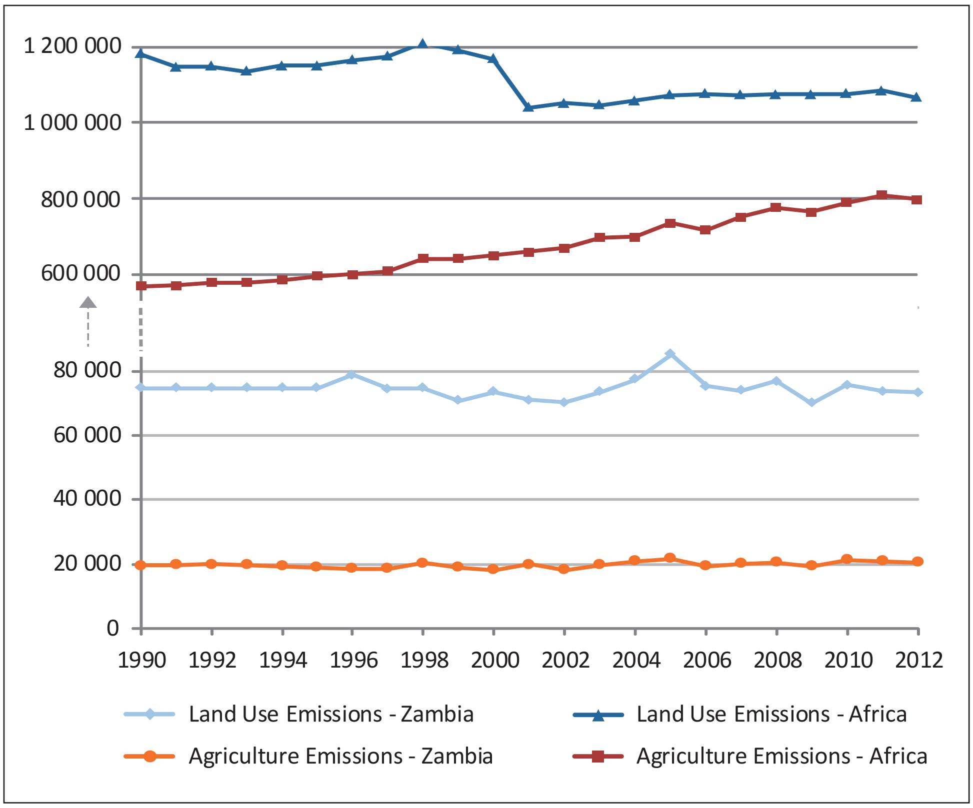
Figure 1 overleaf shows the development of anthropogenic emissions from agriculture and land use between 1990 and 2010 in both Zambia and Africa as a whole. Agriculture related emissions in Zambia are shown to

HIGHLIGHTS – KEY RESULTS

- In Zambia, climate change mitigation can be realized in synergy with increased agricultural productivity and greater adaptation to climate variability.
- Measures for carbon sequestration in smallholder agriculture, such as sustainable land management and agroforestry, reach saturation impact after roughly 20 years. Associated mitigation financing for transformational sector investments could contribute to long-term improvement and growth.
- There is considerable emission reduction potential in the Zambian livestock sector. Priority mitigation benefits can be achieved in synergy with increasing productivity.
- Practical and cost effective approaches to Monitoring, Reporting and Verification (MRV) mitigation benefits in the agricultural sector are an important precondition for improved access to mitigation finance.
- Available estimates of mitigation potentials are a good basis for approaching bilateral and multilateral climate funding facilities in order to increase funding for national agricultural programmes and strategies.

be relatively stable, unlike those from the continent as a whole. By contrast, emissions from land use have been reduced slightly over recent decades in Africa as a whole, but have remained relatively stable in Zambia.

Figure 1: The trend of Agriculture and Land Use induced GHG emissions in Zambia and Africa 1990-2012 (Gg CO_2-eq)



Source: FAOSTAT.

When discussing the issue of climate change mitigation in the AFOLU sector it is important to differentiate between the concepts of reducing current emission sources and increasing carbon sequestration. Both activities can actively contribute to mitigating GHG emissions to the same extent.

There are a number of key questions regarding the issue of GHG mitigation in the agriculture sector in Zambia:

- What role do smallholder systems play in Zambia as contributors to GHG emissions?
- Does smallholder agriculture have the potential to significantly mitigate GHG emissions at the national level?
- Which types or combinations of sustainable land management (SLM) practices aimed at increasing productivity can also provide carbon sequestration and reduce GHG emissions?
- What benefits can farmers and government institutions expect from increasing their efforts to mitigate GHG emissions from AFOLU activities? Would this provide access to international climate finance? Can efforts to mitigate climate change in agriculture contribute to a sustainable transformation of the sector?

What are the key GHG emissions from agriculture and land use in Zambia?

The Second National Communication of the government of Zambia to the United Nations Framework Convention on Climate Change (UNFCCC) identifies the AFOLU sector as the major contributor of national GHG emissions. Land Use Change (LUC) and forestry account for 74 percent of national emissions, and the agriculture sector is responsible for 19 percent, while the rest of the economy only contributes 7 percent (Fig. 2).

A separate policy brief developed under the EPIC Programme assesses the role of GHG emissions from LUC and mitigation potentials from the Reducing Emissions from Deforestation and Forest Degradation (REDD+) programme, while this brief focuses on agriculture's role in reducing GHG emissions.

As far as agriculture related emissions are concerned, the three largest contributions are reported as stemming from savannah burning (30 percent), enteric fermentation (29 percent) and agricultural soils induced emissions (24 percent). A smaller percentage derive from manure management (16 percent).

Apart from such aggregated estimates at the national level that may still be revised by future national assessments, the EPIC Programme analysed emissions and the mitigation potential of specific smallholder farming systems at the field level. The typical production practices of smallholder farms were ascertained using information on input use and agricultural practices from targeted household survey data. Key results with regards to average GHG emission from agriculture are:

According to estimates computed using the FAO Global Livestock Environmental Assessment Model using a Life Cycle Assessment approach based on Tier 2 emission factors[1], livestock are a major source of GHG emissions from agriculture in Zambia. This project estimated total emissions from the livestock sector in Zambia at 5.68 Mt CO_2-eq. (tonnes of CO_2 equivalent) in 2005.

Beef cattle were the highest contributors, accounting for 56 percent of GHG emissions, followed by dairy cattle (28 percent). Goats, pigs and chickens each contribute around 5 percent to overall livestock emissions (Fig. 3).

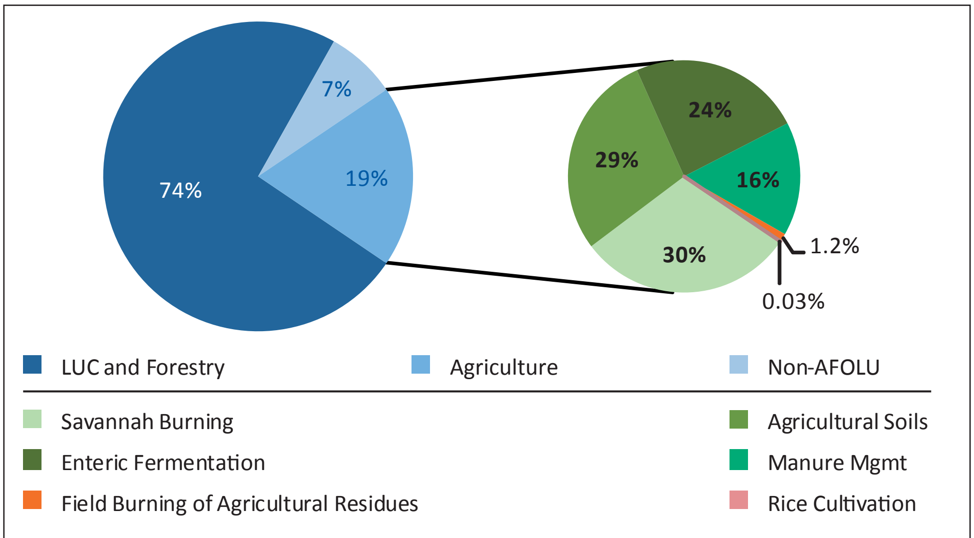
Therefore, cattle grazing, both beef and dairy, is the main contributor as it is widespread in Zambia, while the less common mixed systems are the second most important contributor.
However, when emission impacts are differentiated by GHG source, methane emissions from enteric fermentation are the largest source for ruminants, accounting for about 55 percent of emissions within each system. The second largest source is N_2O emissions, mainly from manure applied to pasture and cropland for livestock feed production (Fig. 4 overleaf).

When considering cropland agriculture, e.g. maize production at three different intensities of nitrogen fertilizer use (0 kg, 25 kg, 85 kg N/hectare), figure 5 shows that average annual emissions range between the low emission levels of 0.1 t CO_2-eq/hectare to 0.6 t CO_2-eq/hectare. The largely low input crop farming systems in Zambia are thus only a moderate contributor to GHG emissions, and their impact is due more to their considerable prevalence than to a large impact per hectare.

It is important to underline that the above results assume that no further soil degradation is taking place and soil carbon levels remain constant.

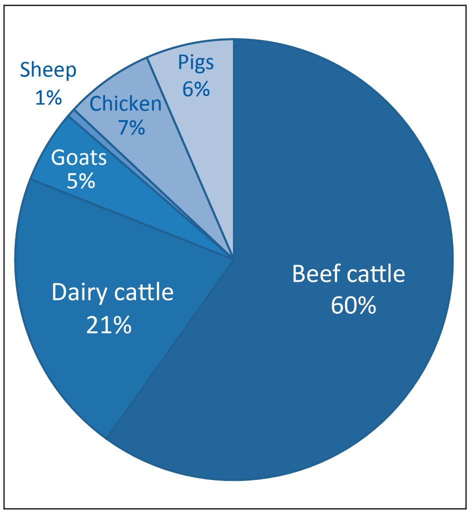
However, if cultivated land continues to degrade through low organic matter inputs to soils, "nutrient mining", the export of crop residues from plots and other related practices, a significant decrease in soil organic carbon stocks may result in CO_2 releases and at the same time reduce soil fertility.

Figure 2: National GHG emissions in Zambia



Source: Government of Zambia, 2014.

Figure 3: GHG emissions by livestock type in Zambia in 2005



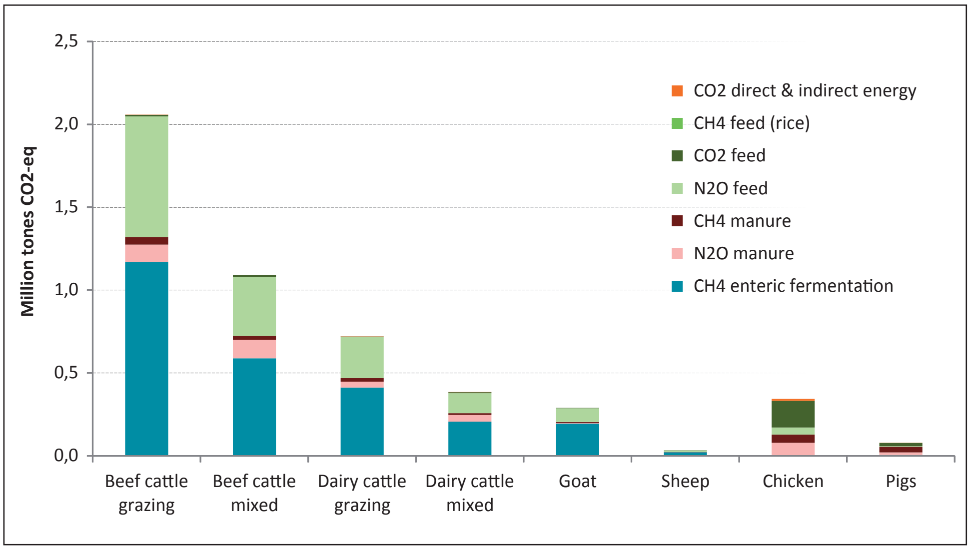
Source: FAO, 2014.

The use of organic and synthetic nitrogen fertilizers is an important complementary measure for soil fertility management, with direct benefits for crop productivity.

An analysis of household data shows that smallholder farmers in Zambia use very low quantities of synthetic fertilizer. Nonetheless, the same analysis shows that when synthetic fertilizers are used they cause relevant increases in GHG emissions from both direct emissions of N_2O from fields, as well as from CO_2 emissions from their production, transport and application.

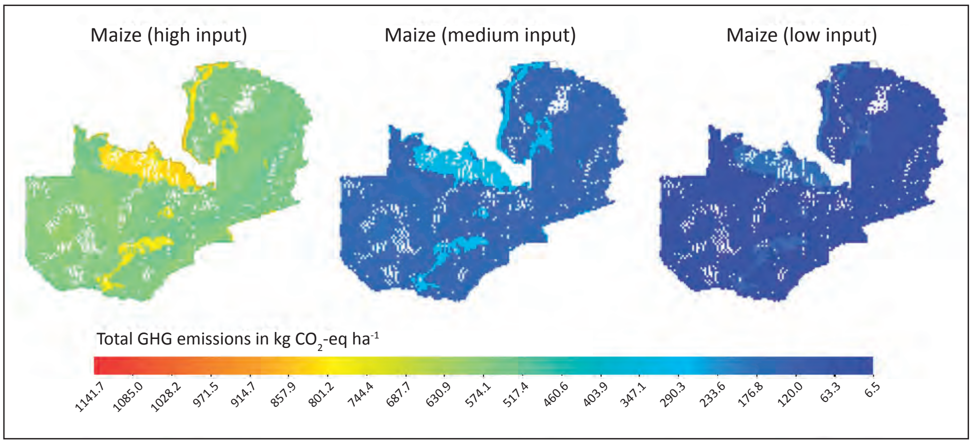
It is thus essential that fertilizer use is targeted, optimizing product type as well as application rate, timing and placement, so that optimal fertilizer efficiency levels can be ensured. Although, even efficient forms of nitrogen fertilizer use lead to significant GHG emissions, such practices ensure that the productivity benefits from fertilizer use are fully realized. As a consequence the ratio of agricultural productivity to GHG emissions would be optimized.

Figure 4: GHG emissions from the livestock sector by emission component (Zambia, 2005)



Source: FAO, 2014.

Figure 5: Annual GHG emissions of conventional maize farming for three fertilizer intensities (kg CO_2-eq/hectare)



Source: FAO, 2014.

1 www.fao.org/gleam

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GHG mitigation potentials – the role of smallholder agriculture in Zambia

While the previous section dealt with the important issue of identifying the largest current emission sources from smallholder agriculture, the EPIC programme also analysed the potential of a wide set of sustainable land management practices and livestock development for GHG mitigation.

a) Sustainable land management for soil carbon sequestration

Sustainable land management practices that provide substantial benefits for soil carbon sequestration are those field actions that increase the amount of organic matter that is added to soil from plant sources and animal waste, as well as practices that reduce the decomposition of existing soil organic carbon stocks. Sustainably managed land can reverse past soil degradation and increase soil carbon levels until reaching a saturation point.

Figure 6 below identifies the average annual mitigation potential of no tillage and reduced tillage, legume rotations, crop residue retention and cover crops of low input maize production in Zambia. The analysis reveals that the various practices combined can lead to annual mitigation levels of between 0.2 and 1.1 t CO_2–eq per hectare. Their mitigation potential is, thus, slightly greater than the average emission levels of conventionally managed maize systems. Therefore, we can conclude that although smallholder cropping systems do not release large GHG emissions per hectare, they may have a similar or slightly larger potential to sequester soil carbon. It must be noted, however, that such potential can be realized over a limited period, often estimated at roughly 20 years, until a new soil carbon stock balance is reached.

The example in figure 6 refers to maize produced without the use of synthetic fertilizer. However, mitigation potentials for other crops and fertilizer use intensities are similar to those reported for maize.

When trying to differentiate between the mitigation effectiveness of different sustainable practices, those that significantly increase soil organic matter inputs (e.g. cover crops) were found to be especially beneficial, and impact throughout the country was relatively homogenous (low spatial variability).

Besides analysing the effect of applying single improved practices in isolation, various combinations of the above practices were also analysed for their mitigation impact. This part of the analysis aimed to identify whether the simultaneous application of improved practices – e.g. promoted by the concept of conservation agriculture – also makes a greater contribution to mitigation outcomes. It was found that there are indeed advantages to simultaneous application. Thus, the analysis underlined the complementary effect of practices that both increase carbon inputs to soil and reduce soil disturbance. For example, the combination of residue retention and reduced tillage in maize systems was estimated to provide greater annual mitigation potential (545 kg t CO_2-eq per ha) than both practices in isolation (266 and 292 kg respectively).

However, this part of the research, as well as the spatial variability within the country, needs further investigation and remains a significant research gap.

b) Agroforestry – higher mitigation potentials through biomass carbon stocks

When it comes to agroforestry systems, we can be more confident of the assessment of mitigation levels. Agroforestry systems have the highest attainable mitigation potential as computed by the mitigation assessment. While the analysis covered different agroforestry systems, including agri-silviculture, alley cropping, improved tree fallow and woodlots, all systems have strongly positive mitigation impacts, with annual sequestration rates ranging between 5 and 15 t CO_2-eq per hectare.

Similarly to the dynamics of soil carbon sequestration, the sequestration of carbon in tree biomass is saturated once the system is at full maturity. It is also important to consider that agroforestry systems only serve as a strong and lasting carbon sink when they are conserved after their establishment. Woodlots that are used as biomass fuels also contribute to GHG mitigation through substituting fossil fuels, although their mitigation strength is different from agroforestry systems that are less frequently logged and re-established.

c) Livestock: Reducing a main emission source and promoting sustainable sector growth

With feasible improvements in forage digestibility, animal health and reproduction management, carbon sequestration and manure management, emissions from livestock in Zambia can potentially be reduced by 32 to 38 percent of total annual baseline emissions, or 1.4 to 1.7 million t CO_2-eq.

The single largest contributing measures are:

- improving grassland management (optimizing grazing pressure and sowing legumes) with a mitigation potential of 23 percent.
- improving feeding practices and forage quality (processing crop residues), which decreases emissions by 7 to 15 percent.
- enhancing manure management systems, including biogas (7percent).

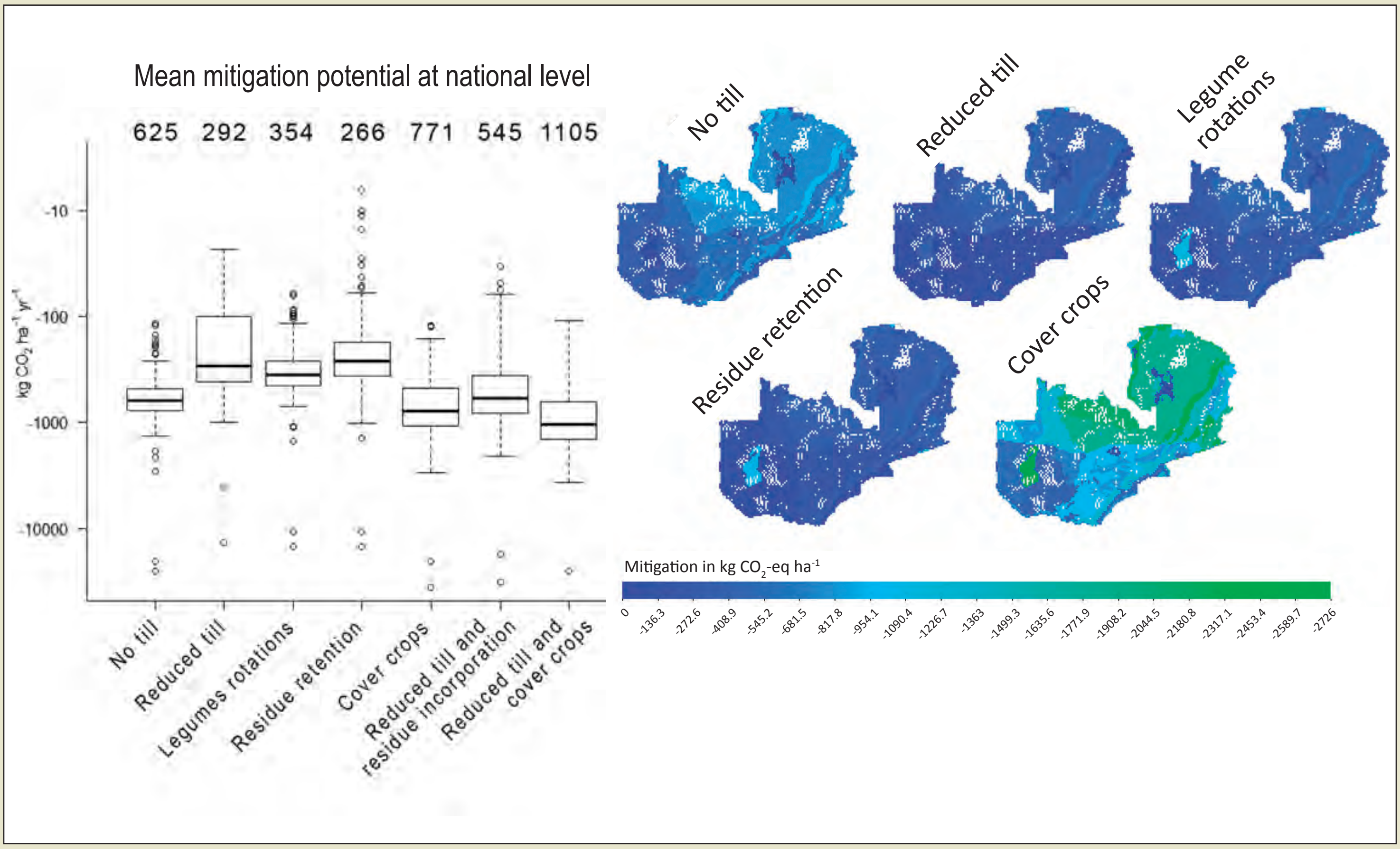
On the other hand, the direct mitigation impact of improved health and reproduction management (increased fertility and decreased mortality) is modest, since they lead to increases in total animal numbers.

When the carbon footprint in relation to the output of meat and milk is considered, as opposed to absolute emission levels, it is evident that interventions on livestock health and reproduction as well as feed digestibility could make a significant contribution to GHG mitigation (14 to 21 percent and 3 to 7 percent respectively). This type of intervention would imply a significant reduction in emission intensities (GHG emissions per output produced) by 42-52 percent for all ruminants.

Lastly, it is important to point out that livestock production is expected to increase substantially in Zambia, with projections for 2030 indicating an increase of 71 percent, 129 percent and 80 percent for beef, milk and small ruminant meat, respectively.

Development efforts that increase the productivity of the growing livestock sector while achieving mitigation benefits are thus a high priority. Gains in productivity resulting from the implementation of the discussed mitigation interventions would contribute to limiting or even offseting the increase in emissions due to the sector's growth.

Figure 6: Annual GHG mitigation potential of different improved land management practices (kg CO_2-eq/ha)



Source: University of Aberdeen, 2014.

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Conclusions and recommendations

The analysis presented in this brief shows that sector development strategies targeting productivity increases as well as resilience to climate variability through specific sustainable land management practices and smallholder livestock development options can also benefit climate change mitigation in Zambia. This underlines the compatibility of economic growth and climate change mitigation measures in agriculture.

The impact of carbon sequestration measures in smallholder agriculture such as SLM and agroforestry reaches saturation after roughly 20 years. Nevertheless, they provide considerable potential for mitigation and can be widely applied throughout the country. Agroforestry systems on their own already provide significant mitigation potential at the farm level, while SLM practices have lower potential at a per hectare level.

Livestock related emission reductions provide mitigation benefits that can be realized indefinitely year after year, when compared to an alternative, unsustainable sector development path (baseline scenario). Providing emission reductions from the livestock sector thus requires especially transparent methodologies for establishing a baseline scenario to justify mitigation claims. Relative to a business-as-usual baseline livestock emissions can potentially be reduced by 32 to 38 percent through improving grassland management practices, forage quality, and manure management systems.

In order to make the agriculture sector better able to meet the technical requirements of mitigation finance, it is of central importance that systems for Measurement, Reporting and Verification (MRV) be established that are both technically transparent and without prohibitive cost implications. The piloting of practical and applied MRV systems may represent the first important step in this regard.

Given the current shortcomings of any market-based climate finance, important financial resources for mitigation measures in agriculture may at this stage only be forthcoming through project and programme finance from bilateral and multilateral sources. Clear national efforts to link governmental agricultural investment strategies to financial facilities, such as the Global Environmental Facility (GEF) or upcoming mitigation finance under the Green Climate Fund (GCF), may thus be of particular relevance for ensuring greater contributions from international finance for a sustainable sector transformation process in Zambia. The transitory nature of mitigation finance makes it especially necessary to use additional resources for investment in key transformational development measures and technologies that could underpin sustainable, long-term impacts.

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ABOUT EPIC

EPIC is a programme of the Food and Agriculture Organization of the United Nations (FAO). It supports countries in their transition to Climate-Smart Agriculture through sound socio-economic research and policy analysis on the interactions between agriculture, climate change and food security.

CONTACTS

Economics and Policy Innovations for Climate-Smart Agriculture (EPIC)
Agricultural Development Economics Division (ESA)
Food and Agriculture Organization of the United Nations (FAO)
Viale delle Terme di Caracalla
00153 Rome, Italy
andrea.cattaneo@fao.org

www.fao.org/climatechange/epic

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