Background Report 5

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Enhancing agricultural mitigation within the CARE International Hillside Conservation Agriculture Project (HICAP) in the United Republic of Tanzania

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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 ABBREVIATIONS AND ACRONYMS

AFSP	Accelerated Food Security Project
CO_2	carbon dioxide
CH_4	methane
CMEAMF	Conservation and Management of the Eastern Arc Mountain Forests
EX-ACT	Ex-Ante Carbon Balance Tool
FAO	Food and Agricultural Organization of the United Nations
FFS	Farmer Field School
GDP	gross domestic product
HICAP	Hillside International Conservation Agriculture Project
IPCC	Intergovernmental Panel on Climate Change
LAC	low-activity clay
MICCA	Mitigation of Climate Change in Agriculture
N_2O	nitrous oxide
NGO	non-governmental organization

1. INTRODUCTION

1.1 Background

Project background

The United Republic of Tanzania's economy relies on the climate, with a large proportion of its gross domestic product (GDP) derived from climate-sensitive activities, including agriculture (GCAP, 2011). About 87 percent of the country's poor live in rural areas. There are great disparities between rich and poor, not only between urban and rural areas, but also across and within regions and districts (C. Besa, 2010). About 80 percent of the country's population is heavily reliant on rain-fed agriculture (including livestock and bee-keeping), which accounts for almost 50 percent of the GDP. Smallholder farmers practice mainly rain-fed agriculture for subsistence purposes and depend on family labour, hand tools and, in some places, animal-drawn implements. The large-scale commercial agriculture sub-sector is very small (1 206 holdings) and produces some crops for export. Current climate variability, including extreme events such as droughts and floods, already results in major economic costs in the country (GCAP, 2011). Regularly occurring extreme events have caused economic losses in excess of 1 percent of annual GDP, reducing long-term growth and affecting millions of people and livelihoods. The United Republic of Tanzania is not adequately adapted to the current climate. The country has a large existing adaptation deficit, which requires urgent action.

The main 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 reduce greenhouse gas emissions.

Operating in the Uluguru mountains of the United Republic of Tanzania, CARE International's Hillside Conservation Agriculture Project (HICAP), was launched in 2009 to enhance the livelihoods of smallholder farmers by promoting the adoption of conservation agriculture and developing institutional support systems for improving food security and conserving natural resources. In 2011, the MICCA Programme joined forces with the HICAP to investigate the mitigation potential of climate-smart agricultural practices by using suitable methodologies to measure greenhouse gas fluxes.

The Ex-Ante Carbon Balance tool

FAO recently developed the Ex-Ante Carbon-balance Tool (EX-ACT), which 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, using the Intergovernmental Panel on Climate Change (IPCC) methodology, which estimates carbon stocks and stock changes per unit of land and through time, expressed in tonnes of carbon dioxide (CO_2) per hectare and per year (Bernoux et al., 2010). The *ex-ante* carbon-balance appraisal can guide the project design and the decision-making process regarding investments. It complements the *ex-ante* economic analysis of development projects. The EX-ACT tool has been used to make estimates at a project level.

1.2 Aim and delimitations

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

The project is limited to farmers that live in the 15 sites (or villages) covered by HICAP. The study analyses the land use changes scenarios linked to activities undertaken by the HICAP team. The main limitation in the analysis is the current lack of available quantitative data. The project area has hardly received any assistance by non-governmental organizations (NGOs). Remoteness, lack of basic infrastructure and electricity, poor roads, and unreliable communications are just some of the key factors that contribute to this lack of data. Up to now, limited research has been undertaken in the project area. The analysis is mainly based upon findings from a 2011 socio-economic survey (Zagst, 2011), qualitative data from workshops, interviews and pictures from the studied sites.

1.3 Expected outcomes

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 uses default emission factors provided mainly 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 on fieldwork, the simplest way to proceed is to use the tier 1 approach. Due to lack of tier 2 data, this 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 of the EX-ACT tool that only incorporates the default land use practices categories provided by the IPCC (Tinlot et al, 2011). In the second phase, different simulations could be done according to different adoption rates of recommended practices and by developing a variety of scenarios based on 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 MICCA Programme components. 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 resulting from 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 the MICCA Programme within HICAP

The MICCA Programme will add value to ongoing community-based efforts to introduce conservation agriculture practices in the area by clarifying the mitigation potential of these practices and the integration of trees on farm and in the landscape. With suitable methodologies the project will measure the increases in carbon accumulation across the landscape that result from climate-smart practices. The findings will provide evidence of the contribution of smallholder farmers can make to mitigating the impacts of climate change.

In October-November 2011, an EX-ACT consultant was sent to Morogoro and the project site in the United Republic of Tanzania to gather quantitative and qualitative data on agriculture (e.g. different land uses, land use changes, agricultural management practices) and to assess using the EX-ACT tool the mitigation potential realized through the additional contribution of the MICCA Programme.

The objective of the consultant's visit was to discuss with the project partners the data availability for applying the EX-ACT tool in HICAP. A workshop was conducted in Morogoro at the CARE International Centre. In addition, two focal group discussions and interviews with farmers were conducted to obtain further data at two of the 15 sites (the villages of Kolero and Kasanga).

The report findings, along with the findings from the socio-economic survey and the recent capacity needs assessment, help to demonstrate the added value of the MICCA Programme and determine which climate-smart practices could be implemented by the MICCA Programme in HICAP. In addition, data on land cover and uses are available through the 2011 socio-economic survey (Zagst, 2011).

2. SETTING THE BASELINE SCENARIO

2.1 Before the data collection

Before any data collection, different scenarios need to be set up (i.e. the scenario of a specific project in comparison with a baseline). In the context of HICAP, three scenarios are illustrated in table 1.

Table 1: Outline of different scenarios

	Baseline scenario	HICAP scenario	HICAP/MICCA scenario	
			Scenario 1	***Scenario 2***
	3 years of implementation phase **17 years of capitalization phase**			
Timeframe	**Non-static situations: evolving over time**			
Data	Data from L.Zagst (2011) findings and past trends	• Data from L.Zagst (2011) findings and past trends • Workshops and field visits • HICAP Baseline survey	• Data from L.Zagst (2011) findings and past trends • Workshops and field visits • Expertise comments from the HICAP team	• Data from L.Zagst (2011) findings and past trends • Workshops and field visits • Expertise comments from the HICAP team
Situation	'Without project' scenario, i.e. without any intervention	'With project scenario', i.e. with HICAP interventions	'With project scenario', i.e. with HICAP/MICCA interventions	'With project scenario', i.e. with HICAP/MICCA interventions
Proposed Changes	• 5% decrease in forest • 14% decrease in woodlands • Increase in paddy, maize areas and degraded lands	10% of maize and rice area transformed into improved agricultural crops	• 20% of rice and 40% of maize area transformed into agricultural crops • Larger focus upon agroforestry compared to the HICAP situation	• 10% of maize and rice area transformed into improved agricultural crops • Larger focus upon agroforestry compared to the HICAP situation

2.2 Baseline and Project Boundaries

As EX-ACT is a land-based accounting tool, it is important to define the total area to be analysed in hectares. Moreover, the total area of interest should be the same in the baseline as for the 'with project' scenario. Land uses and practices may change, but not the amount of land present (Bernoux et al, 2010). In the HICAP-MICCA pilot project, the boundaries are based upon the activities related to the 15 sites of the HICAP area.

The MICCA Programme will measure the greenhouse gas emissions and carbon balance of different land management practices with mitigation potential, including cultivation practices such as the combination of conservation agriculture with agroforestry (Neely, 2011). People in the project area depend heavily on climate-sensitive activities, such as agriculture, as their main income-generating activity and for ensuring food security, especially during the dry season (mainly from June to October).

The study will focus on conservation agriculture as defined by HICAP. According to CARE International and HICAP a 'conservation agriculture adopter' is a farmer who uses the three key conservation agriculture principles: *(i.)* minimum soil disturbance or no tillage; *(ii.)* permanent organic soil cover (such as mulch, crop residue or cover crops); and *(iii.)* diversification of crops grown in rotation. HICAP collects data regularly on adopters through contact farmers who provide information on adopters within their village. This evaluation may be somewhat subjective.

2.3 Limits of the EX-ACT tool

As it has neither an agroforestry nor an inter-cropping module, EX-ACT has certain limitations important to consider for this analysis.

- The aim of the project is to introduce agroforestry as a mitigation activity. For the tool 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. One way for EX-ACT to accommodate this management practice is to assume that part of the maize cropping land will be planted with trees. This assumption is meant to integrate the agroforestry component in the tool; it does not imply that there will no longer be any maize left (i.e. that all of the land under maize will be converted into forest).

- To compensate for the fact that there is no intercropping module in EX-ACT, the annual crop module needs to be used in order to take 'intercropping' into account. If intercropping takes place, such as planting pumpkin with maize, the tool assumes that part of the maize area is converted to pumpkin. However, again, it does not imply that all maize will be converted to pumpkin.

In the future, the addition of agroforestry and intercropping modules in the tool will add value to EX-ACT's performance.

2.4 Project description

The first step for using EX-ACT is to gather information on the project (Bernoux et al., 2010). As mentioned earlier, the project takes place in the southern area of the Uluguru Mountains in the United Republic of Tanzania. Figure 1 represents the map of the area, the type of land and the major interventions made in the area, either by the government or other institutions, including NGOs (S.K. Mvena, T.M. Kilima, 2009).

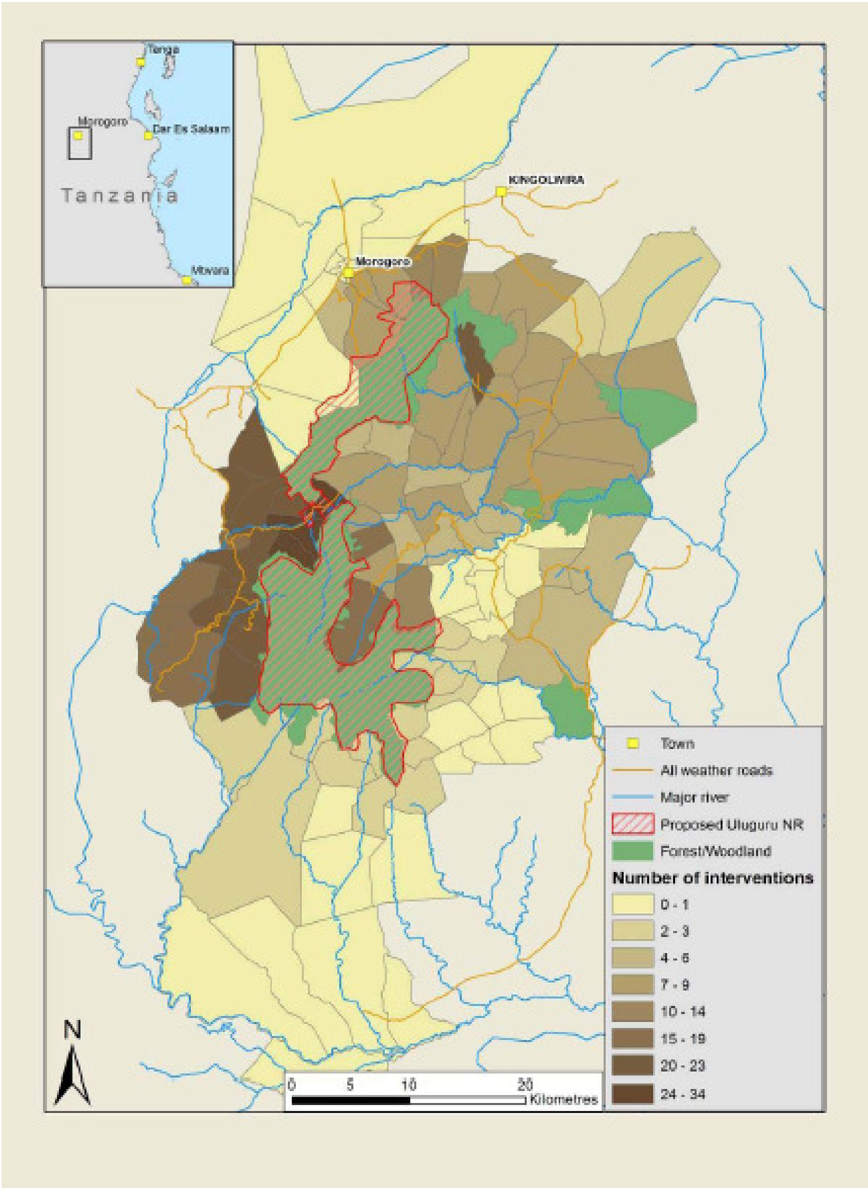

Figure 1: Map of the South of the Uluguru Mountains (S.K. Mvena, T.M. Kilima, 2009)

The project works with 4 948 households in 15 villages covering an area of 16 811.51 hectares with a population of 20 000 men, women, boys and girls *(cf. table 2)*. It is estimated that there are about 1 300 conservation agriculture adopters, although there may be as many 1 906 Farmer Field School (FFS) members who have joined HICAP. According to the last progress report done by CARE (2011), 906 farmers reported to have adopted conservation agriculture[1], during the first three years of the project:

- in the first year (2009): 162 farmers
- in the second year (2010): 243 farmers
- in the third year (2011): 501 farmers

[1] Conservation agriculture adoption comprises a wide range of adoption and it depends on the farmer interpretation. Some farmers don't entirely adopt the three elements of conservation agriculture.

Table 2: Land area per ward and village

VILLAGES	
KOLERO	
Kolero	622.1
Lubasazi	3100.4
Lukange	2419.12
Malani	649.97
Mlagano	1865.08
Temekelo	1045.8
TOTAL KOLERO	**9702.47**
KASANGA	
Kasanga	805.23
Kitonga	884.55
Kizagila	439.05
Longwe	477.42
Ukwama	627.26
TOTAL KASANGA	**3233.51**
BUNGU	
Bungu	1737.87
Balani	1284.35
Koloni-Mihange	853.31
TOTAL BUNGU	**3875.53**
TOTAL	**16,811.51**

Source: Received by Coll Besa, Mgeta, 23.10.11

In addition, due to the hilly nature of the terrain, the environment in which the project operates is challenging for sustainable development interventions *(cf. figure 2)*. Figure 2 illustrates the rough terrain and altitudes of the villages.

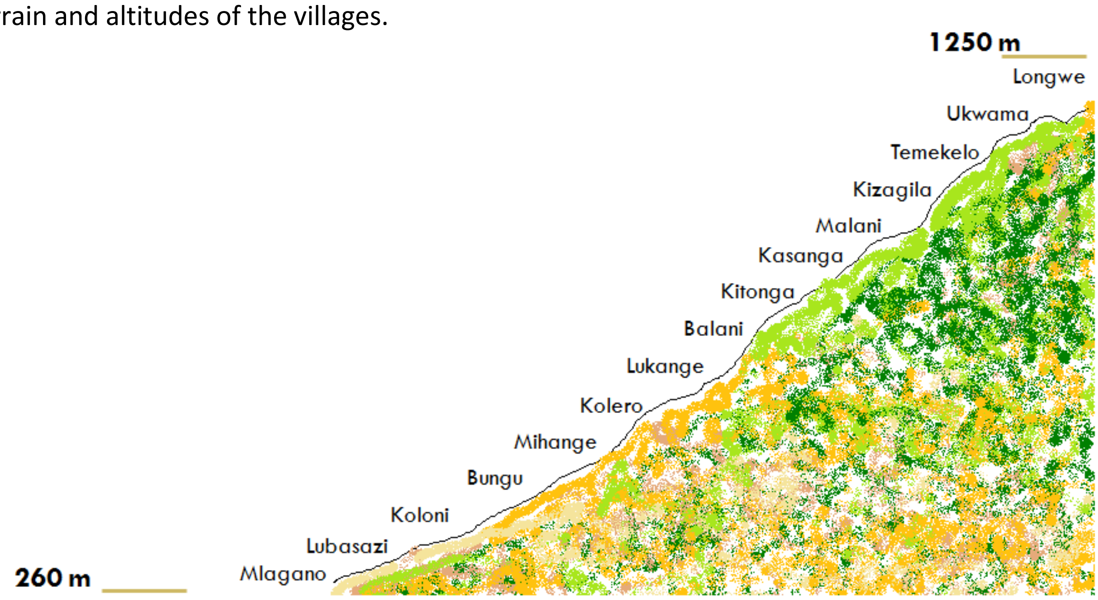

Figure 2: The 15 villages analysed within the HICAP-MICCA project (received by Coll Besa, Mgeta, 23.10.11)

According to IPCC climate and soil maps, the climate in the area is tropical montane and the soil is classified as low-activity clays *(EX-ACT results, cf. footnote 5)*. With regards to the time frame, it was agreed that the implementation phase is three years and capitalization phase seventeen.

Past trends

The scenario for past trends is based upon a study performed by the Ministry of Natural Resources and Tourism, Forest and Beekeeping Division. The study looked at the Forest Area Baseline for the Eastern Arc Mountains (2006). The purpose of the Conservation and Management of the Eastern Arc Mountain Forests (CMEAMF) project was to establish detailed baselines for the current area of forest and deforestation trends in the Eastern Arc Mountains of the United Republic of Tanzania from the 1970s to the 2000s. (CMEAMF, 2006).

Since HICAP is active the southern Uluguru Mountains, the EXACT analysis focused on the study's results from that region. The Ministry study provides a detailed analysis of the land cover maps, indicating forest and woodlands. Forest cover has been more stable than woodlands, mainly due to the implementation of forestry reserves in the 1970s. Increased degradation of woodlands was observed in the 1970s to the 1980s as compared to the periods of 1980s-1990s and 1990s-2000s. In 1998, the remaining blocks of forest habitat covered 527 km^2 in the Uluguru Mountains. It was reported that the Uluguru Mountains suffered, from 1955 to 2001, from a forest loss of 40 percent, going from 300 km^2 to 230 km^2. The main reasons for forestry loss includes clearance for new farmland; pitsawing; harvesting for building materials (timber and poles); medicine; and fuel wood. Slash-and-burn farming practices were also a factor. In 2006, the total area of forest and woodland was observed using satellite images (table 3). For the detection analysis of forest area and woodland changes, see appendix 4.

Table 3: Size of the Uluguru Mountains, coverage of forest and woodland, 2006

Mountain block	Size (Ha)	Forest area (Ha)	Woodland (Ha)
Uluguru	**147 750**	**27 810**	**3000**

Source: CMEAMF, 2006

Between 1975 and 1991, an increase in the rate of forest decline was observed in the Uluguru Mountains. This increase is explained by the expanding population in the area. However, from 1991 to 2000, there was less observable forest and woodland destruction. Table 4 illustrates the change in forest and woodland cover from the 1970s to the 2000s.

Table 4: Forest (F) and Woodland (W) covers change between 1970s and 2000s in the Uluguru Mountains

Area	Year	Total coverage (Ha)		% change		Rate of change	
		F	W	F	W	F	W
Uluguru	**1975**	30,970	83,630	-	-	-	-
	1991	27,920	34,520	-9.1	-33.7	**-0.6**	**-2.1**
	2000	27,050	34,260	-3.0	-8.0	**-0.3**	**-0.9**
	1975- 2000	-	-	-11.8	-39.0	**-0.5**	**-1.6**

Source: CMEAMF, 2006

As observed, the woodlands are more degraded as compared to forest lands (CMEAMF, 2006). The reason for this is that the woodlands are open access areas, where there is no secure tenure or formal user rights. Also, there are no incentives for systematic and sustainable forest management. Furthermore, numerous villages were formed in the 1970s in the Uluguru Mountain, and extensive clearing of woodland was carried out to make way for increased infrastructure and new agricultural lands. Illegal harvesting is being done in the forestry reserves, which cannot be detected by remote sensing.

Moreover, according to the participants from the workshop held in Morogoro in October 2011, the state of the land before the start of HICAP was severely degraded. Farmers had to deal with soil erosion, sedimentation and poor soil fertility. In addition, the farmers were mainly practicing monocropping, slash and burn, tillage and subsoiling to break the hard pan.

Present trends

Most of the qualitative and quantitative data is based upon estimates from the MICCA Programme's socio-economic survey conducted by L. Zagst (October 2011). A total of 333 farmers were interviewed from five out of the 15 villages included in the project. The five villages covered three different geographical zones: low, middle and high lands. The data is also based on the results of a workshop conducted in Morogoro at the CARE Centre *(cf. appendix 2)*.

The workshop was held with experts from the Ministry of Agriculture and Livestock, Extension Officers and CARE-HICAP partners *(cf. appendix 2)*. During the workshop, qualitative information regarding land use changes and agricultural practices was exchanged. This information was agreed on through general consensus among the participants familiar with the project area. According to the participants, over the last ten years, forest and woodlands have been cleared for agricultural crops. These observations are in line with the results presented in the CMEAMF report. In addition, as a result of CARE interventions, there has been an introduction of new improved varieties of maize, sesame, lablab and pigeon pea over the last three years. Cassava is common in the area because it is recognized as drought-resistant crop (FAO, IFAD, 2005).

Slash and burn is being carried out in the area, but is decreasing as a result of extension service and HICAP interventions. The socio-economic survey done by Zagst (2011), revealed that out of 333 interviewed farmers, 54.4 percent still practice slash and burn; 4.8 percent are planting and harvesting trees; and 17.2 percent have adopted, to a certain extent conservation agriculture. Out of 333 farmers, 77.8 percent have no knowledge about conservation agriculture or its practices.

The main conservation agriculture techniques adopted are: (1) planting in rows, (2) avoiding slash and burn; and (3) practicing no or minimum tillage. The rate of adoption is still relatively low. In the sample from the MICCA Programme baseline survey, 22.4 percent of the 333 interviewed farmers had adopted conservation agriculture. Table 6 shows that producers are only partially engaging in conservation agriculture, *(cf. appendix 3: Four examples of farmers in the area, confirming that some conservation agriculture adopters might not fully adopt conservation agriculture).*

Summing up from narratives *(cf. appendix 5)* and Zagst (2011) findings, it can be observed that (1) there are few adopters, (2) farmers who adopt conservation agriculture do it partially based on field observations and (3) certain conservation agriculture plots were incorrectly cultivated (One farmer had planted in rows but without using the proper inter-cropping technique. See figure 4).

According to the focus group discussions held in Kolero, the benefits from conservation agriculture are increased yields. Some farmers obtained 50 percent more maize compared with traditional production (Over three years, maize yields has gone from 4 695 kg/ha to 8 662 kg/ha as a result of using CA). However, the adoption rate is still low *(cf. table 4)*. According to the participants of the workshop, the reason farmers only adopted some of the conservation agriculture principles and practices are the additional labour requirements required, especially for double digging. Also, some farmers sometimes consider new activities, such as conservation agriculture, as risky, if they have not seen any results of the new planting techniques.

Roughly 80 percent of the households rent land from clans that own land. The other 20 percent farm on inherited land, which clans use for themselves for agricultural production. There is some concern that if owners see that the farmers renting their land are suddenly able to increase their productivity and get higher yields, they may take the land away from the farmers and use it for themselves. Issues regarding land ownership and insecure land tenure need to be addressed.

Figure 3: Mixed cropping system of pineapple and groundnuts on slopes

The main motives for promoting conservation agriculture in the region are to improve soil and water conservation (e.g. mixed cropping systems of pineapple and groundnuts, lablab, cow peas, and pigeon peas), mainly in the steep slopes *(cf. figure 3)* and make a contribution to carbon sequestration. According to HICAP partners, M. Coll Besa and E. Mgeta, with the HICAP and the MICCA Programme initiatives, it is also intended to increase the number of agronomic practices available to farmers to improve land management and long-term sustainability in the area through improved seeds and varieties, minimum tillage, permanent soil cover, organic inputs, crop rotations and better water management *(cf. figure 4)*.

Future trends

HICAP is intended to increase and spread conservation agriculture in the area as a way of increasing farm productivity without expanding cultivated lands. Another goal is to increase agroforestry practices on forested lands, and establish forest patches or trees in the fields. There are also plans to support tree planting along the water sources and riparian ecosystems to reduce the amount of siltation and soil erosion and enhance the water retention capacity of the soil.

Figure 4: Mixed cropping system of maize and pumpkin

According to workshop participants, it was assumed that, without any project intervention, more forest will be cleared for future cultivation due to low farm productivity. Also, productivity will not increase significantly, which will in turn cause soil depletion, water shortages, continued slash and burn practices *(cf. figure 5),* and ultimately lead to increased food insecurity and poverty.

Figure 5: Slash and burn in the Kolero ward

The Baseline: Land use and land use changes based on past, present and future trends

According to the study made by Zagst (2011), the dominant crop in the area is maize, followed by cassava and paddy rice *(cf. table 6)*. Based upon the total amount of land, 16 811.51 hectares *(cf. table 2),* it is possible to determine the different land use per crop. The HICAP team has introduced improved seed varieties of maize (TAN 250, TAN 254, STAHA, STUKA M1), lablab, green beans, sesame (lindi white 02), sunflower, pigeon peas (mali variety) and pineapples. *(cf. table 6)*. The only crop that was not present in the project area was lablab, which has been introduced by CARE project team. Hence, the land use for the baseline was set based upon Zagst's findings (2011), results of the workshop held in Morogoro; (3) field visits; and past, present and future trends. The estimations made by Zagst (2011) will be used as the starting point for the analysis.

The forest in the area, as observed from past trends, should be included in the total amount of hectares analysed. In 2006, out of 147 750 hectares of land in the Uluguru Mountains, there are 27 810 hectares of forest and 3 000 hectares of woodland (19 percent and 2 percent respectively). A similar amount was estimated in the analysed area (19 percent is forest and 2 percent is woodland). Thus, in the project area (16,811.51 hectares) 3 194.2 hectares is forest and 336.2 hectares is woodland. That also implies that the total land use for the other crops is 13 281 hectares.

In addition, from 1970 to 2006, the total amount of loss is 12 percent of forest and 39 percent of woodland, for an annual rate of loss of 0.4 percent and 1.5 percent respectively. In the baseline, it was assumed that deforestation and woodland degradation would continue over time. Therefore, over a period of 20 years, 12.7 hectares of forest and 6.6 hectares of woodland would be lost annually and replaced with agricultural crops. As maize occupies a larger proportion of the cultivation as compared to rice paddy, it was assumed that 30 percent of the woodland area could become rice paddy cultivations and 60 percent maize. The expansion of those crops was also mentioned during the Morogoro workshop. Furthermore the remaining 10 percent will become degraded land since it is expected that the land would be either be abandoned or eventually transformed into agricultural lands *(cf. figure 6)*.

Based on an analysis of past trends, part of the forest will be deforested, with wood being used as firewood. Part of the forest area will become set aside lands (i.e. 256 hectares). That is, a decrease of 255.52 hectares and 123.36 hectares correspondingly. Figure 8 illustrates the land use and land use changes for the baseline scenario.

Table 5: Percentage of crops in the HICAP based on Zagst (2011) survey

Crop	%	(Ha)
Maize	28%	3697
Cassava	21%	2846
Paddy	15%	2016
Sesame	12%	1543
Sorghum	10%	1377
Pigeon peas	4%	528
Beans	4%	469
Banana	2%	332
Groundnuts	1%	183
Cow peas	1%	108
Pumpkin	0,31%	41
Pineapple	0,22%	29
Vegetables	0,22%	29
Sweet potato	0,2%	21
Jack fruits	0,12%	17
Lablab	0,12%	17
Tomatoes	0,09%	12
Sugar Cane	0,06%	8
Coconut	0,03%	4
Orange trees	0,03%	4
TOTAL agricultural crops	**100%**	**13282**
Forest		3194
Woodland		336
TOTAL		**16812**

Source: Zagst, 2011

Figure 6: Land use and land use changes for the baseline

INITIAL LAND USE

Maize	3 697
Cassava	2 846
Paddy	2 016
Sesame	1 543
Sorghum	1 377
Pigeon peas	528
Beans	469
Banana	332
Groundnuts	183
Cow peas	108
Pumpkin	41
Pineapples	29
Vegetables	29
Sweet potatoes	21
Jack fruits	17
Lablab	17
Tomato	12
Sugar cane	8
Coconut	4
Orange trees	4
Forest	3 194
Woodland	336
TOTAL	**16 811**

→

LAND USE CHANGE

39.7Ha Woodland → **Paddy**

79.4Ha Woodland → **Maize**

→

FINAL LAND USE

Maize	**3 776**
Cassava	2 846
Paddy	**2 056**
Sesame	1 543
Sorghum	1 377
Pigeon peas	528
Beans	469
Banana	332
Groundnuts	183
Cow peas	108
Pumpkin	41
Pineapples	29
Vegetables	29
Sweet potatoes	21
Jack fruits	17
Lablab	17
Tomato	12
Sugar cane	8
Coconut	4
Orange trees	4
Set aside	**269**
Forest	**2 939**
Woodland	**204**
TOTAL	**16 811**

No improved agronomic practices have been adopted and slash and burn is continuing in the area. No data was available regarding inputs. However, as farmers in general tend not to apply inputs, the amount of inputs is considered negligible (C. Besa, M., 21.01.21).

3. LAND USE AND LAND USE CHANGES IN HICAP AND HICAP-MICCA SCENARIOS

This chapter outlines the two scenarios from table 1. The results from the 'without' and 'with HICAP project intervention' are shown, followed by the results from two different scenarios, (scenario 1 and 2, the 'with' and 'without' HICAP-MICCA). The different results are then compared.

3.1 'With HICAP' scenario

Land uses and land use changes in the HICAP scenario

The land use changes in the HICAP area are based upon information from the baseline scenario and the number of active farmers and FFS members participating in the project. Due to the lack of data on the precise rate of adoption regarding the currently active 1 906 farmers, an assumption can be made in which 10 percent of the land use of maize and rice paddy will be replaced by crops promoted by the project. This should be realistic figure, as previous data indicates that the producers adopt conservation agriculture on one-third of their land. On average, a farmer owns or rents 1.25 hectares and hence 794 hectares (1.25 x 1/3 x 1 906) would be the total land that could potentially be under conservation agriculture. The HICAP team has records showing that about 1 300 farmers currently adopt conservation agriculture to some degree. However, to be realistic, more than 70 percent of the farmers will indeed to implement conservation agriculture. If it is assumed that more than 70 percent of the farmers adopt conservation agriculture practices, it is plausible that the area cultivated will be slightly more than 556 hectares (0.7 x 794). Replacing 10 percent of maize and rice with other crops {[(3697 x 0.1) + (2016 x 0.1)] = 571 hectares} gives an adoption rate of approximately 72 percent. Such assumptions are also backed by Zagst (2011) findings, which indicate that the adoption rate for some conservation agriculture practices, such as mulching and crop rotation, is low. Table 6 illustrates the land use estimates per crop in the project area, based upon Zagst's (2011) findings and past trends regarding forests and woodlands.

Table 6 indicates that a number of crops have increased as compared to the baseline, which may be attributable to the result of HICAP interventions. It shows that farmers growing rice and maize, which used to be cultivated in monocropping systems, are switching to intercropping systems, such as maize mixed with lablab. The crops that will be taken into account in the EX-ACT analysis are the main crops demonstrated in table 6. Since there has been a focus on cowpeas, pumpkin, pineapple, lablab, beans and pigeon pea, these will also be included in the EX-ACT analysis. The other crops, (groundnuts, vegetable, sweet potato, tomato, sugar cane, banana, jack fruit, coconut and orange trees) will be classified as 'other' under annuals or perennials. Table 6 only shows the land uses estimated by Zagst (2011). To do a more realistic scenario, it was assumed that the above-mentioned crops will expand somewhat, replacing maize and rice.

Table 6: Land use and land use changes, baseline and the HICAP scenario

Type of crops	t0 (ha)	Baseline (ha)	Land Use changes (Ha)	HICAP (ha)
Maize	3697	3776	-369,65	**3327**
Cassava	2846	2846		2846
Paddy	2016	2056	-201,63	**1815**
Sesame	1543	1543		1543
Sorghum	1377	1377		1377
Pigeon peas	528	528	100,81	**629**
Beans	469	469	92,41	**561**
Banana	332	332		332
Groundnuts	183	183		183
Cow peas	108	108	92,41	**200**
Pumpkin	41	41	92,41	**134**
Pineapples	29	29	100,81	**130**
Vegetables	29	29		29
Sweet potatoes	21	21		21
Jack fruits	17	17		17
Lablab	17	17	92,41	**109**
Tomatoes	12	12		12
Sugar Cane	8	8		8
Coconut	4	4		4
Oranges	4	4		4
TOTAL agricultural crops	**13282**	**13401**		**13282**
Forest	3194	2939		3194
Woodland	336	204		336
Set aside	-	269		-
TOTAL	**16812**	**16812**		**16812**

EX-ACT gross results

Based upon the information on land uses and land use changes, the results from the EX-ACT tool show that under the baseline scenario land uses are a net source of emissions, whereas with the HICAP interventions, the land uses become net sink *(cf. table 7)*. HICAP interventions result in a net sink of -1.7 tonnes of CO_2 (equivalent) per hectare over 20 years, with an annual average of 0.1 tonnes of CO_2 (equivalent) sequestered. The total carbon sequestered by the HICAP project is -28,709 tonnes of CO_2 (equivalent). Without HICAP, 15 tonnes of CO_2 (equivalent) per hectare is emitted. In total 252 846 tonnes of CO_2 (equivalent) would be emitted without the project.

In the HICAP scenario, the land use changes and agroforestry activities sequester carbon and are net sinks. On the other hand, the cultivation of annual crops remains a net source of emissions. However, with HICAP the source is smaller than for the baseline. For this reason, the cultivation of annuals under the HICAP project results in a net sink of -52 112 tonnes of carbon dioxide (equivalent) *(cf. table 12).* This sink does not result from carbon sequestration, but from a reduction in the greenhouse gas emissions that would be otherwise emitted without the project (57 935 – 110 047 = -48 712). This finding is also relevant when considering other climate-smart agriculture interventions.

Table 7: Gross results with and without HICAP.

Components of the Project	Gross fluxes Baseline (t CO2-eq)		Gross fluxes HICAP scenario (t CO2-eq)	
Deforestation	176,022	Source	0	
Non-forest land use changes	1175	Source	-14,967	Sink
AGRICULTURE				
Annual Crops	110,047	Source	57,935	Source
Agroforestry/Perennial Crops	-34,398	Sink	-71,677	Sink
Final Balance	**252,846**	**Source**	**-28,709**	**Sink**
Result per ha	*15*	*Source*	*-1.7*	*Sink*
Result per ha/year	*0.8*	*Source*	*-0.09*	*Sink*

The results indicate the activities that are sources of greenhouse gas and those that are net carbon sinks *(cf. table 7)*. In the baseline, deforestation and the land use changes from woodland to degraded land are net sources of emissions. Also, slash and burn contributes largely to the net carbon dioxide emissions (equivalents) in both scenarios due to the release of nitrous oxide (N_2O) and methane (CH_4). The net sink from the annuals module in the HICAP scenario results from improved agronomic practices, such as no nor minimum tillage, no slash and burn, improved varieties and extended crop rotations, that have been introduced through conservation agriculture. The perennials module also illustrates a net sink. The net sink generated from both annual crops and perennials is due to the expansion of agroforestry, and illustrates the importance of agroforesty for climate change mitigation.

3.2 'With the HICAP-MICCA Project' Scenarios

The MICCA Programme is adding a climate-smart perspective to HICAP interventions. The HICAP-MICCA pilot project looks at the quantity of emissions resulting from local agricultural practices and the low-carbon options that exist for agroforestry and strengthened conservation agriculture practices. With regards to land use, the MICCA Programme component will promote agroforestry sytems, in which trees sequester carbon and provide additional nutrients for food crop production. In this way, the agroforestry acts as a net carbon sink and contributes to climate change mitigation.

The scenarios of the land use change with the additional contribution of the HICAP-MICCA pilot project are based on information from the baseline scenario and the number of active farmers and FFS members in the project. In the 'with project' scenarios, there is a larger focus on conservation agriculture and assumptions on transformation of maize and rice towards other crops, especially combining annuals and perennials, extending crop rotations, using permanent soil cover and mulching. It is important to notice that maize is being intercropped with leguminous crops such as lablab, pigeon pea and cowpea. There is a clear focus on moving from maize and rice monocropping to intercropping.

In both scenarios, there is a larger focus on non-staple crop, such as sesame, pigeon peas, beans, groundnuts, cow-peas, pumpkin, pineapple, sweet potato, jack fruit and lablab. In addition, the cultivation of maize, rice and sorghum will be improved through conservation agriculture practices without using slash and burn. It was assumed that the cultivation of non-staple crops would expand, partly replacing maize and paddy rice.

Since rice is mainly planted in slopes, to prevent erosion, most of the suggested land use changes are for crops suitable for cultivation on hillsides. However, it is possible to grow the suggested crops using conservation agriculture practices on both slopes and flat lands. Also, as the pilot project focuses on agroforestry, part of the maize plantations will be interplanted with trees. It is, however, important to mention that the objectives of the suggested land use change may change. It is difficult to anticipate such changes as each farmer uses different cultivation systems.

Scenario 1: Land uses and land use changes in the HICAP-MICCA Project

It was agreed in the workshop, for scenario 1, that 40 percent of maize and 20 percent of rice would be replaced by different crops suitable for conservation agriculture *(cf. appendix 5, table 13)*. Table 8 illustrates the land use estimates per crop in the project area. Figures are based upon Zagst (2011) findings and the past trends in regards to forest and woodland. Table 8 illustrates the land uses and land use changes.

EX-ACT gross results

The gross results provided by EX-ACT illustrate that the climate-smart agricultural practices promoted though the HICAP-MICCA pilot project could lead to a net sink of 34 tonnes of CO_2 equivalent) per hectare over 20 years, *(cf. table 9)*. In the HICAP scenario 1, 1.7 tonnes of CO_2 (equivalent) is sequestered per hectare per year. The total carbon sequestered by the HICAP project is -574 550 tonnes of CO_2 (equivalent). Without the HICAP-MICCA project, in total 252 846 tonnes of CO_2 (equivalent) and 15 tonnes of CO_2 (equivalent) per hectare would be emitted.

Table 8: Land use and land use changes, baseline and scenario 1 of HICAP-MICCA

Type of crops	t0 (ha)	Baseline (ha)	Land use changes (Ha)	HICAP-MICCA scenario (ha)
Maize	3697	3776	-1479	2218
Cassava	2846	2846		2846
Paddy	2016	2056	-403	1613
Sesame	1543	1543	148	1691
Sorghum	1377	1377		1377
Pigeon peas	528	528	40	569
Beans	469	469	74	543
Banana	332	332		332
Groundnuts	183	183	81	263
Cow peas	108	108	74	182
Pumpkin	41	42	296	337
Pineapples	29	29	161	190
Vegetables	29	29		29
Sweet potatoes	21	21	20	41
Jack fruits	17	17	20	37
Lablab	17	17	296	312
Tomatoes	12	12		12
Sugar Cane	8	8		8
Coconut	4	4	40	44
Oranges	4	4	40	44
TOTAL agricultural crops	**13282**	**13401**		**12690**
Forest	3194	2939	591	3785
Woodland	336	204		336
Set aside	-	269		-
TOTAL	**16812**	**16812**		**16812**

Table 9: Gross results with and without HICAP/MICCA scenario 1

Components of the Project	Gross fluxes Baseline (t CO2-eq)		Gross fluxes HICAP-MICCA (t CO2-eq)	
Deforestation	176,022	Source	0	
Afforestation and Reforestation	0		-272,169	Sink
Non-forest land use changes	1175	Source	-33,490	Sink
Agriculture				
Annual Crops	110,047	Source	-151,077	Sink
Agroforestry/Perennial Crops	-34,398	Sink	-117,815	Sink
Final Balance	**252,846**	**Source**	**-574,550**	**Sink**
Result per ha	15	Source	-34	Sink
Result per ha/year	0.8	Source	-1.7	Sink

In the baseline, as for the HICAP scenario, deforestation and the land use changes from woodland to degraded land are the major net sources of emissions. Also, slash-and-burn practices contribute significantly to the net CO_2 (equivalent) emissions, which are mainly indicated in the annuals module. The main explanation of the net sink deriving from the annuals module in the HICAP-MICCA scenario is a result of improved agronomic practices through the adoption of conservation agriculture practices, such as no or minimum tillage, no slash and burn, improved varieties and extended crop rotations.

Another assumption built into the scenario is the adoption rate of improved agronomic practices in the annuals module. Since the implementation phase covers three years, it is expected that farmers would continue to constantly adopt the new varieties that HICAP and MICCA are promoting. Hence, the cultivation of some crops, such as lablab, cow peas, pumpkin and beans, is expected to increase amongst the members of the FFS, resulting in a rate of adoption that is linear over time. This assumption has an effect on the gross results. In addition, the perennials module indicates a net sink. The net sink generated from annual crops and perennials is the result of the increase in agroforestry, which again illustrates the importance of this activity for climate change mitigation.

Scenario 2: Land use and land use changes in the HICAP-MICCA pilot project

It was agreed that for scenario 2, 10 percent of maize and 10 percent rice would be replaced with different crops suitable for conservation agriculture practices. This was based on assumptions and general consensus with project partners and staff. *(cf. appendix 5, table 14)*. Table 10 indicates the land use estimates per crop in the project area. As with scenario 1, the figures are based on Zagst (2011) findings and past trends in regards to forest and woodland.

EX-ACT gross results

The gross results provided by EX-ACT illustrate that the climate-smart agricultural practices resulting from the HICAP-MICCA pilot project result in a net sink of 19 tonnes of CO_2 (equivalent) per hectare over 20 years, *(cf. table 11)*. In the HICAP-MICCA scenario 2, 0.9 tonnes of CO_2 (equivalent) is sequestered per hectare per year. The total carbon sequestered by the HICAP-MICCA pilot project activities is 313 767 tonnes of CO_2 (equivalent). Without the HICAP-MICCA pilot project, a total of 252 846 tonnes of CO_2 (equivalent) are emitted, about 15 tonnes of CO_2 (equivalent) is emitted per hectare.

Table 10: Land use and land use changes, baseline and scenario 2 of HICAP-MICCA

Type of crops	t0 (ha)	Baseline	Land use changes (Ha)	HICAP-MICCA
Maize	3697	3776	-370	3327
Cassava	2846	2846		2846
Paddy	2016	2056	-202	1815
Sesame	1543	1543	37	1580
Sorghum	1377	1377		1377
Pigeon peas	528	528	20	548
Beans	469	469	18	487
Banana	332	332		332
Groundnuts	183	183	40	223
Cow peas	108	108	18	126
Pumpkin	41	41	74	115
Pineapples	29	29	81	110
Vegetables	29	29		29
Sweet potatoes	21	21	10	31
Jack fruits	17	17	10	27
Lablab	17	17	74	91
Tomatoes	12	12		12
Sugar Cane	8	8		8
Coconut	4	4	20	24
Oranges	4	4	20	24
TOTAL agricultural crops	**13282**	**13401**		**13134**
Forest	3194	2938	148	3342
Woodland	336	204		336
Set aside	-	269		-
TOTAL	**16812**	**16812**		**16812**

Table 11: Gross results with and without HICAP-MICCA scenario 2

Components of the Project	Gross fluxes Baseline (t CO2-eq)		Gross fluxes HICAP-MICCA (t CO2-eq)	
Deforestation	176,022	Source	0	
Afforestation and Reforestation	0		-68,157	Sink
Non-forest land use changes	1175	Source	-13,929	Sink
Agriculture				
Annual Crops	110,047	Source	-162,587	Sink
Agroforestry/Perennial Crops	-34,398	Sink	-69,093	Sink
Final Balance	**252,846**	**Source**	**-313,767**	**Sink**
Result per ha	15	Source	*-19*	Sink
Result per ha/year	0.8	Source	*-0.9*	Sink

4. DISCUSSION

4.1 Comparison of the EX-ACT Gross Results

Figure 9 compares the three ‘with project’ scenarios and demonstrates the additional contribution of the MICCA Programme, in comparison to the HICAP scenario. The major contributor to climate change mitigation in scenario 1 is reforestation. In scenario 2, changes in the cultivation of annual crops, resulting from improved agricultural practices has the greatest impact on climate change mitigation.

The main difference between the scenarios is reforestation; no or limited slash and burn; and diversified crop production through the introduction of conservation agriculture. It is interesting to note the difference between the amounts of carbon sequestered per hectare as well as for hectare per year. In the HICAP scenario, the project is capable of sequestering 1.7 tonnes of CO_2 (equivalent) per hectare over 20 years, whereas in the HICAP-MICCA scenarios 1 and 2, the project has the potential to store 34 and 19 tonnes of CO_2 (equivalent) per hectare respectively, as a result of increased forest plantation and better farm management practices. This implies that the HICAP-MICCA pilot project, in both case scenarios, can create carbon sink for all activities.

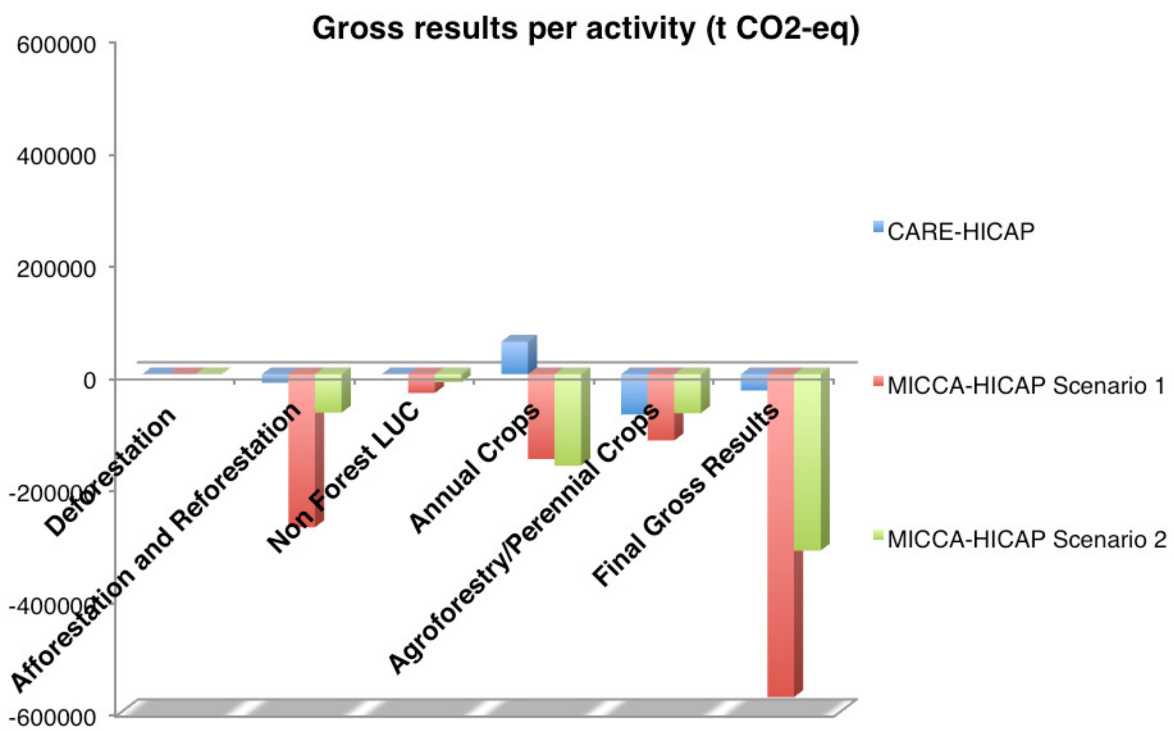

Figure 7: EX-ACT Gross Results

The gross results indicate the projected emissions and the carbon sequestered per activity and for the final scenario. The activity that generates CO_2emissions (equivalents) is the cultivation of annual crops in the HICAP scenario. Emissions are due to the slash-and-burn practices. Scenario 1 has the largest mitigation potential. However, situation 2 might be more realistic and a better option regarding food security, since less staple crops (maize and rice) are converted into other crops for intercropping or agroforestry.

4.2 The final Carbon Balance for the three project scenarios

With the HICAP project the total carbon balance results in a net sink of -281 554 tonnes of CO_2 (equivalent) *(cf. table 12)*. What the carbon balance highlights, is the potential impact in terms of mitigation with the additional changes as a result of HICAP (i.e. land use changes, a larger focus on increased conservation agriculture and decreased slash and burn). Therefore, it is correct to conclude that with the HICAP project, -281 554 tonnes of CO_2 (equivalent) are either reduced or sequestered as compared to the baseline *(cf. table 7)*. The total mitigation potential, with the additional contribution of the MICCA Programme, represents in scenario 1 and 2, -827 395 and -566 612 respectively. The net sink is due to the increased agroforestry, a move from monocropping to diversified cropping (e.g. maize to lablab and rice to groundnuts) and improved agronomic practices

Table 12: The Carbon Balance results of the different scenarios

CARBON BALANCE			
	HICAP	**HICAP-MICCA Scenario 1**	**HICAP-MICCA Scenario 2**
Deforestation	-176,022	-176,022	-176,022
Afforestation and Reforestation	0	-272,169	-68,157
Non Forest land use change	-16,141	-34,665	-15,104
Annual Crops[2]	-52,112	-261,123	-272,633
Agroforestry/Perennial Crops	-37,279	-83,417	-34,695
Final Balance	**-281,554**	**-827,395**	**-566,612**
Added mitigation pot. Compared to HICAP (%)	**-**	**66%**	**50%**
Final Balance per gas			
• **Biomass**	-188,184	**-452,063**	-241,794
• **Soil**	-63,873	**-253,160**	-202,646
• **CH_4**	-8316	-33,967	**-33,967**
• **N_2O**	-21,182	-88,206	**-88,206**
Result per ha	-17	-49	-34
Result per ha/year	-0.8	-2.5	-1.7
Level of uncertainty		**38%**	

[2] Considered annual crops are: maize, rice, cassava, sorghum, groundnuts, pumpkin, vegetables, tomato, beans, sweet potato and lablab.

Table 12 illustrates the additional contribution of the mitigation potential of the HICAP/MICCA pilot project, both for scenario 1 and 2, where the suggested activities, such as increased agroforestry, results in an increased mitigation potential. Scenario 1 indicates an added mitigation potential of 60 percent, while scenario 2 has an added mitigation potential of 50 percent compared to the HICAP scenario. Also, since the area is fairly small (16 812 hectares), the mitigation potential per hectare is quite large in both HICAP/MICCA scenarios: -2.5 and -1.7 tonnes of CO_2 (equivalent) per hectare respectively.

Table 12 indicates the carbon balance per greenhouse gas. The carbon sequestered in biomass and soil highlights the additional contribution of the agroforestry component. Interestingly, scenario 2 has a larger reduction potential of CH_4 and N_2O emissions. This is due to the fact that there is a larger quantity of annual crops remaining; 10 percent of rice and maize is converted compared to the scenario 1, where 20 percent and 40 percent is converted respectively. On the other hand, since there is a larger focus on agroforestry in scenario 1, there is a larger amount of carbon sequestered in the soil and biomass.

Moreover, it is possible to observe that the level of uncertainty for the different scenarios is of 38 percent *(cf. table 12)*. The level of uncertainty is based upon the approach used, in this case the tier 1 approach. If the tier 2 approach were to be used, the level of uncertainty would most likely decrease as it is more region-specific. The level of uncertainty is also linked to the assumptions done in the analysis.

Figure 8 shows the carbon balance for the three situations per activity. The annual crops intervention has a larger mitigation potential in scenario 2. This is because fewer hectares of annual crops are converted to agroforestry or intercropping in scenario 2.

The final carbon balance is however larger in scenario 1, due to a larger amount of intercropping with a focus on afforestation and agroforestry. In terms of food security, this scenario may be questionable. However, 40 percent of maize and 20 percent of rice will not entirely be replaced by forest, there will be intercropping and agricultural food crops (e.g. maize will be mixed with lablab and rice with pigeon peas). The 10 percent conversion scenario, as assumed in the scenario 2, seems nonetheless more realistic in the HICAP/MICCA context for food security reasons and given what is realistically achievable during three years of implementation.

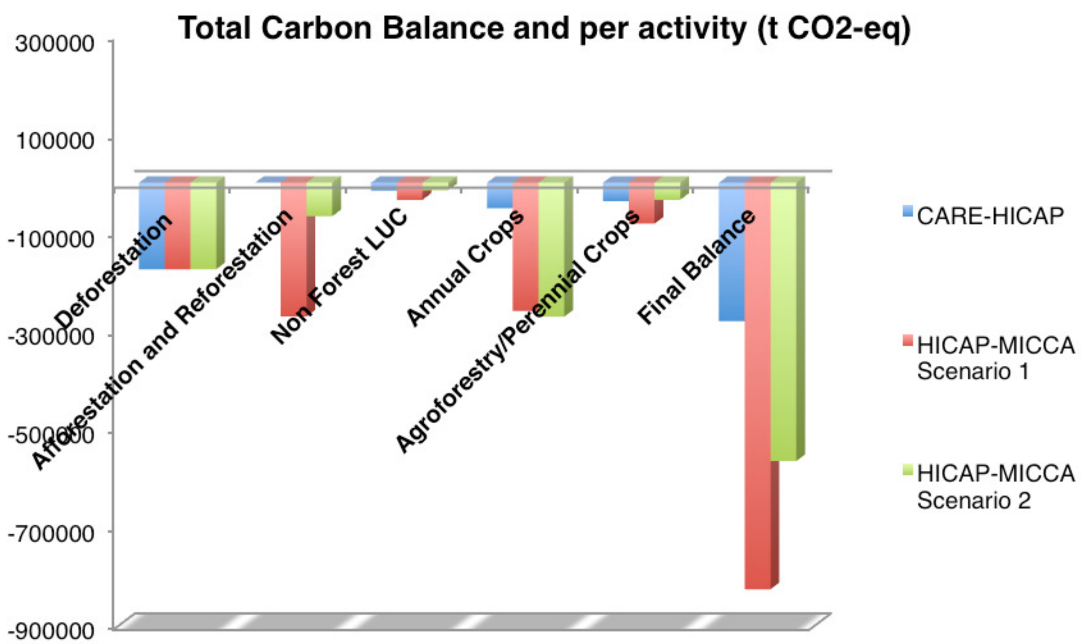

Figure 8: Carbon Balance per activity of the three simulated situations

In addition, figure 9 illustrates the total carbon balance between the three simulated scenarios. Scenario 1 clearly has the largest mitigation potential. However, it might not be the most realistic in terms of alleviating food insecurity, which is the overarching objective of the MICCA Programme along with climate change adaptation.

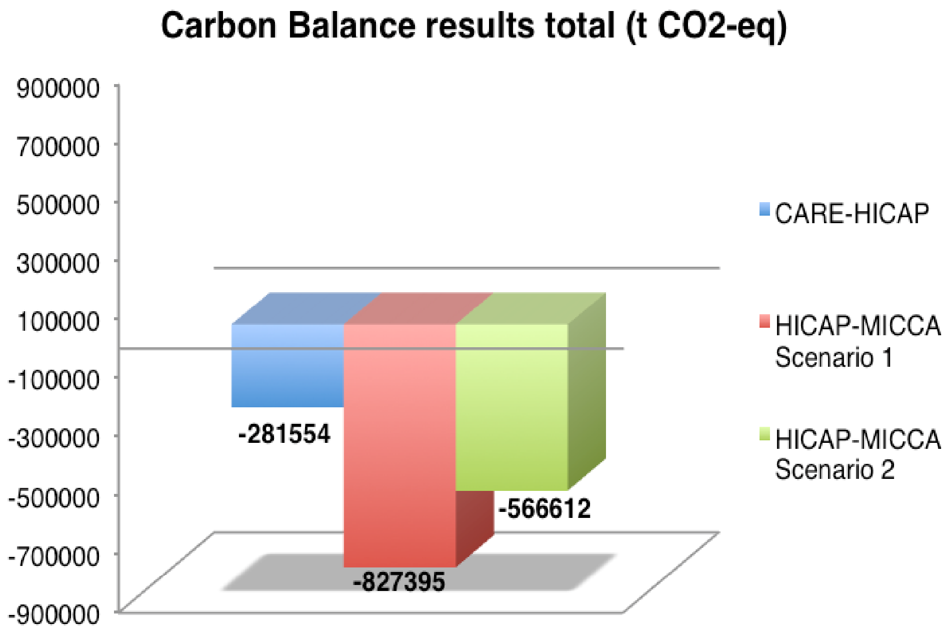

Figure 9: Total carbon balance of the three simulated situations

5. CONCLUSION

The report shows the mitigation potential of the HICAP-MICCA pilot project: Enhancing mitigation within HICAP in the southern Uluguru Mountains of the United Republic of Tanzania. The EX-ACT analysis indicates that the cooperative activities between HICAP and the MICCA Programme, which put an increased focus on agroforestry, reduced or no slash and burn, intercropping and reinforced conservation agriculture, have the potential to bring about:

- a net sink of **-28 709** tonnes of CO_2 (equivalent) for the HICAP scenario
- a net sink of **-574 550** tonnes of CO_2 (equivalent) for scenario 1 of the HICAP-MICCA pilot project
- a net sink **-313 767** tonnes of CO_2 (equivalent) for scenario 2 of the HICAP-MICCA pilot project

Over 20 years, all three scenarios lead to net sinks compared to the baseline. Under the baseline scenario, land use results in a net source of emissions, mainly due to deforestation and slash-and-burn farming practices. For the purpose of this study, scenario 2 seems the most realistic for achieving food security, mitigating climate change and assisting local farmers adapt to changing climatic conditions.

Regarding the carbon balance, the entry point for the MICCA Programme is to illustrate the importance of synergy between climate change mitigation and sustainable agricultural development. The finding of the EX-ACT study indicate that the HICAP alone would contribute to climate change mitigation, but without the MICCA Programme's contribution the project may not tap into the full mitigation potential of the area. It is important to point out that it was assumed that not all farmers would adopt the improved practices. A more realistic assumption is that the currently active farmers will probably fully adopt conservation agriculture practices after the three-year implementation period. The mitigation potential would become larger as the number of farmers involved increases. However, as much of the analysis is based upon assumptions, it is important to highlight the uncertainty of the data entered in the EX-ACT tool. The findings indicate an uncertainty level of 38 percent for all three scenarios.

The results of the report can be put into relation with the EX-ACT study performed on the Accelerated Food Security Project (AFSP) also in the United Republic of Tanzania (Bockel et al., 2010). AFSP sought to contribute to higher food productivity in targeted areas by improving the access of 2.5 million farmers to critical agricultural inputs as a means of averting eventual food crises caused by fluctuating food and input prices (Bockel et al., 2010). For the AFSP study, the main focus was on providing input vouchers and location-specific techniques. It was expected that the level of inputs would vary throughout the project duration.

During the first three years, it was projected that the voucher programme would be fully implemented. The subsequent years, the producers would progressively decrease the level of input use as a result of a higher amount of organic dry matter produced through sustainable land management practices (Bockel et al., 2010). Due to the improved practices, the project generated a net sink carbon balance of 5.8 million tonnes of carbon dioxide (equivalent). The findings emphasize the critical importance of adopting sustainable land management practices.

Although not designed to mitigate climate change, AFSP represents a good example of the synergy between agricultural development and climate change mitigation (Bockel et al., 2010). The support brought by AFSP can restore soil nutrient depletion, increase yields and allow farmers to increase food production. Thus, the project provides both an immediate response to food security needs and a longer-term response to sustainable development. Access to inputs is facilitated for a number of years, and as the soil potential is recovered, farmers buy a reduced amount of inputs to maintain high yields. This can be linked to the results of the simulated HICAP-MICCA scenarios. These scenarios mainly analyse the balance between climate change mitigation and food security but also the resilience of ecosystems resulting from increased biomass above and below ground, as well as biomass in litter, soil and dead wood. The increase in different biomasses is principally due to an amplified focus upon agroforestry and curbing deforestation. If conservation agriculture practices are properly adopted and implemented, it is possible to achieve food security in a climate-smart way. The carbon balance results of the HICAP-MICCA scenarios demonstrate the additional benefit of climate change mitigation to a project whose priority is food security.

Other EX-ACT analyses have shown that agricultural systems and activities not only have various mitigation possibilities, but equally engender adaptation benefits in terms of rural development and food security. Examples include the EX-ACT analysis of the Rio de Janeiro Sustainable Rural Development Project in Brazil and the aforementioned AFSP (Branca et al, 2009; Bockel et al, 2010). It has also been demonstrated from an EX-ACT analysis of the cashew kernel value chain in Burkina Faso that mitigation benefits from agriculture could potentially generate supplementary financing and investment through the development of payments for environmental services (Tinlot, 2010). Such support can hypothetically be developed through international agreements on climate change mitigation financing for developing countries.

Furthermore, this report illustrates the important synergies between two of the three main components of climate-smart agriculture: climate change mitigation and food security. Climate-smart agriculture's adaptation component is addressed indirectly in the HICAP-MICCA pilot project. For example, by decreasing soil erosion through agroforestry, the mitigation practices also have the potential to deliver adaptation benefits for the farmers in that they allow rural communities to become better prepared for extreme weather events. The results of the report illustrate what can be achieved in the area with different adoption rates. This type of analysis is important to consider because it can guide project designers towards different climate-smart options, initiate investments and point to different funding options.

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Personal information

C. Besa, M., Mgeta, E., 23.10.11, Monica.Coll.Besa@co.care.org; enoloba@yahoo.com

C. Besa, M., 21.01.21, Monica.Coll.Besa@co.care.org

APPENDIX 1: PARTICIPANTS LIST, EX-ACT TRAINING, DAR ES SALAAM

EX-ACT training, 24th and 25th of October, 2011

Name	Organization	Title	Contact
Ruth Minja	Min. of Agriculture	Principal cultural research officer	0754367136 ruminja@yahoo.com
Edgar Mgeta	HICAP	Monitoring and evaluation	0715/0782261041 emoloba@yahoo.com
Enock Mangasini	CARE	Technical coordinator, agriculture	0754885886 enock.mangasini@co.care.org
Todd Rosenstock	ICRAF	Research fellow	+254 (0) 719799064 t.rosenstock@cgiar.org
Monica Coll Besa	CARE-MICCA	Morogoro Project Field coordinator	+255 65276011 Monica.coll.besa@gmail.com
Mathew Mpanda	ICRAF	Associate scientist	+255 713833441 m.mpanda@cgiar.org
Shariff Hamal	CARE	Agronomist Project Manager, HICAP/MICCA Initiative, Morogoro	070717282, 076483324 sheriff.hamad@co.care.org
Agnes Assenga	Heifer International	Representative Senior Program Manager	0767453044 agnes.assenga@heifer.org
Janie Rioux	FAO	Capacity Development	Janie.rioux@fao.rog
Caroline Kilembe	Min. of agriculture	Principal agricultural officer	0753766637 carockilembe@yahoo.com
Madeleine Jonsson	FAO	EX-ACT consultant	+46704359712 madeleine.jonsson@fao.org
Mbaraha Stambuli	Min. of Livestock and fisheries division		Muba5010@yahoo.com

APPENDIX 2: PARTICIPANTS LIST, WORKSHOP, MOROGORO

Workshop, 28th of October, 2011

Name	Organization/Title	Contact Email
Janie Rioux	FAO-HQ	Janie.Rioux@fao.org
Madeleine Jonsson	FAO-HQ	Madeleine.Jonsson@fao.org
Edgar Mgeta	HICAP- M&E Officer	emloba@yahoo.com
Monica Coll Besa	MICCA- Project Field Coordinator	monica.coll.besa@gmail.com monica.collbesa@co.care.org
Shariff Hamad	HICAP- Project Manager	Shariff.Hamad@co.care.org
Edward Kimweri	District Forest Officer, Morogoro District Council	ekimwery@yahoo.com
Kombo R.	HICAP- CA Field Agriculture Extension Officer Kolero	-
Barnabas Ndangalasi	HICAP- CA Field Agriculture Extension Officer	-
Yohebeth Herman	HICAP- Enterprise Development Officer	yherman255@gmail.com
Abbasi Rehani	Agricultural Officer (Daldo)	abbasirehani@yahoo.com
Efraim Malisa	HICAP- CA Technical Officer	efratema@yahoo.com

APPENDIX 3: EXAMPLE FROM 4 FARMERS IN THE REGION

Farmer 1: Woman but not a contact farmer but part of the FFS:

- Rents three farms, in total 0.3 hectares
- First farm: plants maize and cow peas on 0.1 hectares. On half she does double digging and plants in rows. On the other half, she only plants in rows *(cf. figure 4).*
- Second farm: 0.1 hectares she uses conservation agriculture (double digging and planting in rows). Maize and cow peas
- Third farm: flooded rice on 0.1Ha where she plants in a traditional manner

Farmer 2: Man and a contact farmer for the Farmer Field Schools (FFS) in Kolero:

- Rents three parcels of land, "three plots"
- Cultivates of a total area of approximately 1.8 hectares
- First plot: 1.2 hectares. On 0.1 hectares, out of these 1.2 hectares, he has partially implemented conservation agriculture practices, plants in rows, maize and cowpeas *(cf. figure 3)*.
- Second farm: 0.3 hectares traditional flooded rice
- Third farm: = 0.3 hectares planning to implement conservation agriculture combining maize and cow peas. Presently farming in a traditional way
- The contact farmer experienced that conservation agriculture was difficult in terms of time. Since he is a contact farmer he mentioned that he doesn't have time to properly implement conservation agriculture on all the land.

Farmer 4: Man, farmer in Kassanga

- Cultivates on three farms
- On the first farm, which is 0.1 hectares, the farmer practices conservation agriculture (plating in rows) and cultivates maize, cow peas and ground nuts *(cf. figure 6).*
- On the second and the third farm, which is on 0.2 and 0.4 hectares respectively, the farmer plants traditional cassava, where he slashes and burns, cultivates and then plants.

APPENDIX 4: FOREST AND WOODLAND CHANGES FROM 1970 TO 2000

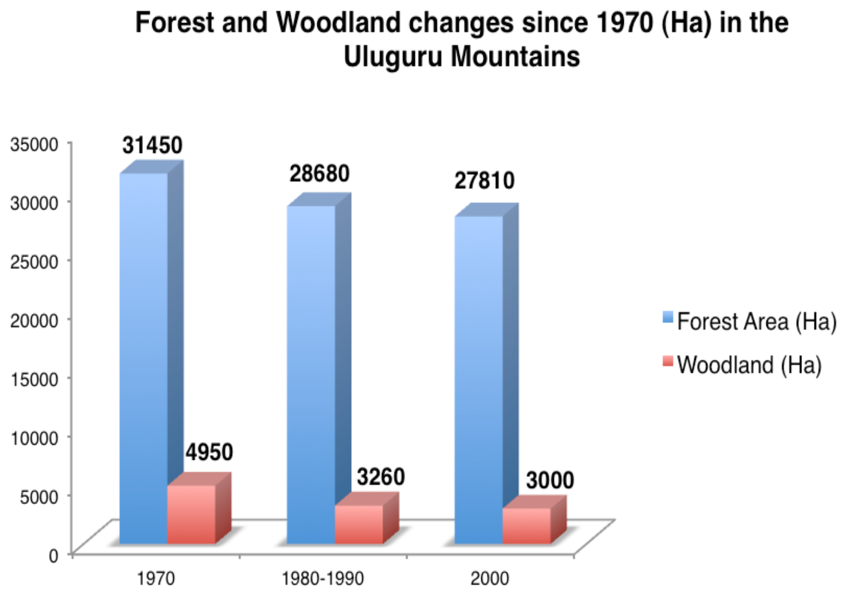

Figure 10: Forest area and woodland changes over time in the Uluguru Mountains (CMEAMF, 2006)

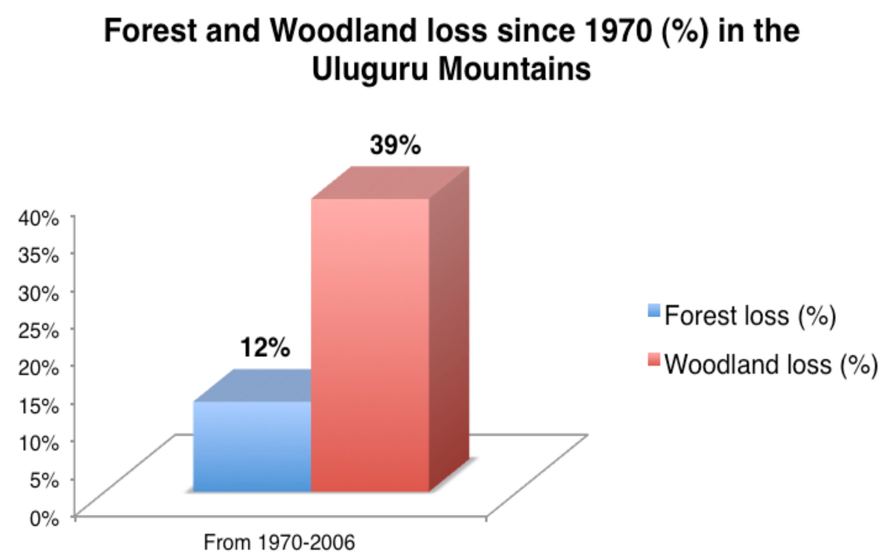

Figure 11: Forest area and woodland changes over time in the Uluguru Mountains (CMEAMF, 2006)

APPENDIX 5: LAND USE CHANGES OF MAIZE AND RICE IN THE HICAP-MICCA SCENARIO

Table 13: Scenario 1: Land use change of maize and rice in the HICAP-MICCA scenario

Land use changes maize, i.e. 40% of 3697Ha	
Forest	40%
Lablab	20%
Pumpkin	20%
Sesame	10%
Cow peas	5%
Beans	5%
TOTAL	**100%**
Land use changes rice, i.e. 20% of 2016Ha	
Pineapple	40%
Groundnuts	20%
Orange trees	10%
Jack fruits	5%
Sweet potatoes	5%
Coconut	10%
Pigeon peas	10%
TOTAL	**100%**

Table 14: Scenario 2: Land use change of maize and rice in the HICAP-MICCA scenario

Land use changes maize, i.e. 10% of 3697Ha	
Forest	40%
Lablab	20%
Pumpkin	20%
Sesame	10%
Cow peas	5%
Beans	5%
TOTAL	**100%**
Land use changes rice, i.e. 10% of 2016Ha	
Pineapple	40%
Groundnuts	20%
Orange trees	10%
Jack fruits	5%
Sweet potatoes	5%
Coconut	10%
Pigeon peas	10%
TOTAL	**100%**