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COMPETE

Competence Platform on Energy Crop and Agroforestry Systems for Arid and Semi-arid Ecosystems - Africa

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AIDS	Acquired Immunodeficiency Syndrome
ARC	Agricultural Research Council
AU	African Union
COMPETE	Competence Platform on Energy Crop and Agro-forestry Systems for Arid and Semi-arid Ecosystems
FANRPAN	Food Agriculture and Natural Resources Policy Analysis Network
FAO	Food and Agriculture Organization of the United Nations
GWP	Global warming potential
HIV	Human Immunodeficiency Virus
HRBAP	Human Right based approach to Programming
IEA	International Energy Agency
IFAD	International Fund for Agricultural Development
IUCN	International Union for Conservation of Nature
MBEP	Minority Business Executive Program
MDGs	Millennium Development Goals
NEPAD	New Partnership for Africa's Development
NGOs	Non-Government Organizations
N2O	Nitrous oxide
PDFM	Supply Chain Development Programme
PDRT	Root and Tubers Development Programme
PRSPs	Poverty Reduction Strategy Papers
SADC	Southern African Development Community
SEDA	Small Enterprise Development Agency
SSA	Sub-Sahara Africa
UNCECSR	United Nations Covenant on Economic, Cultural and Social Rights
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change

EXECUTIVE SUMMARY

Biofuels are heating up debates and energising activities on many policy fronts. On the surface they offer significant opportunities to address poverty, environmental issue, and sustainable development goals both domestically and globally. Despite these benefits, however, critics of the bioenergy drive have argued that the scale of production that would be expected to meet global and national demands would have devastating impacts that are social, economic and environmental in nature. Some of the concerns raised include the impact of biofuels on food security, biodiversity, water resources and land tenure and security issues arising from expected expansion of biofuel production.

The report argues that some of these issues could be resolved if energy crop production is integrated into agroforestry systems. This will have an effect of reconciling different producer needs whereby energy crops are grown together with food crops on the same acreage and this will also help in attaining MDGs. The aim of this report was therefore to analyse the potential contribution of improved energy crops and agroforestry systems towards achievement of MDGs. The specific objectives were to;

- Discuss socio-economic and environmental benefits of energy crops, agroforestry and improved energy crop and agroforestry systems in terms of improving energy access by the poor, creating additional sources and means of income generation, improving food security and mitigating environmental pollution at household levels
- Analyse the linkages between benefits of improved agroforestry and attainment of MDGs 1 and 7
- Identify major barriers/negative effects to the attainment of the MDGs
- Propose policy options and measures for scaling-up use of biofuels in SSA

A case study approach was used to highlight the benefits from energy crops, agroforestry as well as integration of the two. Cases were drawn from SSA countries Nigeria, South Africa, Mali, Benin and Brazil.

In analysing the potential of improved energy crops and agroforestry systems to MDG achievement an indicator matrix was used whereby the benefits (indicators) from each system (energy crop, agroforestry, and integration of energy crop and agroforestry system) were scored, ranked and compared. From the analysis done the report argues that while there are benefits to be accrued from separate implementation of energy crops and agroforestry systems, the benefits were however higher when the two were integrated, scoring 100% on all indicators.

However, the report suggests that, this analysis should not be taken to mean that with energy crops and agroforestry then MDG achievement is a done deal. The analysis was based on qualitative information and it did not consider other factors which could possibly hinder or facilitate progress towards achievement of MDGs. Basically what the analysis shows is that in an ideal situation with right policies in place which enables all the impediments to be dealt with, political will, international cooperation and commitment and dedication among all stakeholders then biofuels could go a long way. However, with the current scenario whereby in SSA most countries do no have biofuel policies and strategies to guide implementation of biofuel production and there are threats with regards to impacts of biofuels on food security and greenhouse gas emission among others then this will remain a far fetched dream. In addition, the prevailing environment where food prices are rocketing and there is an economic meltdown will make the task even more challenging requiring an unswerving and collective long-term effort.

Finally, the report suggests policy actions which could help to guide in implementation of improved energy crop and agroforestry systems based on issues which have been raised in the report with regards to barriers of implementation of the systems. It was suggested that;

- Policies that allow mechanisms that improve overall agricultural productivity (conservation agriculture, agroforestry) and bring more arable land to sustainable use have potential to improve both food and fuel production.
- Policies formulated to effect agroforestry must meet the boarder policy objectives of SSA countries.
- Policies should be formulated which devolve land and forests tenures to local people.
- Mechanisms should be put in place to reform policies so that energy crops and agroforestry should also be given policy space
- There is also need for capacity building of all stakeholders including farmers, extension services, scientists and research in order to ensure sustainable implementation and management of improved agroforestry systems.
- Supportive programs should be put in place for the production of energy crop to help subsistence farmers with access to capital, training, reliable markets, extension services and credit.

1. INTRODUCTION

Biofuels are heating up debates and energising activities on many policy fronts, where on the surface they offer significant opportunities to pursue poverty, environment, and development goals both domestically and globally. There are both synergies and trade-offs between these goals and levels (Dufey, 2007). The IEA Bioenergy Task 40 reports (Smeets et al, 2004) that "Africa has the largest bioenergy potential in the world'. This is defined as the production of biofuels after food, fuel and fodder needs for local populations and livestock have been satisfied (and without deforestation). Though bioenergy is not a new concept, it has resurfaced now due to security of supply of fuels caused by a looming peak (energy resource depletion) and increasingly expensive fossil fuels thereby making biofuels competitive (Sinkala, 2007). Thus biofuels are a golden opportunity for developing countries, regarded as central for sustainable development and poverty reduction. Governments reiterated the need to expand access to reliable, affordable and environmentally friendly sound energy services for estimated 1.6 billion people around the world (UN, 2007).

While some progress has been achieved in Asia in providing access to modern energy, this is not the same in Africa where more than 500 million people in sub-Saharan Africa do not have electricity in their homes and rely on solid biomass (fire wood, agricultural residues, animal wastes, etc. (UN, 2007).

A number of projects and organisations have shown that the production and use of biofuels from local feedstock can make a positive contribution to improving access to sustainable and affordable energy (Dufey, 2007). Cultivation and harvesting of energy crops can enhance agricultural productivity and local economic development directly as well as indirectly through crop by-products. Arguably their greatest appeal lies in their potential to reduce greenhouse gas emissions by partial replacement of oil as a transport fuel. This could help countries meet their commitments under the Kyoto Protocol and mitigate the effects of climate change.

However, critics of the bioenergy drive have argued that the scale of production that would be expected to meet global and national demands would have devastating impacts that are social, economic and environmental in nature (Dufey, 2007; Naylor et al. 2007; http://www.iiasa.ac.at). There are fears that the bio-fuel agenda will compete with the growing of food crops and thus lead to food insecurity. There are also fears that governments are promoting bio-fuels and making decisions without adequate policy and institutional frameworks to guide implementation. Within the debate on impacts biofuels would have on communities, the tendency for most researchers was to concentrate on food and economic impacts. However, recently there has emerged a need to understand, not only food security, but also various improved systems on the management and protection of biodiversity, access to land, rural livelihoods and management of scarce resources such as water. Whether energy crops will be a blessing or a curse for sub-Sahara African (SSA) countries will depend on the nature of policies adopted and implemented by countries.

The novelty of biofuels, the vast array of issues involved and the lack of knowledge to tackle many of them together with diverging political and business interests mean that consensus is elusive. It is against this background that several initiatives in SSA are being undertaken to understand the context of biofuels in SSA economies and its peoples.

One such initiative is the Competence Platform on Energy Crop and Agroforestry Systems for Arid and Semi-arid Ecosystems – Africa (COMPETE). Previous studies arising from this project identified and analysed national policies on biofuels in the region (Jumbe et al*,* 2007). In addition, Banda and Gandure (2009) analysed and assessed the performance of biofuels policies towards their sustainable production.

This study of WP6 is a follow-up to the research output conducted around policy trends in bioenergy crops in sub-Saharan Africa (Banda & Gandure, 2009) and also link this to findings from other work packages in order to contribute to the main object of COMPETE, which is to stimulate sustainable bioenergy production in Africa. This paper builds on the previous work done by analysing the potential contribution of improved energy crops and agroforestry systems towards achievement of Millennium Development Goals (MDGs). MDGs have become goals and sign post to assist nations to assist nations in monitoring (quantifying) their achievements of human poverty. These are:

- Eradicate extreme poverty and hunger
- Achieve universal primary education
- Promote gender equality and empower women
- Reduce child mortality
- Improve maternal health
- Combat HIV/AIDS, malaria and other diseases
- Ensure environmental sustainability
- Develop a Global Partnership for Development

According to Bioenergy report (2007), "promotion of the biofuels industry in developing countries has the capacity to propel such countries to achieve the MDGs through poverty reduction (especially job creation and economic enhancement), health impact and climate change". With regards to this paper, biofuel contribution towards achievement of MDGs will be benchmarked against two goals; eradication of extreme poverty and hunger and ensuring environmental sustainability.

2. OBJECTIVES

The main focus of this paper is to assess how improved energy crops and agroforestry systems could offer optimum potential in achievement of the MDGs (1and 7) in SSA. The study objectives are;

- Discuss socio-economic and environmental benefits of energy crops, agroforestry and improved energy crop and agroforestry systems in terms of improving energy access by the poor, creating additional sources and means of income generation, improving food security and mitigating environmental pollution at household levels
- Analyse the linkages between benefits of improved agroforestry and attainment of MDGs 1 and 7
- Identify major barriers/negative effects to the attainment of the MDGs
- Propose policy options and measures for scaling-up use of biofuels in SSA

3. METHODOLOGICAL APPROACH

The methodology used in this paper incorporates case study, desk top literature review and descriptive analysis of the energy crops and agroforestry systems opportunities. Case studies were selected because they served as the basis for providing both qualitative and qualitative data necessary to understand the complex connections between peoples and environment. Case studies were chosen from Nigeria, South Africa, Mali, Benin and Brazil. These were chosen because:

- South Africa is leading in bioenergy activities in SADC (Banda and Gandure, 2009)
- In Nigeria there are good examples of agroforestry systems in practice
- Benin represents a success story of growing energy crops together with food crops
- Mali shows the advantage of good implementation and management of bioenergy production
- Brazil was chosen because of its successful soybean-livestock integration system

3.1 Understanding the improved energy and agroforestry systems and MDG nexus

In order to fully understand the value-addition of improved agroforestry systems towards achievement of MDGs 1 and 7, a review of the progress made so far towards achieving the goals in Africa was undertaken. Although all eight MDGs adopted under the Millennium Declaration in 2000 are enhanced by the introduction and expansion of renewable energy sources, the MDGs most critically influenced by biofuels produced in developing countries are: MDG 1 (eradicate extreme poverty and hunger) by the generation of incomes and employment and productive opportunities in the rural areas; and MDG 7 (environmental sustainability) by providing alternatives to current patterns of conventional energy production and consumption based on fossil fuels, and ensuring that the production and use of cleaner fuels and improved energy efficiency contribute to a wiser use of natural resources, to reduce environmental degradation, to mitigate emission that contribute to climate change and to respect the local and global environment (Nishimoto 2004).

The understanding of the linkages between improved energy crops and agroforestry systems and MDGs was made possible through matrix ranking. The benefits from the three separate systems (energy crops alone, agroforestry without energy crops, and improved agroforestry with energy crops) were compared and ranked. They were ranked from 1-5, scoring depending on the potential impact of the system on livelihoods and environment. Potential of agroforestry systems to MDG attainment was thus assessed based on the benefits which were used as indicators. It was difficult to use the established indicators (AU, 2005) because the indicators are more quantitative and are derived at national levels. Since the study was based on document reviews focusing on small-scale projects, which only contributed a small percentage towards the national figures, it was not possible to use the dictated indicators. Hence, for purposes of this study, modified qualitative indicators were used.

For MDG1 indicators used are: income, energy access, food security/crop yields, employment creation, improvement in health services were used as indicators. For MDG7 indicators used are: forest coverage, biodiversity, greenhouse gas emission, improved water source, soil fertility.

Table 1: MDG indicators used

MDG	Indicator
1	Income Energy access Food security/crop yields Employment creation Water and sanitation
7	Forest coverage Biodiversity Greenhouse gas emission/ Carbon sequestration Improved water source and sanitation/water quality improvement Soil fertility/ Soil protection/restoration

3.2 Framework of Analysis

The framework of analysis consist of understanding the interlinkages of improved energy crops and agroforestry systems as linked to MDGs. Key is also the provision of definitions and concepts. The linkage to MDG is attempted and its link to improved livelihood given. Though the analysis seems to give a conceptual isolation to the concepts, in practice they merge in an interrelated system. The livelihoods approach will be used to analyse the contribution of improved energy crops and agroforestry towards the achievement of MDGs. This is relevant taking into cognisance the fact that the MDGs provide a unique framework for promoting the international cooperation that is needed to help poor countries escape the poverty trap and to benchmark progress *en route*. In light of this, the livelihood approach which places people at the centre of development and works to support people's efforts to achieve their own livelihood goals (Boyd *et al*, 2000) can help us to understand linkages between MDGs and improved agroforestry systems. At the heart of the approach lies an analysis of the different assets upon which individuals draw upon to build their livelihoods. These are:

- Natural capital: land, water, vegetation, biodiversity and environmental services
- Social capital: social resources (networks, groups, trust, social relations, etc)
- Human capital: skills, knowledge, good health and ability to labour
- Physical capital: basic infrastructure (transport, communication, shelter, energy, etc)
- Financial capital: financial resources (savings, access to credit, bank loans, remittances, etc) (Boyd et al, 2000).

A closer look at these different assets shows that they are all enshrined within the MDGs. The availability of these assets basically mean that individuals are able to expand their livelihood strategies and can also indicate degree of empowerment from various livelihood options of which the improved energy crop and agroforestry system is one of them. The livelihoods approach will be used in conjunction with the human rights based approach to programming (HRBAP). This approach is consistent with the UN Secretary General's Reform Programme which calls on the UN to mainstream human rights into all its activities (including research) (AU, 2005). The focus requires working closely with individuals, households and communities. At the centre of research and analysis is the recognition of the need for action to be placed at these levels if sustainable solutions are to be found. Thus with regards to contribution of improved agroforestry systems towards attainment of MDGs, focus will be placed more at small-scale projects where the households, farmers and community are involved in the activities and decision-making processes. The emphasis will be on the sustainable development of biofuels to increase modern energy access to households and thereby improve their lives and livelihoods.

4. THEORETICAL FRAMEWORK

The theoretical framework guiding the analysis of this paper will be clarified under 4 major concepts:

1) Energy crops
2) Biofuels
3) Agroforestry systems
4) Integration of energy crops in agroforestry systems

4.1 Energy Crops

Energy crops are a type of biomass from which biofuels are made. Energy crops are specifically grown to produce some form of energy, which may be generated through direct combustion or gasification of the crops to create electricity and heat, or by converting them to liquid fuels such as ethanol for use in vehicles (MBEP, 2002).

A study in SADC region identified the following as key energy crops for biofuel production; palm oil, sweet sorghum, sugarcane, sunflower, soybean, *Jatropha curcas* and cassava (Takavarasha et al., 2005). These crops were ranked according to their potential in the production of biofuels, employment creation, level of production costs, yield, and impacts on food security, foreign exchange savings and energy balance.

Table 2. Energy crops recommended by a study in SADC for biofuel production

Energy Crop	Rank	Reasons
Sugarcane	1	• already grown in the region for ethanol production • generates a lot of employment • produced from a by-product of sugar, hence there a double benefit • foreign exchange benefit
Soy beans	2	• same reasons as sugarcane • expanded use for biodiesel can be achieved in one season • scores high for biodiesel production
Oil Palm	3	• Scores high for biodiesel
Sunflower	4	• Ranked fourth because not widely grown in the region
Sweet Sorghum	5	• Ranks low because not yet commercially grown
Jatropha	6	• Not yet commercially grown
Cassava		• Not a major crop in the region

Source: Takavarasha, *et. al* (2005)

4.2 Biofuels

In recent years, concerns about energy security, climate change and support for rural development have climbed rapidly up political agendas, both in developing and industrialised countries. Bioenergy occupies a unique position at the nexus of energy, environment, climate change and rural development agendas (IUCN, 2008). Consequently, bioenergy and biofuels in particular, have seen record levels of support in the form of subsidies, mandates and investments as governments seek to maximise the perceived synergies between the various opportunities offered by bioenergy. Biofuels are gaining importance in SSA, in the light of rising fossil fuel prices, depleting oil reserves and increasing 'greenhouse effect', associated with the use of fossil fuels (Reddy et al, 2007). Since biofuels are produced from energy crops, they offer enormous opportunities to improve income levels of smallholder farmers in developing countries, which are predominantly agrarian economies. Local production of biofuels is projected to have a broad range of positive economic, social and environmental implications. At a national level, producing more biofuels will generate new technologies, new industries, new jobs, new markets assisting economic growth in rural areas besides reducing environmental pollution, increases savings in foreign exchange through import substitution, and attraction of money under what is known as the Clean Development Mechanism of the Kyoto Protocol (Dufey, 2006).

Research has found that the biofuel industry can generate more jobs per unit of output than the fossil fuel industry, sometimes at lower cost (COMPETE, 2009). The World Bank reports that biofuel industries require about 100 times more workers per joule produced than the fossil fuel industry (Katha *et al*., 2005). Therefore, by generating greater demand for agricultural products, biofuel programs have the potential to significantly increase employment in rural areas. For example, In Sub-Saharan Africa, the World Bank estimates that a region-wide blend of ethanol (10 percent of gasoline and 5 percent of diesel) could yield between 700,000 and 1.1 million jobs (Kojima and Johnson, 2005). Such massive jobs programs are achievable because biofuels production can be very labour intensive.

However, large pools of cheap labour may not be available in higher income developing countries, where mechanization and off farm employment tend to push up agricultural wages but push down agricultural employment (COMPETE, 2009). Further, energy crops can be divided into those that do, and those that do not, displace other crops. When energy crops that involve tree growing displace other crops in regions where there is little farm mechanization, the switch typically involves a reduction, sometimes a huge reduction, in local employment. Generally speaking, tree crops normally require much less labour than agricultural crops. This is not usually the case with non-tree energy crops, such as sugarcane, which may employ more people than the non-fuel crop that they displace. Nor is it the case with energy crops that do not displace other crops, because these involve expanding crop production on to “new” lands, such as currently unproductive land and the margins of productive farm fields (COMPETE, 2009). Biomass energy crop production can therefore contribute to rural employment creation, provided it is designed and implemented in a manner that involves carefully assessing and addressing local employment needs. Positive job impacts cannot be assumed automatically (Kartha *et al*, 2005).

Whilst it is true that well-planned bioenergy development can reduce greenhouse gas emissions from a range of sources, increase rural incomes, reduce waste, improve access to energy, and improve overall energy security and independence – the reality is that current expansion of production, particularly of first-generation liquid biofuels, is increasingly cause for concern (IUCN, 2008). Recent research suggests that many of the concerns are at root triggered by demand for additional land for producing bioenergy, which may have a number of direct and indirect impacts on: food prices/security, increased greenhouse gas emissions, loss of biodiversity, land rights and other equity issues (IUCN, 2008).

4.2.1 Sustainability Issues Related to Biofuels Production and Use in SSA

It has been suggested that biofuels have the potential to provide communities in SSA countries with multiple essential services such as income generating and educational activities. However, if developed improperly, the effects could be increased food prices and a wider schism between the rich and poor in these countries (UN, 2007). A number of issues need to be considered in the sustainable development of biofuels at the small scale level as discussed below.

Policy direction

Biofuels are a fairly modern, diverse and cross–cutting sub–sector that brings together food security and energy issues. This intersection between energy security and industrial production creates a lot of challenges for policy makers in SSA around biofuels. This is because the so called “biofuels portfolio” falls within two critical and powerful ministries in most African nations. These are energy and agriculture leading to challenges in terms of policy development, programme implementation and investment. These split responsibilities have in most countries created strong territorial issues.

Economic and social development

As biofuels develop in SSA, the tendency is often to seek large scale production which can rely on intensive cash crop cultivation and mechanized harvesting and production chains, this could lead to a sector dominated by a few agro-energy industries, without creating significant gains for small farmers. This raises the concern of potentially aggravating socio-economic inequity. One major constraint according to MPEP (2002) is farmers’ reluctance to adopt new crops that have uncertain markets as well as uncertain paybacks. They want a reliable demand for crops before they can invest the money to plant them. Conversely, energy producers want a guaranteed supply of an energy source before making the capital investments to build new facilities.

Climate change mitigation

Biofuels as a global phenomenon has been pushed by environmental groups that see it linked to greenhouse gas emission reduction. Most countries in SSA are signatories to the UNFCCC conventions. These are commitments from countries to reduce global greenhouse gas emission. However, the question still remains on how effective biofuels will be to perform this role and whether biofuels is the right yardstick to use. They cite intensive farming practices utilizing more energy (fossil fuels) through extensive mechanization. For SSA, which has low net emissions of green house gases, arguments are that they have other urgent priorities like poverty, and energy availability is pre-condition to move people to economic development. While bioenergy production is meant to reduce green house gas emissions, some analysis have actually indicated a wide divergence in carbon balances in the production chain, according to technologies used, locations and production systems, with some even leading to greater emissions than fossil fuels (FAO, 2009). There is also a potential of creating ‘carbon debts’ which might take decades to ‘repay’, when land with high carbon content such as forest is converted to grow energy crops. A comprehensive carbon balance assessment must also take into account indirect land use change which refers to emissions from land that has been put into agricultural production, because other agricultural land has been converted to bioenergy crops or because of increased demand for food crops as a result of energy cropping.

Food security and energy

One of the main sustainable development concerns is that biofuels especially when produced on a large scale may divert agricultural production away from food crops and drive prices up. Energy, if grown on a large scale, may compete with food crops in a number of ways including land use, investment requirement, infrastructure support, water, and fertilizers. In South Africa for example, the average price for maize in 2005 increased by 28% and for sugar by 12.6% with some experts attributing this rise to growing demand for ethanol in global markets (UN, 2007). Concerns also rise over growing crops for export, when the needs for energy access at home are significant.

Biodiversity, water soil and forestry

Demand for biofuels could increase the pressure for deforestation by requiring more land for biofuel crops. This can contribute to soil erosion, increase drought risks and affect local biodiversity through possible introduction of invasive species for biofuel production (FAO, 2009). In Africa, as in other regions, agricultural ecosystems can be complex and fragile. About 65% of total cropland and 30% of the pasture land in SSA are affected by degradation, with consequent declining agricultural yields (UN, 2007). Soils are typically low in fertility and organic matter content and soil fertility has been declining with removal of vegetation and overexploitation of land. The use of fresh water resources is also concern.

Land use and tenure security

Land is at the centre of biofuels production. This is because large tracts of land are required to gain maximum profit from biofuels for both ethanol (as in the case of sugar plantation) and biodiesel and in the case of oil crops production. The land question rides on the fact that large tracts of land (e.g in Madagascar where 452,500 ha of land was taken for biofuel projects) are taken away from communities who are socially, and economically vulnerable groups. While private investment in the agricultural sector offers significant potential to complement public resources, and many countries with reasonably functioning markets have derived significant benefits from it, it is likely that if rights are not well defined, governance is weak, and those affected lack voice, such investments can carry considerable risks. These include displacement of local populations (see Box 1), undermining or negating existing rights, and causing corruption, food insecurity, local and global environmental damage, loss of livelihoods or land access. There has been an increase in number of land conflicts linked to biofuels. In terms of land use, the aim of a sustainable biofuels policy, it is argued, should be to manage the diverse land use spectrum of both large and small scale development, in time and space, with change resulting from interactions among ecological, economic and socio-political factors.

Box 1-Land-grabbing for agro-fuels in Southern countries threatens smallholder farmers

There is currently a massive land grab for agro-fuels in Southern countries, much of it conducted by European companies wanting to export to the EU. The plans of private companies for acquiring domestic land constitute a threat to smallholder farmers, whose lands are likely to be confiscated and who are then reduced to unemployment. In Northern Ghana over 10,000 hectares, involving six settlements near Kpachaa, are being cleared of vegetation and developed into a jatropha plantation. In the same region, large tracts of land are being developed for the production of ethanol fuel from sugar cane.

In some areas of Senegal, such as Bigona, if the forest is cleared to cultivate jatropha it means that 68% of rural households' incomes will be wiped out and all poverty-control goals annihilated. International investors are currently in discussions with the Senegalese government over plans aimed at producing agro-fuels with jatropha and sugar canes in areas of between 50,000 and 200,000 hectares.

In Tanzania, 60% of fertile land with irrigation potential has been allocated for agro-fuels production in the Rufiji region. The expansion of monoculture plantations diverts scarce land and water away from food production – precisely those resources to which smallholder farmers, particularly women, have least access.

In Ghana, the shea trees, whose nuts, harvested to be sold on local markets for cosmetic and soap production provides an important source of supplementary income for poor rural women, have been ploughed under to make way for jatropha production for biodiesel. Moreover, farmers have reported that jatropha was planted not on marginal land but rather on the land most suitable for food crops. "Not only is land-grabbing causing the displacement of local food production and farmers, but conflicts over access to land, water and other resources are developing subsequently. Even more alarming, cases of violations of peoples' rights to access land, resulting from the pressure to monopolise land use for biodiesel and ethanol production, have been documented, for example in Guatemala".

Source: CONCORD, 2009

According to Bioenergy (2009), agricultural and forestry-based means of generating bioenergy can play an important role in addressing some of these key sustainability issues. Several adaptation strategies and options related to bioenergy have been identified such as development of agroforestry, reforestation and afforestation.

4.3 Agroforestry Systems

Agroforestry has increasingly become a focal entry point for development and for environmental stewardship notably as climate change adaptation and mitigation has risen in importance. Agroforestry is a collective name of land use systems in which woody perennials (trees, shrubs, etc.) are grown in association with herbaceous plants (e.g. crops, pastures, etc.) and/or livestock in a spatial arrangements, a rotation, or both in which there are both ecological and economic interactions between the tree and the non-tree components of the system (Lundgren and Nair, 1985).

This land use system is an old-age practice, which has been in existence for generations, even though it may not be specifically identified by that name. Improved agroforestry tries to take the best out of the traditional agroforestry methods and combine them with new scientific findings and inventions (Reyes, 2008). Thus improved agroforestry encompasses many of the land use that have been practiced for a long time such as intercropping, crop rotation and soil conservation techniques, and it also commonly means intercropping particularly with nitrogen-fixing leguminous species. Recently, agroforestry research and development has come to view agroforestry as a landscape level system which can play significant roles in provision of environmental services and livelihoods for communities (Zero Draft, 2009). Agroforestry has its roots in both agriculture and forestry.

There are various forms of agroforestry systems:

- Silvicultural (trees with crops)
- Silvopastoral (trees with pastures and livestock)
- Entomoagroforestry (trees with insects such as honey bees, silkworm)
- Aqua-agroforestry (trees with aquatic organisms such as fish, crustaceans) (Lallje, 2007)

Different practices of silvicultural agroforestry are in existence:

- hedgerow intercropping
- short fallow rotations
- contour hedgerows
- live fences
- windbreaks
- improved tree fallows
- phased intercropping
- integrated tree crop systems
- intercropping of different tree species (Zero Draft, 2009)

Recent interest in agroforestry has been generated against a background of depletion/degradation of non-renewable resources, rapidly deteriorating problems of forest exploitation (Merem 2005), which are manifested in loss of biodiversity, soil degradation and unfavourable hydrological changes (Aweto 2000, 2001). Agroforestry has shown its potentials as a land management alternative for maintaining the soil fertility and productivity thereby removing the need to buy mineral fertilizers which is difficult for poor farmers (Reyes, 2008). Interaction between components of an agroforestry system means that a plant and its environment would modify each other to the extent that the environment causes a response in plant function and growth, and the plant then has an effect on the environment by changing one or more of its factors (Huang, 1998).

There are many services and goods which are offered by improved agroforestry systems. Trees recycle nutrients, protect soils and provide fodder, income, food, medicines, oils, fibres, fuel wood and timber. The multifunctional nature exhibited by agroforestry systems can solve several problems simultaneously (Lundgren and Raintree, 1983). Some of the advantages of growing crops under tree canopies are: reduction in climatic damages, reduction in soil erosion, less undergrowth and reduction in pests and diseases (Evans, 1982). Thus, agroforestry offers a variety of options to create diverse, multipurpose plantings that support energy objectives as well as other services critical for sustainability of the lands and people (Gordon et al, undated). These options range from providing additional conservation services for mitigating adverse impacts from other biofuel production systems to serving as feedstock sources.

In order to get the full benefits from agroforestry it is essential to use locally grown trees as illustrated by the use of *Faiderbhia albida* in Northern Ethiopia. According to Hadgu et al (2009), within the Tigray region in Northern Ethiopia, farmers take care of naturally growing trees in and around their farm land in order to improve soil fertility and increase crop yields. This tree species has a special phenology as it sheds its leaves during the rainy season and keeps them during the dry season, i.e. from October to June. Thus *F. albida* sheds its leaves when ploughing begins and hardly competes for light and water during the growing season of the crop. Furthermore, *F. albida* trees fix nitrogen and provide nitrogenous and other nutrients to a crop when their leaves are incorporated into the soil (Rao et al., 1998). In addition, the trees serve as fence and fuel, and provide fodder and shade to the livestock. This means that the presence of *F. albida* within the traditional smallholder farming system provides ecosystem services which can be categorized as provisioning services (including food production), regulating services (e.g. climate regulation, nutrient cycling, soil conservation), and supporting services (e.g. biodiversity) (Costanza et al., 1997; Daily, 1997; MEA, 2003). Also, manure from livestock fed fallen leaves of *F. albida* is commonly used as a fertiliser in farming systems in Ethiopia (Tekalign et al., 1991). However, there is a downside to agroforestry systems where legumes play a prominent role and are effective in improving the nutrient status of nitrogen-depleted soils. Studies have shown that if the nitrogen exceeds the agronomic requirements of subsequent crops or is not used efficiently, there is a risk of volatilization in the form of nitrous oxide (N_2O). N_2O is one of the most important trace gases and has a global warming potential (GWP) 200-300 times higher than that of carbon dioxide. Thus there is growing concern that the wide scale use of woody legumes might result in massive release of N_2O gas into the atmosphere (Albrecht, 2004).

4.3.1 Factors hindering practice of Agroforestry

It should however, be noted that while there are many benefits which could be derived from improved agroforestry systems there are some constraints which can prevent its adoption.

Lack of policy

According to the Zero Draft on Agroforestry Policy initiatives (2009), no specific agroforestry policies and no single 'policy space' exists for coordinating the range of policies that have impacts on agroforestry. This is supported by findings from Tanzania. According to Ngatunga and Nshubemuki (2006), findings from studies done in Tanzania indicate that although there are currently a number of government and local policies aiming at improving both the agricultural sector and natural resources sectors, no distinct policy statements exist on agroforestry. In the forestry policy documents, though, there are many policy statements and directives on woodfuel, farm forestry and trade on forestry products. However, but all these ostensibly refer to forestry. This magnifies the potential for omissions or conflicts resulting in gaps and perverse policy incentives.

Seed and Germplasm

A reliable source of high quality germplasm at local levels is often cited as the major constraint for agroforestry (Zero draft, 2009).This is due to the lack of knowledge on seed handling, collection, bulking, propagation, and multiplication techniques even where it is locally available. Trading of agroforestry tree germplasm with and across countries is also very poor thus restricting communities' access to superior germplasm or more reliable supplies.

Land Tenure and Security

Improved cultivation systems such as agroforestry require medium to long term investments. Farmers are not committed to long term investments if their land tenure is not secure because they are not sure of what could happen to their investments. For instance, the land tenure system in Tanzania has placed constraints on the long-term investment in land that would be vital for increasing the agricultural productivity (Edwards et al, 2007; Msikula, 2003), as about 30% of the farmers are tenants on leased land. Thus implementation of agroforestry systems in Africa should take into account the prevailing land tenure systems in a way that creates benefits to local communities, especially the rural population (COMPETE, 2009).

Knowledge, skills and information

Lack of knowledge and understanding can also hinder uptake of improved agroforestry systems. According to Lundgren and Nair (1985) each agroforestry system is unique, combining the experience and knowledge of forestry, agriculture, ecology, soil science and rural socio-economics. This therefore calls for capacity building of all stakeholders including farmers, extension services, scientists and research in order to ensure sustainable implementation and management of improved agroforestry systems. Lack of access to extension services and information can also impinge on the adoption of agroforestry.

Capital and Credit

Adoption can also be hindered by inadequate access to capital to invest in agroforestry systems. If financial resources are lacking, farmers will be less willing to invest as daily struggle for survival will take precedence over future benefits to be accrued in agroforestry systems. Thus shorter term investments are favourably supported over longer term investments like agroforestry (Zero draft, 2009).

It should also be noted that agroforestry systems can have adverse effects on soils:

- Loss of organic matter and nutrients in tree harvest
- Nutrient competition between trees and crops
- Moisture competition between trees and crops
- Production of substances which inhibit germination or growth (allelochemicals)
- Acidification of soil by some tree species (Lallje, 2007)

4.4 Integration of Energy Crops into Agroforestry Systems

The previous sections have shown that there are many potential benefits which can be accrued from agroforestry systems and energy crops. However, there are also likely detriments to be encountered. According to FAO (2009), negative environmental impacts of bioenergy production, in particular those related to carbon, soil and water resources can be mitigated through good agricultural practices such as minimum tillage, integrated pest and soil management, multiple cropping, appropriate crop choice and crop rotations. Use of these practices is also believed to reduce threat to biodiversity, particularly soil diversity, through retention of crop residues and diversified crop rotations. All these practices are encompassed in the improved agroforestry systems as presented earlier on in this paper.

Thus it can be safely concluded that for better sustainable environmental management, energy crops should be integrated into improved agroforestry systems. Promoting integrated local food-energy production systems by combining feedstock production with crop production and feeding livestock on biomass not used for energy production or soil cover can avoid waste and increase the overall system productivity for food and energy (FAO, 2009). Through incorporating energy crops in agroforestry systems it means that the diverse needs of individual farmers in harnessing the natural resources around them are taken care of. There are likely to be reduced conflicts over land because the same piece of land will be used to provide food, fodder as well as fuel.

Effective implementation and management of agroforestry systems can be a solution to all the potential detriments which can result from biofuel production systems. This is due to the fact that agroforestry is in essence a way of reconciling conflicting needs of nature farmers and foresters through a constructive change in the pattern of shifting cultivation. It aims to optimize the use of land resources to stabilize the environment and to provide stable products and trees (http://www.afuna.org). Nair (1984) noted that agroforestry allows food and wood at the same time and on the same piece of land, conserves the ecosystem, yet offering sustainable production from the land and is compatible with the social cultural aspirations and economic conditions of the farmers.

Adoption of improved energy crops and agroforestry systems can however be hampered by combined factors which affect energy crop production and agroforestry. One issue which quickly comes to mind is that of policy. It has been shown that biofuels can either fall in the energy or agriculture portfolio, something which affects policy formulation and implementation. Agroforestry is a cross-cutting sub-sector and if energy crops are to be added then this would further compound the situation. Which portfolio will govern its management, is it agriculture, energy, or forestry or will they all be involved in policy formulation and management, if so how feasible will that be?

Despite the importance of improved energy crops and agroforestry systems there is limited information available on the potential contribution of these systems towards the achievement of MDGs. This paper will try to examine possible benefits which are likely to accrue through incorporation of improved energy crops into agroforestry systems to communities in the developing world using the MDGs as benchmark for performance measurement.

5. POTENTIAL OF IMPROVED ENERGY CROPS AND AGROFORESTRY SYSTEMS TO ACHIEVEMENT OF MDGS IN SSA

From research in SSA, very little data exists that demonstrate the likely and direct linkage and benefits which could be accrued from the integration of energy crops and agroforestry in as far as achievement of MDGs is concerned. The real challenge and opportunity lies in how these two can be integrated to sustainably meet the future renewable energy and climate change targets. However, the synergy of agroforestry creates enhanced performance, efficiencies and benefits which cannot be realized individually in the agricultural or forestry sector.

5.1 Review of Progress towards Achievement of MDG 1 and 7 in SSA

The Millennium Declaration's eight MDGs are intended to bring together developing and developed countries in partnership to reduce poverty, ensure gender equality, combat environmental degradation, improve access to social services, especially education, maternal health care, safe drinking water and improved sanitation, and combat HIV/AIDS, malaria and other communicable diseases (AU, 2005). Achieving MDGs in Africa is of paramount importance if the AU's vision and mission are to be realized and the objectives of New Partnership for Africa's Development (NEPAD) achieved.

Goal 1: Eradicate Extreme Poverty and Hunger

The problem of poverty is much deeper and more widespread in SSA than other regions where half of the population lives in extreme poverty and one-third in hunger with some 300 million Africans living on less than $1 a day (AU, 2005). The progress made in African countries towards achievement of MDG 1 is varied. While in some countries there is positive progress, in other countries poverty and hunger is actually worsening. Thus, some countries are expected to meet the target of halving the proportion of people with hunger and extreme poverty by 2015 while for other countries it will be impossible to do so.

While economic growth is necessary to achieve development and poverty reduction, it is not sufficient (AU, 2005). Countries will in addition need to implement policies that will strengthen the links between stronger growth and higher incomes for the poorest households. Poverty reduction has been an overarching policy of all countries and because of this all countries have poverty reduction strategy papers (PRSPs) and poverty reduction programmes that focus on raising family incomes, providing equitable and efficient delivery of public services such as health, education, water and sanitation, and ensuring basic nutrition. The strategies and programmes also focus on agricultural expansion to strengthen food security and on the promotion of non-agricultural and informal sector employment. Furthermore, programmes and projects are prepared by public and non-public partners such as NGOs (AU, 2005).

Goal 7: Ensure Environmental Sustainability

According to national reports from African countries, efforts to sustain the environmental ecosystem by combating deforestation and environmental degradation have been weak in many countries (AU, 2005). Deforestation has taken place in Benin, Nigeria and slightly in Zimbabwe. However, reforestation efforts in Senegal and Morocco have increased forested coverage in these countries .High and increasing population densities in large areas of many African countries have generated a negative impact on agricultural production and environmental integrity. Evidence has revealed that owing to increasing human and livestock population pressure on arable land and forest resources large areas in SSA have been exposed to serious loss of soil fertility, degradation and ecological imbalance. One significant result is declining agricultural productivity which is why poverty in the continent is so heavily concentrated among the rural population. Considerable investments have also been made in improving access of population to safe water and sanitation even though much of the investment has been concentrated in urban areas (AU, 2005). Inadequate water and sanitation is a primary cause of water borne diseases and major cause of poverty and the disparity between rich and poor (UNCECSR, 2002).

5.2 The Cases

Analysis of the progress made so far towards achievement of MDGs 1 and 7 shows that there is a niche for improved energy crops and agroforestry systems in attainment of these goals. This will be illustrated through case studies from countries in SSA. These cases represent a collaborative effort to explore the potential of improved energy crops and agroforestry systems to provide sustainable livelihoods and local sources of energy for people in rural areas of developing countries as a means to assess MDGs.

Case 1 presents the benefits which can be accrued from alley cropping. Alley cropping is a type of agroforestry whereby food crops and woody species are intercropped. Food crops are grown in the alleys formed by hedgerows of planted trees and shrubs, preferably legumes. The hedgerows are cut back at planting and periodically pruned during cropping to prevent shading and to reduce competition with the food crops. However, the hedgerows are allowed to grow freely when there are no crops. One major advantage of alley cropping is that the cropping and fallow phases take place concurrently on the same land, thus allowing the farmer to crop the land for an extended period without a break.

Case 1: Agroforestry-Alley cropping in Nigeria

A case study of alley cropping in Ibadan, south western Nigeria, showed that leguminous species such as *leucaena* and *Gliricidia* grown in hedgerows in alley farming can yield large quantities of biomass and nutrient yield as compared to non-legumes such as *Acioa* or *Alchornea cordifolia*. Alley farmed plots with *Leucaena* and *Gliricidia* have higher soil organic matter and nutrient status than in tilled control plots. Alley farming was shown to reduce runoff and soil erosion compared with control plots. Runoff and erosion was reduced by the physical barrier of the hedgerows, and also by the better physical condition of the soil under the hedgerows resulting from higher faunal activity, which increase water infiltration.

Case 2: Energy Crop Production-South Africa Sunflower Project

This case details a project, Mafura-Makhura Incubators, in South Africa which was started in order to search for alternative energy sources to avert energy prices and benefit small scale farmers. The project was created as a joint partnership of big business, government and small scale farmers. The National Department of Agriculture and Agriculture Research Council (ARC) with funding from the Department of Science and Technology, Small Enterprise Development Agency (SEDA) and the Limpopo Department of Agriculture. The vision of the organisation is ensuring development of fully equipped small scale farmers (women and men) who can compete in the biofuels chain. Small scale farmers are trained in biofuels farming practices and agricultural. Both women and men are key participants in the projects which aim for a 50% women and men's participation although this has yet to be realized. The new trainees to the programme sign an “incubation” agreement which enables the provision of seeds, fertilizers and training in production skills and business development.

They also are bound to the programme for 3 years as repayment for start up capital they receive from the programmes. To overcome the cost of inputs a cooperative was created to which the “incubates” are shareholders. Participants in the project relate to improved livelihood, incomes and skills since joining the programme. Interviews with women farmers engaged in the project indicated that sunflower growing for biodiesel production could greatly contribute to their overall welfare and the future of their children through their increased incomes. They were happy that the biofuel production had empowered them economically. Some have also seen changes in their social relations at the household level since engaging in the project. They made more decisions about not only reproductive issues (e.g. cooking) but also productive issues, such as farm management, use of natural resources and finances (Karlsson and Banda, 2009).

Case 3: Energy Crop Production- Mali- Biofuel processing from Jatropha

A 15-year project in the township of Garalo, Mali, aims to set up electricity generators fuelled by jatropha oil for 10 000 people and to reduce village poverty. The population is mainly engaged in agriculture (mostly millet, sorghum and rice, as well as cotton for income generation), raising cattle and fishing. Electricity is required to pump water for irrigation, to operate agricultural processing equipment, to chill vegetables and for lighting and refrigeration services in small shops and restaurants. Jatropha (mainly *Jatropha curcas*) is well known in Mali where it is used for protective hedges, erosion control and traditional soap-making. The project will implement 1 000 ha of plantations of jatropha and other oil-producing plants and will provide training at different levels to ensure quality of the processed oil. Expected environmental benefits include carbon-dioxide emission savings of 9 000 tonnes per year as well as protection of soil against erosion to combat deforestation and desertification. The money spent on locally grown fuel stays in the community to stimulate the local economy. On a macro-economic level, this implies a reduction of the country’s expenses on imported fossil fuels, saving hard-earned foreign currency reserves**.**

Focus discussion with communities in the project at Garalo recount how electricity had contributed to education, health (there was now an ambulance stationed at Garalo to transport patients to the central hospital in Bamako), improved communication and governance. Women have moved into the centre of development of the community. Women were quoted to say “we are now part of the key decision-making process on biofuels of Garalo” (Banda and Gandure, 2009).

Case 4. Integrating energy crop into agroforestry systems -Cassava production in Benin, food and fuel

As in many other sub-Saharan countries, Cassava is a major staple food in Benin, and represents over 56% of the country's production of roots and tubers. Since 1991 production of fresh cassava roots in Benin has tripled. The country produced about 2.96 million tonnes (t) of fresh cassava roots in 2005 compared to approximately 1.05 million t in 1991. Expansion of cassava production largely exceeds population growth, which is a strong indication for production growth as well as the importance of traditional processing. The harvested areas increased from 136.000 ha in 1994 to over 240.000 (the highest peak) in 2004. About 85% of all cassava roots are produced in southern and central Benin, where agro-ecological conditions are best adapted to the crop. Mixed cropping is still dominant, and subsistence farming is still the primary farming system for this species. In 2005, less than 5% of farmers were using chemical fertilizer.

Together with the increase of harvested areas, a significant increase of unitary yields of cassava plantations was observed in recent years, growing from 8.28 t/ha in 1994 to almost 14 t/ha in 2005. The large increase of cassava production is largely due to the successful implementation of two development programs over the last 8 years: the Root and Tubers Development Program (PDRT), financed by IFAD and West Africa Development Bank, and the Cassava Supply Chain Development Program (PDFM), financed by the government of Benin. Thanks to these initiatives, new improved cassava varieties were introduced, and an intensive dissemination activity for the promotion of modern cultivation and processing techniques (agroforestry-intercropping with other crops) was carried on. In 2008 a feasibility study financed by the World Bank and the Ministry of Energy of Benin, indicated cassava as one of the most suitable feedstock for bioethanol production in Benin, based on the following points:

1) Cassava is well known by farmers and well adapted to the majority of agroecological conditions of Benin;
2) With the current average yields (15 t/ha) a theoretical production of 2.500 liters of ethanol per hectare is possible. If the current trend of increase of unitary yields is maintained, the target of 20 t/ha will be achieved in a few years (some districts in the centre-north already show yields steadily above 25 t/ha), corresponding to an ethanol yield of 3.500-4.000 liters per hectare. This yield is comparable to that of corn based ethanol, but with an improved energy balance. In addition, thanks to increased yields, a reduction of cultivation costs will be possible, thus ensuring an increasing cost competitiveness of this crop for industrial uses;
3) The risk of food vs. fuel competition seems limited, considering that in 2007 Benin showed a positive food balance sheet of 1.771 kt surplus over a total production of 3.110 kt.

Theoretically this amount of roots could produce more than 250 kt of bioethanol, which is more than the current national demand of ethanol in case of introduction of mandatory E5 blends. If correctly managed, the establishment of a bioethanol market in Benin could then act as a driver for the further development of cassava production (for energy as well as for food production), by providing a potential destination for surplus production and subsequently stimulating the development of a modern farming system (with a progressive introduction of improved varieties, fertilizers and mechanization) and a more efficient organization of the supply chain. Moreover, the adoption of a sustainable farming system, based on the cultivation of energy crops (for Benin not only cassava but also sweet sorghum was indicated as a potential feedstock for ethanol production) in strict rotation with food crops, particularly legumes (soybean, groundnut etc.) could bring significant improvements to the productivity of the latter. Indeed, the food crops that usually show very weak yields when cultivated in a subsistence farming model, could benefit from the residual fertility of the previous energy crops (cultivated as cash crops and thus theoretically provided with enough fertilizers) and of the infrastructures (i.e. irrigation equipments, logistic infrastructures, roads, storage facilities, mechanization equipment etc.) made available for the production of energy crops.

Source: M. Cocchi (2009)

Case 5: Soybean-cattle Integration- Brazil

The following case from Brazil presents a good example of crop-livestock integration from which developing countries can learn.

It is believed that one of the strong tendencies of Brazilian agribusiness over the coming years is the Crop-Livestock Integration process in which grain (soya and corn) is produced in degraded pastures with the objective of rehabilitating the soil fertility and improving pasture's productivity. Crop-Livestock Integration was shown to significantly improve soil fertility which favours the crop-pasture rotation process, minimizing the risks of agribusiness, improving yield for producers and reducing pressure for new agricultural and livestock production areas. Under the Crop-Livestock System, the producer reconciles cattle farming and grain production on the same acreage. In winter, with pasture recovered, cattle are fed with fodder and pasture grasses. Crops are rotated through no-till techniques that reduce risk of soil erosion. (See figure 1),

Source: ABIOVE (2007)

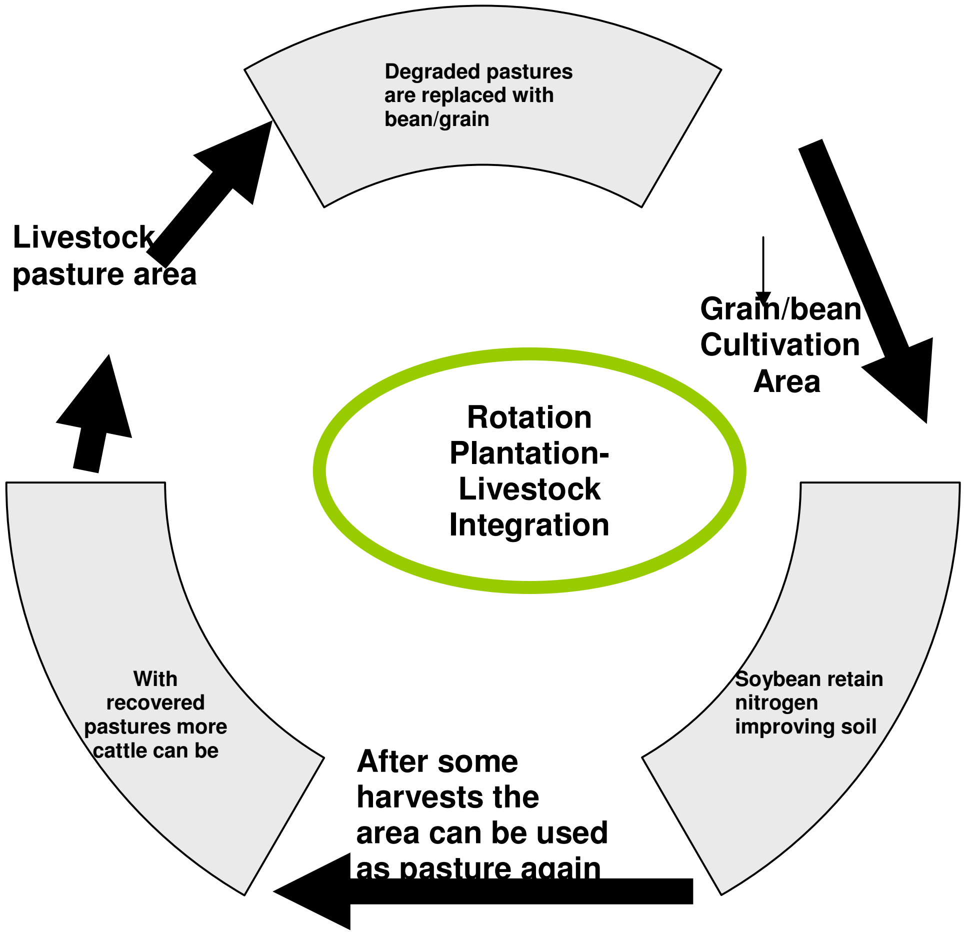

Figure 1: Schematic Diagram of Crop- Livestock Integration System. Adapted from ADIOVE, 2007

The potential benefits of the improved energy crops and agroforestry systems shown in the case studies and examples are summarised as shown in figure 2.

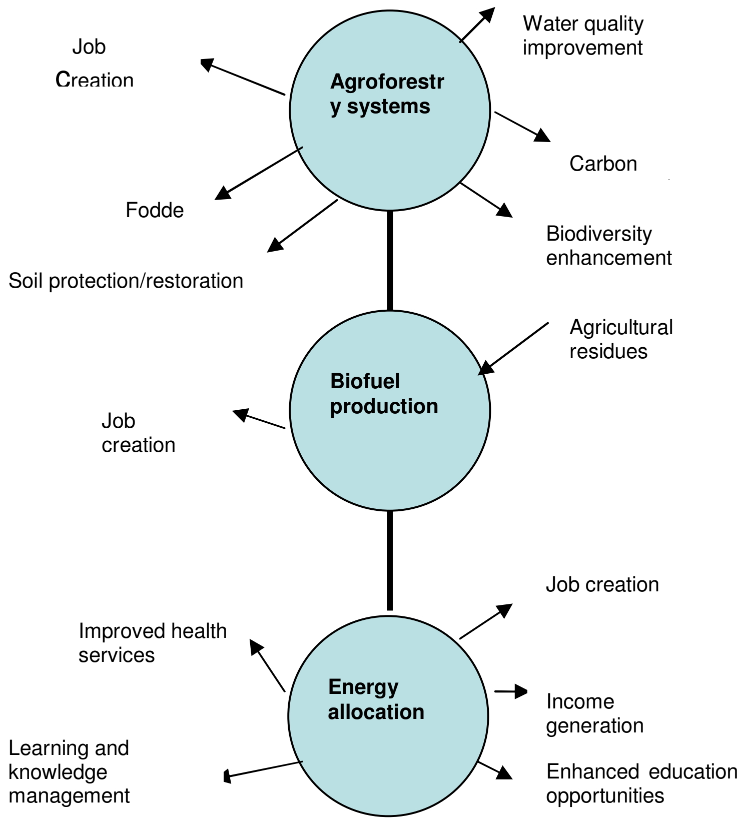

Figure 2: Direct benefits of energy crops and agroforestry systems. Adapted from Buchholz et al (undated).

5.3 Links between Energy Crop, Agroforestry, integration of energy crops into agroforestry and MDGs

Using information from the case studies and examples described in the paper, it is evident that bioenergy production as a livelihood option has potential to produce many positive livelihood outcomes (benefits). These positive outcomes are greatly influenced by the livelihood assets at one's disposal. As seen from the cases farmers were provided with financial resources, training, land, inputs and physical infrastructure such as irrigation equipment, roads and transport for biofuel production According to Boyd *et al* (2000), common livelihood outcomes might include more income, increased well-being, reduced vulnerability, improved food security and more sustainable use of the natural resource.

These outcomes can be contextualised to the MDGs where they relate very well. The following section tries to link common livelihood outcomes to MDGs and possible contribution of energy crops and agroforestry systems towards their achievement using information from case studies and examples provided in the paper. A ranking matrix using MDG indicators will help to do that.

Table 3: Potential Contribution of energy crops, agroforestry and integration of energy crop into agroforestry to achievement of MDG 1 and 7

Type of System	MDG1	Comment	MDG7	Comment	Total contribu-tion
Energy Crop Production	4 (40%)	Scores high on: Income generation Employment generation Energy access Water and sanitation	3 (30%)	Scores high on: Greenhouse gas emission Soil protection Improved water source	7 (70%)
Agroforestry	2 (20%)	Income generation Food security	5 (50%)	Greenhouse gas emission Soil protection Water quality improvement Forestry coverage Biodiversity enhancement	7 (70%)
Integration of energy crop into agroforestry	5 (50%)	Income generation Employment generation Energy access Water and sanitation Food security	5 (50%)	Greenhouse gas emission Soil protection Improved water source/water quality improvement Forestry coverage Biodiversity enhancement	10 (100%)

From the table it can be inferred that integration of energy crop and agroforestry system scored higher (100%) than agroforestry and energy crop production (70%) implying that there is a lower chance of attaining MDGs where these are implemented in isolation of each other compared to when the two are integrated. Energy crops score highly on MDG 1 whereas agroforestry scores highly on MDG 7 and vice-versa. The reason agroforestry scores lowly on MDG 1 is that it does not allow for employment creation as it is less labour intensive than energy crop production where production starts from production of seedlings, planting, harvesting up to processing of the crop to biofuel. In addition, there is no production of energy (except for fuel wood) which is meant to aid economic growth and development of an area. However, energy crop production scores lower on MDG 7 than agroforestry because of concerns of loss of biodiversity due to clearing of land and possible introduction of invasive species. It also does not allow for permanent forest coverage as the crops usually are harvested in a short-term.

From this analysis it can be inferred that if energy crops are incorporated into agroforestry, better impacts on MDG 1 and MDG 7 are achieved. The conversion of marginal lands under energy crops to agroforestry will help improve the environment by increased carbon sequestration, reduction in carbon emission, and increase in oxygen in the atmosphere and biodiversity enhancement.

The review of progress made so far in achieving MDGs showed that there is little progress in curbing environmental degradation and poverty which is mainly concentrated in rural poverty because of reduction in agricultural productivity. There is a window of opportunity in integrating energy crops into agroforestry systems as it allows for biodiversity enhancement, soil protection, greenhouse gas emission reduction and forest coverage thereby reducing environmental degradation and improving agricultural productivity, hence food security.

However, this analysis was based on qualitative information and did not consider other factors which could possibly hinder or facilitate progress towards achievement of MDGs. In an ideal situation with right policies in place, political will, international cooperation and commitment and dedication among all stakeholders, integration of energy crops and agroforestry systems could contribute to the achievent of MDGs. However, with the current scenario whereby most SSA countries do no have policies and strategies to guide implementation of biofuel production this will remain a far fetched dream.

This was also echoed by UN (2008) when it noted that the goal of cutting in half the proportion of people in the developing world living on less than a $1 a day by 2015 will be largely due to extraordinary economic success in most of Asia. However, this will not be same for SSA where little progress has been made in reducing poverty. According to the UN-Secretary General, Ban Ki-Moon, while some good progress has been recorded in some MDGs in the last decade, the tasks have become more challenging now to undertake largely because of the prevailing unconducive environment. In his own words, "We face a global economic slowdown and a food security crisis, both of uncertain magnitude and duration. Global warming has become more apparent. These developments will directly affect our efforts to reduce poverty: the economic slowdown will diminish the incomes of the poor; the food crisis will raise the number of hungry people in the world and push millions more into poverty; climate change will have a disproportionate impact on the poor. Some of the recent adverse developments reflect a failure to give these matters sufficient attention in the past. The imminent threat of increased hunger would have been lessened if recent decades had not been marked by a lack of investment in agricultural and rural development in developing countries. Climate change would be a less immediate threat if we had kept pace with commitments to sustainable development enunciated again and again over the years. And the current global financial turmoil reveals systemic weaknesses that we have known about – and left inadequately addressed – for some time now" (UN, 2008).

The Secretary-General also could not have summed it any better when he said: "Looking ahead to 2015 and beyond, there is no question that we can achieve the overarching goal: we can put an end to poverty. In almost all instances, experience has demonstrated the validity of earlier agreements on the way forward; in other words, we know what to do. But it requires an unswerving, collective, long-term effort. Time has been lost. We have wasted opportunities and face additional challenges, making the task ahead more difficult. It is now our responsibility to make up lost ground – and to put all countries, together, firmly on track towards a more prosperous, sustainable and equitable world" (UN, 2008)

6. CONCLUSIONS AND POLICY RECOMMENDATIONS

From the discussion, it is apparent that improved energy crop and agroforestry systems have the potential of improving the livelihoods of people in SSA and that they can stimulate economic development. It was also shown that integration of energy crops into agroforestry systems can contribute towards achievement of the MDGs.

However, for this to be achieved implementation and management of improved energy crops and agroforestry systems would need to be done in a sustainable manner addressing issues such as scarce water resources, biodiversity concerns, food versus fuel concerns, capacity building and training, research and development, access to inputs, markets and capital, land tenure and security.

A number of policy issues which need attention came up in the paper and some of suggested activities which might resolve the concerns are:

Protection of Biodiversity

Policies formulated to effect agroforestry must meet the boarder policy objectives of SSA countries. Some of the objectives are stated in international treaties. For example, the Convention on Biological Diversity requires member states to protect and encourage customary use of biological resources, respect and maintain the knowledge, innovations and practices of local communities. Thus, indigenous energy crops in a particular area should be capitalized to avoid introduction of possible invasive alien species.

Land tenure

Land access will underpin successful improved energy crop and agroforestry development. Current land tenure fails to ensure the security of land ownership. Thus policies should be formulated which devolve land and forests tenures to local people.

Policy Coordination

Agroforestry should be given space in various intersectoral committees such as on energy, food security, climate change. Mechanisms should be put in place to reform policies so that energy crop and agroforestry systems are given policy space.

Food security

Policies that allow mechanisms that improve overall agricultural productivity (conservation agriculture, agroforestry) and bring more arable land to sustainable use have the potential to improve both food and fuel production. Degraded land should be the first option for large scale energy crop farming so as to help in the rehabilitation of soils and also avoid competition for land between energy and food crops.

Knowledge base

Comprehensive and accurate data on crop water requirements of various energy crops should be done and matched with available water resources in a particular area before these can be grown to avoid water use conflicts. In addition, efforts should be taken to identify compatible tree-crop combinations, crop production potential and suitable agronomic techniques. There is also need for capacity building of all stakeholders including farmers, extension services, scientists and research in order to ensure sustainable implementation and management of improved agroforestry systems. Finally, agroforestry and energy crop management should be included in extension programmes.

Research and Education

The field of research on environmental impacts of energy crops and biofuels is relatively new. While some studies have attributed greenhouse gas emission reduction to energy crops and biofuels there are concerns that sometimes they can increase emissions. Thus, it is important to carry out life-cycle accounting of biofuel production including direct and indirect land use changes, agricultural practices and energy crop processing and end uses. Research should also be done in:

- Identifying suitable energy crops for each particular area depending on prevailing biophysical factors.
- Identifying different compatible energy crop-tree combinations for each agroforestry system.
- Nitrogen agronomic requirements of various energy crops to avoid risk of volatilization of excess nitrogen from leguminous trees into the air.

Supportive programs should be put in place for the production of energy crops to help subsistence farmers. These programs should offer to farmers:

- Access to capital to invest in improved energy crop and agroforestry systems
- Training in agroforestry farming techniques
- Reliable markets for their energy crops
- Extension services on agroforestry
- Long-term credits into agroforestry

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