Background Report 6

Mitigation potential of the MICCA Programme Pilot Project:

Enhancing agricultural mitigation within within the east Africa dairy development project (EADD) in Kenya

Assessing the climate change mitigation potential of the EADD-MICCA pilot project with the Ex-Ante Carbon Balance Tool (EX-ACT)

MICCA

EX ACT

FAO FIAT PANIS

Mitigation of Climate Change in Agriculture (MICCA) Programme
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Mitigation potential of the MICCA Programme Pilot Project: Enhancing agricultural mitigation within the east Africa dairy development project (EADD) in Kenya

Assessing the climate change mitigation potential of the EADD-MICCA pilot project with the Ex-Ante Carbon Balance Tool (EX-ACT)

Madeleine Jönsson

EX-ACT Consultant
Food and Agriculture Organization of the United Nations (FAO)
Policy Assistance Support Service (TCSP)

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LIST OF ACRONYMS AND ABBREVIATIONS

CO_2 Carbon Dioxide

CH_4 Methane

DFBA Dairy Farmers Business Association

EADD The East African Dairy Development Program

EX-ACT The Ex-Ante Carbon Balance Tool

FAO The Food and Agricultural Organization of the United Nations

ICRAF World Agroforestry Centre

ILRI International Livestock Research Institute

IPCC Intergovernmental Panel on Climate Change

MICCA Mitigation of Climate Change in Agriculture

N_2O Nitrous Oxide

1. INTRODUCTION

1.1 Background

The primary goal of FAO's Mitigation of Climate Change in Agriculture (MICCA) Programme is to facilitate the contribution of developing countries to climate change mitigation by supporting them in moving toward low-emission agriculture. The Programme works to build evidence of the contribution smallholder farmers can make to climate change mitigation through the adoption of climate-smart practices and technologies that strengthen food security and reduce greenhouse gas emissions.

In Kenya, the MICCA Programme works with the East Africa Dairy Development Project (EADD). The Project works with smallholder farmers to increase dairy production and household incomes in sustainable manner. EADD is funded by Gates Foundation and implemented by Heifer International in collaboration with the World Agroforestry Centre (ICRAF), the International Livestock Research Institute (ILRI), TechnoServe and African Breeders Services.

The EADD-MICCA pilot project seeks to provide evidence of the mitigation potential of climate-smart agricultural practices and measure greenhouse gas fluxes that result from the adoption of these practices.

FAO recently developed the Ex-Ante Carbon-balance Tool (EX-ACT). EX-ACT provides *ex-ante* estimates of the impact of activities in the agriculture (including livestock), forestry, and other land use sectors on greenhouse gas emissions and carbon sequestration. EX-ACT determines the impacts on the carbon-balance by comparing two scenarios: 'without project' (the 'business as usual' or 'baseline') and 'with project' (Bernoux et al., 2010).

EX-ACT is a land-based accounting system that uses the Intergovernmental Panel on Climate Change (IPCC) methodology for estimating carbon stocks and stock changes per unit of land and through time. Estimates are expressed in tonnes of carbon dioxide (CO_2) per hectare and per year (Bernoux et al., 2010). The EX-ACT appraisal can help guide the project design and the decision-making process regarding investments. The EX-ACT, which is used to make estimates at a project level, complements the *ex-ante* economic analysis of development projects.

1.2 Aim and delimitations

The objectives of the study are to quantitatively estimate using EX-ACT the greenhouse gas emissions of a reference scenario (EADD without the intervention of the EADD-MICCA pilot project activities) versus the emissions resulting from the MICCA Programme's contribution to EADD (adding climate-smart agricultural activities to EADD's ongoing activities).

The EADD-MICCA pilot project works with the dairy farmers in the division of Kaptumo in Nandy South District in Western Kenya and with members and non-members of EADD living in the project area. The study analyses land use change scenarios linked to dairy production and the introduction of climate-smart agricultural management practices.

Much of the required quantitative data for an EX-ACT analysis is not available. Some of the analysis in this report is based upon qualitative and semi-quantitative data from stakeholder workshops, farmer interviews and observations during field visits in October 2011.

1.3 Expected Outcomes

Climate change mitigation potential, which is reflected with the carbon balance indicator, can be calculated with EX-ACT according to two approaches: the tier 1 and the tier 2 approach. The tier 1 approach mainly uses default emission factors provided by the IPCC. (Bernoux et al, 2010). The tier 2 approach allows for the inclusion of *ad-hoc* emission factors, which are more adapted to the local context and more accurate than the IPCC's default factors. It is possible to use either approach, or combine the two in a single carbon-balance appraisal. When precise field data is not available from fieldwork, the simplest way to proceed is to use the tier 1 approach. Due to lack of tier 2 data, this EX-ACT analysis only follows the tier 1 approach. For more accurate results, research can be carried out to gather data on emission factors provided by literature, local research or field measurements. When data is not available locally, the simplest way to proceed is to use the tier 1 approach.

In a first phase, EX-ACT could be applied to foresee the expected impacts of targeted project activities, using the tier 1 approach (Tinlot et al, 2011). In the second phase, simulations could be done based on different adoption rates of recommended practices to develop a variety of scenarios reflecting differing degrees of optimism or desirability of results.

In a third phase, the carbon-balance appraisal could be repeated using accurate tier 2 emission factors integrated in the EX-ACT tool. (Tinlot et al, 2011). This should support the generation and use of tier 2 coefficients through field measurements and other activities foreseen under the MICCA Programme. The proposed process requires using the tool at smallholder farmer level.

It is useful to have a rapid, rough estimation of the climate change mitigation potential of the project and develop different carbon-balance scenarios for selected climate-smart practices (Tinlot et al, 2011). This would also facilitate the comparison between tier 1 and tier 2 appraisals.

1.4 The role of MICCA within the EADD Project

Working with EADD partners in Kaptumo, the MICCA Programme's efforts add value to dairy development efforts by building capacity for the integration of climate-smart practices. These practices simultaneously increase productivity and income and strengthen ecosystem resilience within smallholder farming systems and along the value chain. The Programme will quantify subsequent greenhouse gas reductions and other benefits.

In October-November 2011, an EX-ACT consultant was sent to Kaptumo to gather quantitative and qualitative data on agricultural management practices as well as land use and land use changes. The consultant also assessed the baseline scenario for greenhouse gas emissions and the mitigation potential of activities introduced through the EADD-MICCA pilot project.

2. SETTING THE DIFFERENT SCENARIOS

2.1 Before the data collection

Before any data collection, different simulated scenarios need to be established (i.e. the scenario of specific project activities in comparison with a baseline). In the context of the EADD, three scenarios are illustrated in table 1 (Bernoux et al, 2010).

Table 1: Outline of different scenarios

	Baseline scenario	EADD scenario	EADD-MICCA Scenario 1	EADD-MICCA Scenario 2
	3 years of implementation phase 17 years of capitalization phase			
Timeframe	**Non-static situation, i.e. evolving over time in parallel with the project situation**			
Data	• Data from ICRAF and EADD • Data from Wambugu, C. 2012	• Data from ICRAF and EADD • Workshops and field visits • EADD Baseline study • Data from Wambugu, C. 2012	• Data from ICRAF and EADD • Workshops and field visits • Expertise comments from the EADD team • Data from Wambugu, C. 2012 • Data from ICRAF and EADD • Workshops and field visits • Expertise comments from the EADD team • Data from Wambugu, C. 2012	
Situation	'Without project' scenario, i.e. without any intervention from EADD or MICCA	'Wth project' scenario, i.e. with EADD interventions	"With project" scenario, i.e. with EADD/MICCA interventions	
Proposed land use changes	• 69 ha decrease in forest • 200 ha decrease in maize • 269 ha Increase in tea • Increase of 1 cow per farmer, i.e. 30,000 heads	• 196 ha decrease in maize • 969 ha of improved grassland with inputs • Constant number of heads, i.e. 22 500 heads • 35% increased adoption of feeding practices • 30% increased adoption of breeding practices	• 951 ha decrease in maize • 500 ha decrease in grasslands • 979 ha of improved grasslands with inputs • 2 021 ha of improved grasslands without inputs • Constant number of heads, i.e. 22 500 heads • 89% increased adoption of feeding practices • Agroforestry • Soil conservation	• 688 ha decrease in maize • 500 ha decrease in grasslands • 460 ha of improved grasslands with inputs • 815 ha of improved grasslands without inputs • Constant number of heads, i.e. 22 500 heads • 50% increased adoption of feeding practices • Agroforestry • Soil conservation
Proposed adoption rate changes for different grassland uses	• N/A	• 1% for zero grazing • 15% for mainly stall feeding with some grazing • 35% for mainly grazing with some stall feeding • 50% for only grazing	• 50% for zero grazing • 30% for mainly stall feeding with some grazing • 20% for only grazing	• 20% for zero grazing • 30% for mainly stall feeding with some grazing • 30% for mainly grazing with some stall feeding • 20% for only grazing

2.2 Baseline and project boundaries

As EX-ACT is a land-based accounting tool, it is important to define the total area in hectares to be analysed. The area should be the same in the baseline as for the 'with project' scenario. Land uses and management practices may change, but not the amount of land present (Bernoux et al, 2010). For the EADD-MICCA pilot project, the boundaries are based upon the activities in the Kaptumo division. All land uses are included in these boundaries, not only dairy production and distribution.

The MICCA Programme will measure the greenhouse gas emissions and/or the carbon sequestration potential of different land management options (e.g. improved pasture) and animal feeding practices. The Programme will also introduce climate-smart agricultural practices such as agroforestry, sustainable land management, improved fodder production and biogas production.

2.3 Limitations of the EX-ACT tool

EX-ACT has certain limitations important to consider for this analysis. It does not have an agroforestry nor an intercropping module

- The aim of the EADD-MICCA pilot project is to introduce agroforestry as a climate change mitigation activity. For EX-ACT to reflect this, the reforestation and land use change modules need to be used. It is assumed that part of the maize cropping land would be planted with trees. This does not mean that all of the land planted with maize will be converted into forest, but that trees will be introduced in maize fields.

- Without an intercropping module, EX-ACT used the annual crop module. If intercropping is practiced, such as planting beans with maize, the tool assumes that part of the maize area is converted to beans. However, it assumes that maize will be grown with beans, thus increasing nitrogen fixing in the soil.

2.4 Project description

The first step for using the tool is to gather information on the project (Bernoux et al., 2010). As mentioned earlier, the project is being carried out in the Nandi South District, Kaptumo Division, in the Rift Valley Province. *(cf. figure 1).* EADD's activities in the Kaptumo Division began in 2009.

The Nandi South District is comprised of two the Kaptumo and Aldai Divisions. The EADD-MICCA pilot project is operating in both divisions. (Mudavadi, 21.11.2011). There are 7 500 farm families in the Kaptumo Division. A total of 3 451 farmers are members of the Kaptumo Dairy Farmer Business Association (DFBA), with 1 600 of them active milk suppliers. The study covers the Kaptumo Division. The total area analysed is 8 637 ha. Farmer families produce on an average area of 1.15 ha (8 637 ÷ 7 500) (Mudavadi, 21.11.2011).

The climate for the area is tropical moist. The soil is classified as high activity clay soils (EX-ACT results, *cf. footnote 8*). The mean annual rainfall in the region is 1 500 - 2 200 mm. The altitude of the region is 1 800 – 2 000 meters above sea level (Jaetzold and Schmidt, 1983). The time frame for EADD has been set for 20 years; an implementation phase of three years and a capitalization phase of seventeen years.

Figure 1: Kaptumo, Kenya (Google earth, 2012)

2.4.1 Present Land Uses

Tables 2, 3 and 4 indicate the present land use as well as fertilizer and pesticide use for the Kaptumo Division. The fertilizers are applied on tea and food crops (Wambugu, 2012). For perennial fodder production (e.g. Napier grass), which is classified as grassland, farmers apply manure. Pesticides are also applied to crops. For the EX-ACT analysis, land uses, land use changes and use of inputs was taken into account. Other land uses (i.e. horticulture and green houses representing 395Ha) are not found within the project boundaries nor the application of insecticides, hence the area analysed is 9032Ha – 395Ha = 8637Ha (*cf. table 2).* The Ministry of Agriculture, Kaptumo Division, provided the data.

Table 2: Land Uses, Kaptumo Division

Type of land use	Ha
Food crops (mainly maize)	3 270
Grassland	3 385
Forest	115
Coffee	51.4
Tea	1 700
Fodder	115
Other (horticulture and green houses)	395
TOTAL	**9 032**

Source: Ministry of Agriculture, Kaptumo Division, 02.11.2011

Table 3: Fertilizer use, 2011, Kaptumo Division

Type of fertilizer	Kg/year
DAP (Diammonium Phosphates)	180 000
NPK	120 000
Urea	7 500
CAN	90 000
TOTAL	**397 500**

Source: Ministry of Agriculture, Kaptumo Division, 02.11.2011

Table 4: Pesticide use, 2011, Kaptumo Division

Type of pesticide	Liters (l)/year
Herbicides	12 000
Insecticides	7 500
Others (Acaracides etc)	5 500
TOTAL	**25 000**

Source: Ministry of Agriculture, Kaptumo Division, 02.11.2011

During the workshop in Kaptumo[1], which was attended by experts from the Ministry of Agriculture and Livestock, Extension Officers and EADD coordinators, quantitative information regarding the land use change and agricultural practices was exchanged. According to participants, in many places maize cultivation has been replaced by tea. The decrease in maize cultivation is due to favourable tea prices and an increase in the fodder production for dairy production (Kirui, 20.03.2012). Another reason for the decline of maize cultivation, is the subdivision of land. Many young people prefer to cultivate cash crops and fodder crops for dairy production. Grassland has, over the past three years, been improved with specific fodder grass for the animals (i.e. Napier and Rhodes grass). Slash and burn is being done in the area, but the practice is decreasing due to extension services. Zero or minimum tillage is in its infancy, used by only very few farmers.

Figure 2: Pasture land, Kaptumo Division, 20.10.11

Extension officers reported increasing problems of soil acidification. In addition, the soil is poorly structured, and farmers are experiencing soil erosion in different areas, mainly on slopes. In general, the quality of the agricultural land is decreasing due to continued use of chemical fertilizers and increased levels of aluminium. Over-grazing is present in the area. Due to the lack of quantitative soil analysis, the description of the state of the land was made according to qualitative data and through visual observations and pictures *(cf. figure 2, 3).*

Figure 3: Pasture land, Kaptumo Division, 20.10.11

According to the workshop participants, dairy cattle producers currently use four types of feeding and management systems.

i. Zero-grazing systems, which involves only stall-feeding and providing fodder such as chopped maize and Napier grass to the livestock. The adoption rate for this system is less than is 1 percent due to high initial investments and ongoing costs (i.e. material and construction, labour and feeding management).

i. Semi-zero grazing systems, which combines stall-feeding and some grazing. This system is used by 15 percent of the farmers.

ii. Mainly grazing with some stall-feeding combing pasture and fodder. Between 50-60 percent of the farmers use this system.

iii. Free grazing on natural pastures is done by 30-35 percent of the farmers.

[1] See Appendix 1 for the list of participants

2.4.2 Inputs

Fertilizer application depends on the type of land use. (Wambugu, 2012). NPK is generally applied on the tea and coffee plantations, while the DAP and CAN is applied on maize *(cf. table 3)*.

Figure 4 shows the quantity of N, P and K in a 50 kg bag. There are 25 units of N and 5 units of P and K. Therefore, in each bag there is 12.5 kg of N {(25 x 50) ÷ 100} and 2.5 kg of P and K {(5 x 50) ÷ 100}. Table 5 indicates that 120 tonnes of NPK (2 400 bags) is applied each year. This works out to an annual application of 30 000 kg of N (2 400 x 12.5) and 6 000 kg of P and K (2 400 x 2.5) K. Box 1 illustrates the calculations for the other fertilizers and herbicides used in the area.

Figure 4: NPK fertilizer bag, used in the Kaptumo area, 20.10.11

Box 1. Calculations of fertilizers and herbicides

CAN is a fertilizer applied on maize production in the area (Wambugu, 2012). When using CAN, the amount of N applied need to be calculated (Simplot, 2011). The product used is CAN17, implying that there is 17 percent of N used, which is equal to 15.3 tonnes of N per year (90 x 0.17).

In the case of DAP, according to a previous case study on food security in Tanzania, 46.5 percent of the DAP is P_2O_5 and 18 percent is N. This means that out of 180 tonnes of DAP applied each year 83.7 tonnes of P_2O_5 per year (0.465 x 180) and 32.4 tonnes of N per year (0.18 x 180) (Bockel et al., 2010).

The applied herbicides in the area also need to be considered *(cf. table 4)* (Agsesa, 2011). The type of herbicides used in the area is the KALACH 480 SL and contains 480g per litre of active ingredients. In total, 12 000 litres of herbicides are used per year. This amounts to the application of 5.76 tonnes of active herbicides per year {(0.48kg per litre x 12 000 litres) ÷ 1000}.

2.4.3 Livestock

Currently, 3 451 farmers are registered with the DFBA, with 1600 of them supplying milk to the chilling plant (Mudavadi, 21.11.2011). However, this study covers the total amount of farm families in the area (7 500). It is estimated that each farmer owns an average of three dairy cows with an average production of 5.6 litres of milk per cow per day. Daily milk production ranges between 2-10 litres per cow. In addition to feeds (i.e. crushed maize, Napier and Rhodes grass and additional protein intake), livestock requires 20-30 litres of water per day. Based on the figures given it is estimated that 22 500 (7 500 X 3) animals belong to Kaptumo DFBA members. The EX-ACT calculation used this figure for the analysis. In the scenario, 'with the EADD project', it is assumed that the number of animals will remain constant, but that better breeds will be raised and better quality feeds used.

Without any project intervention (EADD or EADD-MICCA), it is expected that the number of heads will increase over the next 20 years by approximately one cow per farmer. This would lead to a 25 percent increase in the number of animals for a total of 30 000 heads (Kirui, 20.03.2012). The increased number of heads is due to a variety of factors, including low milk productivity caused by limited or no improvements in feeding (IPCC, 2007[2]); and lack of improved breeding and/or specific veterinary services and vaccines. These factors create incentives to increase the number of animals per farmer as a way of increasing income. This assumption was also based on the amount of land available, as increasing herd size is only possible for those with grazing lands. As the land per farmer is relatively small, the maximum increase is one cow per family.

2.4.4 Future land use and land use change for the baseline scenario

According to workshop participants, in a future scenario, without any EADD or EADD-MICCA intervention, there is a risk of increased deforestation in the area. Forest is currently being cleared to expand tea plantations and provide wood for domestic use. It was estimated that over 20 years approximately 3 percent of the land would be deforested annually, for a total 69 hectares. In addition, fodder production will likely replace some food crops, such as maize (Kirui, 20.03.2012). Farmers presently prefer to plant high-income crops rather than traditional crops, such as maize, which in the past were planted for both subsistence and cash (Wambugu, 2012). The cultivation of new cash crops with good market value, such as passion fruit, may increase.

Figure 5 shows the predicted land use changes for the baseline scenario during the estimated 20-year time phase. The total amount of land analysed is 8 637 hectares.

Initial land use (ha)	
Grassland	3 500
Maize	3 270
Forest	115
Tea	1 700
Coffee	52
TOTAL	**8 637**

→

Land use change without EADD
69 Ha of Forest → Tea
200 Ha Maize → Tea

→

Final land use without EADD (ha)	
Grassland	3 500
Maize	3 070
Forest	65
Tea	2 250
Coffee	52
TOTAL	**8 637**

Figure 5: Land use and land use changes of the baseline scenario

In the baseline, it is assumed that the 115 hectares of fodder production was not part of the initial land use. This fodder production (Napier and Rhodes grass) was implemented through the EADD project. Therefore, for the initial baseline, this 115 hectares of fodder is considered grassland in a moderately degraded state.

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[2]According to the IPCC 4th Assessment Report, chapter 8, pg. 510: *"Improved feeding practices: Methane emissions can be reduced by feeding more concentrates, normally replacing forages (Blaxter and Claperton,* 1965; Johnson and Johnson, 1995; Lovett et al., 2003; Beauchemin and McGinn, 2005). Although concentrates may increase daily methane emissions per animal, emissions per kg- feed intake and per kg-product are almost invariably reduced. The magnitude of this reduction per kg-product decreases as production increases. The net benefit of concentrates, however, depends on reduced animal numbers or younger age at slaughter for beef animals, and on how the practice affects land use, the N content of manure and emissions from producing and transporting the concentrates (Phetteplace et al., 2001; Lovett et al., 2006). Other practices that can reduce CH_4 emissions include: adding certain oils or oilseeds to the diet (e.g., Machmüller et al., 2000; Jordan et al., 2006c); improving pasture quality, especially in less developed regions, because this improves animal productivity, and reduces the proportion of energy lost as CH^4 (Leng, 1991; McCrabb et al., 1998; Alcock and Hegarty, 2006); and optimizing protein intake to reduce N excretion and N_2O emissions (Clark et al., 2005)."

Presently, the farmers cultivate an average area of 1.15 hectares with 40 percent grassland, 38 percent maize, 20 percent tea, 1.3 percent fodder and trees and 0.6 percent coffee *(cf. figure 5).* It was also indicated that much of the maize production and forest had been replaced by tea, and that this type of land use change will continue in the future.

Based on workshop discussions, it is plausible to assume that, without any project intervention, 6 percent of the land planted with maize crops would become tea plantations over the next 3 years (Kirui, 20.03.2012). It is also estimated that 3 percent of the forest would be replaced by tea, leading to loss of 69 ha of forest.

Concerning improved agronomic practices, according to the MICCA Programme's baseline survey (Zagst 2011), which included 375 randomly selected households in the Kaptumo Division, the most common improved practices are ridge cultivation (93.8 percent), planting in rows (91 percent), planting hedge rows (91.2 percent), application of manure (90.4 percent), crop rotation (83.9 percent), and timely weeding (80.7 percent). It is worth highlighting that some climate-smart agricultural practices are already carried out in the area. However, it was mentioned during the Kaptumo Workshop, that crop residues, especially from maize production, are often burnt.

3. LAND USE AND LAND USE CHANGES IN THE EADD AND EADD-MICCA SCENARIOS

The chapter presents the results from three land use scenarios. The results from the ‘without’ and ‘with’ EADD project are shown, followed by the results from the EADD-MICCA scenarios 1 and 2 compared to the baseline. Table 5 illustrates the main differences between the scenarios.

Table 5: Main differences in adoption rates between the three scenarios.

Adoption rate by feeding practice	EADD Scenario	EADD-MICCA Scenario 1	EADD-MICCA Scenario 2
Zero grazing	1%	50%	20%
Mainly stall feeding with some grazing	15%	30%	30%
Mainly grazing with some stall feeding	50%	-	30%
Only grazing	35%	20%	20%
Improved feeding practices	35%	89%	50%
Improved breeding practices (only EADD)	35%	35%	35%

3.1 ‘With EADD’ scenario

3.1.1 Land use and land use change scenario with EADD

The land use changes with EADD are based upon information from the baseline scenario and the number of farmer families. Each family cultivates 1.15 hectares of land (approximately 8 637 ha ÷ 7 500 persons).

Figure 6: Napier grass fertilized with organic manure, 20.10.2011

EADD plans to increase the fodder production for livestock, moving from mainly grazing and some stall-feeding to high quality fodder production and increased stall feeding. The main motives for an increased zero-grazing system include: improved livestock productivity by constantly providing animals with water and fodder; a reduced risk of pests and disease and the costs of disease control; increased insemination; and better management of manure for organic fertilizer (e.g. for Napier grass production) or biogas. (*cf. figure 6*).

Grasslands are intended to be used for fodder production. In the analysis, fodder production is considered as grassland, but improved with inputs. About 40 percent of the land is grassland or about 3 500 ha (0.4 X 8 637). As indicated in the baseline scenario, the percentage of farmers practicing different feeding methods are:

i. Zero-grazing - <1 percent;
ii. Mainly stall feeding with some grazing - 15 percent;
iii. Mainly grazing with some stall feeding- 50 percent; and
iv. Only grazing - 35 percent.

If one percent or 75 (0.01 x 7 500) of the farmer families farmers adopt zero grazing on the average holding of land, which is 0.46 ha (1.15x 0.4), then 34.5 ha (75 x 0.46 ha) would be used for zero-grazing systems. This would transform the farmers' grassland to fodder production (Napier and Rhodes grass) (Kirui, 14.02.2012). In reality, the land close to the house is used for fodder production. Natural grasslands are generally closer to water sources and not necessary found near the house (Rioux, 16.04.2012).

In the second system, mainly stall-feeding with some grazing, three-quarters of the grassland is improved with inputs for fodder production. This would mean that 1 125 farmers (0.15 x 7500) produce on 388 ha (1125 x 0.46 x 0.75) (Kirui, 04.05.12). The assumption that three-quarters of grassland would be improved is based on the fact the farmers are mainly stall feeding. They will focus on providing their animals with a higher amount of fodder compared to the farmers practicing 'mainly grazing with some stall-feeding'.

In the third case, mainly grazing with some stall feeding, one-quarter of the grassland is improved with inputs (Kirui, 04.05.12). A total of 3 750 farmers (0.5 x 7500) producing on 1 725 ha of grassland (3750 x 1.15) on which 431 ha (1725 x 0.25) will become fodder.

The fourth case, only grazing, does not apply in this context, since no improvement will occur.

The total for the three systems from moderately degraded grassland to improved grassland with inputs management, is 854 ha (34.5 + 388 + 431). In addition, from table 2, there is presently 115 hectares of land under fodder, which should be added to the fodder production total. In total, under the 'with EADD' scenario the grassland that is improved with inputs is 969 ha (854+115) *(cf. figure 7).*

Initial land use		→	**Final land use**	
Grassland, moderately degraded	3500		Grassland, moderately degraded	2531

Figure 7: Land use, grassland

Figure 8: Tea seedling nursery, Kaptumo, 22.10.2011

The assumptions regarding land use change from maize to tea is based on discussions at the Kaptumo workshop and the information provided by individual farmers. It was assumed that EADD members in the Kaptumo Division (7 500 farm families) will expand their tea production as a result of tree nurseries *(cf. figure 8)*, and reduce maize production (Wambugu, 2012).

Currently, 40 percent of the land is planted with maize and 20 percent with tea. Over the next 20 years, with EADD support, tea production is expected to increase by six percent over the baseline scenario (J. Kirui, 20.03.2012). Thus, the land area where maize is replaced by tea is production is 3 073.8 ha {3 270 - (3 270 x 0.06)}, which means 196.2 ha of maize will be replaced by to tea *(cf. figure 9)*.

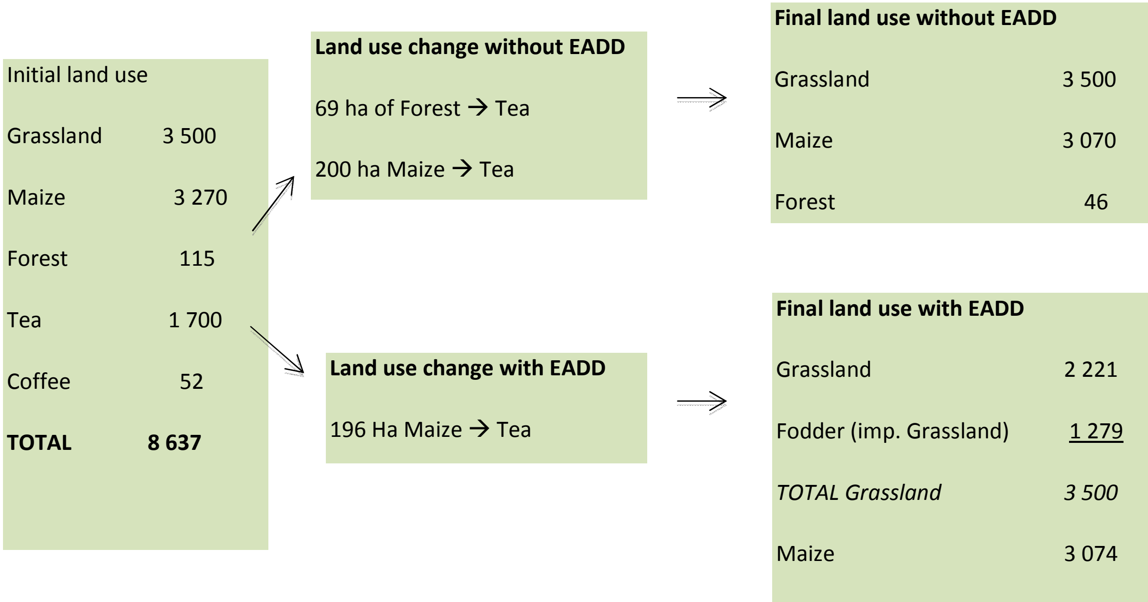

Figure 9: Land use and land use change with and without the EADD Project

3.1.2 Livestock

With an estimated 7 500 farm families, each with an average of three heads of cattle, there are approximately 22 500 heads of cattle (7 500 x 3) cattle in the Kaptumo Division. Currently 30-40 percent of the 1 600 EADD farmers actively supply milk to the DFBA and are adopting the improved feeding practices (i.e. providing Napier grass and feed with high protein content). Another 150 famers of those supplying milk are also providing mixed dry matter to their livestock. However, EADD targets all farmer families in the area. Based on the current adoption rate of 35 percent, it is expected that approximately 2 625 farmers (0.35 x 7 500) will provide improved feed to their livestock over the next 3 years. This would involve a total of 7 875 cows (2 625 x 3).

With regards to breeding practices, EADD intends to improve and upgrade artificial insemination to obtain more productive breeds (Tango Int., 2010; EADD, 2009). According to the workshop, there is a good adoption rate for these practices with more than 30 percent of the DFBA farmers engaged. As already mentioned, EADD targets 7 500 farm families or about 2 250 farmers (7500 x 0.3) who raise in total approximately 6 750 cows (2 250 x 3 animals).

3.1.3 Inputs

In addition to the land use and the land use change figures, the amount of fertilizers and pesticides applied on the different crops was also taken into account in the EX-ACT analysis *(cf. table 6)*. In terms of inputs, there will be no change in quantities applied without or with EADD scenario.

Table 6: Fertilizer and pesticide use[3]

	Fertilizers		
	Start (T/yr)	**Without (T/yr)**	**With (T/yr)**
Urea	7	6.75	7
N	76	77	76
P	87	82	83
K	6	7	7
	Pesticides		
Herbicides	6	6	6

Source: Ministry of agriculture, Kaptumo Division, 02.11.11

3.1.4 EX-ACT Gross Results

Based upon previous information on land use, land use change, livestock and inputs, the results from the EX-ACT tool indicate that both scenarios are net sources of emissions *(cf. table 7)*. The 'with EADD' scenario is a net source of 22 tonnes of carbon dioxide (equivalent) per ha over the next 20 years *(cf. footnote 4)*. The total carbon dioxide (equivalent) emitted under the 'with EADD' scenario is 213 672 tonnes or 25 tonnes of carbon dioxide (equivalent) per ha. Without EADD, a total of 518 299 tonnes of carbon dioxide (equivalent) or 60 tonnes per ha is emitted. This means that EADD reduced greenhouse gas emissions by more than 50 percent.

Table 7: Gross results with and without the EADD Project scenarios.

Components of the Project	**Gross fluxes Baseline (tCO2-eq)**		**Gross fluxes EADD Project (tCO2-eq)**	
Deforestation	50 767	Source	0	
Non Forest land use change	-21 168	Sink	-20 744	Sink
Agriculture				
Annual Crops	-133 445	Sink	-169 227	Sink
Agroforestry/Perennial Crops	-74 172	Sink	-60 700	Sink
Grassland	0		-69 983	Sink
Livestock	679 642	Source	517 828	Source
Inputs	16 674	Source	16 498	Source
Final Balance	**518 299**	**Source**	**213 672**	**Source**
Result per ha	*60*	*Source*	*25*	*Source*
Result per ha/year	*3*	*Source*	*1.2*	*Source*

The results also point out which activities are carbon sources and which are net carbon sinks *(cf. table 7)*. Livestock and inputs are net sources, with livestock being the largest emitter of carbon dioxide (equivalent). However, compared to the baseline, the emissions from livestock are reduced in the 'with EADD' scenario. Without EADD intervention, the farmers would likely increase their herd by one cow per family to increase the milk production.

[3] For the input calculations see Appendix 3

If the 'with project' scenario is a smaller source of emissions than the baseline scenario, the carbon balance for the 'with project' scenario will be a net sink, as greenhouse gas emissions are reduced compared to the baseline. In the livestock activity 161 814 tonnes of emissions of carbon dioxide (equivalent) (517 828 - 679 642) are reduced as a result of management improvements attributable to EADD interventions.

The main explanation of the net sink deriving from land use change and grassland in the 'with EADD' scenario is that 969 hectares of grassland has been improved through the plantation of Napier and Rhodes grass, with the Napier grass being fertilized with manure. Grasslands have a high potential to store carbon through sequestration and are estimated to potentially offset 4 percent of the world's greenhouse gas emissions (Soussana et al., 2010). Therefore, going from moderately degraded to improved grassland with inputs means that carbon will be sequestered.

Livestock causes methane emissions and contributes to climate change. This is the case for both scenarios *(cf. table 7).* In the 'with EADD' scenario, the sinks are due to:

- improved agricultural practices with annual crops;
- no deforestation;
- increased agroforestry with fodder trees; and
- improved grassland management.

Figure 10 illustrates the net sources and sinks generated from EADD interventions. The net sinks generated from annual crops are a result of improved management practices and the reduction or elimination of slash and burn. These emissions are generated in the baseline by the burning maize residues. It is however important to keep in mind that residues are mainly fed to livestock in the field or brought back home with only a small part being burnt (Wambugu, 2012). The largest source of emissions is livestock, and it is due to this activity that EADD is a net source of emissions. In addition, according to figure 10, the activities that sequester carbon are: land use changes, cultivation of annual crops, agroforestry and grassland management. The activities generating carbon dioxide emissions are livestock and the application of farming inputs.

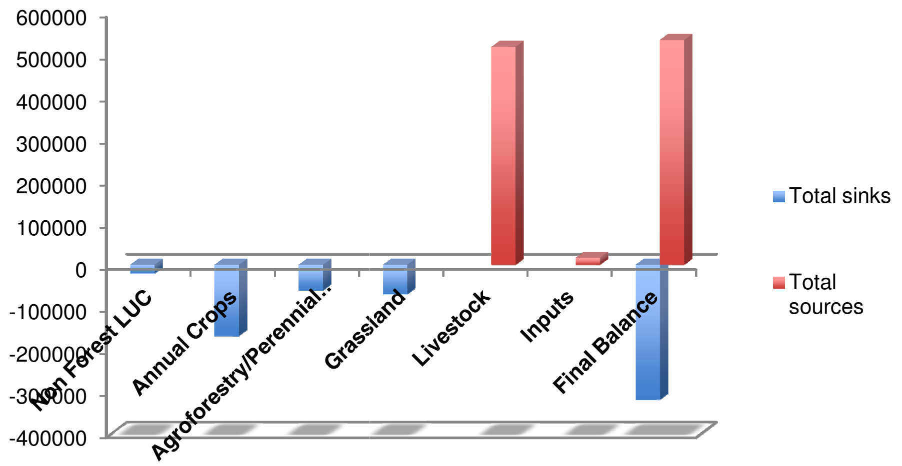

Figure 10: Net sinks and sources emitted by the EADD project (Source: cf. footnote 4)

3.2 'With the EADD-MICCA pilot project' scenarios

3.2.1 Land use and land use changes with the EADD-MICCA pilot project intervention

Figure 11: Lucerne production

The MICCA Programme is adding a climate-smart perspective to EADD interventions. The Programme takes into consideration the quantity of emissions and investigates low-carbon options for improved feeding and manure management. With regards to land use, the MICCA Programme component promotes agroforestry. Trees integrated into farm operations sequester carbon and provide additional fertilizer for both fodder and food production. In this way, the agroforestry activities act as a net carbon sink and contribute to climate change mitigation.

Along with an increased focus on agroforestry, the EADD-MICCA pilot project activities also seek to expand fodder production by identifying the most suitable species, seeds and varieties and increasing the density of trees per ha. This is also the case for pasture and fodder production. There is also a focus on: crop rotations and permanent soil cover, which follows the concepts of conservation agriculture; manure management and biogas production; increasing agroforestry and tree planting (woodlots and orchards); improved water management that link the DFBAs in Kaptumo Division (i.e. installation of water tanks for the purpose of rain water harvesting).

Figure 12: Rhodes grass

Livestock will be improved through enhanced feeding practices. Different types of fodder, (e.g. Napier and Rhodes grass) as well as silage and hay will be combined. This will increase dry matter feeding for livestock, which is preferable to wet matter feeding that requires more energy for digestion. To increase protein intake for the animals, lucerne and dismodium production will be increased *(cf. figure 11, 12)*. In addition, improved agronomic practices will equally be used for the cultivation of annual crops. As illustrated in figure 5, improvement in manure application will be reinforced by the MICCA Programme.

3.2.2 Scenario 1: The EADD-MICCA project with focus on higher adaptation rates

3.2.2.1 Land use and land use changes

The analysis of land use change regarding grassland (i.e. improved through fodder production), was conducted in the same way as for the EADD scenario *(cf. figure 13).* One of the focuses of the MICCA Programme is to promote integrated tree and livestock production systems. It was assumed that the adoption rate for zero-grazing will rise to 50 percent of the farmers (Kirui, 20.03.12). This assumes that on 7 500 farms, 3 750 farmers will adopt a zero-grazing system, converting or improving part of their grassland (50 percent) and converting part of their maize production (15 percent) into fodder. The other 15 percent of the grassland will be improved without inputs.

Producing on 1.15 ha of land, the total area is 4 313 ha. Of this area, 40 percent is grassland. This means that 863 ha {(4 314 x 0.4) x 0.5} of grassland will be improved with inputs. However, as mentioned previously, there is 115 ha of fodder production being promoted through the EADD Project. In total, the grassland that is improved with inputs is 979 ha (863+115). The remaining grassland that will be improved without inputs is 259 ha (4 313 x 0.4 x 0.15)**.** This will be added to the remaining improved land, 2 780 ha (3500-979 + 259), as there will be an eased grazing pressure as a result of improved grazing systems, such as zero-grazing. Currently, 38 percent of the land is under maize production, which means that 259 ha of maize (4 341 x 0.38 x 0.15) will be converted into fodder production.

Some of the remaining 50 percent of the farmers will most likely adopt a system that uses 'mainly stall feeding with some grazing' and use the maize production for fodder instead. (J. Kirui, 20.03.12). It was assumed that 30 percent of the farmers will adopt such a system. The area analyzed is also 4 341 ha in which 496 ha (4 341 x 0.38 x 0.3) of maize will be transformed into improved grassland. In total, 755 ha of maize fields will be converted to fodder production (i.e. grassland improved with inputs) *(cf. figure 13).* The other 20 percent of the farmers will not change their livestock system nor the area of their maize production. The total amount of fodder production after the land use change is 1 039 ha.

Initial land use (Ha)		→	**Final land use (Ha)**	
Grassland, moderately degraded	3 500		Grassland, improved without inputs	2 021

Figure 13: Land use, grassland

The land use changes in the EADD-MICCA context are mainly based on the land use change assumptions used in the EADD scenario for tea and fodder production and on an additional climate-smart component that focuses on increased agroforestry and fodder production *(cf. figure 14)*.

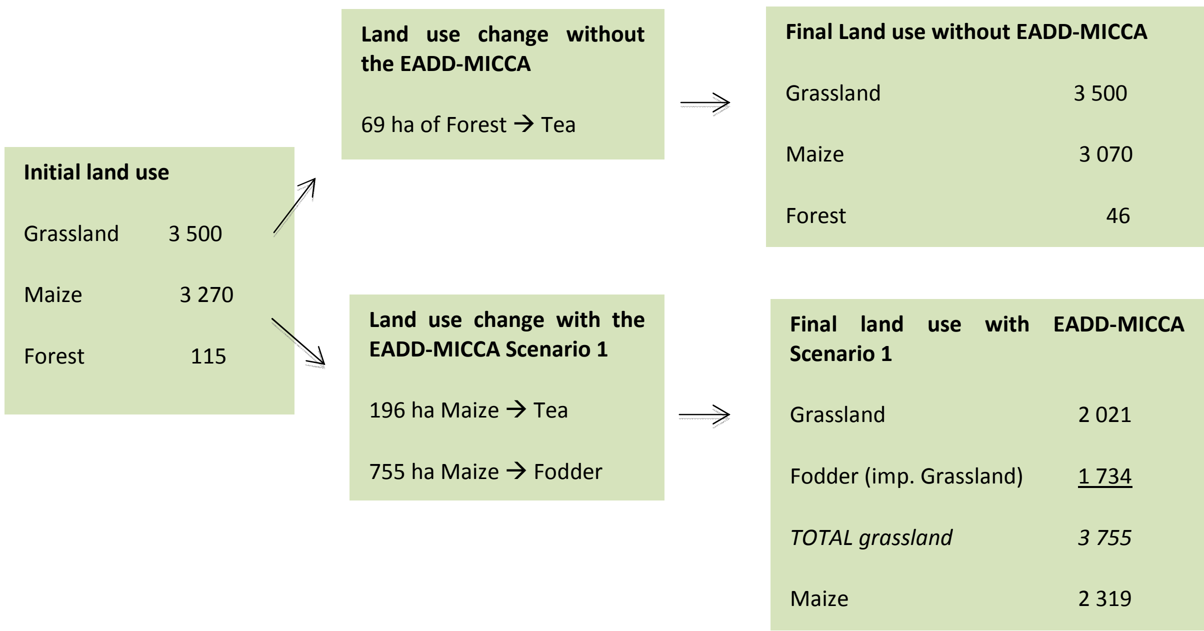

Figure 14: Land use and land use changes with and without the EADD-MICCA project, scenario 1 (ha)

It is planned to plant more trees in the area; approximately 200 trees per ha according to participants at Kaptumo workshop. As a large part of the grassland will become used for fodder production, trees will be planted in these areas. It was estimated that 500 ha of grassland will be planted with trees in an agroforestry system. Based on these numbers 100 000 trees (500 x 200) will be planted in the area. In addition, 196 ha (3 270 x 0.06) will planted with tea or other cash crops, such as passionfruit trees. As mentioned earlier, there is no agroforestry module in EX-ACT. As some maize will continue to be planted and intercropped with trees, categorizing this land use change as a conversion from cropland to forest is not accurate. Even though this activity it is not intended to establish a forest and is part of new agroforestry practices, the 'reforestation/afforestation' module was chosen in EX-ACT to reflect tree planting in maize fields. For the increase in the area of tea plantations, the perennials module was used to distinguish the cash crop perennials from the agroforestry systems.

3.2.2.2 Livestock

The objective of the EADD-MICCA project is to improve livestock feeding practices. However, it is understood that not all farmers will provide their herd with good quality feeds. The number of farmers providing their cattle with crop residues and concentrates remains low. The ratio of crop residues in the feed ration of does not exceed 20 percent, and the average is 9 percent (Zagst, 2011). One reason for the low rate of adoption could be the lack of awareness about the positive impact of crop residues on milk production, especially in the dry season. Productivity also depends on the season and fodder availability.

As mentioned, there are approximately 22 500 cattle in the Kaptumo Division. With the EADD-MICCA project it is expected that 90 percent of the farm families will adopt improved feeding practices. This is partly based upon the activities to improve grassland management and shift some maize cultivation to fodder production. Approximately 86 percent of the total grasslands will be improved in the EADD-MICCA project scenario, and 23 percent of the maize will be converted to improved grassland *(cf. figure 13 and 14)*. As mentioned earlier, improved fodder is generally cultivated close to the house, so in many cases this activity does not contribute to improving grasslands (Rioux, 16.04.2012). These improved production systems should increase the productivity of the cows in the area. Hence, the interventions involve 6 750 farmers (7500 x 0.9) raising approximately 20 250 cows (6 750 x 3). The rate of adoption for the analysed area is then 89 percent (20 050 ÷ 22 500) for improved feeding practices. Regarding improved breeding practices, as this is part of ongoing EADD activities, the adoption rate of 35 percent was assumed as was the case in the EADD only scenario.

3.2.2.3 Inputs

Table 8 indicates the baseline total amount of fertilizers and pesticides applied according to land use, without and with the EADD-MICCA project scenario 1.

Table 8: Fertilizer and pesticide use according to land use

	Fertilizers		
	Start (T/yr)	**Without (T/yr)**	**With (T/yr)**
Urea	7	7	5
N	76	77	66
P	87	83	64
K	6	7	7
	Pesticides		
Herbicides	6	6	6

It was assumed that the same amount of fertilizers and pesticides will be applied. The difference in their use is related to land use change.

3.2.2.4 EX-ACT Gross Results[4] for Scenario 1

The gross results provided by EX-ACT illustrates that climate-smart agricultural practices introduced through the EADD-MICCA pilot project have the potential to create a net carbon sink of -30 tonnes of CO_2 (equivalent) per ha over 20 years. The project has the capacity to reduce the greenhouse gas emissions by 1.5 tonnes of tonnes of CO_2 (equivalent) per ha each year *(cf. table 9 and footnote 5)*. Without the EADD-MICCA project, the analysed area would be a net source of emissions, emitting 518 2991 tonnes of CO_2 (equivalent) over 20 years or 63 tonnes of CO_2 (equivalent) per ha annually. The overall outcome of the suggested additional collaboration of the MICCA Programme in EADD brings about a net sink of 257 243 tonnes of CO_2 (equivalent).

The major sources of emissions from the EADD-MICCA pilot project are livestock production and the application of inputs. The greenhouse gas emissions from the livestock activities are slightly less than the baseline. The difference in tonnes of CO_2 (equivalent) between the baseline and the project scenario is due to the fact that in the EADD-MICCA scenarios the number of animals does not increase over time and improved breeding and feeding practices are adopted.

Table 9: Gross results with and without the EADD-MICCA Project scenario 1.

Components of the Project	Gross fluxes Baseline		Gross fluxes Scenario 1	
Deforestation	50 767	Source	0	
Afforestation and Reforestation	0		-322 469	Sink
Non-Forest land use change	-21 168	Sink	-114 403	Sink
Agriculture				
Annual Crops	-133 455	Sink	-130 304	Sink
Agroforestry/Perennial Crops	-74 172	Sink	-60 700	Sink
Grassland	0		-159 815	Sink
Livestock	679 642	Source	515 870	Source
Inputs	16 674	Source	14 577	Source
Final Balance	**518 299**	**Source**	**-257 243**	**Sink**
Result per ha	*60*	*Source*	*-30*	*Sink*
Result per ha/year	*3*	*Source*	*-1.5*	*Sink*

The reforestation activity is the main pilot project activity that contributes to climate change mitigation. As mentioned above, EX-ACT's reforestation module was chosen to represent the agroforestry activity, which accounts for 46 percent of the climate change mitigation *(cf. table 9)*. As result of the improved grassland management with inputs (i.e. production of Napier and Rhodes grass) through the EADD-MICCA interventions, the grassland activities generate the second largest carbon sink (26 percent). Figure 15 illustrates the net sources and sinks generated by the EADD-MICCA project per activity.

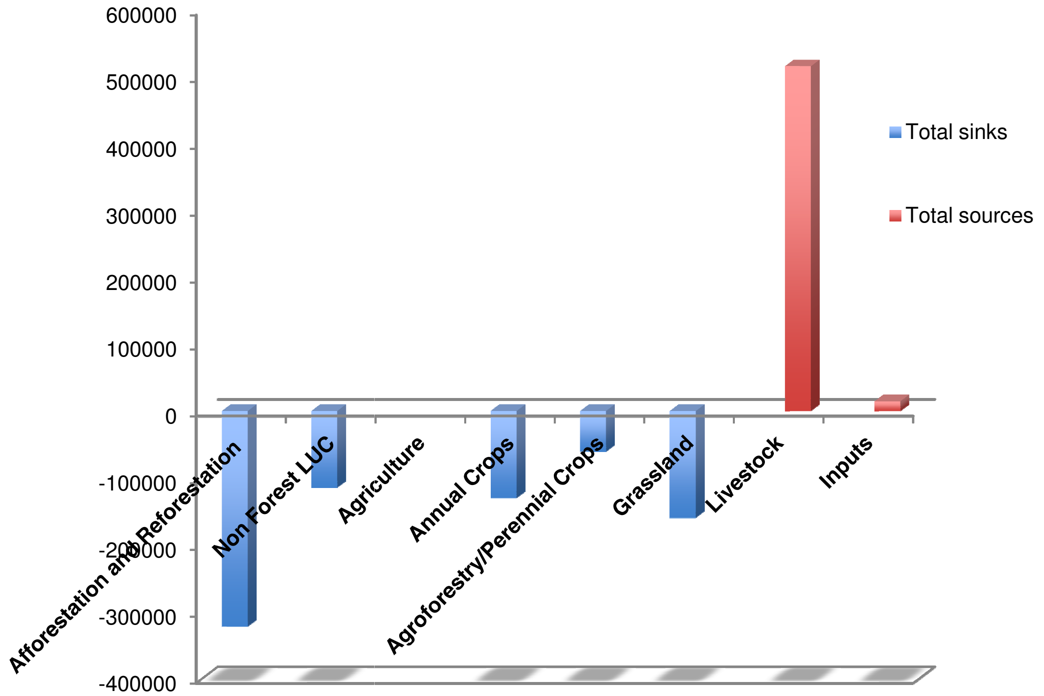

Figure 15: Net sinks and sources generated through the EADD-MICCA project activities, scenario 1. Source: EX-ACT Results (cf. footnote 5).

Figure 15 highlights the importance of climate change mitigation. The carbon sequestered in the soil and biomass as a result of improved agricultural systems outweighs the greenhouse gas emissions generated by the livestock activity. Moreover, such improvements (i.e. improved fodder production and combining food crops with trees in agroforestry systems) should also bring other benefits. Improved fodder will improve the productivity of the cows and agroforestry by preventing soil erosion and improving soil nutrition can strengthen the resilience ecosystems, increase crop yields and help safeguard food security.

3.2.3 Scenario 2: The EADD-MICCA project with focus on more realistic adaptation rates

3.2.3.1 Land use and land use changes

The analysis for land use change as a result of improving grasslands though increased fodder production was done in the same way as for EADD-MICCA scenario 1 *(cf. figure 14).* It was assumed that the adoption rate for zero grazing would rise to 20 percent of the farmers (Kirui, 20.03.12). This number is also reflects the findings of various studies on adoption rates for zero grazing in different African countries. The study done by Nicholson et al. (1999) noted that the adoption rates for zero grazing from 22 to 75 percent. However, the results from Batz et al. (2003) in their study performed in the Meru District, Kenya, indicates very low adoption rates (all below 3 percent) for zero grazing in the area. Also, another study done by Mpunga & Dube (1993) in Zimbabwe, noted different adoption rates for zero grazing depending on areas. Certain regions were below 10 percent while others varied from 50 to 75 percent.

If an adoption rate of 20 percent is assumed for the zero-grazing systems in Kaptumo, then 1 500 farmers (7 500 ÷ 5) will adopt a zero-grazing system, convert or improve part of their grassland (50 percent) and convert part of their maize production (15 percent) into fodder. The other 15 percent of the grassland will be improved without inputs.

Producing on 1.15 ha of land, the total area is 1 725 ha (1.15 x 1500). Out of this area, 40 percent is grassland, which means that 345 ha of grassland (1725 x 0.4 x 0.5) will be improved with inputs. It represents the zero-grazing adaptation option. As mentioned previously, EADD is working with farmers to establish 115 ha of fodder production. In total, the grassland that is improved with inputs is 460 ha (345+115). In addition, the remaining grassland that will be improved without inputs covers 104 ha (1 725 x 0.4 x 0.15) and will be added to the remaining improved land without inputs**,** as there will be an eased grazing pressure as a result of improved grazing systems, such as zero grazing. Currently, 38 percent of the land is under maize production, so 98 ha (1 725 x 0.38 x 0.15) of maize fields will be converted into fodder production. The total amount of land used fodder production (i.e. improved grassland with inputs) after the land use change is accounted for is 952 ha (460+492).

It is assumed that 30 percent of the farmers will adopt a 'mainly stall feeding with some grazing' system and use the maize production for fodder instead (Kirui, 20.03.12). The area analyzed is 1 035 ha (7500 farmers x 1.15 ha x 0.4 x 0.3) of which 393 ha (1 035 x 0.38) of maize will be transformed into improved grassland. In total, 492 ha of maize will be converted to fodder production (i.e. grassland improved with inputs) *(cf. figure 16).*

In addition, 30 percent of the farmers will adopt a 'mainly grazing with some stall feeding' system. This scenario also covers 1 035 ha, but as it is mainly grazing, the grasslands will not be improved. It is similar for the remaining 20 percent of the land, which will be used only for grazing. The area used only for grazing is 690 ha. It is not expected that these farmers will change the livestock system or the area of their maize production.

Initial land use (Ha)	
Grassland, moderately degraded	3500

→

Final land use (Ha)	
Grassland, not improved	1725
Grassland, improved without inputs	815

Figure 16: Land use, grassland

To clarify, the 815 ha of degraded grasslands affected by EADD-MICCA interventions represents the initial area of moderately degraded grassland (3 500 ha) minus the grassland converted to agroforestry (500 ha) minus the grassland improved without inputs (815 ha) minus the grassland improved with inputs (460 ha) minus the grassland that remains unaffected (1 725) The land use changes in the EADD-MICCA context are mainly based supon the land use change assumptions used in the EADD scenario for tea and fodder production and an additional climate smart component of increased agroforestry and fodder production *(cf. figure 17)*.

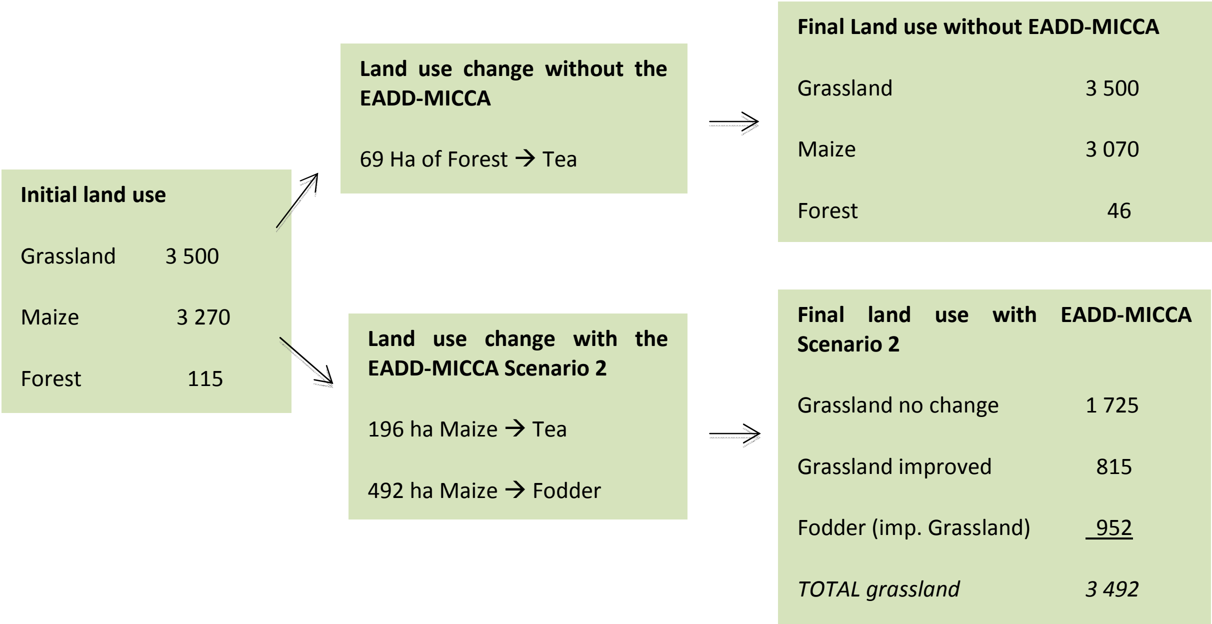

Figure 17: Land use and land use changes with and without the EADD-MICCA Project, Scenario 2 (ha)

As with scenario 1, it is planned to plant more trees in the area; approximately 200 trees per ha. The results of the EX-ACT analysis for scenario 2 regarding agroforestry and intercropping are the same as for scenario 1.

3.2.3.2 Li

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Assuming 22 500 cows in the scenario, it is expected that 50 percent of the farm families will adopt improved feeding practices. Based upon the numbers from figure 16 and 17, approximately 36 percent of the total grassland will be improved in the EADD-MICCA project scenario, and 15 percent of the maize fields will be converted to improved grassland *(cf. figure 16 and 17)*. These improved production systems should increase the productivity of the cows. Hence, this scenario involves 3 750 farmers (7500 x 0.5) and the number of animals is 11 250 (3750 x 3). The rate of adoption for the analysed area is then 50 percent (11 250 ÷ 22 500) for improved feeding practices. The adoption rate for improved breeding (35 percent) remains the same as it concerns only EADD's work.

3.2.3.4 Inputs

Table 10 demonstrates the total amount of fertilizers and pesticides applied per land use initially, without and with the EADD-MICCA project, scenario 2.

Table 10: Fertilizer and pesticide use according to LU

Fertilizers			
	Start (T/yr)	Without (T/yr)	With (T/yr)
Urea	7	7	6
N	76	77	70
P	87	83	70
K	6	7	7
Pesticides			
Herbicides	6	6	6

It was assumed that the same amount of fertilizers and pesticides will be applied. The difference applied per scenario is related to land use changes.

3.2.3.5 EX-ACT Gross Results[5] for Scenario 2

The gross results provided by EX-ACT indicate that the climate-smart agricultural practices added through the EADD-MICCA pilot project have the potential to create a net carbon sink of -17 tonnes of CO_2 (equivalent) per ha over 20 years. These interventions have the potential to sequester 1 tonnes of CO_2 (equivalent) per ha per year *(cf. table 11 and footnote 6)*. Without the EADD-MICCA project, the analysed area would be a net source of emissions, emitting 60 tonnes of CO_2 (equivalent) per ha annually. Over a period of 20 years, 518 299 tonnes of CO_2 (equivalent) would be emitted. Overall the proposed EADD-MICCA pilot project activities have the potential to create a net sink of 145 391 tonnes of CO_2 (equivalent).

Table 11: Gross results with and without the EADD-MICCA project scenario 2.

Components of the Project	Gross fluxes Baseline		Gross fluxes Scenario 2	
Deforestation	50 767	Source	0	
Afforestation and Reforestation	0		-322 469	Sink
Non Forest land use change	-21 168	Sink	-81 777	Sink
Agriculture				
Annual Crops	-133 455	Sink	-143 878	Sink
Agroforestry/Perennial Crops	-74 172	Sink	-60 700	Sink
Grassland	0		-69 157	Sink
Livestock	679 642	Source	517 234	Source
Inputs	16 674	Source	15 357	Source
Final Balance	**518 299**	**Source**	**-145 391**	**Sink**
Result per ha	*60*	*Source*	*-17*	*Sink*
Result per ha/year	*3*	*Source*	*-1*	*Sink*

[5] The full EX-ACT analysis of the EADD-MICCA scenario 2 can be observed HERE

The main activity contributing to climate change mitigation is reforestation. The reforestation module was chosen to analyse the agroforestry activity, which accounts for 48 percent of the project's climate change mitigation potential *(cf. table 11)*. As result of the improved grassland management with inputs (i.e. production of Napier and Rhodes grass) through the EADD-MICCA interventions, the grassland activities generate the second largest carbon sink (21 percent). Figure 18 illustrates the net sources and sinks generated per activity by the EADD-MICCA project in scenario 2.

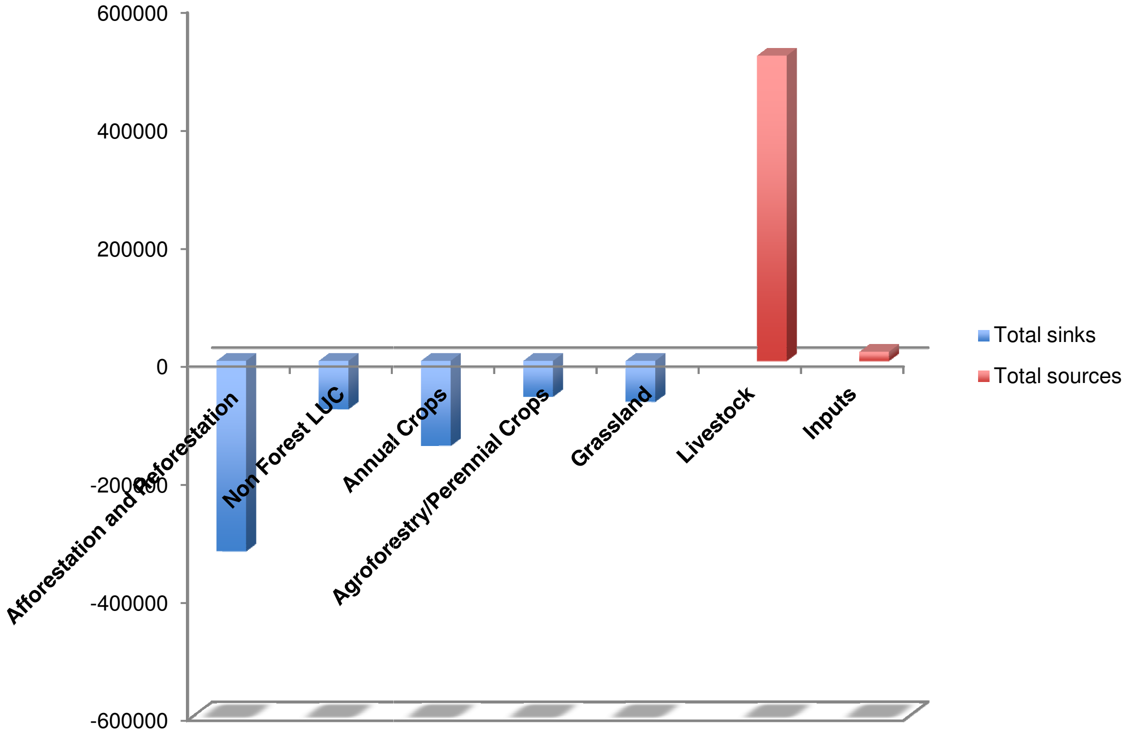

Figure 18: Net sinks and sources generated through the EADD-MICCA project activities. Source: EX-ACT results (cf. footnote 6).

4. DISCUSSION

The following section discusses the EX-ACT results from the three scenarios: 'with EADD' and 'with EADD-MICCA' scenarios 1 and 2. It compares the gross results and the carbon balance of the three scenarios.

4.1 Comparison of EX-ACT Gross Results

Table 12 compares the three 'with project' scenarios and indicates the added contribution of MICCA Programme interventions in EADD. The reforestation activity, which increases agroforestry practices in the area, is the major contributor to climate change mitigation. The grassland activity also represents a sizeable sink in MICCA-EADD scenarios 1 and 2. The major differences between scenario 1 and 2 are the adaptation rates for fodder production and improved feeding practices; with scenario one assuming a higher adoption rate. An important finding from the analysis is that dairy production systems can be climate-smart with a few selected additional practices, such as agroforestry and improved fodder production. Because they increase above-ground and below-ground biomass, these additional practices can also bring co-benefits in terms of sustainable land management and ecosystem resilience. They help prevent soil erosion, and the carbon they sequester increases soil nutrition.

There is a larger land use change in the EADD-MICCA scenario 1, with 755 ha of maize converted into grassland for fodder. In addition, in this scenario, the 2 021 ha of grassland that will not be improved with inputs will be improved by easing the grazing pressures on this land. In EX-ACT, this improvement is categorized as 'improved without inputs'. For the EADD-MICCA scenario 2, less land planted in maize is converted to fodder production, which is why the result in the 'non-forest land use change' is smaller. In general, because adoption rates are assumed in scenario 2 (e.g. for the zero-grazing conversion and adoption rates for improved feeding), the changes and improvements are somewhat more realistic compared to scenario 1. Scenario 2 has the potential to sequester 17 tonnes of CO_2 (equivalent) per ha.

Scenario 1 has a larger potential to sequester carbon: 30 tonnes of CO2 (equivalent) per ha. Even though scenario 1 has a larger mitigation potential, scenario 2 is probably more realistic in terms of what the pilot project can achieve in 3 years. Scenario 2 also puts greater emphasis on food security, ensuring that the production of maize, a staple food crop in the region, is not jeopardized.

Table 12: EX-ACT Gross Results, the EADD scenario versus MICCA-EADD scenarios 1 and 2.

Components of the Project	Gross fluxes EADD Project	Gross fluxes Scenario 1	Gross fluxes Scenario 2
Deforestation	0	0	0
Afforestation and Reforestation	0	-322 469	-322 469
Non-forest land use change	-20 744	-114 403	-81 777
Annual Crops	-169 227	-130 304	-143 878
Agroforestry/Perennial Crops	-60 700	-60 700	-60 700
Grassland	-69 983	-159 815	-69 157
Livestock	517 828	515 870	517 234
Inputs	16 498	14 577	15 357
Final Balance	**213,672**	**-257,243**	**-145,391**
Result per ha	*25*	*-30*	*-17*
Result per ha/year	*1*	*-2*	*-1*

The annual crops activities result in a larger sink in the EADD scenario, as there is more area planted with annual crops (i.e. maize production) *(cf. figure 19).*

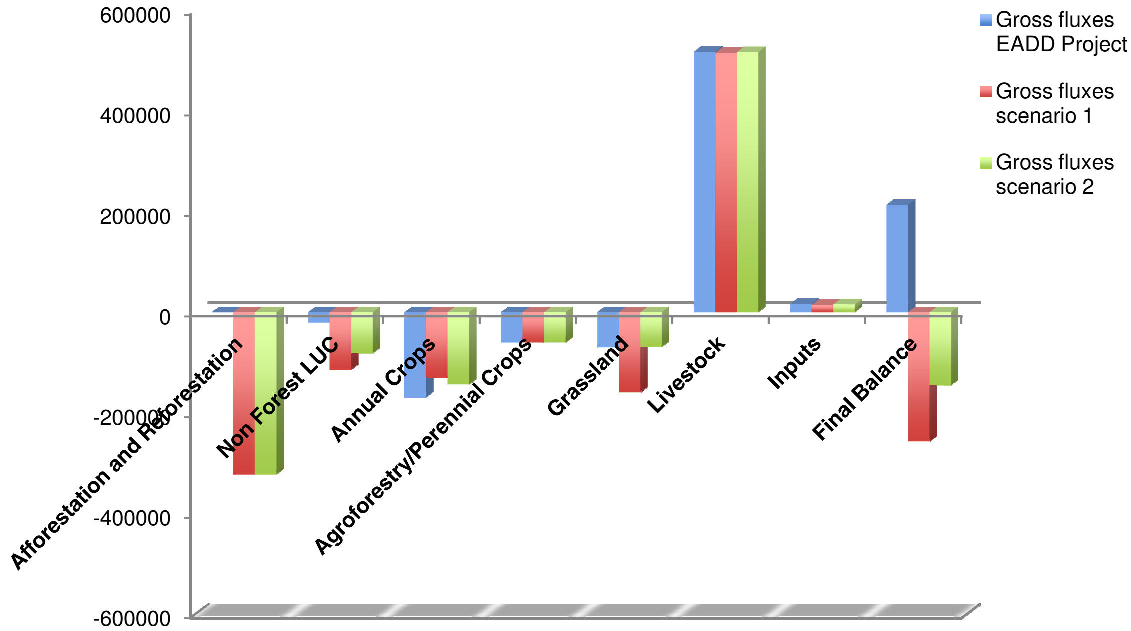

Figure 19: The net sinks and sources generated by the the EADD versus the EADD-MICCA project.

The EADD scenario ends up as a net source of CO_2, while the EADD-MICCA scenario 1 and 2 are net CO_2 sinks. As observed in figure 19, the gross carbon fluxes in the livestock activity are almost equal in the three situations. This indicates the importance of reforestation and improved grassland for climate change mitigation.

4.2 The final EX-ACT carbon balance[6] between the three project scenarios

With the EADD project the total carbon balance results in a net sink of -304,627 tonnes of CO_2 (equivalent) *(cf. table 13)*. The EADD project scenario provides a smaller net sink compared to the EADD-MICCA scenarios 1 and 2.

For EADD, the carbon balance highlights the potential impact in terms of climate change mitigation that result from their interventions (i.e. the land use change, improved agronomic practices, livestock feeding and breeding practices). It is correct to conclude that through EADD activities, CO_2 (equivalent) is either sequestered or emissions are minimized compared to the baseline *(cf. table 13)*.

[6] The carbon balance represents the potential impact of the project in terms of mitigation, indicating the net amount of carbon sequestered (carbon sink) or emitted (carbon source) as a result of the project. It shows if the project is able to supply environmental services in the form of carbon sequestration and contribute to climate change mitigation. (Bernoux et al., 2010).

The additional activities supported by the EADD-MICCA pilot project in scenario 1 have the potential to provide a total net carbon sink of 755 542 tonnes of CO_2 (equivalent). *(cf. table 13).* The total carbon balance for EADD-MICCA scenario 1 shows the net carbon sequestered or greenhouse gas emissions mitigated. The net sink results from: changes in land use; improved farming, livestock and grassland management practices; and reduced deforestation and increased agroforestry.

The EADD-MICCA scenario 2 provides a smaller sink compared to scenario 1. As indicated in table 13, this difference is mainly due to the grassland activity. In scenario 2, less grassland is improved (i.e. turned into fodder or as a result of eased grazing pressure). Consequently, a smaller amount of carbon is sequestered in the soil. There are also fewer changes in land use (i.e. maize being converted to tea or fodder production). Nonetheless, the findings indicate that scenario 2 sequesters 77 tonnes of CO_2 (equivalent) per ha over 20 years and 4 tonnes of CO_2 (equivalent) per ha per year. The difference, compared to scenario 1, which sequesters 4.5 tonnes of CO_2 (equivalent) per ha per year, is only 0.5 tonnes of CO_2 (equivalent) per ha. In addition, there is a high amount carbon gained in the biomass due primarily to the agroforestry component

Table 13: The Carbon Balance results of the EADD and the EADD-MICCA scenario 1 and 2.

Components of the Project	EADD Project		EADD-MICCA Scenario 1		EADD-MICCA Scenario 2	
Deforestation	-50 767	Sink	-50 767	Sink	-50 767	Sink
Afforestation and Reforestation	0		-322 469	Sink	-322 469	Sink
Non Forest Land Use Change	423	Source	-93 235	Sink	-60 610	Sink
Agriculture						
Annual Crops	-35 782	Sink	3 141	Sink	-10 434	Sink
Agroforestry/Perennial Crops	13 472	Source	13 472	Source	13 472	Source
Grassland	-69 983	Sink	-159 815	Sink	-69 157	Sink
Livestock	-161 814	Sink	-163 772	Sink	-162 408	Sink
Inputs	-176	Source	-2 098	Sink	-1 317	Sink
Final Balance	**-304,627**	**Sink**	**-775,542**	**Sink**	**-663,689**	**Sink**
Final Balance per gas						
• **CO_2 Biomass**	-38 384	Sink	-369 225	Sink	-366 198	Sink
• **CO_2 Soil**	-68 786	Sink	-206 200	Sink	-98 967	Sink
• **N2O**	-50 621	Sink	-51 289	Sink	-51 061	Sink
• **CH4**	-146 836	Sink	-148 827	Sink	-147 464	Sink
Result per ha	*-35*	*Sink*	*-90*	*Sink*	*-77*	*Sink*
Result per ha/year	*-1.8*	*Sink*	*-4.5*	*Sink*	*-4*	*Sink*
Level of uncertainty	**32%**		**37%**		**41%**	

Compared to the EADD scenario, the study's findings indicate that the MICCA-EADD pilot project, with its focus on agroforestry, has the potential to increase climate change mitigation by 63 percent in scenario 1 and by 47 percent in scenario 2. The carbon sequestered in the biomass and soil differs greatly between the EADD scenario and the EADD-MICCA scenarios. The differences highlight the additional contribution of the agroforestry component *(cf. table 13).* In EADD-MICCA scenario 1, the mitigation benefits result from reforestation and improved practices for cultivating annual crops. Over 20 years, the implemented activities sequester 90 tonnes of CO_2 (equivalent) per ha. The finding that the agroforestry component acts as a source of emissions does not imply that the activity generates CO_2 emissions *per se*. In this case, the baseline scenario sequesters more carbon compared to the 'with project' scenario *(cf. table 6 and 8)*. With regards to the EADD-MICCA scenario 2, although less than for scenario 1, there is still a high amount carbon gained in the biomass, mainly as a result of agroforestry.

The level of uncertainty for the different scenarios, which depends on the approach used (in this case the tier 1 approach), is 38 percent *(cf. table 13)*. Using the tier 2 approach, which is more region-specific, would likely reduce the level of uncertainty. The level of uncertainty is linked to the assumptions made in the analysis. Scenario 1 has the highest level of uncertainty, which is normal since there are larger land use changes and higher adoption rates used with the tier 1 approach.

Figure 17 shows the carbon balance per project activity. All activities lead to net carbon sinks. These sinks are created either by sequestering carbon (i.e. through reforestation, land use change, annual crops, agroforestry and grassland management) or by reducing the greenhouse gas emissions compared to the baseline (i.e. better livestock practices and fewer inputs). Based on the gross results, the livestock activity, *(cf. for example table 11)* is a net source of emissions for all scenarios. Nonetheless, it is a smaller source of emissions in the 'with projects' scenarios compared to the baseline. As a result, the carbon balance for the livestock activity in the 'with project' scenarios (the gross results 'with' project minus the gross results from the baseline) indicates a carbon sink. The livestock activity in the 'with project' scenarios reduces greenhouse gas emissions compared to the baseline, but it is still a net emitter of greenhouse gases.

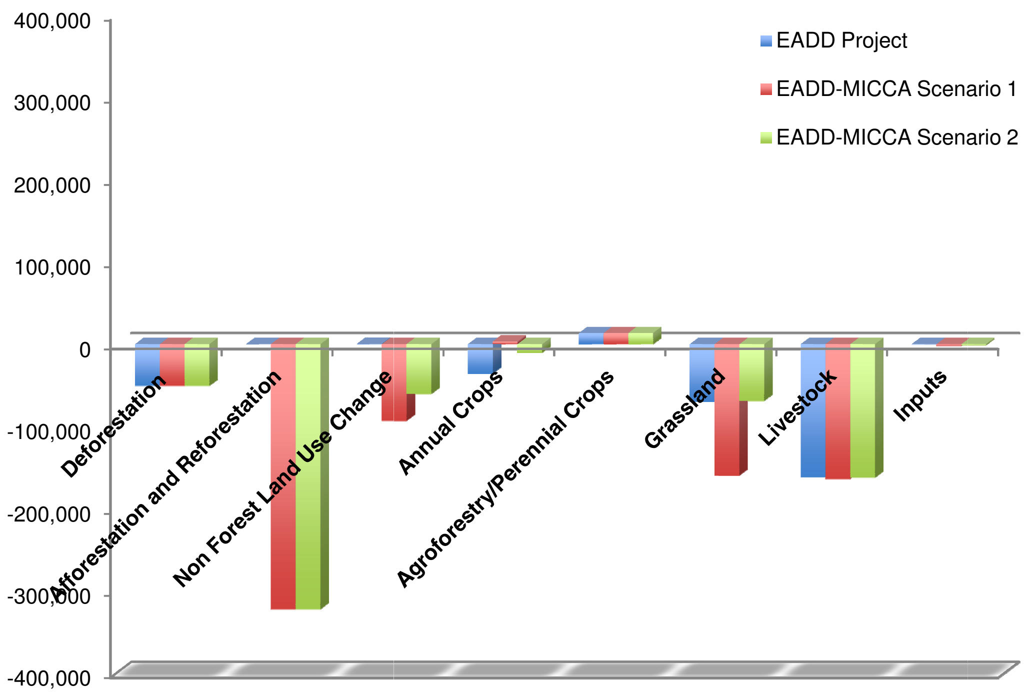

Figure 20: The carbon balance per activity and in total for the EADD and the EADD-MICCA scenario.

5. CONCLUSION

The report indicates the mitigation potential of the EADD-MICCA pilot project, 'Enhancing mitigation within the EADD' in Kaptumo Division, Kenya. Building on the work already accomplished by EADD, the joint pilot project puts an increased focus on agroforestry and improved farming and livestock practices. Results from two different scenarios indicate that the EADD-MICCA pilot project has the potential to create a net sink of -775 542 tonnes of CO_2 (equivalent) and 663 689 tonnes of CO_2 (equivalent) respectively, compared to the EADD only scenario. EADD interventions alone have the potential to be a net sink of 304 627 tonnes of CO_2 (equivalent) *(cf. figure 21)*.

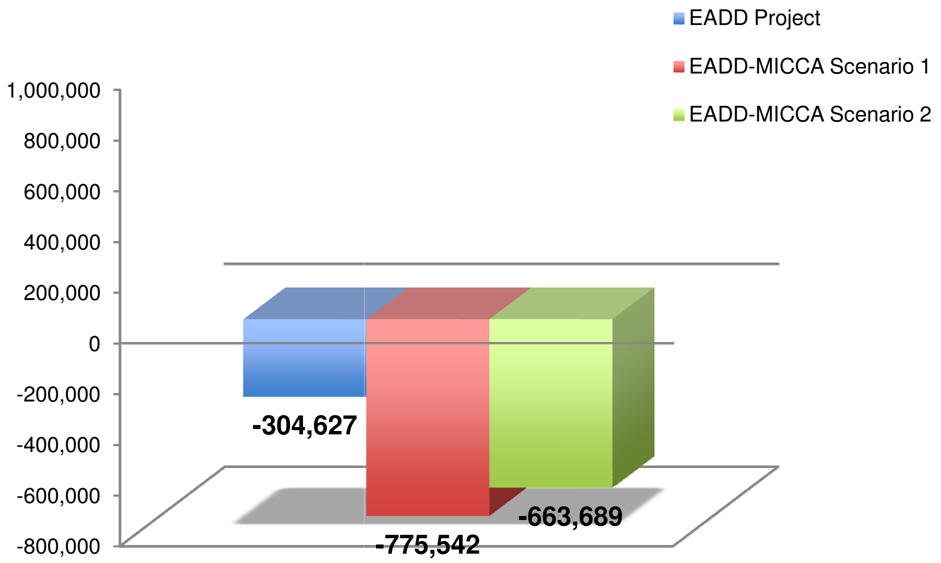

Figure 21: Comparison between three carbon balance scenarios

The EX-ACT study illustrates the importance of the synergies between EADD and the MICCA Programme. By itself, EADD is mitigating climate change in that it is reducing greenhouse gases emissions compared to the baseline scenario. However, EADD will not create a carbon a sink but will continue to be a source of emissions equivalent to 213 672 tonnes of CO_2 *(cf. table 7)*. For the EADD-MICCA scenario 1, all farmer families have been included in the analysis with the assumption that there would be almost full adoption rate over a three-year implementation period. If not all families adopt the suggested management interventions, the mitigation potential will be reduced. Scenario 2 assumes more modest adaptation rates. This scenario may offer a better balance between climate change mitigation and food security because it assumes that less land currently used for maize cultivation will be reforested. However, since the corn would be part of an agroforestry system, maize would be mixed with trees for the purpose of increased soil nutrition, which is beneficial for food crop productivity. As the findings are based upon several key assumptions, it is important to highlight the data uncertainties. There is an uncertainty level of 41 percent for scenario 1; 37 percent for scenario 2; and 32 percent for the EADD scenario.

The results of the report can be put into relation with the EX-ACT study performed on the National Agricultural and Pilot Fishery Programme (NAPFP) in Eritrea (Branca, 2009). The NAPFP promotes sustainable agriculture and livestock development and the protection and conservation of natural resources. It takes into consideration natural resource degradation and its consequences on vulnerability to climatic events and food security (Branca, 2009). By promoting the adoption of sustainable land management practices (i.e. catchment protection activities, afforestation/reforestation, smokeless stoves and rangeland rehabilitation), the NAPFP contributes to climate change mitigation. In the NAFPP EX-ACT study, the baseline scenario was found to be a net source of greenhouse gas emissions. Because of the sustainable land management practices, the 'with project' scenario was found to be a net sink. Even though the project's livestock activity was a net source of emissions, the final result of all activities indicated that the project created a net sink of 3 million tonnes of CO_2 (equivalent) over 20 years. This mainly derived from reforestation and improved cropland activities. The findings emphasize on the critical importance of adopting sustainable land management practices.

Although not designed to mitigate climate change, the NAPFP in Eritrea is a good example of how a livestock project can contribute to climate change mitigation (Branca, 2009). The NAPFP interventions help restore depleted soil nutrient, increase yields and allow farmers to increase food and livestock production. They provide both an immediate and long-term response to local food security. This is similar to the results of the EADD-MICCA scenarios.

The EADD-MICCA scenarios primarily consider the balance between climate change mitigation and food security. The scenarios also look at the changes in ecosystem resilience brought about by increases in above- and below-ground biomass in litter, soil and dead wood. The increase in biomass is principally due to an increased agroforestry, reduced deforestation and improved grassland management. With the implementation of better management practices, it is possible to achieve food security in a climate-smart way. It is also noteworthy that the two EADD-MICCA scenarios, both of which focus on livestock, can contribute to climate change mitigation when compared to the baseline. The mitigation is achieved either through reduction of greenhouse gas emissions in livestock production or through carbon sequestration achieved through agroforestry and improved grassland management. The carbon balance results for the EADD-MICCA scenarios demonstrate the additional climate change mitigation benefits that can be gained from a project whose main priority is food security.

Other EX-ACT analyses have shown that climate-smart agricultural systems have not only mitigation possibilities, they are equally capable of providing benefits in terms of rural development and food security. An example of this is the EX-ACT analysis of the Rio de Janeiro Sustainable Rural Development Project in Brazil and the Accelerated Food Security Project in the United Republic of Tanzania (Branca et al, 2009; Bockel et al, 2010). In addition, an EX-ACT analysis of the cashew kernel value chain in Burkina Faso indicated that climate change mitigation benefits from agriculture could also potentially generate supplementary financing and investment through the development of payment schemes for environmental services (Tinlot, 2010). Such support can hypothetically be developed through international agreements on mitigation financing for developing countries.

This report illustrates the important synergy between two of the three main components of climate-smart agriculture: climate change mitigation and food security. Climate-smart agriculture's third component, adaptation to climate change, is addressed indirectly in that the mitigation activities also have the potential to generate adaptation benefits. Decreased soil erosion due to the adoption of agroforestry practices can help farmers increase their adaptive capacity to extreme weather events. The findings of the report indicate what can be achieved in the area with different adoption rates of for climate-smart farming, forestry and livestock practices.

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Personal information

P., Mudavadi, 21.11.11, Patrick.mudavadi@eadairy.org

J., Kiuri, 20.03.12, J.Kirui@cgiar.org

J., Rioux, 16.04.2012, Janie.rioux@fao.org

APPENDIX 1: PARTICIPANTS LIST, KAPTUMO WORKSHOP

Workshop in Kaptumo, 21st of October 2011

Name	Org/role	Email
Richard Biwott	Kapcheno/V.Secretary	richardbiwott@yahoo.com 0723960469
Wilfred K.Kemboy	Kapcheno/Chairman	0727268531
Obadiah Chepkwong	Ministry of agriculture	okchepkwony@yahoo.com
Lena Keino	Min. of water & irrigation	nandisouthdwo@yahoo.com
Lydia Chirchir	Kapcheno Dairy/Treasurer	0723097197
Simon K. Omasaki	Kapcheno dairies/Extension manager	skomasaki@yahoo.com
Patrick Mudavadi	EADD/ICRAF Coordinator	0726257756
Dawood Idenya	Ministry of livestock	dawoodidenya@yahoo.com
Caroline W. Githiomi	MOLD/Nandi south	cshirok@yahoo.com
Todd Rosenstock	ICRAF	t.rosenstock@cgiar.org
Madeleine Jönsson	FAO/EX-ACT-MICCA Consultant	Madeleine.jonsson@fao.org
Janie Rioux	FAO/MICCA Consultant	Janie.rioux@fao.org

APPENDIX 2: PARTICIPANTS LIST, EX-ACT TRAINING, NAIROBI

EX-ACT Training, 17^{th} and 18^{th} of October 2011

Name	Organization	Title	Contact
Stanley Kimereh	FAO	Programme Assistant	Stanley.kimereh@fao.org
Joseph N. Kamande	Ministry of Livestock		jnkamande@gmail.com
Josephine Kiuri	ICRAF/EADD	ICRAF-EADD Coordinator	j.kiuri@cgiar.org
Patrick Muldavadi	EADD	EADD/ICRAF Coordinator	p.muduvadi@cgiar.org
Todd Rosenstock	ICRAF/MICCA	Research Fellow	t.rosenstock@cgiar.org
Janie Rioux	FAO HQ	Capacity development consultant	Janie.rioux@fao.org
Joab Langi Osumba	Ministry of Agriculture	Agricultural advisory services officer	Joab.osumba@acci.co.ke jlosumba@gmail.com
Madeleine Jönsson	FAO HQ	FAO/EX-ACT-MICCA consultant	Madeleine.jonsson@fao.org

APPENDIX 3: INPUT CALCULATIONS

With and without the EADD Project

Fertilizers				
	Type of LU	**Start (T/yr)**	**Without (Ha*T/Ha/yr)=(T/yr)**	**With (Ha*T/Ha/yr)=(T/yr)**
DAP, P_2O_5	Maize	83.7	(3070*0.0247)=76	(3074*0.0247)=76
DAP, N		32.4	(3070*0.0096)=29	(3074*0.0096)=30
Urea		7.5	(3070*0.0022)=7	(3074*0.0022)=7
N	Tea, coffee	30	(2021*0.017)=34	(1948*0.017)=33
P		6	(2021*0.0034)=7	(1948*0.0034)=6
K		6	(2021*0.0034)=7	(1948*0.0034)=6
CAN17	Maize	15.3	(3070*0.0045)=14	(3074*0.0045)=14
TOTAL N	All LU	76	77	76
TOTAL P		87	82	83
TOTAL K		6	7	7
TOTAL UREA		7	7	7
Pesticides				
Herbicide	All plantations	6	6	6

With and without the EADD-MICCA Project, Scenario 1

Fertilizers				
	Type of LU	**Start (T/yr)**	**Without (Ha*T/Ha/yr)=(T/yr)**	**With (Ha*T/Ha/yr)=(T/yr)**
DAP, P_2O_5	Maize	83.7	(3070*0.0247)=76	(2319*0.0247)=57
DAP, N		32.4	(3070*0.0096)=29	(2319*0.0096)=22
Urea		7.5	(3070*0.0022)=7	(2319*0.0022)=5
N	Tea, coffee	30	(2021*0.017)=34	(1948*0.017)=33
P		6	(2021*0.0034)=7	(1948*0.0034)=7
K		6	(2021*0.0034)=7	(1948*0.0034)=7
CAN17	Maize	15.3	(3070*0.0045)=14	(2319*0.0045)=10
TOTAL N	All LU	76	77	66
TOTAL P		87	83	64
TOTAL K		6	6.8	7
TOTAL UREA		7	7	5
Pesticides				
Herbicides	All plantations	6	6	6

With and without the EADD-MICCA Project, Scenario 2

Fertilizers				
	Type of LU	**Start (T/yr)**	**Without (Ha*T/Ha/yr)=(T/yr)**	**With (Ha*T/Ha/yr)=(T/yr)**
DAP, P_2O_5	Maize	83.7	(3070*0.0247)=76	(2582*0.0247)=64
DAP, N		32.4	(3070*0.0096)=29	(2582*0.0096)=25
Urea		7.5	(3070*0.0022)=7	(2582*0.0022)=6
N	Tea, coffee	30	(2021*0.017)=34	(1948*0.017)=33
P		6	(2021*0.0034)=7	(1948*0.0034)=7
K		6	(2021*0.0034)=7	(1948*0.0034)=7
CAN17	Maize	15.3	(3070*0.0045)=14	(2582*0.0045)=12
TOTAL N	All LU	76	77	70
TOTAL P		87	83	71
TOTAL K		6	6.8	7
TOTAL UREA		7	7	6
Pesticides				
Herbicides	All plantations	6	6	6

APPENDIX 4: EX-ACT MODULES DESCRIPTION

EX-ACT is made up of different modules, which can be used to simulate the impact of project activities on the carbon balance (see Table beneath). The user only uses the modules that are of relevance for the specific project.

Table : Overview of Modules used for C-Balance calculations

Name of the Module	IPCC-category	GHG concerned	Main methodologies and references
Deforestation	Land converted to another land-use: Forestland to land	Mostly CO_2, but also CH_4* and N_2O*	**Volume 4 (Chapter 4) of NGGI (IPCC, 2006)**
Afforestation & Reforestation	Land converted to another land-use: land to Forestland	Mostly CO_2, but also CH_4* and N_2O*	**Volume 4 (Chapter 4) of NGGI (IPCC, 2006)**
Forest degradation	Forestland remaining Forestland	Mostly CO_2, but also CH_4* and N_2O*	**Volume 4 (Chapter 4) of NGGI (IPCC, 2006)**
Other Land Use Change	Land converted to another land-use: non Forest land to another non Forest land	CO_2	**Volume 4 (Chapters 4-6) of NGGI (IPCC, 2006)**
Annual Crops	Cropland remaining Cropland	Mostly CO_2, but also CH_4* and N_2O*	**Volume Mitigation" (Chapter 8) of the fourth Assessment Report of the IPCC (Smith et al., 2007a)**
Agroforestry /Perennial Crops	Cropland remaining Cropland	Mostly CO_2, but also CH_4* and N_2O*	**Volume Mitigation" (Chapter 8) of the fourth Assessment Report of the IPCC (Smith et al., 2007a)**
Rice	Cropland remaining Cropland	Mostly CH_4, but also N_2O*	**Volume 4 (Chapter 5) of NGGI (IPCC, 2006)**
Grassland	Grassland remaining Grassland	Mostly CO_2, but also CH_4* and N_2O*	**Volume 4 (Chapter 6) of NGGI (IPCC, 2006)**
Organic soils	-	Mostly CO_2, but also CH_4* and N_2O*	**Volume 4 (Chapter 7) of the NGGI-IPCC-2006.**
Livestock	Not a land use category	CH_4 and N_2O	**Volume 4 (Chapter 10) of NGGI (IPCC, 2006) and Volume "Mitigation" (Chapter 8) of the fourth Assessment Report of the IPCC (Smith et al., 2007a)**
Inputs	Not a land use category	CO_2 and N_2O	**Volume 4 (Chapter 11) of NGGI (IPCC, 2006) and Lal (2004)**
Other Investments	**Not a land use category**	**CO_2**	**Volume 1 of NGGI (IPCC, 2006), Lal (2004) and U.S. Department of Energy (2007)**

*From biomass burning (Chapter 2 of NGGI - IPCC, 2006)