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Candidate Agroforestry Technologies and Practices for Uganda

[1]Clement Akais Okia, [1]Jacob Godfrey Agea, [2]Jude Sekatuba, [2]Gerald Ongodia,
[2]Balikitenda Katumba, [2]Vincent Ibwala Opolot and [2]Henry Mutabazi
[1]Department of Community Forestry and Extension, Faculty of Forestry and Nature Conservation,
Makerere University P.O. Box 7062, Kampala Uganda
[2]National Forestry Resources Research Institute (NaFORRI), P.O. Box 1752, Kampala Uganda

Abstract: Agroforestry is rapidly gaining interest of many farmers in Uganda and it is widely thought that it can make a significant contribution towards addressing the high levels of poverty and associated land degradation in the country. For this to happen, however there is need to promote agroforestry technologies and innovations that farmers can invest in and that in turn generate incomes. This study therefore, presents an inventory of agroforestry technologies/practices in Uganda and prioritises these technologies/practices according to Association of Agricultural Research in Eastern and Central Africa (ASARECA) criteria and TOFNET (Trees on Farm Network of ASARECA) different problems domain areas in Uganda. The inventory involved the use of structured questionnaires administered to various agroforestry stakeholders. Sixty organizations were surveyed comprising NGOs, CBOs, District extension departments, research and training institutions from 11 districts of Uganda (Iganga, Kabale, Kampala, Kisoro, Kumi, Mbale, Mbarara, Mukono, Ntungamo, Wakiso and Soroti). Validation and prioritization of the agroforestry technologies/practices were conducted in a stakeholders' workshop. Twenty-one agroforestry technologies/practices were documented ranging from apiculture, aquaforestry, biomass transfer, to homegardens and woodlots. High value fruit tree orchards, home gardens, woodlots, trees on cropland, contour hedges, improved fallowing, relay and rotational cropping, fodder banks, apiary systems, ornamental/avenue planting, trees on hillsides were the top ten highly scored technologies according to ASARECA criteria. According to TOFNET criteria, most of the technologies were spread in nearly all the problem domain areas (Lake Victoria and associated river basins, humid highlands, marginal areas, buffer zones and urban/peri-urban) of Uganda. This therefore, calls for the need to promote diversified agroforestry technologies/practices, which might be the best option to reduce risks and satisfy farmers' wants directly from the land resources under their management.

Key words: Agroforestry, technologies, practices, innovations, TOFNET, ASARECA, Uganda

INTRODUCTION

The association of trees, agricultural crops and animals in a farming system is an ancient practice throughout the world, probably dating back as far as 7000 B.C, in the form of shifting cultivation (World Agroforestry Centre, 2006). The term agroforestry was coined in 1977 and it describes a farming system in which trees, agricultural crops and livestock are produced at the same time or in sequence on same piece of land (World Agroforestry Centre, 2006). It is an innovation promoted for efficient and increased farm productivity, overcoming adverse soil (Young, 1997) and climatic changes and exploiting market opportunities (Price, 1995; Brenner, 1996). Agroforestry has therefore, been evolving overtime, capturing a lot of international attention as a viable alternative to many traditional land use systems. Current thinking places agroforestry as a dynamic ecologically-based natural resources management system that through the integration of trees on farms and in the agricultural landscape diversifies and sustains production for increased socioeconomic and environmental benefits (Agea *et al*., 2007). In this respect, agroforestry has potential for increased household access to a range of forest products including food, fuelwood, building materials, medicine and fodder.

By World Bank estimates, over 1.2 billion people derive their livelihoods from agroforestry systems. Owing to its capacity to enhance multiple functions in agriculture, agroforestry will become increasingly important in land-use practices around the world (World Agroforestry Centre, 2008). If properly conceived

Corresponding Author: Clement Akais Okia, Department of Community Forestry and Extension, Faculty of Forestry and Nature Conservation, Makerere University P.O. Box 7062, Kampala Uganda

and practiced, agroforestry can contribute to sustained productivity of natural resource base by enhancing soil fertility, controlling erosion, enhancing microclimate of cropping and grazing lands and general improvement of the environment. The importance of agroforestry in Africa can therefore, not be understated (Cook and Grut, 1989; Kerkhof, 1990; Okigbo, 1990). For Uganda, the country has two strong paradigms for exploiting the potential benefits of agroforestry (Agea *et al*., 2007).

Firstly, the potential for agroforestry to improve farmers' livelihoods is in line with the national Plan for Modernisation of Agriculture (PMA) part of its poverty eradication strategy, which aims at modernizing agriculture/developing farming for improved food security and commercial gain. Unlike other agricultural modernization plans, which focus on mechanization and high-tech systems, the PMA focuses on ensuring that subsistence farmers have better access to a wide variety of sustainable, low-input agricultural techniques-including agroforestry (World Agroforestry Centre, 2003).

Secondly, the district forest services within the decentralised government framework, enables service providers to promote appropriate agroforestry interventions depending on local conditions. In addition, there are a number of strong campaigns by government and non-government organizations in favour for agroforestry in order to relieve the pressure on natural forests (Agea *et al*., 2007). Agroforestry technologies and innovations can therefore, make significant contribution towards addressing high levels of poverty and associated land degradation in Uganda. For this to happen, however, there is need to promote agroforestry technologies and innovations that farmers can invest in and that in turn generate incomes and/or save them costs they incur. It is upon this background that this study sought to develop an inventory of agroforestry technologies and innovations in Uganda and to prioritise them according to Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) criteria and also, according to Trees on Farm Network (TOFNET) different problems domain areas in Uganda.

MATERIALS AND METHODS

Uganda, the pearl of Africa and source of the great River Nile is a land-locked country in East Africa, located between 4°N and 1°S of the equator and 30°W and 35°E of Greenwich. It borders with Sudan in the North, the Democratic Republic of Congo in the West, Rwanda in the Southwest, Tanzania in the South and Kenya in the East. Uganda covers an estimated area of about 241,038 km^2, of which 197,097 km^2 is open land; 43,941 km^2 is open water and swamps (Microsoft Encarta Online Encyclopaedia, 2009). The country lies on the African plateau at altitudes ranging on average, between 900-1,500 m above sea level. Uganda's temperatures are moderate throughout the year. In Kampala, near Lake Victoria, average daily temperatures range from 18-28°C (65-83°F) in January and from 17-25°C (62-77°F) in July; in Kabale, in the highlands of the southwest, they range from 9-24°C (49-75°F) in January and from 8-23°C (47-74°F) in July (Microsoft Encarta Online Encyclopaedia, 2009).

Except for its Northeastern border area and small areas in the Southwest, Uganda generally receives sufficient rain throughout the country to permit crops to grow once or even twice a year. Most areas of the country have distinct dry and wet seasons, though the Lake Victoria area receives rain throughout the year. The driest areas, in the north, usually receive about 900 mm (40 in) annually, while the wettest, in the South, receives more than 1,500 mm (60 in) (Microsoft Encarta Online Encyclopaedia, 2009). Uganda has a population of 31,367,972 (2008 estimate). The country has an average population density of about 157 people/km^2 (407/$mile^2$). About 12% of the population is urbanized. Average life expectancy in 2008 was about 51.3 years for men and 53.4 years for women (Microsoft Encarta Online Encyclopaedia, 2009).

The study involved two approaches. First, structured questionnaires were administered to stakeholders involved agroforestry promotion (Extension staff, project managers, researchers). A total of 61 organizations were surveyed comprising NGOs (62%), CBOs (20%) and others (18%) i.e., District extension departments, research and training institutions. The questionnaire survey covered 11 districts of Uganda (Iganga, Kabale, Kampala, Kisoro, Kumi, Mbale, Mbarara, Mukono, Ntungamo, Wakiso and Soroti). The second approach involved a stakeholders' workshop to validate and prioritize the agroforestry technologies and innovations that were identified in questionnaire survey. The technologies and innovations were validated and prioritized first according to ASARECA criteria and secondly, according to TOFNET different problems domain areas in Uganda.

According to ASARECA criteria, workshop participants prioritized the above technologies by first scoring them on a scale of 1-10 (least contribution) (maximum contribution) on the attributes of economic feasibility, environmental sustainability, social acceptability, ease of adoptability and gender equitability (parity). An average score for each technology was derived from the participants' ranking. Secondly, the average score of each technology was then weighted based on the ASARECA criteria (Economic criteria- 30%, environmental criteria-25%, social criteria-20%, adoptability-15% and gender parity-10%). A judgement was then made on which technologies seem to have the highest potential. According to the different TOFNET problems domain areas in Uganda, the identified agroforestry technologies were prioritized according to the technologies most suitable for Lake Victoria and associated river basins; humid highlands; marginal areas; buffer zones; urban and peri-urban sites. Results were analysed descriptively using Excel Spread Sheet.

RESULTS

An inventory of agroforestry technologies in Uganda: The results of the inventory of agroforestry technologies in the eleven surveyed districts of Uganda revealed a number of technologies/innovations as being used by farmers. A total of twenty-one technologies/innovations were documented and these ranged from apiary systems, agrosilvofishery (aquaforestry), biomass transfer, boundary planting, improved fallowing, fodder bank to other technologies such as windbreaks/shelter belts, trees on cropland, homegardens and woodlots (Table 1). Some technologies such as high value tropical fruit tree orchards (elite *Mangifera indica*, *Persea americana*, *citrus*, *Carica papaya*, *Psidium guajava*, *Passiflora edulis*, *Anona senegalensis*, *Anona cherimoya* and *Anona muricata*) were reported to be common especially in warmer areas while, those of high value temperate fruit tree orchards such as apples and pears were said to practiced in cold and humid highland areas especially of Kabale, Mbale and Kapchowra districts of Uganda.

Technologies such as homegardens and woodlots were reported to be predominantly common in central Uganda. But generally speaking, most of the technologies such as apiculture, agrosilvofishery (aquaforestry), trees scattered on croplands and trees on pasture/rangeland cut across the whole country. Other technologies however, need improvement because it was reported during the survey that some farmers are still stuck with their traditional ways of doing things. Such technologies include apiculture and trees on cropland. In the case of trees on cropland, most farmers were said to just retain the trees scattered all over the farm and that rarely are these trees deliberately planted. This has an implication in that it makes tilling the land especially by ox-plough difficult. While, for the case of apiculture (a form of silvopastoral system where bees are considered as a mini-livestock), traditional methods of apiary technology are still very rampant in most parts of the country. Modern apiary technologies such the use of Kenya Top Bar Hives (KTBH) is yet to pickup.

Prioritized agroforestry technologies according to ASARECA criteria: Stakeholders' prioritization of the technologies according to ASARECA criteria revealed very interesting patterns. Fruit tree gardens/orchards, home gardens, woodlots, apiary (apiculture) and Agrosilvofishery (aquaforestry) were ranked highly on the attributes of economic feasibility (Table 2).

Home gardens, woodlots, trees on cropland and terrace stabilisation/contour hedges, trees on hillsides and windbreaks and shelter belts technologies were ranked best in the aspect of Environmental sustainability. With regard to social acceptability, fruit tree gardens/ orchards, home gardens, ornamental/avenue planting technologies top the list. Considering the ease of adoptability and the issue of gender parity, fruit tree gardens/orchards and home gardens were the two highly ranked technologies. Combining all the five criteria, fruit tree gardens/orchards; home gardens; woodlots; trees on cropland; terrace stabilisation/contour hedges; improved fallowing, relay and rotational cropping; fodder banks; apiary systems, ornamental/avenue planting and trees on hillsides were the top ten highly scored technologies, respectively.

Prioritised agroforestry technologies according to the different TOFNET problems domain areas in Uganda: According to TOFNET criteria, agroforestry technologies were prioritized according to different problems domains in Uganda, which included Lake Victoria and associated river basins, humid highlands, marginal areas (drylands), buffer zones and peri-urban areas. With reference to Lake Victoria and associated river basins, apiary (apicultural) systems, home gardens, boundary planting, Agrosilvofishery (aquaforestry), river bank /lakeshore/ terrace stabilization, Windbreaks and shelter belts, trees on farmland (e.g., Jatropha-vanilla and taungya technologies were the priority technologies according to the results from focus group discussions (Table 3). For humid highlands such as south-western Uganda, Mbale and Kapchorwa districts; trees on hillsides, terrace stabilization and contour hedges, fruit orchards (temperate), hedgerows, woodlots and improved fallows were chosen as priority agroforestry technologies in the workshop.

Workshop participants also placed apiary technology (apiculture); trees on pastures and rangelands; fodder banks; windbreaks and shelterbelts; live fences; fruit orchards (tropical) and taungya as priority technologies for marginal areas especially the drylands. While for buffer zone problem domain; apiary (apiculture), seed banks/seed orchards, boundary planting, biomass transfer, medicinal plant gardens and sericulture were

Table 1: An inventory of agroforestry technologies in Uganda

Technology/practices	Remarks
Apiary systems (Apiculture)	A form of silvopastoral system where bees are considered as a mini-livestock. Traditional methods of apiary systems are still very common in most parts of Uganda. Common honey bees in Uganda are *Apis mellifera adansonii*, *Apis mellifera scutelatta*, *Apis mellifera monticola,* stingless bees (*Hypertrigona gribodoi*, *Meliponula bocandei*, *Meliponula erythra*, *Meliponula nebulata* and *Meliponula lendiliana*)
Agrosilvofishery (Aquaforestry)	Common in over 31 districts of Uganda. Hedges and trees are often planted around ponds to help stabilise the pond banks, protect the pond from siltation and supply feeds to the pond. Most cultured fish species in Uganda include Nile tilapia (Oreochromis niloticus), North African catfish (Clarias gariepinus), carp (Cyprinus carpio), Tilapia zilli and Oreochromis leucostictus, Tilapia rendalli, black bass and trout giant river prawn (Macrobrochium rosenbergii) and the red swamp crawfish (Procambarus clarkii)
Biomass transfer	Mulching or green-leaf manure using foliage of trees and shrubs cut and carried to cropping areas. Common tree and shrub species used in biomass transfer are: *Mucuna pruriens, Canavalia ensiformis*, *Tithonia diversifolia, Sesbania sesban, Crotalaria ochroleuca*, *Calliandra calothrysus*, *Dolichos lablab* and *Tephrosia vogelli* species
Boundary planting	Used mainly to mark boundaries (boundary markers). But can also be used to provide protection from strong winds and also a source of firewood, fodder, timber and fruits. Common species are *Senna spectabilis* (cassia), Ficus sp., *Casuarina equisetifolia, Leucaena leucacephala*, *Sesbania sesban*, *Azadirachta indica*, Eucalyptus sp., *Mimosa scabrella.*
Improved fallowing, relay/rotational cropping	Improved fallowing is an attempt to improve traditional shifting cultivation to rejuvenate soil fertility. Instead of waiting for nature to revegetate, leguminous nitrogen-fixing multipurpose trees and shrubs are planted on the field. Common trees/shrubs used are *Sesbania sesban*, *Crotalaria grahamiana*, *Crotalaria paulina*, *Crotalaria ochloleuca*, *Mucuna pruriens*, *Canavalia ensiformis*, *Dolichos lablab*, *Tephrosia vogell, Gliricidia sepium* and *Calliandra calothyrsus.* Relay or rotation cropping is the practice of growing a series of dissimilar types of crops in the same area in sequential seasons for various benefits such as to avoid the build up of pathogens and pests that often occurs when one species is continuously cropped. The technology also seeks to balance the fertility demands of various crops to avoid excessive depletion of soil nutrients.
Fodder banks	Fast growing fodder tree species planted in a block on their own or in a mixture with fodder grasses for cut and carry. Common shrubs used are *Calliandra calothyrsus*, *Leucaena diversifolia, Leucaena leucacephala, Gliricidia sepium* and *Desmodium rensonii.*
High valued fruit tree gardens/orchards	High value tropical fruit tree orchards such as elite *Mangifera indica, Persea americana*, *citrus* (oranges), *Carica papaya*, Psidium guajavsa, *Passiflora edulis*, *Anona senegalensis*, *Anona cherimoya* and *Anona muricata* are common especially in warmer areas. High value temperate fruit tree orchards such as apples and pears are common especially in cold highland areas of Kabale, Mbale and Kapchorwa districts
Hedgerow/ alley cropping	Closely planted lines of suitable trees and spaced about five metres apart – usually by direct seeding or transplanting from tree nurseries. The lines are placed across a slope, within areas where crops or vegetables are grown. Only viable in high potential areas.
Home gardens	Common in areas of high population density. Dominant species include *Carica papaya, Psidium guajavsa, Persea americana, Mangifera indica, Passiflora edulis, Anona senegalensis, Anona cherimoya, Anona muricata, Artocarpus heterophyllus, Cyphomandra betacea, Ficus natalensis, Markhamia lutea, Azadirachta indica, Albizia lebbeck, Maesopsis eminni.*
Live fences	Used to control the movement of animals and people. Besides their main function, live fences often provide fuelwood, fodder, food and act as windbreaks or enrich the soil, depending on the species used. Common species includes: Dovyalis caffra, Ficus sp., Jatropha sp., *Gliricidia sepium* and *Erythrina* sp.
Medicinal plant gardens	Common medicinal gardens include: Artemisia annua, Ricinus communis, Phytolacca dodecandra, Iboza multiflora, *Solanum incanum*, Vernonia amygdalina, Aloe vera, *Abrus precatorius, Psidium guajava, Albizia coriaria, Erythrina abyssinica.*
Ornamental/avenue planting	Trees/shrubs are planted at homesteads or along avenues to provide aesthetic values and sometimes shade. Common species include *Delonix regia, Casuarina equisetifolia, Albizia saman, Bauhinia variegata, Araucaria cunninghamii, Eucalyptus camaldulensis*, *Cassia siamea*, Dovyalis macrocalyx, Dracaena fragrans.
Seed banks/seed orchards	Mainly for afforestation programs. e.g. at Kifu in Mukono, Nyabyeya Forestry College and Tree Seed Center to supply quality planting seeds. Some NGOs and farmer groups with support from research institutions have also established seed orchards of mainly improved fruit trees to facilitate scaling up of agroforestry in different parts of Uganda.
Sericulture	Silk is a natural textile fibre produced by silk worms which feed on mulberry tree leaves. Sericulture as an industry was initiated in Uganda in 1986 and commercial production started in 1992. Common tree species is mulberry tree (*Morus* sp.).
Taungya system	Planting of cash or food crops between newly planted trees in a plantation. Farmers raise crops while the trees are still young. After 2-3 years, depending on the tree species and spacing, the canopy closes and light-demanding annual crops can no longer be planted. Farmers then transfer to other open areas to repeat the process. Provided there is mutual understanding between parties, it's said to be a viable practice for plantation establishment.
Terrace stabilisation/ contour hedges	Common in highland areas like Kabale and Mbale districts. Common trees/shrubs used are *Calliandra calothyrsus*, *Leucaena diversifolia, Leucaena leucacephala.*
Trees on cropland	Trees mainly found scattered in crop fields without any particular pattern. Main practice in most parts of the country. In central Uganda, it is dominated by Jatropha-vanilla technology, banana-coffee and *ficus* practices.
Trees on hillsides	Common on fragile ecosystems like hillsides of southwestern Uganda. Helps stabilize the hillsides and prevent soil erosion. Common species are Ecalyptus and Cypress, pines, Black wattle.
Trees on pastures and rangelands	Trees are either scattered randomly or arranged according to some systematic pattern on established pastures or rangelands. Common in areas of extensive grazing land. Common species include Acacia sp., Ficus sp and Euphobia sp.
Windbreaks and shelter belts	Strips/belts of vegetation composed of trees, shrubs and vines to protect croplands from strong winds. They can provide protection to crops over a distance equivalent to 15-20 times the height of the trees in the windbreak. They can also help minimize wind erosion and reduce moisture loss.
Woodlots	Single tree species or a mixture established usually for firewood, poles and timber. Common tree species are Eucalyptus, Cassia, *Grevillea robusta, Cupressus lustanica*

Table 2: Prioritized agroforestry technologies according to ASARECA criteria

Agroforestry technology	Economic feasibility	Environmental sustainability	Social acceptability	Ease of adoptability	Gender parity	Total weighted score
High value fruit tree gardens/orchards	9 (2.7)	6 (1.5)	8 (1.6)	8 (1.2)	8 (0.8)	(7.80)
Home gardens	8 (2.4)	8 (2.0)	7 (1.4)	8 (1.2)	8 (0.8)	(7.80)
Woodlots	8 (2.4)	8 (2.0)	6 (1.2)	5 (0.75)	6 (0.6)	(6.95)
Trees on cropland	7 (2.1)	8 (2.0)	6 (1.2)	6 (0.9)	6 (0.6)	(6.80)
Terrace stabilisation/contour hedges	7 (2.1)	8 (2.0)	6 (1.2)	5 (0.75)	5 (0.5)	(6.55)
Improved fallowing, relay and rotational cropping)	7 (2.1)	7 (1.75)	6 (1.2)	5 (0.75)	6 (0.6)	(6.40)
Fodder banks	7 (2.1)	6 (1.5)	6 (1.2)	6 (0.9)	6 (0.6)	(6.30)
Apiary systems	8 (2.4)	7 (1.75)	5 (1.0)	4 (0.6)	5 (0.5)	(6.25)
Ornamental/avenue planting	5 (1.5)	7 (1.75)	7 (1.4)	6 (0.9)	6 (0.6)	(6.15)
Trees on hillsides	6 (1.8)	8 (2.1)	5 (1.0)	5 (0.75)	5 (0.5)	(6.05)
Agrosilvofishery (aquaforestry)	8 (2.4)	6 (1.5)	5 (1.0)	4 (0.6)	5 (0.5)	(6.00)
Windbreaks and shelter belts	5 (1.5)	8 (2.0)	6 (1.2)	5 (0.75)	5 (0.5)	(5.95)
Medicinal tree gardens	6 (1.8)	6 (1.5)	6 (1.2)	5 (0.75)	6 (0.6)	(5.85)
Boundary planting	5 (1.5)	7 (1.75)	5 (1.0)	6 (0.9)	6 (0.6)	(5.75)
Trees on pastures and rangelands	6 (1.8)	7 (1.75)	5 (1.0)	5 (0.75)	4 (0.4)	(5.70)
Seed banks	7 (2.1)	6 (1.5)	5 (1.0)	4 (0.6)	5 (0.5)	(5.70)
Hedgerow/Alley cropping	6 (1.8)	7 (1.75)	5 (1.0)	4 (0.6)	5 (0.5)	(5.65)
Sericulture	7 (2.1)	6 (1.5)	4 (0.8)	4 (0.6)	4 (0.4)	(5.40)
Taungya system	5 (1.5)	6 (1.5)	5 (1.0)	4 (0.6)	5 (0.5)	(5.10)
Biomass transfer	5 (1.5)	6 (1.5)	4 (0.8)	5 (0.75)	5 (0.5)	(5.05)
Live fences	4 (1.2)	6 (1.5)	5 (1.0)	5 (0.75)	5 (0.5)	(4.95)

Figures bracketed are the weighted rank scores. Those un-bracketed are the un-weighted rank scores

Table 3: Prioritized agroforestry technologies according to the different TOFNET problems domains in Uganda

Problems domains	Priority agroforestry technologies/innovations
Lake Victoria and associated river basins	Apiary (apiculture)
	Homegardens
	Boundary planting
	Agrosilvofishery (aquaforestry)
	River bank /lakeshore /terrace stabilization
	Windbreaks and shelter belts
	Trees on farmland (e.g., Jatropha-vanilla, Coffee-banana-ficus)
	Taungya system
Humid highlands	Trees on hillsides
	Terrace stabilization and contour hedges
	Fruit orchards (temperate)
	Hedgerows
	Woodlots
	Improved fallowing
Marginal areas (drylands)	Apiary (apiculture)
	Trees on pastures and rangelands
	Fodder banks
	Windbreaks and shelter belts
	Live fences
	Fruit orchards (tropical)
	Taungya
Buffer zones	Apiary (apiculture)
	Seed banks/seed orchards
	Boundary planting
	Biomass transfer
	Medicinal tree gardens
	Sericulture
Peri-urban areas	Home gardens
	Woodlots
	Ornamental/avenue plantings
	Windbreaks and shelter belts
	Biomass transfer
	Fodder banks
	Boundary planting

considered the priority agroforestry technologies. With regard to the problematic peri-urban areas, the following technologies were considered as priorities: home gardens, woodlots, ornamental/avenue plantings, windbreaks and shelter belts, biomass transfer, fodder banks and boundary planting.

DISCUSSION

Many Ugandans today, have great expectations from agroforestry. Yet, if current efforts to understand, develop and disseminate agroforestry technologies/practices are to have any hope of meeting even a reasonable proportion of current expectations, its deployment, as a newly organized branch of applied science, must take place within a certain context. This study therefore, attempted to prioritize agroforestry technologies and/or practices in Uganda according to ASARECA and TOFNET criteria. It was therefore, clear from our results that certain agroforestry technologies for instance fruit tree gardening, homegardens, woodlots, apiary/apiculture and Agrosilvofishery (aquaforestry) will be easily taken-up because of their economic feasibility or rather financial profitability. Raintree (1983) also underscored the importance of economic feasibility as a criterion to selection of agroforestry technologies. He emphasizes the need of going beyond qualitative functional specifications to quantify and evaluate the relative economic advantage of different agroforestry alternatives. This will give agroforestry technologies a fair chance of being adopted. There is no doubt that because of the galloping poverty in Uganda, farmers will always first look at economic feasibility of either enterprises or technologies they would adopt.

It has long been recognized that environmental sustainability of agroforestry technologies is one of the other fundamental criteria and, in fact, one of the most appreciated and hoped-for of agroforestry technologies (Murniati *et al*., 2001). Available information indicates that agroforestry can provide a greater range of environmental benefits than conventional types of annual crop cultivation. Such environmental benefits may include increased biodiversity and vegetation cover, reduced soil erosion and land degradation, increased water quantity and quality, increased water infiltration and soil quality, enhanced production of organic matter; enhanced soil fertility; improved microclimate for associated crops and livestock; increased availability of fuelwood, protection from strong winds and provision of shade. It is not therefore, surprising that the workshop participants in our study highly prioritized homegardens, woodlots, trees on cropland, contour hedges, trees on hillsides and windbreaks and shelter belts as the best in regards to environmental sustainability. One of the often-key motivations for farmers to practice agroforestry is that the technologies should be able to generate these benefits in addition to economic/financial benefits accruing from such technologies (Agea *et al*., 2007).

Social considerations of agroforestry technologies is often much emphasized in agroforestry literature. For example Burch and Parker (1991), pointed out that social aspects of agroforestry are critical factors in choosing agroforestry technologies, practices and systems. Social acceptability implies how the technology would fit within the ever-dynamic land tenure systems (Bruce and Fortmann, 1988), labour requirement (Hoskins, 1987), cultural norms and beliefs (Agea *et al*., 2007). It is therefore within this framework that stakeholders in present study ranked fruit tree gardening, homegardens, ornamental and avenue planting as the top priority agroforestry technologies according to this social acceptability criteria. Social acceptability is henceforth, by no qualm important because agroforestry conventionally emphasizes the relationship of its components such as trees with people.

The ease of adoptability as a determinant that underpins farmers' choices of agroforestry technologies and innovations has also been reported in agroforestry literature. Rogers (1995) identified five key characteristics of technology that determine their adoption potential as relative advantage, trialability, compatibility, observability and complexity. The most significant of these are usually high relative advantage, high compatibility and low complexity (Tornatzky and Klein, 1982). In the study, considering the ease of adoptability, fruit tree orchards and homegardens were the two highly ranked technologies. It is important to note however, that some innovative agroforestry technology/practices are influenced by gender issues and in most cases adapted by women and customized to fit the farm niches and products over, which they tend to have greater control. In this respect, fruit tree orchards and home gardens were again prioritized as the best technologies that take into account particularly the women concerns and interests. This pattern of ranking is strongly supported by Akinnifesi *et al*. (2006) who found out that 86% of the planting sites in Malawi and 98% in Zambia were located on homesteads.

Women were also the principal managers of these sites and were likely to benefit the most from production. Women were also, the principal recipients of training in the local production of fruit concentrates, jam, juice and other products in Malawi, Tanzania, Zambia and Zimbabwe (Ham *et al*., 2008). Since, farmers always have multiple criteria upon which they base their decisions of whether to uptake an agroforestry technology or not, fruit tree gardening; homegardens; woodlots; trees on cropland; terrace stabilization (contour hedges); improved fallowing, relay and rotational cropping; fodder banks; apiculture, ornamental/avenue planting, trees on hillsides are highly favoured technologies when all the five criteria combined.

Past studies have shown that agroforestry systems, technologies and practices can also be prioritised and/or classified according ecological zones and/or problem domain areas in order to provide a framework for evaluating those systems, technologies or practices and to develop action plans for their improvement. Nair (1985) and Young (1997) for example classified tropical and sub-tropical agroforestry systems according to humid and sub-humid lowland, dry regions and highlands. In the study, the stakeholders prioritised agroforestry technologies/practices into four-problem domain areas of Lake Victoria and associated river basins; humid highlands; marginal areas; buffer zones; urban and peri-urban areas. The prioritization here reflected the inherent problems in these areas. As such, intensive agroforestry technologies such as homegardens were more associated with Lake Victoria basin and urban/peri-urban problem domain areas. Technologies such as temperate fruit tree orchards were more unique to cold and humid highlands while tropical fruit orchards were better suited for drylands. It must however, be strongly noted that prioritising agroforestry technologies/practices according to problem domain areas alone cannot be taken as a satisfactory basis for prioritisation because several agroforestry technologies/practices are relevant to any problem domain area; depending on the special conditions of any problem domain area, the emphasis of the technology/practice will also vary.

CONCLUSION

This article has focused on candidate agroforestry technologies/practices for Uganda. A number of technologies/practices have been discussed in relation to ASARECA criteria of prioritization of agroforestry technologies and TOFNET different problem domain areas in Uganda. Fruit tree orchards; homegardens; woodlots; trees on cropland; terrace stabilisation (contour hedges); improved fallowing, relay and rotational cropping; fodder banks; apiary systems, ornamental/avenue tree planting; trees on hillsides were the top ten highly scored agroforestry technologies according to ASARECA criteria of prioritization. Technologies such as temperate fruit orchards were more unique to humid highlands, while tropical fruit orchards were better suited for drylands. Intensive agroforestry technologies such as homegardens were more associated with Lake Victoria basin and urban/peri-urban problem domain areas. Meanwhile, technologies like (apiculture), boundary planting and biomass transfer are more preferred for buffer zone areas.

RECOMMENDATIONS

There is a need for promotion of diversified agroforestry technologies/practices. Whether, on Lake Victoria and associated river basins; humid highlands; marginal areas; buffer zones; urban/peri-urban areas, diversified agroforestry technologies may be the most appropriate form of land use where land tenure constraints or an unfavourable political economy make it imperative for small landholders, in trying to reduce risks, in order to satisfy most of their basic needs directly from the land resources under their control.

There is also need for revision of government policies to enhance and encourage the development of agroforestry technologies in ways that are economically appropriate for the farmers. These policies should include long-term development strategies; national and regional program plans and structures, financial incentives (such as loans and subsidies) and establishment of agroforestry technologies demonstration sites in the different regions of the country.

Lastly, there is urgent need for consolidation of scientific and technological robustness of agroforestry technologies through intensification of on-farm testing of innovations with farmers. This would be a positive step towards up-scaling the candidate technologies.

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REFERENCES

Agea, J.G., S. Namirembe, M. Bukenya, A. Zziwa and D. Waiswa, 2007. Agroforestry In-Service Training Manual: Design of Appropriate Agroforestry Interventions in Uganda. Fountain Publishers, Kampala Uganda. ISBN: 978-9970-02-677-7.

Akinnifesi, F.K., F. Kwesiga, J. Mhango, T. Chilanga, A. Mkonda, A.C.C. Kadu, I. Kadzere, D. Mithofer, J.D.K. Saka, G. Sileshi, T. Ramadhani and P. Dhliwayo, 2006. Towards the Development of Miombo Fruit Trees as Commercial Tree Crops in Southern Africa. Forests, Trees and Livelihoods, 16: 103-121.

Brenner, A.J., 1996. Microclimatic Modifications in Agroforestry. In: Ong, C.K. and P. Huxley (Eds.). Tree-Crop Interactions: A Physiological Approach. CAB International, Wallingford, UK., pp: 159-187.

Bruce, A. and L. Fortmann, 1988. Whose Trees! Westview Press, Boulder, CO, USA.

Burch, R.B. Jr. and J.K. Parker, 1991. Social Science Application in Asian Agroforestry. Winrock International, Arlington, VA, USA.

Cook, C.C. and M. Grut, 1989. Agroforestry in Sub-Saharan Africa. World Bank, Technical Paper No. 112, Washington, DC.

Ham, C., F.K. Akinnifesi, S. Franzel, D.P.S. Jordaan, C. Hansmann and C. De Kock, 2008. Opportunities for Commercialization and Enterprise Development of Indigenous Fruits in Southern Africa. In: Akinnifesi, F.K., R.R.B. Leakey, O. Ajayi, G. Sileshi, Z. Tchoundjeu, P. Matakala and F.R. Kwesiga (Eds.). Indigenous Fruit Trees in the Tropics: Domestication, Utilization and Commercialization. Nairobi: World Agroforestry Centre; Wallingford, U.K: CAB International Publishing, pp: 254-272.

Hoskins, M.W., 1987. Agroforestry and the Social Milieu. In: Steppler, H.A. and P.K.R. Nair (Eds.). Agroforestry: A Decade of Development. ICRAF, Nairobi, Kenya, pp: 191-203.

Kerkhof, P., 1990. Agroforestry in Africa. Panos Institute, London.

Microsoft Encarta Online Encyclopaedia, 2009. Uganda. http://encarta.msn.com.

Murniati, D.P., D. Garrity and A.N. Gintings, 2001. The contribution of agroforestry systems to reducing farmers' dependence on the resources of adjacent national parks. Agrofor. Syst., 52: 171-184.

Nair, P.K.R., 1985. Classification of agroforestry systems. Agrofor. Syst., 3: 97-28.

Okigbo, B.N., 1990. Sustainable Agricultural Systems in Tropical Africa. In: Edwards, C.A., L. Rattan, P. Madden, R.H. Miller and G. House (Eds.). Sustainable Agricultural Systems. Soil and Water Conservation Society, Ankeny, pp: 323-352.

Price, C., 1995. Economic evaluation of financial and non-financial costs and benefits in agroforestry development and te value of sustainability. Agrofor. Syst., 30: 75-86.

Raintree, J.B., 1983. Bio-economic Considerations in the Design of Agroforestry Cropping Systems. In: Huxley, PA. (Ed.). Plant Research in Agroforestry. ICRAF. Nairobi.

Rogers, E.M., 1995. Diffusion of Innovations. 4th Edn. The Free Press, New York.

Tornatzky, L.G. and K.J. Klein, 1982. Innovation characteristics and innovation adoption-implementation-a meta-analysis of findings. IEEE. Trans. Eng. Manage., 29: 28-45.

World Agroforestry Centre, 2003. Agroforestry in Action-Agroforestry a priority in modernizing Ugandan agriculture. Annual Report. International Centre for Research in Agroforestry (ICRAF), Nairobi, Kenya.

World Agroforestry Centre, 2006. Agroforestry for improved livelihoods and Natural resources conservation An Agroforestry Policy Brief. International Centre for Research in Agroforestry (ICRAF), Nairobi, Kenya.

World Agroforestry Centre, 2008. Annual Report 2007-2008: Agroforestry for food security and healthy ecosystems. World Agroforestry Center (ICRAF), Nairobi, Kenya, pp: 68.

Young, A., 1997. Agroforestry for Soil Management. CABI, Wallingford, UK.