LAND USE SYSTEM ANALYSIS FOR ANNUAL CROPS AND WOODY PERENNIALS COMBINATIONS IN THE LOWER SHIRE VALLEY

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EXECUTIVE SUMMARY

Agro-ecosystems in Malawi are complex and diverse as they respond to human resource uses. As such, all the landscapes in which the woodlands are found tend to be dominated by human settlements and therefore are exposed to different levels of use for provision of different services including energy, construction materials, and a diversity of non-timber forest products. As such, a variety of indigenous and exotic trees are grown or maintained and managed on farms to provide a variety of products and service functions that are always on demand.

There are different farming systems both traditional and improved that are being practiced by most farm families in the Lower Shire Valley. According to the study findings, the main food crops in the Lower Shire Valley are maize, sorghum, millet (finger and brush), beans and pigeon peas. Sorghum is resistant to drought hence, acts as an alternative staple food to maize especially during drought periods while cotton is the major commercial crop in the Lower Shire districts. In addition, the Lower Shire Valley is one of the areas in Malawi with a high number of livestock. The Lower Shire Valley with 112,014 cattle comes second after Mzimba district in terms of cattle population. These animals, for example, Cattle and goats are a source of milk; chicken are a source of eggs; while Cattle, goats, chicken and other domesticated animals also provide meat and cash income. Cattle and goats are grazed in *dambos*, natural woodlands and farmland.

The study found that households and smallholder farmers retain or grow on their farmland some preferred tree species for food production. Such trees may have the ability to ameliorate the soil, provide fruits as food to supplement diet, fodder to livestock and also conserve soil water. A variety of tree species are retained on the farmland to maintain soil fertility. The trees include; *Faidherbia albida, Acacia polyacantha, Gliricidia sepium, Albizia lebbeck and Senna siamea*. Apart from other uses, *Moringa oliefera* and *Zyziphus mauritiana* are used for live fencing while *Adansonia digitata, Z. mauritiana, Brideria micrantha* and *Cordylla africana* are retained as sources of fruits. Most of the woody components in agro-ecosystems occur naturally long after years of selective management by farmers. Farmers decide which tree species to retain on farm based on their multiple uses and allied products of a tree species. Regrettably, important tree species in the Lower Shire Valley are also being threatened by land conversion and overharvesting. Artificial regeneration in nurseries and assisted natural regeneration on farm is therefore needed to allow the sustainable use of these tree resources.

The study revealed that the major constraints being faced by the farmers which affect livelihoods are land degradation, declining soil fertility, shortage of fuelwood, lack of planting materials for fruit trees and shortage of fodder in the dry season. It was observed that several agroforestry technologies such as homestead planting,

woodlots, mixed intercropping and live fencing could be promoted to improve food production. From the study, some of the current policies on issues of land tenure and the extension system set-up in the country were shown to be weak to increase productivity.

1.0 Introduction and background

A variety of indigenous and exotic trees are grown or maintained and managed on farms to provide a variety of products and service functions. Previous work on the description of the farming systems by World Agroforestry Centre (ICRAF) was mainly based on the current farming systems with emphasis on the role of crops and animals. The only traditional system that has been a subject of detailed studies is that of *Faidherbia albida* agroforestry system which is popular in Bwanje Valley and other Lake Shore areas. There are other traditional systems that have some tree species that are prominent in farming systems such as *Syzygium cordatum* in Tsangano, *Erythrina abysinica* in Lilongwe and Kasungu plain, *Bauhinia thoningii* in Lilongwe and Mchinji, *Philenoptera violaceae* (formerly *Lonchocapus capassa)* in Balaka and Lakeshore areas, *Azadirachta indica* and *Moringa oleifera* in the Shire Valley (Chirwa *et al.* 2004). These farming systems have not been studied in detail to understand the role and management interventions that will improve the overall productivity of the system.

Agro-ecosystems in Malawi are complex and diverse as they respond to human resource uses. These ecosystems include, by definition, people and their institutions, as well as the agricultural biodiversity and trees in the landscape that they use and influence through their diverse range for their livelihood and well-being. Trees in the landscape represent a key element in managing the relationship between forest and agriculture that result into agricultural biodiversity in traditional forest land use management (Chirwa and Mala 2016).

All the landscapes in which the woodlands are found tend to be dominated by human settlements and therefore are exposed to different levels of resource exploitation for provision of different services including energy, construction materials, and a diversity of non-timber forest products. The current status of the woodlands is largely driven by the land use to which they are exposed with the main drivers of forest cover change being agricultural expansion, energy, in the form of fuel wood and charcoal, urbanization, and extractive mining (Handavu *et al.* 2018).

A growing human population has had a great influence on land use change, resource use and management in Malawi. Increasing population, accelerating deforestation, poor soil and water management, increasing poverty and land degradation directly impact the food security and human health of millions of Malawians (ICRAF 2014).

The human-nature processes for managing agricultural biodiversity have been documented in the tropics but the relationships between the management of woody perennials (trees) and the dynamics of land use systems remain poorly investigated as well as their adaptability to the traditional forest management systems (Chirwa and Mala 2016).

Peham (1996) conducted a survey around Chaoni in Machinga district, where he found that many households and smallholder farmers retain or grow and manage different tree species on their farmlands. Some of the species included *Cussonia arborea*, *Bridelia micrantha* and *Acacia tortilis* because of their compatibility with crops. *Pterocarpus rotundifolius* and *Ficus* species were apparently retained due to their water retention abilities (normally used as water indicators) while *Vitex, Ficus, Strychnos* species, and *Vangueria infausta* provide additional nutrition from the fruits. Species used as source of poles and timber included *Bequaetiodendra magalismontanum* and *Pterocarpus angolensis*.

The objective of this study, therefore, was to investigate the existing combinations involving annual crops and woody perennials (trees and shrubs) including tree use and management practices and develop strategies for improving and/or optimising the system's performance. The specific objective was to evaluate and observe how the households and smallholder farmers integrate, sustainably manage and utilize different tree species in their farming systems in order to satisfy their basic needs for food, healthy, shelter, income, security and welfare. This report presents findings of a study on land use practices conducted in the Lower Shire Valley.

2.0 MATERIALS AND METHODS

2.1 Study Site description

Chikwawa district (Figure 1) is located in the Lower Shire Valley, which falls under silvicultural zone A (Hardcastle 1978). The climate is relatively hot and dry with a mean annual rainfall of between 700- 1000mm and the rain season starts from November to April. The mean annual temperature ranges from 25°C - 26°C. The mean monthly temperatures are at their highest (27.5°C - 30°C) (Venema 1991). Soil analysis for samples collected (0-30cm depth) in Chikwawa fields revealed that the general physical property of the soil in farmlands is sandy loam. The soils have a relatively medium content of nitrogen and exchangeable potassium whereas available phosphate is considerably high which is in contrast to what is found in most soils in Malawi where they lack phosphorus (Chirwa *et al* 2004). The soil reaction is medium ranging from pH 5.5 – pH 6.8 indicating a slight acidity to neutral. This however makes it possible for most plant nutrients to be readily available for plant use.

Nsanje (Figure 1) is the southernmost district in Malawi lying in the Lower Shire River Valley. It straddles the Shire River in the north (the river forms most of Nsanje's eastern boundary) and is surrounded by Mozambique. Mwabvi Game Reserve lies in the north-western part of the district and can be accessed from Bangula or Sorgin

(both along the M-1 road). Elephant Marsh lies partially in the northern part of the district and can be accessed via the eastern bank road. Elevation is around 61m above sea level except for some hills in the south-western part of the district which reach near to 610 m above sea level. Temperatures get as hot as 52 °C in November and around 8 °C in June. Rainfall averages around 750 mm yearly from January through April.

The hydrology of the Lower Shire Valley is dominated by the Shire River, the only outlet of Lake Malawi and one of the crucial tributaries to the Zambezi River (Mwale *et al*. 2015). In addition to the Shire River, flooding in the region is caused by the flash flooding of the Ruo River and a dense network of smaller streams, that flash flood in the rainy season, mainly caused by the rainfall falling in the upper districts. Floods are likely to occur on an annual basis and the floods risk in the Lower Shire Valley is a combination of the hazard characteristics (e.g. location, high levels of siltation, land use change, deforestation) and contributing vulnerability factors (e.g. socio-economic and environmental susceptibility) (Mwale *et al*. 2015). There are limited studies on droughts and dry spells conducted in the Lower Shire Valley to ascertain hazard characteristics and vulnerability factors. However, it is common knowledge that dry spells occur in the rainy season, in the months from December to February, and lead to reduced crop yields, lack of accessibility to safe water sources and scarcity of land for animal grazing (GoM 2015). Due to the high dependence on rain-fed agriculture, prolonged dry-spell impacts in the Lower Shire Valley have resulted several times in serious humanitarian crisis (GoM 2011).

2.2 Social economic status

Chikwawa and Nsanje district are predominantly composed of Mang'anja people and Sena people respectively. The Mang'anja has a matrilineal line of system while the Sena practice patrilineal system. The traditional cash crop is cotton while the staple food is maize, which tends to be substituted by sorghum during drought periods.

Maize, millet, sorghum, rice, sweet potatoes, beans and cotton are all grown using almost entirely rain fed agriculture. In Nsanje, maize is grown in marshes post rain season; people within Nsanje Boma grow around Ndindi marsh area; and those within Bangula use Chisamba and Makhanga marshes. Traditionally, cattle are kept for prestige rather than as source of income. The Lower Shire has a lot of livestock such as cattle, goats, sheep, and domesticated birds. Presently, cattle are an important source of income but also as a security. Most of the rich people in the Lower Shire accumulated their wealth through livestock farming. Fishing is another economic activity that sustains lives of many. Other forms of income in Lower Shire Valley are seasonal hired labour at Illovo Sugar Company in Nchalo.

2.3 Methodology

Apart from using relevant published literature, documents, reports on sustainable land management covering the study area, the study used field visitation, field observation, and key informant interviews within the study area to gather data for the study. The key informants consisted of local leaders, Lead farmers and agricultural extension agents. Focus group discussion which were supposed to be part of the data collection method, were not done due to Covid 19 pandemic restrictions.

Field visitation was undertaken for field data collection after preparing clear protocols and guidelines for each component of data collection. The main components of field data collection in this case were instrument design and enumerator coaching. Each of these components was carried out based on best practices in field data collection. The research team therefore established clear channels for regular communication among entire data collection team to effectively collect quality data.

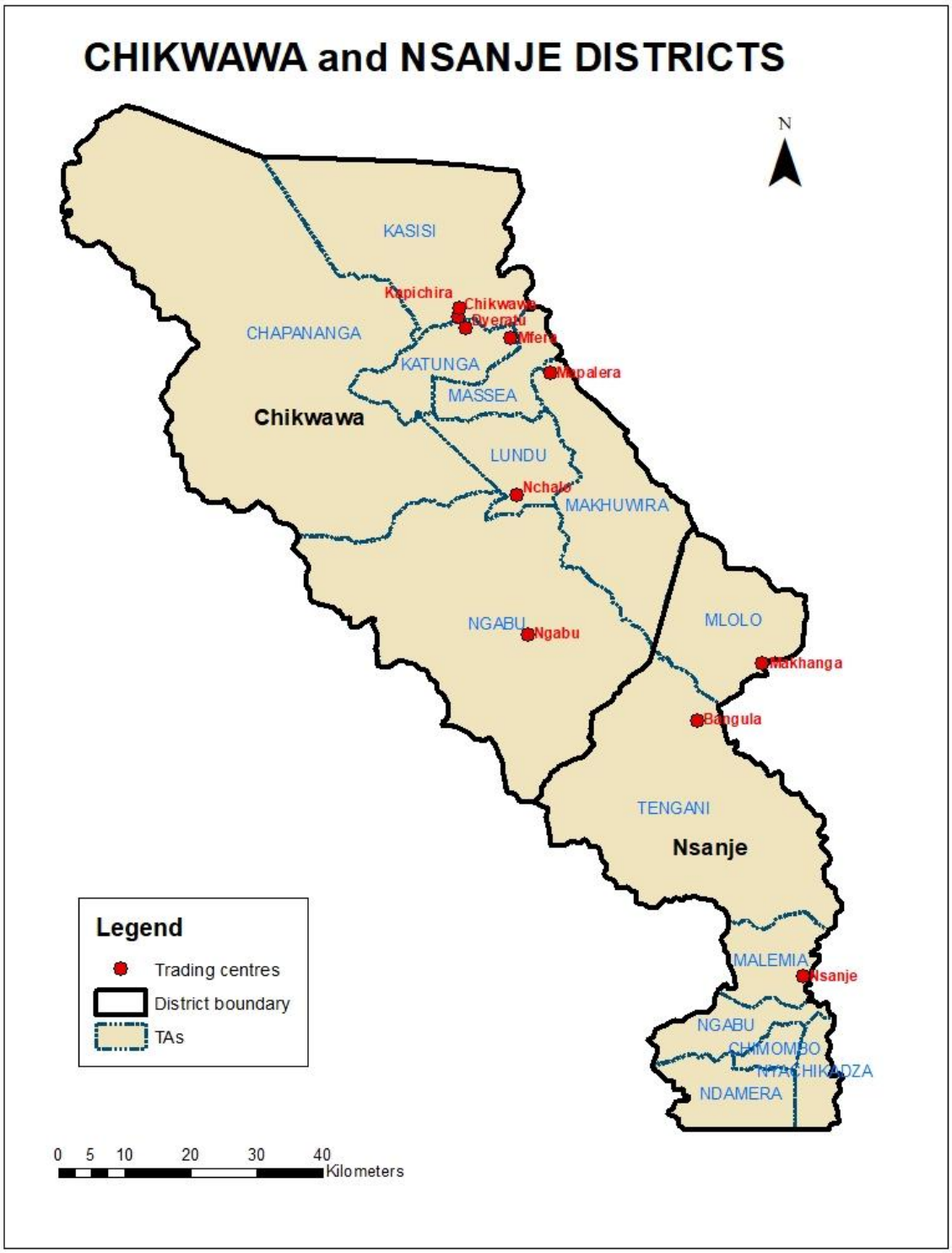

Figure 1: Map of the Lower Shire Valley showing Location of the study area

Observation method was used in data collection. This is a data collection method by which knowledge of the researched phenomenon was gathered through making observations of the phenomena, as and when it occurred. Observation is a way of gathering data by watching behavior, events, or noting physical characteristics in

their natural setting. Observation is used in the social sciences as a method for collecting data about people, processes, and cultures. For a study of this nature, observation method was found to be suitable as it enabled good capture of the various landscape configurations. To provoke open discussion during Key Informant Interviews, overt observation was applied in this study as opposed to covert.

Key Informant Interviews were conducted in the study area to collect data for the study. Key Informant Interviews are qualitative in-depth interviews with people who know what is going on in the community and their surroundings. Within the context of research on woody perennials – annual crop combinations, key informant refers to the person with whom an interview about a particular practice was conducted. The purpose of Key Informant Interviews was to collect information from a wide range of people including community leaders, professionals, or key players who have firsthand knowledge about the community practice. Key Informant Interviews in this study involved interviewing local leaders, lead farmers and extension agents as these were regarded as having a particularly informed perspective on woody perennials – annual crop combinations that were being studied within the Lower Shire Valley. Key informant interviews were conducted as one-on-one assessments that allowed the data collection team to gain insight about the said land-use practice and the motivation behind the practice.

2.4 Data Analysis

Data analysis was heavily dependent on the researcher's analytic and integrative skills and personal knowledge of the social context where the data was collected. The emphasis was "sense making" or understanding a phenomenon, rather than predicting or explaining. As such, content and thematic analysis was applied to the collected qualitative data to generate sense or understand the phenomenon (Schilling 2006).

Content analysis is one of the most common methods to analyze qualitative data and in this study it was used to analyze gathered information from interviewees. Content analysis was used to analyze content systematically on who said what, to whom, why, and to what extent and with what effect in a qualitative manner (Schilling 2006).

Thematic analysis involved working out the concept, thought, opinion or belief that was expressed by respondents. Thematic analysis is used in qualitative research and focuses on examining themes or patterns of meaning within data. This method emphasizes both organization and rich description of the data set and theoretically informed interpretation of meaning (Schilling 2006).

Therefore, in this study, where qualitative data was collected, content and thematic analysis was used to explain the data. The choice of these approaches was based on their suitability to the data that was collected.

3.0 RESULTS AND DISCUSSION

3.1 Agro-ecosystems of the study area

A variety of agricultural crops are grown in the Lower Shire during both the main and winter cropping seasons. The main food crops are maize, sorghum, millet, beans and pigeon peas. Cotton is the major commercial crop in the Lower Shire Valley districts. Sorghum is resistant to drought hence, acts as an alternative staple food to maize especially during drought periods.

There are different farming systems both traditional and improved that are being practiced by most farm families in the Lower Shire Valley. For instance, making of ridges is not commonly practiced; instead, minimum tillage is used for crop establishment in contrast to what is practiced in many parts of the country where plants are planted on the ridges. Intercropping system of farming is very well adopted in most parts of the districts where maize is planted together with pigeon peas or other legume crops including Agroforestry trees. The other traditional farming systems were observed in Nyachirenda EPA in TA Ndamera, Nsanje where people are converting part of Lulwe forest into agricultural land. Cultivation of hill steep slopes (Figure 2) is intensifying in the area and reducing area under forest cover but also expose the cultivated land to serious soil erosion even though terracing is applied to the disturbed area. Vetiver is also planted on cultivated slopes in an attempt to check surface run-off.

Figure 2: Hill slope cultivation in Ndamera area of Nsanje district

3.1.1 Livestock Farming

The Lower Shire Valley is one of the areas in Malawi with a high number of livestock. The most common types of domestic animals are cattle, goats, pigs and chicken.

According to NSO (2019), 92,737 households in the Lower Shire Valley keep 213,850 goats, 32,993 pigs, 112,014 cattle, 4698 sheep and 480,011 chickens. This translates into livestock densities of 32 goats per km^2, 5 pigs per km^2, 17cattle per km^2, and 72 chickens per km^2. The Lower Shire Valley comes second after Mzimba district in terms of cattle population. People keep livestock especially cattle not only for sale but also for societal prestige. These animals, for example, Cattle and goats are a source of milk; chicken are a source of eggs; while Cattle, goats, chicken and other domesticated animals also provide meat and cash income. Movement of livestock and meat from the Shire Valley is strictly regulated by the Department of Veterinary services to control foot and mouth disease.

Cattle and goats are grazed in *dambos*, natural woodlands and farmland. During the cropping season, there are recognized user rights to the land but once the agricultural crops are harvested, the rest of the community have usufruct rights to the land as grazing of livestock becomes the major activity off cropping season (Chirwa *et al* 2004). However, there may be competition for land between cattle owners and the 'land owner' especially when the owner of the farmland has planted trees on their farm to control and strengthen tenureship. Generally, farming and tree planting in the Lower Shire Valley is constrained by animal grazing. Notwithstanding, farmers take advantage of the winter rains to cultivate in the wetlands where crops like maize, sweet potato, cassava and vegetables are grown.

A number of indigenous and exotic tree species and/or shrubs were identified as fodder for livestock (Table 1). Some of these are planted on homesteads and farmland. Plants such as *Manihot glaziovii (Mpira),* reeds (Mabango) and elephant (Nsenjere) are another good source of animal fodder in the Lower Shire Valley.

Table 1: Common tree species browsed by livestock in the Lower Shire Valley

Livestock	Tree species browsed	Vernacular Name
Goats	*Boscia salisfolia*	*Mtakala/Mtukila*
Sheep	*P. violaceae*	*Chimphakasa*
Pigs	*Z. mauritiana*	*Masau*
	S. quinquiloba	*Msetanyani*
	C. africana	*Mtondo*
	A.indica	*Neem*
	Vossia cuspitata	*Kateta/Kauteka/Nduvi*
	M. obstifolia	*Mbewe*
	S. siamea	*Kesha wa Milimo*
	C. imberbe	*Msimbiti/Nkolong'onjo*

3.1.2 Tree component in the farming system

The Lower Shire Valley is predominantly covered with *Acacia* and *Combretum* species. The common species found on the natural woodlands include *Bauhinia petersiana, Diplorhynchus condylocarpon, Philenoptera violaceae, Dalbegia melanoxylon, Albizzia versicolor, Cordyla africana, Sterculia Africana, Sterculia quinqueloba, Kigelia Africana, Acacia polyacantha, Faidherbia albida, Combretum imberbe, Sclerocarya birrea, Azanza garkeana, Ficus spps, Pterocarpus rotundifolius, Brachystegia speciformis, Bridelia micrantha, Adansonia digitata, Acacia tortilis, Albizzia harveyi, Acacia nigrescence* and *Palm trees*. Most of these tree species are multipurpose in nature and retained on farm because they are able to provide products like fruits for food; wood for cooking and heating energy; poles for construction and fodder for livestock nutrition including other services such as soil fertility improvement and soil and water conservation.

Homestead planting was found to be popular in the Lower Shire Valley. Tree species such as *Azadirachta indica*, *Senna siamea*, *Senna spectabilis* and *Moringa oleifera* feature highly when it comes to homestead planting. Most households, government institutions such as schools and offices and religious institutions in the Lower Shire Valley have planted trees within their premises to provide shade against the scorching heat that is experienced in summer which is characterised by being very hot and dry. Most of the institutions are planted with *Azadirachta indica* (Neem trees).

The study found that households and smallholder farmers retain or grow on their farmland some preferred tree species for food production (Table 2). Such trees may have the ability to ameliorate the soil, provide fruits as food to supplement diet and also conserve soil water. Respondents from the Lower Shire Valley indicated that *Senna spectabilis, Gliricidia sepium, Faidherbia albida, Acacia polyacantha, Moringa oriefera*, *Sesbania sesban* (in rice fields), *Philenoptera violaceae* and *Albizzia lebbeck* are used to maintain soil fertility; *Zyziphus mauritiana, Mangifera indica, Bridelia micrantha, Sclerocarya birrea* and *Ficus* spps including *Moringa oleifera* provide food. *Cordyla Africana* retains moisture and used for live fencing to protect agricultural crops against browsing animals. *Azadirachta indica* (Neem), another multipurpose tree is widely found in homesteads and farmlands of the Lower Shire Valley, is used as shade, fodder and medicine. It was indicated by the respondents that the desire to raise more seedlings for agroforestry, fruits and other uses is constrained by lack of improved planting material for the preferred species. In a bid to manage the existing trees on farm, some farmers in the Lower Shire Valley have adopted Farmer Managed Natural Regeneration (FMNR).

Farmer Managed Natural Regeneration is a systematic regeneration of trees from tree stumps, roots or naturally growing seedlings. This also includes coppicing and pollarding of fully grown trees whose tree parts are taken out for use while the main stem shoot or stem is left to regenerate. FMNR provides a quick and cheap option for tree raising in the face of high cost of raising trees from seedlings as well as poor survival of tree seedlings especially in the semi-arid areas of the Lower Shire Valley. FMNR is founded on two facts which are the ability of most indigenous tree species to coppice or regenerate and the ability of farmers to influence coppicing or regeneration. It is through FMNR that most indigenous trees that are valued by farmers in the Lower Shire Valley are sustained and conserved on farm for various benefits.

In the area of Group Village Headman Kuleti, Ndamera area in Nsanje, over fourty (40) farming households out of 251 farming households practice Conservation Agriculture (CA), representing a meagre uptake of 15.9% in which *Gliricidia sepium* has been introduced for soil fertility improvement and other uses. CA fits well with farming style in the Lower Shire Valley where ridging is not popular due to flooding. CA offers an opportunity to farmers to mitigate the impacts of climate change to their farm productivity (NCATF 2016). This is the case because with CA farmers are able to adapt effectively to adverse weather conditions, improve soil health, reduce farm labour demands, and minimise negative effects of Agriculture on the environment. Nonetheless, CA is yet to be widely adopted in the Lower Shire Valley.

Introduction of *Gliricidia sepium* in CA (Figure 3) responds well to two of the three principles of CA which are to maintain soil cover and diversification with crop rotations and/ or intercrops. The woody species is a versatile, fast-growing tree favoured by farmers for living fences, fuel, fodder, green manure, shade, support for crops, and erosion control. *Gliricidia sepium* survives long dry seasons of the Lower Shire Valley. It grows well on many soil types; volcanic, sandy, stony and heavy clays, including vertisols. It is reported to tolerate some salinity and slightly alkaline soils. It will tolerate acid soils, but not severe acidity (pH less than 4.5) nor high aluminum saturation (greater than 60%) (Glover 1989).

Gliricidia sepium is propagated by cuttings or seed. Cuttings are made from branches 1.5 to 2.0 years old and are 30 to 50 cm long. Branches used for cuttings are those that are straight and healthy, and without side branches. The top of the cutting should be cut on a slant to prevent water collection and subsequent rot. The bark on the lower portion of the cutting should be scarred through to the cambium with a sharp knife to encourage rooting. One-third of cuttings length should be buried for successful regeneration. However, trees established from cuttings have a shallow root system and a short bole hence susceptible to uprooting by heavy winds. The species sprouts quickly after fire and may thus benefit from burning. *Gliricidia sepium* has become common throughout the country towards the end of the 19th century.

Figure 3: *Gliricidia sepium* introduced in Conservation Agriculture fields through use of seedlings and cuttings

Most of the woody components in agro-ecosystems occur naturally long after years of selective management by farmers. Farmers decide which tree species to retain on farm due to multipurpose uses and allied products. Those retained are mostly woody components that have multiple uses in a wide range of needs including fire wood, poles, soil nitrogen fixing, fodder, medicine, crafts and others. Small holder farmers' decision to manage certain trees on farm is also based on the recognition of ecological services which woody components such as *Gliricidia sepium* play in the nutrient cycle for crop production including moisture retention in the agro-ecosystem.

Table 2: Woody perennials retained on farmland in the Lower Shire Valley

District	Extension Planning Area	Traditional Authority (T/A)	Local Name	Botanical Name	Uses
Nsanje	Nyachirenda	Ndamera	Kesha wa Milimo	*Senna spectabilis*	Nitrogen fixer, Fodder, Poles, Fuel wood, Shade
Nsanje	Nyachirenda	Ndamera	Mango	*Mangifera indica*	Fuel wood, Food, Shade
Nsanje	Nyachirenda	Ndamera	Neem	*Azadirachta indica*	Poles, Timber, Medicine, Fuel wood, Crafts, Shade, Fodder, Soil fertility, Soap, Contraception, Pesticide
Nsanje	Nyachirenda	Ndamera	Malambe	*Adansonia digitata*	Food, Fibre, Shelter, Crafts
Nsanje	Nyachirenda	Ndamera	Chimphakasa	*Philenoptera violaceae*	Soil enrichment, fuel wood, land restoration, food, Moisture retention, shade, fodder
Nsanje	Nyachirenda	Ndamera	Neem	*Azadirachta indica*	Poles, Timber, Medicine, Fuel wood, Crafts, Shade, Fodder, Soil fertility, Soap, Contraception, Pesticide
Nsanje	Nyachirenda	Ndamera	Gilisidiya	*Gliricidia sepium*	Nitrogen fixer, Fodder, Fuel wood, Poles, Biomass
Nsanje	Nyachirenda	Ndamera	Msangu	*Faidherbia albida*	Nitrogen fixer, Fodder, Canoe making, Timber, Fuel wood, Apiculture, Medicine, Dye, Fibre, Soil biomass, Shade, Moisture retention, Crafts

District	Extension Planning Area	Traditional Authority (T/A)	Local Name	Botanical Name	Uses
Nsanje	Nyachirenda	Tengani	Msangu	*Faidherbia albida*	Nitrogen fixer, Fodder, Canoe making, Timber, Fuel wood, Apiculture, Medicine, Dye, Fibre, Soil biomass, Shade, Moisture retention, Crafts
Nsanje	Nyachirenda	Tengani	Kesha wa Maluwa	*Senna siamea*	Nitrogen fixer, Fodder, Poles, Fuel wood, Shade
Nsanje	Nyachirenda	Tengani	Neem	*Azadirachta indica*	Poles, Timber, Medicine, Fuel wood, Crafts, Shade, Fodder, Soil fertility, Soap, Contraception, Pesticide
Nsanje	Nyachirenda	Malemia	Lukina	*Leucaena leucocephala*	Nitrogen fixer, Land restoration, Furniture, Paper pulp
Nsanje	Dzunde	Malemia	Nthethe	*Acacia polyacantha*	Nitrogen fixer, Fodder, Fuel wood, Soil conservation, Land restoration, Timber, Medicine
Nsanje	Dzunde	Malemia	Ombwe	*Tephrosia vogellii*	Nitrogen fixer, Fodder, Fuel wood, Medicine, Biomass
Nsanje	Dzunde	Malemia	Gilisidiya	*Gliricidia sepium*	Nitrogen fixer, Fodder, Fuel wood, Poles, Biomass
Nsanje	Nyachirenda	Ndamera	Neem	*Azadirachta indica*	Poles, Timber, Medicine, Fuel wood, Crafts, Shade, Fodder, Soil fertility, Soap, Contraception, Pesticide
Nsanje	Nyachirenda	Ndamera	Chammwamba	*Moringa oleifera*	Nitrogen fixer, Food, Fodder, Fuel wood, Medicine, Shade, Biomass
Nsanje	Nyachirenda	Ndamera	Jerejere	*Sesbania seban*	Nitrogen fixer, Fodder, Fuel

District	Extension Planning Area	Traditional Authority (T/A)	Local Name	Botanical Name	Uses
					wood, Medicine, Shade, Biomass
Chikwawa	Mikalango	Ngabu	Neem	*Azadirachta indica*	Poles, Timber, Medicine, Fuel wood, Crafts, Shade, Fodder, Soil fertility, Soap, Contraception, Pesticide
Chikwawa	Mikalango	Ngabu	Jacaranda	*Prosopis juliflora*	Fuel wood, Crafts, Fodder, Live fences, Fence posts, Bee keeping,
Chikwawa	Mikalango	Ngabu	Gilisidiya	*Gliricidia sepium*	Nitrogen fixer, Fodder, Fuel wood, Poles, Biomass
Chikwawa	Mikalango	Ngabu	Nthethe	*Acacia polyacantha*	Nitrogen fixer, Fodder, Fuel wood, Soil conservation, Land restoration, Timber, Medicine
Chikwawa	Mbewe	Katunga	Jacaranda	*Prosopis juliflora*	Fuel wood, Crafts, Fodder, Live fences, Fence posts, Bee keeping
Chikwawa	Mbewe	Katunga	Gilisidiya	*Gliricidia sepium*	Poles, Timber, Medicine, Fuel wood, Crafts, Shade, Fodder, Biomass
Chikwawa	Mbewe	Katunga	Msangu	*Faidherbia albida*	Nitrogen fixer, Fodder, Canoe making, Timber, Fuel wood, Apiculture, Medicine, Dye, Fibre, Soil biomass, Shade, Moisture retention, Crafts
Chikwawa	Mbewe	Lundu; Ndakwera	Kesha wa Milimo	*Senna spectabilis*	Nitrogen fixer, Fodder, Poles, Fuel wood, Shade

District	Extension Planning Area	Traditional Authority (T/A)	Local Name	Botanical Name	Uses
Chikwawa	Mbewe	Lundu; Ndakwera	Mtangatanga	*Albizzia lebbeck*	Poles, Medicine, Fuel wood, Crafts, Shade, Soil fertility, Fodder
Chikwawa	Mbewe	Lundu; Ndakwera	Mkuyu	*Ficus spp*	Shade, Medicine, Fuel wood, Moisture retention
Chikwawa	Mbewe	Lundu; Ndakwera	Mtondo	*Cordyla africana*	Poles , Crafts, Fuel wood, Timber, Shade
Chikwawa	Mbewe	Lundu; Ndakwera	Masau	*Zyziphus mauritiana*	Food, Hedge, Crafts, Fuel wood
Chikwawa	Mbewe	Lundu; Ndakwera	Chimphakasa	*Philenoptera violaceae*	Poles , Crafts, Fuel wood, Timber, Shade
Chikwawa	Mbewe	Lundu; Ndakwera	Gilisidiya	*Gliricidia sepium*	Nitrogen fixer, Fodder, Fuel wood, Poles, Biomass
Chikwawa	Mbewe	Lundu; Ndakwera	Msangu	*Faidherbia albida*	Nitrogen fixer, Fodder, Canoe making, Timber, Fuel wood, Apiculture, Medicine, Dye, Fibre, Soil biomass, Shade, Moisture retention, Crafts
Chikwawa	Mbewe	Lundu; Ndakwera	Mango	*Mangifera indica*	Fuel wood, Food, Shade
Chikwawa	Mbewe	Lundu; Ndakwera	Mthethe	*Acacia polyacantha*	Nitrogen fixer, Fodder, Fuel wood, Soil conservation, Land restoration, Timber, Medicine
Chikwawa	Mbewe	Lundu; Ndakwera	Mpaso/ Msopa	*Bridelia micrantha*	Poles , Crafts, Fuel wood, Timber, Shade, Food
Chikwawa	Mbewe	Lundu; Ndakwera	Mtondowoko	*Sclerocarya birrea*	Poles , Crafts, Fuel wood, Timber, Shade, Food

District	Extension Planning Area	Traditional Authority (T/A)	Local Name	Botanical Name	Uses
Chikwawa	Mitole	Kasisi; Maseya, Mlilima, Katunga	Masau	*Zyziphus mauritiana*	Food, Hedge, Crafts, Fuel wood
Chikwawa	Mitole	Kasisi; Maseya, Mlilima, Katunga	Nsumwa	*Dirospyros mispiliformis*	Poles, Crafts, Fuel wood, Timber, Shade, Food, Medicine
Chikwawa	Mitole	Kasisi; Maseya, Mlilima, Katunga	Msangu	*Faidherbia albida*	Nitrogen fixer, Fodder, Canoe making, Timber, Fuel wood, Apiculture, Medicine, Dye, Fibre, Soil biomass, Shade, Moisture retention, Crafts
Chikwawa	Mitole	Kasisi; Maseya, Mlilima, Katunga	Mvunguti	*Kigelia africana*	Poles, Crafts, Fuel wood, Timber, Shade, Medicine
Chikwawa	Mitole	Kasisi; Maseya, Mlilima, Katunga	Mtondo	*Cordyla africana*	Poles , Crafts, Fuel wood, Timber, Shade
Chikwawa	Kalambo	Chapananga	Msangu	*Faidherbia albida*	Nitrogen fixer, Fodder, Canoe making, Timber, Fuel wood, Apiculture, Medicine, Dye, Fibre, Soil biomass, Shade, Moisture retention, Crafts
Chikwawa	Kalambo	Chapananga	Chimphakasa	*Philenoptera violaceae*	Poles , Crafts, Fuel wood, Timber, Shade

District	Extension Planning Area	Traditional Authority (T/A)	Local Name	Botanical Name	Uses
Chikwawa	Kalambo	Chapananga	Mvunguti	*Kigelia africana*	Poles, Crafts, Fuel wood, Timber, Shade, Medicine
Chikwawa	Kalambo	Chapananga	*Mtakala/Mtukila*	*Bosnia salisfolia*	Pole, Crafts, Fuel wood, Timber, Shade, Medicine
Chikwawa	Kalambo	Chapananga	Msetanyani	*Sterculia quinqueloba*	Poles, Crafts, Fuel wood, Timber, Medicine
Chikwawa	Kalambo	Chapananga	Mtangatanga	Albizia versicolor	Poles, Medicine, Fuel wood, Crafts, Shade, Soil fertility, Fodder
Chikwawa	Kalambo	Chapananga	Mango	*Mangifera indica*	Fuel wood, Food, Shade
Chikwawa	Kalambo	Makhuwira; Maseya	Msangu	*Faidherbia albida*	Nitrogen fixer, Fodder, Canoe making, Timber, Fuel wood, Apiculture, Medicine, Dye, Fibre, Soil biomass, Shade, Moisture retention, Crafts
Chikwawa	Kalambo	Makhuwira; Maseya	Mtangatanga	Albizia versicolor	Poles, Medicine, Fuel wood, Crafts, Shade, Soil fertility, Fodder
Chikwawa	Kalambo	Makhuwira; Maseya	Mango	*Mangifera indica*	Fuel wood, Food, Shade
Chikwawa	Kalambo	Makhuwira; Maseya	Neem	*Azadirachta indica*	Poles, Timber, Medicine, Fuel wood, Crafts, Shade, Fodder, Soil fertility, Soap, Contraception, Pesticide
Chikwawa	Kalambo	Makhuwira; Maseya	Kesha wa Milimo	*Senna siamea*	Nitrogen fixer, Fodder, Poles, Fuel wood, Shade

3.2 Woody Perennials Regeneration

The importance of forests and trees in improving human welfare is increasingly recognised in Malawi. Both natural and man-made forests play an important role in providing basic human needs (fuel, fodder, fibre, pharmaceuticals, etc) and income, hence contributing to socio-economic development. The current Forest Policy and Act thus provide an enabling framework for promoting participation of local communities in forest conservation and management including tree ownership. Woody species in the Lower Shire Valley are naturally and artificially regenerated to provide the various human needs.

3.2.1 Natural regeneration of trees

Woody species have both vertical and horizontal extensive root systems, which facilitate recuperation after being cut and naturally regenerate. These extensive root systems tend to produce root suckers and coppices once the aboveground parts are removed. Natural regeneration associated with coppicing has been reported mostly in Malawi (Chirwa *et al.* 2015). In the slopes of Lurwe hill in Nsanje where people are clear cutting for permanent agriculture, tree regeneration is through roots or coppices. Subsequent management of the regenerated tree species has been selective, maintaining only those species of their choice. It was also observed that some cultural practices on farm such as deep ploughing encourage tree regeneration. The 'nicking' of the cut edge will encourage sprouting from the stump (Lowore and Abbot 1995), while deep ploughing is said to increase the stocking rate by causing root suckers to develop (Chidumayo *et al.* 1996).

3.2.2 Artificial and assisted regeneration of trees

Artificial regeneration is that obtained by planting young trees or applying seeds, which is termed seeding or direct seeding. The relative importance of artificial regeneration as compared with natural regeneration depends on a large number of factors including weather conditions which determine the success rate of regeneration. Considering the weather conditions in the Lower Shire Valley, natural regeneration is the right option to restore trees of socio-economic value. This is necessary because several socio-economically important tree species of the Lower Shire Valley are under threat by land conversion and overharvesting. Nonetheless, assisted tree regeneration both artificial regeneration in nurseries and assisted natural regeneration on farm are needed to allow the sustainable use of tree resources and reverse tree losses. Chirwa *et al.* (2015) also reported that assisted natural regeneration is used in forest restoration in Malawi. Pollarding was also observed to be a common practice in Lower Shire Valley especially for trees on the farmland. Another approach being actively promoted is farmer managed natural regeneration (FMNR). This is common in the Lower Shire Valley where farmers select and protect regenerating trees of their choice and density based on their interests. For example, once species like *A. Indica*, *S. Siamea* and *M. oleifera* are introduced in a homestead, they are left to naturally regenerate but kept under check to control their density to ensure that there is space for other household investments.

3.2.3 Farmer Managed Natural Regeneration

Most of the indigenous tree species in Table 2 are managed by farmers in the Lower Shire Valley through Farmer Managed Natural Regeneration (FMNR). These tree species are nurtured by farmers to regenerate on their fields, while keeping them under the primary function of agricultural production. FMNR involves encouraging the systematic re-growth of existing trees or self-sown seeds. In the Lower Shire Valley, FMNR has commonly been practiced with living tree stumps with the ability to coppice (re-sprout) or seeds in the soil that can germinate including standing trees that have their tree parts removed for use and the main shoot left to regenerate. Most fields in the Lower Shire Valley have coppicing tree trunks, roots, and seeds in the ground from which there is the potential for FMNR.

For regeneration to take place in the farmer's field, there has to be a soil seed bank or root stock available in the soil which germinates or re-sprouts for it to develop into a seedling or sprout. For the seedling or sprout to grow, it survives harsh field conditions characterized by environmental stress and frequent disturbance. In addition, a farmer has to have interest in the growing seedling or sprout for it to be protected and not removed. In functional ecology these steps are described as environmental filters where functional traits explain species' ability to pass through the filters (Myers and Harms 2009). Most knowledge about natural regeneration comes from field observations where agricultural fields are abandoned, and the natural ecosystem is allowed to regenerate. However, this is not feasible for much degraded land in agricultural landscapes that farmers depend on for their livelihood. According to Crossland *et al*. (2018), abandoning a field for restoring functions is often not an option to smallholder farmers because of prevailing household small land holding as a result of arable land scarcity.

Vegetation restoration through FMNR addresses multiple problems simultaneously, including land degradation, soil infertility and erosion, biodiversity loss, food insecurity, fuel wood, building timber and fodder shortages and dysfunctional hydrological cycles (exacerbated flood and drought events, reduced ground water recharge, drying of springs, wells and streams). FMNR is both an effective climate mitigation and adaptation intervention. FMNR responds well to the ecosystem restoration declaration by the United Nations (UN). The UN General Assembly recently declared 2021–2030 as the decade of ecosystem restoration. It aims to massively scale up the restoration of degraded and destroyed ecosystems to fight the climate crisis and enhance food security, water supply and biodiversity.

3.3 The traditional tree legume-based system

The Shire Valley agro-ecosystem has in some parts including Chididi and Lundu area thrived on the versatile and resilient *Faidherbia albida*. The species has special

phenology as it sheds its leaves during rainy season and keeps them during the dry season. As such, the species hardly competes for light and water during the growing season of annual crops such as maize and sorghum. In addition, *F. albida* trees fix nitrogen and provide other nutrients to a crop when their leaves are incorporated into the soil. The trees serve as fuel or fence and provide fodder and shade to livestock. Hence, within the traditional smallholder farming system, the species provides ecosystem services which are provisioning services, regulating services and supporting services (e.g biodiversity) (MEA 2003).

Farmers in the Lower Shire Valley acknowledge the positive effect of *F. albida* trees on yields of crops such as maize and sorghum. For a long time, farmers have retained a low density of trees in their farmlands or two-tiered systems in order to improve the yield of understorey crops (Akinnifesi *et al*. 2008). Traditionally, farmers grow crops under scattered trees of *Faidherbia albida*, including the albida/maize system in southern and central Malawi. *F. albida* has a unique characteristic of shedding most of its leaves during the wet season and resuming leaf growth during the dry season which makes it possible to cultivate under its canopy with minimum shading effect on the companion crop. Substantial benefits are realized from these practices as resource-use by trees and associated crop components rarely overlap. The optimal combinations of trees, crops and livestock help smallholder farmers understand how to benefit from the myriad ways in which the diversity of species and life forms that nature offers (Garrity *et al*. 2010). However, tree density for *Faidherbia albida* on farm is restricted to some parts within the Lower Shire Valley and threatened by pressure for wood and charcoal production. In the absence of restocking through seedling regeneration, the Lower Shire Valley risk losing its *Faidherbia albida* population.

3.4 Socio-ecological management of trees in agroforestry systems

Crop production is low in the Lower Shire Valley leading to a state of perpetual food insecurity right away from household level. Available limited livelihood options such as farming and livestock keeping are hit hard by the impacts of climate change and variability. The Shire River Basin is vulnerable to climate change and variability due to the El Niño phenomenon which is responsible for the alteration in weather patterns in many countries (UNDP 2006). There is evidence of a shift in the weather pattern of the Shire River Basin towards more extreme climate events, drought, flood, erratic rainfall and higher temperature. Over the years, the Shire River Basin has experienced some of the worst changes in weather patterns, characterized by severe droughts and intense floods (World Bank 2010). These events have caused a significant decrease in production, crop failure and food insecurity but also contributed to environmental problems in the Lower Shire Valley.

Deforestation, overgrazing, land degradation, soil erosion, flooding and water pollution are current environmental problems in the Lower Shire Valley. These have wider ramifications on land and general productivity. The Shire Valley Irrigation Project (SVIP), considering the importance of sound environmental management, included in its project design environmentally-friendly activities such as agro-forestry, woodlot establishment, proper water and land utilization. The SVIP also considered monitoring and controlling of vector borne diseases and environmental rehabilitation to enhance the quality of the environment, minimize the effects of flooding and soil loss, and create a sustainable environment for irrigation and hydropower development (Word Bank 2010; GoM 2017).

Crop production by smallholder farmers is based on the limited use of agricultural inputs, such as fertilizer and credit, due to some constraints accessing these inputs. As a result, farmers experience low crop yield and agricultural production, leading them to rely heavily on casual labor, the sale of charcoal and firewood and petty trade for cash income to purchase food.

The sale of timber, charcoal and other forest products represent substantial income input for the households in the Lower Shire Valley. A study by Fisher (2004) highlighted also the high level of dependence on forest products by households in southern Malawi. Survey results from this study revealed that sales of charcoal and timber are high return activities that may contribute to reducing income inequality across households. According to Sileshi and Beedy (2009), the main underlying driver of charcoal sales in the Lower Shire Valley is poverty mostly influenced by family size and the number of times crops failed (food insecurity) during the past years. Families who experienced numerous crop failures during the past years have a higher likelihood to sell firewood. Crop failure leads to food insecurity and forces farmers to hire out and embrace non-farm activities as coping strategies. These strategies help households to cope with income shocks, but may increase the pressure on forest resources and the incidence of deforestation, further increasing the vulnerability to climate variability. Such being the case, Agroforestry interventions and/or technologies suited to the Lower Shire Valley once successfully adopted, should address food insecurity. Casey and Muir (1987) noted that if forestry is to take rural development perspective, tree planting and management might no longer be seen as purely a forestry issue but also as part of farming system.

3.4.1 Homestead tree planting

Homestead tree planting is popular in the Lower Shire Valley and the commonly planted tree species are *Azadirachta indica* (Neem), *Senna* species (Kesha) and

Moringa oleifera (Chammwamba), among others. The extent of homestead tree planting in the Lower Shire Valley is significant and presents the forest mosaics visible in the villages and other institutions.

Azadirachta indica has been extensively introduced throughout the Lower Shire Valley where it has contributed considerably to tree cover. The species among its other several uses, provide good shade to the hot temperatures of the Lower Shire Valley. The tree leaves and other tree parts are also used for medicine and are a very popular treatment to considerable number of ailments. However, the species is said to be invasive. Although it does not possess some of the attributes of other invasive species, e.g. long seed viability, ability to compete with other plants in the seedling stage, it does produce seed prolifically, and seed dispersal is often aided by birds and mammals. This has allowed it to become widespread in the Lower Shire Valley and feared to be invasive. Bingelli (1999) describes *A. indica* as a moderately invasive species.

The tree grows better at low altitudes on a variety of soils, clayey or sandy, saline or alkaline. It does particularly well, however, on black cotton soils and deep, well drained soils with good subsurface water. Unlike most other multipurpose tree species, *A. indica* thrives on dry, stony, shallow soils and even on soils with hard calcareous or clay pans at a shallow depth (Tewari 1992). The tree improves soil fertility and water holding capacity because it has the unusual property of calcium mining, thereby neutralizing acidic soils. Its extensive root system also has a rare physiological capacity to extract nutrients from highly leached sandy soils. *A. indica* can grow on soils with a wide pH range. The optimum growth is at pH 6.2 to 7, but it can also grow well down to pH 5 and survive in soils between pH 3 and 9 (Lemmens *et al*. 1995). All these attributes make the species well adapted to the Lower Shire Valley.

In the Lower Shire Valley*, Moringa oleifera* is planted as a hedge and for fencing because of its characteristics of sprouting so quickly once a cutting is planted. The species readily produces viable seeds and as such does not require any specific pollinator for wide scale distribution (Sagona *et al*. 2019). This could be the reason why the species is widely distributed in the Lower Shire Valley and other parts of the country. *Moringa oleifera* is used primarily as a nutritional supplement, its unique combination of essential amino acids as proteins, phyto-chemicals, antioxidants, minerals and vitamins appear to improve and relieve many medical conditions. So far, no other plant has been identified to contain all eight essential amino acids (Lengkeek 2004). These eight amino acids cannot be made by our own bodies and as such they have to be obtained outside and they are critical for maintaining a healthy body. Some of these amino acids have been found to regulate blood sugar and energy levels, and help to maintain a calm state within the human body system. As such, Moringa has been used for stress relief, hypertension, anaemia, as an anti

inflammatory and to improve overall well-being. The tree leaves are a nutritional supplement which can be mixed in porridge or relish, taken as tea, or swallowed directly with some water. They can also be mixed in flour for bread or cakes. The fresh leaves can also be cooked into a relish either as a vegetable or even mixed with a curry. The seed pods can also be eaten as green beans and provide a source of protein and medicine.

Senna siamea is another species commonly grown in the Lower Shire Valley due to its adaptability to semi-arid conditions. It is a medium-sized, fast-growing tree legume that is used as fodder and browse for ruminant livestock in the Lower Shire Valley. Its fruits and pods are edible by livestock and its wood is used for fuel or for making poles and furniture including being used as an ornamental. In any case, the species use as fodder, is restricted to feeding ruminants only because its leaves, flowers and pods foliage contains alkaloids and anti-nutritional compounds that are toxic to non-ruminants such as pigs and poultry (Heuze *et al*. 2019). The root system consists of a few thick roots, growing to considerable depth, and a dense mat of rootlets in the top 10-20 cm of soil, which may reach a distance of 7 m from the stem in 1 year and eventually a distance up to 15 m. According to Heuze *et al*. (2019), all parts of the plant can be used for tanning. The concentrations of tannin vary from 17% in the leaves to 9% in the bark and 7% in the fruits. While *Senna siamea* is popular in restoring degraded areas, the species poses a significant risk of invasion in the Lower Shire Valley due to its fast growth and prolific seed production. *Senna siamea* begins to bear seed annually at the age of 2-3 years. It regenerates naturally by seed, and seeds may lie dormant on the ground for many years until favourable conditions occur for germination.

These characteristics have enabled the species spread widely in the Lower Shire Valley where other tree species have proved difficult to raise due to harsh climatic conditions. Another species that is being managed in Lower Shire Valley for other uses but a worst invader is *Prosopis juliflora*.

3.4.2 *Prosopis juliflora* invasion and its social and environmental implications

Prosopis juliflora is an introduced alien plant species that has an impact on people's adaptation spectrum in the Lower Shire Valley. *Prosopis juliflora* is a small, fast growing, drought-resistant, evergreen tree of tropical American origin (Maundu *et al*. 2011). It is alleged that the species was introduced intentionally to the Lower Shire Valley by government agencies to use as live fences for crop gardens so that they are protected from livestock damage. Others allege that the species was dispersed by cattle dung of herds of cattle many years ago when the herds were being bought from Mozambique into Malawi. *Prosopis juliflora* pods can be used as livestock fodder and are fed upon by native herbivores. It has good timber and shade and

quickly turns bare arid environments, green. These qualities render the tree species as an attractive candidate for arid land environmental rehabilitation programmes (Maundu *et al*. 2011). In the Lower Shire Valley, people have imposed different management prescriptions to the species so that they satisfy their wood product and service needs. Although *Prosopis juliflora* is being used as fuelwood, live fence, shade, and dry season fodder including land conservation, the threat posed by the species in terms of invasion of fertile agricultural lands, prime grazing lands, and loss of biodiversity are becoming enormous in the Lower Shire Valley. *Prosopis juliflora* is deep-rooted and coppices well when cut above ground. These factors make it highly invasive and hard to control once established.

Land use/cover changes, competitive ecological advantages, and climate change are key factors that are driving the invasion of *Prosopis juliflora*. As such, the species has found its niche in the Lower Shire Valley where it is spreading with ease. The species was observed being used in fencing sugar plantations in Nchalo which are owned by Illovo Sugar Company. When species that are invasive in nature gets firmly established in an ecological region, its control can be difficult and eradication is usually impossible while its impact on biodiversity and ecosystem processes can be very serious (Shiferaw *et al*. 2019). On the other hand, seed dispersal for the species is one of the most prolific and successful, making its spread spontaneous. Both livestock and wildlife species play a critical role in the dispersal of *Prosopis juliflora*.

Figure 4: *Prosopis juliflora* being used as live fence to keep away livestock from crop field

3.5 Drivers of land degradation in the Lower Shire Valley

There is a serious land degradation going on in the Lower Shire Valley which has affected available livelihood options for the people. The high population growth rates in the Lower Shire Valley are associated with declining land holding, decreasing soil fertility and increased poverty. High population growth puts pressure on land use, pushing smallholder farmers to marginal and less fertile areas not suitable for crop production. The extreme pressure on natural resource by the community has translated into severe land degradation in some parts of the Lower Shire Valley districts. This environmental pressure leads to more drought and flood and exacerbates the impact of climate change in the Lower Shire Valley.

Change in land use in the Lower Shire Valley pose a great threat to biodiversity. Biodiversity and ecosystem functions are declining because of increased demand for food production and inappropriate practices for the use of natural resources (MEA 2003). The consequence of this has been environmental degradation and low agricultural productivity especially in the Lower Shire Valley where food insecurity is a perpetual problem. Soil erosion and soil fertility loss caused by human induced and natural drivers are among the factors contributing to agricultural productivity failure. However, tree-based cropping systems offer an opportunity to increasing crop productivity in semi-arid and nutrient – deficient smallholder farming systems (Rao and Mathuwa 2000). Trees have the potential to increase system productivity by reducing nutrient losses through leaching into the subsoil, reducing soil erosion, providing protection from wind erosion, reducing weed population, enhancing resistance to cyclic environmental changes, enhancing efficient utilization and recycling of resources and increasing available nutrients for crops by root exudates effects.

4.0 CONCLUSION AND RECOMMENDATION

4.1 Conclusion

The study has found that the main food crops are maize, sorghum, millet, beans and pigeon peas while cotton is the major commercial crop in the Lower Shire Valley. Intercropping system of farming is very well adopted in most parts of the districts where maize is planted together with pigeon peas or other legume crops including agroforestry trees. Cultivation of hill steep slopes is intensifying in the area in an attempt to extend smallholder farmers' land holding capacity. This practice has negative impacts as it does not only reduce area under forest cover but also expose the cultivated land to serious soil erosion. The Lower Shire Valley remains one of the areas in Malawi with a high number of livestock. The most common types of domestic animals are cattle, goats, pigs and chicken. These domesticated animals are grazed in *dambos*, natural woodlands and farmland. Animal grazing tend to be a constraint to good farming practices and tree planting in the Lower Shire Valley. However, a number of indigenous and exotic tree species and/or shrubs were identified as fodder for livestock and live fences to relieve the pressure of grazing animals on farm land.

The Lower Shire Valley is predominantly covered with *Acacia* and *Combretum* species. Most tree species are multipurpose in nature and retained on farm because they are able to provide products like fruits for food; wood for cooking and heating energy; poles for construction and fodder for livestock nutrition including other services such as soil fertility improvement and soil and water conservation. The study found that smallholder farmers retain or grow on their farmland some preferred tree species for food production. *Azadirachta indica* (Neem), *Moringa oliefera, Senna spp* and *Prosopis juliflora* are multipurpose trees widely found in homesteads and farm lands for various uses. Woody species in the Lower Shire Valley are naturally and artificially regenerated and some farmers manage the existing trees on farm by practicing Farmer Managed Natural Regeneration (FMNR).

Deforestation, overgrazing, soil degradation, flooding and water pollution are current environmental problems in the Lower Shire Valley. The Shire River Basin is vulnerable to climate change and variability which cause a significant decrease in production, crop failure and food insecurity. The pressure on natural resource exacerbated by change in land use has translated into severe land degradation and loss of biodiversity in some parts of the Lower Shire Valley. Nonetheless, while tree planting is key in reversing general land degradation, tree species such as *Senna spp* and *Prosopis juliflora* have characteristics that make them invade new places by spreading widely where other tree species have difficulties to grow.

4.2 Recommendations

Based on the findings, the study made the following recommendations:

There is a need to deal with land tenure issues to strengthen individual user rights to the land that would enable farmers to optimally use their land all year around. Policy issues on land ownership or tenancy need to be addressed in line with the current Land Policy and law to manage conflicting land use by cattle owners and other farming communities. There is also potential of using some AF technologies/ practices in controlling grazing on agricultural crops outside main cropping season while at the same time asserting authority on an individual's land such as live fencing with species like *Zyziphus mauritiana* and others, that are already prevalent in the area.

There is a need for a specific policy to guide farmers to move beyond the daily copping adjustments and adopt more sustainable adaptation strategies to climate change and food insecurity in the Lower Shire Valley. These should include wide scale development of sustainable farming systems through promotion and adoption of climate-resilient varieties, improved soil fertility and conservation practices and agro-forestry technologies. Investment in these strategies should be backed by necessary institutions to facilitate their adoption by farming households.

Government through the District Councils should facilitate access to improved extension services to enhance provision of information and training on improved farm management and agroforestry which are very essential to adapting to long-term climate change. More education is also necessary to increase awareness of the available adaptation opportunities to enhance smallholder farmers' ability to implement strategies for drought/flood preparedness and to apply any emerging agroforestry technologies effectively for food security but also climate change mitigation and adaptation.

Follow up visits by extensions agents and NGOs to promote agroforestry and other farming technologies are either a few or lacking. The separation of forestry and agricultural extension makes the promulgation of agroforestry technologies and practices, which have cross cutting issues between agriculture and forestry very difficult and end up confusing smallholder farmers. There is therefore, need at policy level, to revisit the set up of the extension system in general to harmonise extension approaches in Malawi.

While considering climate change adaptation spectrum as the capacity of local communities to be resilient to climate-related shocks (e.g. droughts and floods) and non-climatic risks (e.g., food insecurity), which affect livelihood strategies and food security in the Lower Shire Valley, the invasion of *Prosopis juliflora* in the Lower Shire

Valley needs serious attention to avert future unintended harmful environmental and socio-economic consequences.

High adaptability of *Moringa oleifera*, *Senna siamea/spectabilis* and *Azadirachta indica* in the Lower Shire Valley is a motivation to afforestation as these are some of the few successful tree species that can be promoted in afforestation programme to rehabilitate degraded areas alongside other multiple benefits from these species.

In high population densities and small land holdings as that of the Lower Shire Valley, meeting household needs from tree products such as firewood, building materials, fruits and income generation remain farmers' great desire. As such research should identify better species for improved agroforestry technologies well suited to the Lower Shire Valley in order to attain long term sustainable food security.

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