Policy Brief: Adaptation and Mitigation Options

Territorial Approaches to Climate Change Project for Mbale Region, Uganda[1]

May 2013

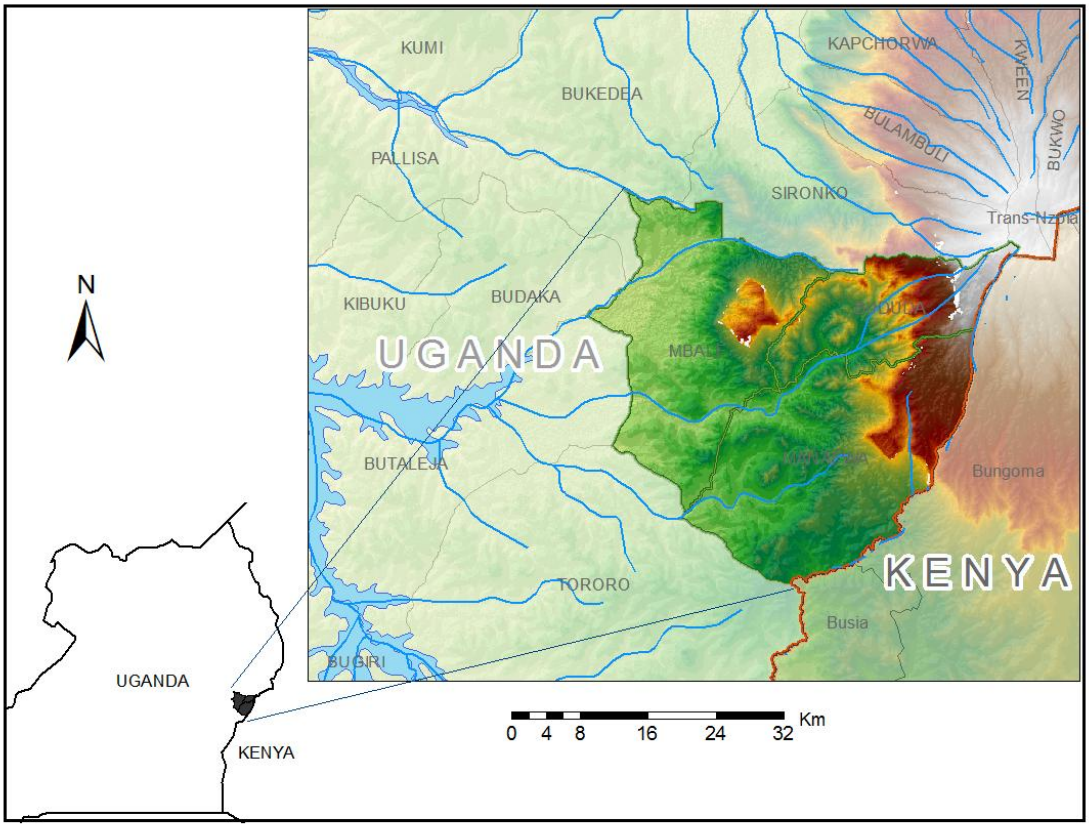
Empowering lives.
Resilient nations.

[1] Shortened version of full report prepared by Mr. Moses Masiga (August 2012)

Background

Forecasts about future warming for Africa range between 0.2°C (low scenario) and just over 0.5°C per decade (high scenario). Climate models forecast that East Africa is likely to experience a 5–20% increase in rainfall from December to February and 5–10% decrease in rainfall from June to August by 2050[2]. These climate change trends are also projected to cause more frequent and intense El Niño-Southern Oscillation (ENSO) events, leading to widespread and more frequent droughts in some areas and more intense and /or extensive flooding in others. These changes and events will have negative impacts on the availability of water resources, food and agricultural security, human health and biodiversity.

The Mt. Elgon Region of Uganda, where the districts of Mbale, Manafwa and Bududa are located, is already seen as one of the most vulnerable areas to climate change in Uganda, exemplified by the tragic landslide that occurred in Bududa District in March 2010.



The overall objective of Mbale Territorial Approach to Climate Change Project (Mbale TACC) is to increase resilience to climate change impacts and to reduce emissions in sub-national territories in developing countries and countries with economies in transition.

[2] IPCC (2007) Climate Change 2007: The Physical Science Basis. Contribution of Work Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate, Cambridge University Press, Cambridge, United Kingdom.

The Mbale TACC[3] is introducing integrated and coordinated planning to adapt to and mitigate the impacts of climate change in the target districts (Mbale, Manafwa and Bududa). The broad key steps in preparing a green, low emission and climate resilient development strategy have been to:

1) design multi-stakeholder participatory climate planning and coordination process;
2) prepare climate change profiles and vulnerability scenarios;
3) identify strategic options leading to green, low-emission, climate-resilient development trajectories;
4) prioritize strategic options through technological, social, and financial feasibility and cost-benefit analysis;
5) prepare green, low-emission and climate-resilient development roadmap[4].

This brief presents the key results of a study which:

- assessed the adaptation options and the adaptive capacity of communities in terms of coping and managing changes, and sectoral and structural changes required for adaptation;
- analysed the energy needs and greenhouse gas (GHG) mitigation potential, options and opportunities;
- priorities for adaptation and mitigation, synergies and trade-offs were also analysed.

Greenhouse gas (GHG) emissions were estimated based on the Intergovernmental Panel on Climate Change (IPCC) 2006 guidance[5], while energy needs were estimated based on the national energy balance, national household surveys and statistical surveys. Local data was collected through key informant interviews and discussions with District Farmers' forums and literature reviews. Economic analyses comprised gross margin and partial budget analyses. The results and conclusions are shown in the section below.

Adaptation Options and Adaptive Capacity for Mbale Region

- The region is and will continue to be vulnerable to climate change resulting in flooding and landslides. The impacts of these are loss of human life, homes and property, and livelihoods[6]. Gradual changes in temperatures and rainfall in Mt. Elgon region could boost agricultural production[7]. Increasing rainfall and temperatures could spur food crop production (bananas,

[3] The Mbale Territorial Approach to Climate Change (TACC) project stemmed from a strong community link between Mbale Region in Uganda, including Bududa, Manafwa and Mbale Districts, and Pontypridd, in Wales, United Kingdom.

The TACC Project for the Mbale region of Uganda has been implemented by the United Nations Development Programme (UNDP) and benefits from financial support provided by the Danish Embassy, the Department for International Development (DFID), the Global Environment Facility (GEF) and UNDP, as well as from technical and development support provided by the Welsh Assembly Government.

[4] UNDP (2011) Preparing Low-Emission Climate-Resilient Development Strategies - Executive Summary. UNDP. Available from: http://www.undp.org/content/undp/en/home/librarypage/environment-energy/low_emission_climateresilientdevelopment/in_focus/preparing-lecrds---executive-summary/

[5] IPCC (2006) 2006 Guidelines for National Inventories for Greenhouse Gases. Available from: http://www.unfcc.int

[6] Mbogga, M.S. (2012) Climate Profiles and Climate Change Vulnerability Assessment for the Mbale Region of Uganda. Report to the TACC Project, UNDP, Uganda.

[7] CCAFS (2010) Report on CCAFS Regional Scenarios Development for East Africa, CCAFS Scenarios Team. Available from: http://cgiar.ccafs.org

beans and maize), but could also lead to a reduction in Arabica coffee production. Coffee berry borer (*Hypothenemus hampei*), the most destructive pest of coffee worldwide, has already benefited from the temperature rise in East Africa[8]. For livestock, the distribution and prevalence of vector-borne diseases may be the most significant effect of climate change[9].

- Whereas the value of forestry, freshwater resources and biodiversity in the Mt Elgon National Park are high, they do not contribute adequately to adaptation in Mbale region. Agriculture takes place in areas gazetted as central forest reserves and there are efforts to degazette some of these to acknowledge land use change. This is because the resources are not aligned towards adaptation needs. The largest portion of forestry resources lie within Mt. Elgon National Park, which is the most important watershed for the region[10]. However, the forestry resources on cultivated land are dominated by eucalyptus, which generally reduce soil fertility and increase the risk of soil erosion[11]. Mbale Region would benefit from having a forest plan that shows land allocated for commercial forestry and important areas of the watershed that need to be protected with indigenous tree species.

- Agricultural production, while high especially in Bududa and Manafwa Districts, is largely concentrated on rain fed annual crops, which have been replacing traditionally grown perennials such as coffee and bananas. Annual cropping systems using traditional methods, notably excessive and often unnecessary annual tillage. Moreover, given the high population density, there are generally no land left under fallow, few terraces and steep slopes are cultivated[12]. Therefore, current agricultural practices are accelerating soil degradation and increasing the risk of landslides induced by climate change-linked intensive rainfall. Intensive livestock production is a leading enterprise in Bududa District, but the small farm sizes and low incomes of farmers mean that only a few farmers are able to invest in a general productive enterprise[13]. Climate smart agriculture approaches offer low-cost opportunities for farmers to adapt to increasing weather variability and predicted climate change.

- For the Mt. Elgon Region, the primary hazards include: landslides and floods, also refugee influx. There is also increased deforestation, as farmers are forced to cultivate at higher levels of Mt

[8] Jaramillo J, Muchugu E, Vega FE, Davis A, Borgemeister C, et al. (2011) Some Like It Hot: The Influence and Implications of Climate Change on Coffee Berry Borer (Hypothenemus hampei) and Coffee Production in East Africa. PloS ONE 6(9): e24528. Doi:10.1371/journal.pone.0024528

[9] van den Bossche P. and Coetzer, J.A.W. 2008 Climate change and animal health in Africa, *Rev. sci. tech. Off. int. Epiz.*, 2008, 27 (2), 551-562.

[10] NFA (2009) National Biomass Survey for Uganda 1990 – 2005, National Forestry Authority, Kampala, Uganda.

[11] Mbale DLG (2004) District State of Environment report, Mbale District Local Government, Mbale, Uganda.
Kitutu K.M.G (2004) Local perceptions of landslide problems in Manjiya County, Mbale District, Eastern Uganda, Mountain Ecosystems, Resources and Development in Uganda, a publication of Mountain Resource Centre, Department of Geography, Makerere University (2004), pages 94-98 ISBN 9970-05-017-6
NEMA (2011a) Economic Contribution of Forestry Resources to Uganda's Economy, National Environment Management Authority, Uganda. Available form: http://www.nemaug.org

[12] Population Secretariat (2008) National State of Population Report 2008, Uganda Population Secretariat, Kampala, Uganda. Available from: http://www.popsec.org

[13] NEMA (2008a) National State of Environment Report, National Environment Management Authority, Uganda. Available from: http://www.nemaug.org

Elgon, resulting in species loss. These higher altitude areas may become the few areas still able to grow coffee if temperatures rise two degrees, which is likely to reduce coffee growing areas to one-tenth of their former size[14].

- Whereas Mt. Elgon National Park has successful collaborative resource management arrangements on the northern side of the park (Kapchorwa District), only a few members of the Mbale Region benefit from the non-wood forest products in the national park. Although protection of the watershed for freshwater is a significant contribution from the park, enterprises such as bee keeping, planting the park boundary with trees for farmers' commercial benefit, among other actions, would further enhance local resilience.
- Over 90% of the population in Mbale Region is based in rural areas (Mbale DLG; Bududa DLG; Manafwa DLG, 2011). Therefore urban development has been limited. However, because of the high population density and the few urban centres, the day-time population in Mbale Municipality and the other urban centres is often quite high (Mbale Municipality Environment Officer, 2012 pers.comm.). The high population pressure in rural areas places a great strain on the poor infrastructure of roads, and public facilities such as hospitals and schools. Therefore, when landslides and floods occur, the opportunity of a rapid response is limited due to the poor roads and terrain. In addition, the absence of meteorological infrastructure and data means that the option of good quality early warning systems have to await the upgrading of the infrastructure[15].
- Overall, Mbale region has 82 health facilities for a population > 1million[16]. However, the level of safe water coverage is still less than the national average[17]. Because of the few health facilities in the region, many people rely on the support of villages health teams to meet their health needs. PONT partnership is piloting a phone-based communication tool for mid-wives and pregnant women, where the nearest health facility can be alerted in case of emergencies such as difficult deliveries for women. These communications systems could be extended to other health and non-health emergencies.
- In terms of education sector performance, only 6%, 12.7% and 25.9% of the children enrolled in primary school continued into secondary schooling in Bududa, Manafwa and Mbale Districts respectively. With the low human resource development, the community will continue to rely on the natural assets base for adaptation in the medium term.

Energy Demand and Greenhouse Gas Emissions

- For the energy sector, as much as 80% of the lighting in the Mbale region is from traditional kerosene lamps commonly referred to as "*tadooba*" and only 3.5% of the households use electricity for lighting. Energy for cooking is generally obtained from firewood (85%) and charcoal (11.3%) - kerosene (1.7%) and electricity (0.4%) are hardly used (UBOS/UNHS, 2010).

[14] Oxfam (2008) Turning up the heat: climate change and poverty in Uganda, Published under the Oxfam Online imprint by Oxfam GB in Uganda. Available from: http://policy-practice.oxfam.org.uk/publications/turning-up-the-heat-climate-change-and-poverty-in-uganda-112505

[15] Mbogga, M.S. (2012) Climate Profiles and Climate Change Vulnerability Assessment for the Mbale Region of Uganda. Report to the TACC Project, UNDP, Uganda.

[16] MoH (2010) Statistical Abstract, Ministry of Health, Uganda. Available from: http://www.health.go.ug

[17] MWESPR (2010) Water and Environment Sector Performance Report 2010, Ministry of Water and Environment, Uganda. Available from: http://www.mwe.go.ug

Traditional three stone open fires heated with firewood are the main form of cooking (83%) complimented by the traditional metal stove (10%) and only 4% used improved stoves.

- Total energy use in Mbale region is estimated at 883 and 24.5 million tons of firewood and charcoal respectively. Gasoline/petrol, kerosene and diesel are used in quantities of 5,749.85; 1,370.88; and 8,731.91 tons of oil equivalents (TOE) respectively while annual electricity consumption is 14,701 MWh. Therefore at current electricity usage, a 2.5 MW plant electricity would supply all year round at current demand.
- Scenarios proposed in the study show that energy demand could grow at the rate of population growth in Mbale region of 3.4% per annum or at the national energy demand growth of 8%. In the lower case (3.4%), GHG emissions from firewood and charcoal would increase from 0.3 to 0.75 million tCO_2e- and 0.025 to 0.063 million tCO_2e-, respectively from 2012 to 2030. In the higher case (8%), GHG emissions from firewood and charcoal would grow from 0.3 - 1.22 million tCO_2e- and 0.025 - 0.1 million tCO_2e- respectively from 2012 to 2030. At the same time, electricity demand would grow to 27,307.24 MWh (4.44 MW) or 58,746.5 MWh (9.56 MW) by 2030 at a 3.5% or 8% annual rate of growth in electricity demand.
- The electricity potential in Mbale region is estimated at only 0.5 MW on R. Manafwa and 9MW at Muyembe/Sirimityo[18]. This potential would cover more than 90% of the electricity needs of the region at the estimated rate of growth by 2030. However, feasibility studies are as yet incomplete and the government has not yet included these projects within its medium term plans. Also, there is need to continue explore opportunities from alternatives such as co-generation with waste, for the rest of the population who will not have access to electricity by 2030.
- For livestock, the three sources of GHG emissions considered are enteric fermentation, direct and indirect nitrous oxide which are estimated at 255,477 tCO_2e-/year, 233,714 tCO_2e-/year and 20,514 tCO_2e-/year for 2010, based on the national livestock census 2009 and updates from Mbale region District veterinary officers. Scenarios for enteric fermentation emissions show that emissions could increase up to 414,073.82 tCO_2e-/year and 644,188.45tCO_2e-/year at a 3.6% or 8% annual rate of growth in livestock numbers envisaged in the Agricultural Sector Investment and Development Strategy.
- The GHG emissions sources for croplands included emissions from the use of inorganic fertilisers (nitrogen), agricultural residue burning especially during land preparation and emissions from losses in soil organic matter stocks due to erosion. An estimate of 994,207 tCO_2e-of GHG emissions was calculated for the croplands in Mbale region.
- For Mbale Region, tolerable rates of soil erosion are about 2.2tons/ha/year, and it is envisaged cumulative tolerable soil losses for the region would be 22 and 44 tons/ha by 2020 and 2030 respectively. However, based on current land use practices (business as usual scenario) cumulative soil losses are likely to reach between 115 and 230 tons/ha, losses equivalent to 1,180 and 2,352.5tC.

[18] ERA (2007) Small hydro power development in Uganda, Electricity Regulatory Authority. Kampala, Uganda. Available from: http://www.era.or.ug

- Forest carbon storage for Mbale region was estimated at 286,634.7 tCO_2e/ year[19]. The projected scenarios are also likely to indicate a similar increase under a business as usual scenario even though the challenge of increased demand for fuelwood and land for agriculture may reduce the net forest increase observed. Afforestation and reforestation activities in Mt. Elgon and commercial trees planted in Bududa and Manafwa.

- The waste generated in Mbale region is estimated at 200t/year; 150t/year generated in Mbale District and the rest from Manafwa and Bududa Districts. While waste is envisaged to increase to 457 and 1,425 tons/year by 2020 and 2030, total emissions would be expected to increase from 5,107.5 to 11,680 tCO_2e/year and 36,392 tCO_2e/year in 2020 and 2030.

Most Promising Options for Climate Change Adaptation and Mitigation in Mbale Region

- Opportunities for adaptation include:
    - changes in farming practices (e.g. crop diversification, low tillage, conservation agriculture, climate smart agriculture);
    - rainwater harvesting;
    - improving water use;
    - protection against soil erosion;
    - drainage / flood prevention;
    - improved regulation and enforcement of legislation and regulations for managing wetlands, riverbanks and farming in hilly areas.

- Mitigation options and opportunities are:
    - energy efficient stoves;
    - municipal solid waste project;
    - biogas carbon project;
    - SALM livestock/carbon project;
    - afforestation/reforestation in degraded areas;
    - agro-forestry – shade coffee project;
    - electricity production from waste;
    - territorial carbon project / voluntary bundled package.

- Processes of adaptation include:
    - structural or technological choices;
    - legislative, regulatory and financial interventions;
    - institutional or administrative changes;
    - market based;
    - increasing technology, information and knowledge tools to enhance adaptive capacity, and on-site operations.

Economic Analysis of Adaptation Options

(i) Rain water harvesting and other smallholder irrigation systems

[19] NEMA (2011a) Economic Contribution of Forestry Resources to Uganda's Economy, National Environment Management Authority, Uganda. Available form: http://www.nemaug.org
NFA (2009) National Biomass Survey for Uganda 1990 – 2005, National Forestry Authority, Kampala, Uganda.

A survey undertaken by the Ministry of Agriculture, Animal Industry and Fisheries[20] established that the four most common irrigation systems for smallholder farmers are: (i) roof catchment water harvesting for domestic use, livestock and for backyard irrigation; (ii) drip irrigation kit for 1 acre of land focussing on high value crops; (iii) rain water run-off water harvesting unit for 2-5 acres; and (iv) pressured irrigation system over 5 acres. The most cost-effective unit for the Mbale region is the rain water run-off water harvesting unit for 2-5 acres at Ushs 4.6 million/acre. The unit is cost-effective because it also takes advantage of the fact that the Mbale region has excess rainfall and therefore run-off can be stored underground and then extracted either by hand, by foot or motor pump.

(ii) Intercropping Bananas and Coffee

An evaluation of bananas and coffee grown under a single (monocrop) crop stand and an intercrop of the two found that a banana-coffee intercropping is more profitable than sole planting of either crop by a gross margin of 5.15 and 6.7 million/ha/year. In a study[21], it was found that coffee yields were nearly similar in monocropped and intercropped coffee-banana. Even though the number of coffee trees/ha decreases slightly when intercropped, but yields per tree are higher. Whereas banana yields suffer when intercropped with Robusta coffee, with Arabica coffee, the yields are higher.

(iii) Aforestation/Reforestation and agro-forestry

TACC Mbale is working with ECOTRUST to implement an afforestation/reforestation methodology within an agro-forestry system in Mbale region. The target will be to increase the shade for Arabica coffee, under Arabica coffee- banana systems in the region. Illustrative analyses based on a Maesopsis methodology developed by ECOTRUST indicated that if farmers increased their tree cover by 400 trees/ha, and got carbon revenue payments in addition to the revenue from timber after a 20 year project cycle, their average annual earnings would average US$ 210/ha higher than the US$ 163/ha from only having a wood lot[22]. In the case of Mbale, farmers would still benefit from improved micro-climate and higher income from an intercropped system[23]. This would be sufficient to encourage farmers to plant woodlot trees on their farm. It is important that food security measures are in place.

(iv) Payments for watershed services

Integrated soil and water conservation measures are necessary adaptation interventions for the Mbale region landscape. Payments for watershed services have been identified as components of conservation agriculture, rainwater harvesting and agro-forestry practices. If introduced systematically among upstream smallholders across the landscape, integrated soil and water conservation measures can benefit downstream water users such as the Mbale Municipality and the regional National Water and Sewerage Corporation (NWSC) and they can be considered as watershed services, for which upstream smallholders will be to be compensated for their efforts / costs. Individual interventions could include improved trash lines, which cost a labour

[20] MAAIF (2005) Operationalisation of the Rural Development Strategy for Increased Agricultural Productivity. *MAAIF, Entebbe, Uganda*

[21] Van Asten, P.J.A., Wacregi, L.W.I., Muhasa, D. and Uringi, N.O. (2011) Agronomic and Economic Benefits of Coffee-Banana Intercropping in Uganda's Smallholder farming system, Agricultural Systems, 104 (4) 326 – 334.

[22] Ecotrust (2009) Trees for Global Benefits Annual Report for Uganda 2009, Ecotrust, Entebbe, Uganda. Available from: http://www. planvivo.org

[23] Van Asten, P.J.A., Wacregi, L.W.I., Muhasa, D. and Uringi, N.O. (2011) Agronomic and Economic Benefits of Coffee-Banana Intercropping in Uganda's Smallholder farming system, Agricultural Systems, 104 (4) 326 – 334.

equivalent of US$ 30/ha/year to set up and take up 10% of land[24], mulching of fields particularly banana plantations that cost a labour equivalent of US$ 150/ha/year, and *Fanya Juu* (an embankment established on upper part of the channel terrace) cost a labour equivalent of US$ 90/ha/year to construct and maintain (Ellis-Jones and Tengberg, 2000). The pro-poor rewards for ecosystem services in Africa (PRESA) project and Nature Harness Initiatives (NAHI) are using the potential of improved drainages on Mt. Elgon in Kapchorwa District to design watershed payments. The estimated labour costs were US$ 150/ha (NAHI Executive Director 2012, Pers. Comm.). The potential for success of watershed payments will be in designing a cost-effective institutional structure and having adequate regulatory support such as a bylaw or ordinance, which is the case in Kapchorwa District.

(v) Malaria control programmes for adaptation to emerging risk of malaria

The mainstay of intervention strategies under the Uganda National Malaria Control Program (NMCP) are; prompt case management using Artemisia combination therapy (ACT), Long Lasting Insecticide Treated Mosquito Nets (LLINs), Indoor Residual Spraying (IRS) using efficacious insecticides and IPT in pregnant women[25]. Epidemic preparedness and response IEC/BCC and monitoring and evaluation and research and health systems strengthening are part and parcel of the strategy.

According to the World Health Organization[26], Uganda has the world's highest malaria incidence, with a rate of 478 cases per 1,000 people/ year (or 36,233 per 100,000 people) people World Bank 2008. The cost of implementing case management, vector control, intermittent presumptive treatment (IPT), disaster preparedness response, and information and awareness creation would increase by US$ 123,127 per year from current levels, if the malaria cases increased by 10%[27]. While the budget for maintaining a village health team beyond current NGO interventions is estimated at Ushs 200 million/year/ District or Ushs 600 million for all the three Districts[28].

(vi) Non-wood forest enterprises

Non-wood forest products (NWFPs) in Uganda are numerous and include food products and food additives, medicinal products, clothing and products used for house construction. For the purpose of this report, 15 NWFPs were extracted from a national survey on the economic value of forestry resources in Uganda[29]. They include: butterflies; pet animals; honey; Aloe Vera; drums and fiddles; tonic root; bark powder from *Prunus Africanus*; bark tree; bamboo shoots; shea butter; termarinds; African tulip; Gum Arabica; mushrooms; and rattan cane. At the

[24] Mutunga K and Critchley W (2001) Farmer's initiatives in land husbandry Technical Report No 27, Regional Land Management Unit, Nairobi, Kenya.

[25] MoH (2011) Ministry of Health Statistical Abstract 2010, Uganda. Available from: http://www.education.go.ug

[26] WHO (2012) Uganda Country Profile. Available from: http://www.who.org

[27] MoH (2002) Malaria Control Strategic Plan 2001/2 – 2004/5, Malaria Control Programme - Ministry of Health, Kampala, Uganda.

UBOS (2010) Uganda National Household Survey Report 2009/2010, Uganda Bureau of Statistics, Kampala, Uganda. Available from: http://www.ubos.org/UNHS0910/chapter9_Domestic%20Energy%20Resources.html

Mbale TACC (2010) Mbale TACC Project Document. Available from: http://www.taccmbale.org

[28] MoH (2010) Statistical Abstract, Ministry of Health, Uganda. Available from: http://www.health.go.ug

[29] NEMA (2011a) Economic Contribution of Forestry Resources to Uganda's Economy, National Environment Management Authority, Uganda. Available form: http://www.nemaug.org

NEMA (2011b) National State of Environment Report 2010, National Environment Management Authority, Kampala, Uganda

national level the contribution of NWFPs was valued at US$ 19.64 million about 1.24% of the value of all forest products in the country.

(vii) Adaptation for smallholder agriculture

Adaptation of farming practices ranges from crop diversification to introducing a mix of livestock and cropping at farm level to investing in anti-erosion measures, adoption of the range of "climate smart agriculture" approaches (including reduced tillage, conservation / evergreen agriculture) and multiple practices for managing drought or flood management at the local level. Technological advancements can also play a significant role in climate change adaptation. Technology-related options include the sowing of new drought-resistant varieties, such as the NERICA varieties recently developed by the Africa Rice Centre, the GIS-based decision support system for rainwater harvesting, and improved weather forecasts that provide timelier information (e.g. using rural radio), including intra-seasonal rainfall distribution. Livestock intensification achieved through forage production along farm boundaries and slopes for soil and water conservation. Although farmers may also seek to produce silage and import pasture or hay from neighbouring regions of the country.

Adaptation in agriculture can also be achieved by choosing yield-increasing production techniques that include: improved varieties developed to adapt to the Mt. Elgon region. The Zonal Agricultural Research and Development Institute (ZARDI) at Buginyaya in Sironko District is developing an inventory of agricultural seed, legumes, agroforestry species, livestock and soil and water conservation technologies that could be adopted for Mbale region in time for the ITCP.

Economic Analysis of Opportunities for Mitigation

- *Economic opportunity from managing enteric fermentation using biogas technology*

  Economic analysis of the mitigation opportunities from managing enteric fermentation in Mbale region was derived based on data developed under the Uganda Domestic Biogas Programme[30]. Of the three dairy enterprises with biogas digesters, $6m^3$, $9m^3$ and 12 m^3, the largest $12m^3$ digester made a profit by the fourth year if the initial capital investment in the digester was considered, based on a 20% interest rate[31]. However, gross benefits from the second year onwards exceeded the operational costs. In other words, if the farmers were able to get a cheap source of capital for the biogas digester, dairy cattle and land, it is feasible for such diary digester projects. What is more likely however is working with farmers who have the required dairy cows, and land.

- *Economic opportunity from greenhouse gas mitigation in the forest sub-sector*

  The economic analysis was undertaken based on the case of the Trees for Global Benefits project under ECOTRUST Uganda (the Plan Vivo Standard). ECOTRUST is adapting an agro-forestry design for the Mbale TACC project. In a typical case of scaling up an afforestation/reforestation program, if the number of trees were increased by 400 trees/ha on at least 10% of the farmlands from the current base, the area covered by trees would increase

[30] Sengendo, M., Turyahabwe; E., Kato, C., Muganzi, M., Kamara, E., Rugumayo, A., Nyanzi, S., Mubiru, D. and Mussazi, M. (2010) Programme Implementation Document (Pid) For Uganda Domestic Biogas Programme, Hivos, SNV and Heifer International, Kampala, Uganda.

[31] BOU (2012) Bank of Uganda Quarterly Economic Report September 2012, Kampala, Uganda. Available from: http://www.bou.or.ug

by 10,764ha. This would increase the net benefits from the tree component by US$ 2.37 million. However, this area may have had crops on it before and therefore, a net loss would be made equivalent to US$ 1.74 million. Following the Maesopsis methodology[32], total carbon accumulation over a 20-year period will be 125 tCO_2e- per hectare, while the annual carbon offset will be 61 tCO_2e/ha, at US$ 3.5/ha (actual earnings received by farmers). The annual earnings for the farmer could increase to US$ 210/ha (>US$ 163/ha).

- *Mitigation opportunities for croplands*

  Partial budget analysis conducted among farmers further east of Mbale but in a similar ecosystem, in western Kenya, showed that agricultural production with minimal fertilizer use inorganic alone resulted in a net loss of US$ 10/ha, when improved seeds were introduced to the SALM practice farmers earned net revenue of US$ 162/ha, when improved seeds and fertilizers were added, the net revenue was US$ 309/ha and when agroforestry was added to SALM practice, the net revenue was US$ 177/ha [33]. However, over the medium to longer-term, SALM brings benefits in-terms of reduced risk of crop failure and reduced inter-annual variation in yields. The partial budget analysis results showed that mitigation was more economically beneficial if it also enhanced farmers' ability to improve their livelihoods with additional practices.

- *Opportunity in the energy sector: low-energy improved stove*

  In Mbale region, over 99% of the households use fuelwood (charcoal or firewood), while over 90% use firewood for cooking. It is estimated that total emissions from firewood are 306,187.75 tCO_2e. The potential reductions using improved stoves for the entire territory have been estimated at about 40% of all emissions[34]. This is equivalent to 122,475.2 tCO_2e. Regarding potential revenues from a carbon project, the amount of emissions reduction as well as market prices are crucial. The entire market for VERs under the Gold Standard was at €6 for 2009/2010. The gross revenue could be €734,851.2/ year. However, projects often have to consider investment costs leading to the project design, a baseline and ongoing development / operational costs such as monitoring, thus without external support, the net revenue is likely to be lower. Mbale TACC is already developing a project concept for low energy stove technology.

Recommendations

- Adaptation opportunities include: encouraging reduced tillage, conservation agriculture, crop diversification (including intercropping and increasing perennial crop cover) , "climate smart agriculture", agroforestry, evergreen agriculture; non-wood forest products enterprises such as bee keeping, Aloe Vera, bark powder from Prunus Africanus, bamboo shoots, mushrooms, and alternative enterprises like fish farming can increase local livelihoods; rainwater harvesting was highlighted as a major adaptation opportunity for the areas in the Mbale region where access to water for domestic and production purposes is usually lower; integrated pest management and

[32] Ecotrust (2009) Trees for Global Benefits Annual Report for Uganda 2009, Ecotrust, Entebbe, Uganda. Available from: http://www. planvivo.org

[33] Tennigkeit, T. (2010) Land-based agricultural carbon finance: potential, operations and economics, African Carbon Forum Workshop Session, Nairobi, Kenya.

[34] GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit) (2005) *Programme for Biomass Energy Conservation in SADC Countries*. Fact Sheet. GTZ: Eschborn, Germany.

integrated vector control for coffee leaf rust and coffee berry borer diseases and Nagana and tick borne diseases, respectively; and managing incidence of malaria in the Mbale region.

- Whereas Mbale region has high abundance of natural assets and institutions to initiate adaptation actions, the extent of vulnerability in the region requires a much higher level of adaptive capacity than is currently available. Support is required to put in place a medium to long-term strategy, especially planning for land/natural resource use and allocation, infrastructure, and social services and development of human capital.
- The most promising mitigation opportunities for scaling–up include: the biogas units from dairy intensification; sustainable agriculture and land management, including improved manure management but also including either agro-forestry and/or improved seeds and efficient use of fertilisers; increased use of leguminous (nitrogen fixing) crops to reduce the need for inorganic fertilisers; improved stove technology either as a CDM project or a voluntary carbon project; soil and water conservation and agro-forestry to reduce loss of soil organic matter through soil erosion (this could be designed as an afforestation/reforestation project for the voluntary carbon market); afforestation and reforestation initiatives as part of protection of vulnerable and degraded areas, and also as part of agro-forestry for shade coffee, and improving soil properties with use of composts, mulch and manure; and scaling-up the municipal solid waste project in the future, currently the waste production is not adequate for scaling-up but it is forecasted that within the next eight years, there may be an opportunity to scale-up. Opportunities for hydroelectric power of up to 9.5 MW also exist in the region.
- At the landscape scale, a set of technologies for the energy sector can be used to design programmatic CDM projects. For example the Mbale territory could promote use of improved stove technologies such as improved cooking stoves (for domestic and institutional settings), also improved methods of charcoal production and managing enteric fermentation through biogas units and these could be presented as CDM PoAs. Similarly, even if several mitigation and adaptation opportunities are possible, Integrated Territorial Climate Plan (ITCP) will need to set performance standards, regulations and show compliance to the plan and regulations. Potential interventions to ensure compliance include agro-ecological and physical plans and regulations for land use. The land use plans and regulations will need to be backed by bylaws and/or ordinances.