CONSERVING BIODIVERSITY ON FARMLAND

A Guide to Agriculture Extension Work

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CONSERVING BIODIVERSITY ON FARMLAND:

A Guide to Agriculture Extension Work

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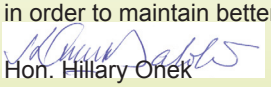
FOREWORD

The diversity and presence of life (biodiversity) on agricultural land is important for maintaining the health and productivity of farm lands. Organisms on farm land like insects e.g. bees, microorganisms and trees all play an important role in agricultural production. However, agriculture as practiced today threatens wild plant and animal species and the natural ecosystem services upon which both humans and biodiversity depend. One of the current environmental related challenges facing agriculture today is the trend of shifting from mixed to monoculture, which greatly affects the abundance and richness of pollinator agents on farmland. This decline in pollinator population due to loss of suitable habitat as a result of clear-cut logging, over-use or miss-use of pesticides, new diseases and parasites of pollinators, removal of hedges and other habitat from farms, directly affects agricultural productivity on farms. Continuous cultivation of land without fallowing or adding organic manure also highly affects levels of agriculture production. This calls for sensitization of the farming communities on the importance of maintaining a pollinator-friendly environment for the benefit of their crops as well as their own well-being.

In the case studies presented in this handbook, the fine balance between agricultural production and biodiversity conservation offers better solutions for farmers. It's important to note that emphasis on either agricultural production or biodiversity conservation alone may disturb the equilibrium, hence becoming unsustainable in the long run. Therefore, there is a vital need to maintain this equilibrium in order to promote the sustainable development of rural communities by increasing productivity of agricultural land, while at the same time conserving biodiversity. Likely measures to improve levels of biodiversity on farmland, such as the retention of tall trees, increased diversity of non-crop habitats and provision of suitable habitats for honey-producing systems will also contribute to improved sustainable livelihoods by improving soil conditions. Hence a win-win situation for humans and wildlife.

This is a practical guide for extension workers, which is a useful tool for agricultural extension service for sustainable agriculture. It is expected that this handbook will raise the profile of biodiversity in agricultural and environmental policies by building the capacity and knowledge of central and local governments, farmers and civil society to develop and promote land management approaches that integrate agricultural productivity and biodiversity conservation; with the ultimate aim of integrating biodiversity needs into relevant existing and new government policies, plans and strategies. The practices within the handbook clearly present how they should be undertaken and how both the farmer and the biodiversity will benefit.

We should all remember that farming is the main source of income for the largest population in Uganda. It is thus important for farmers to keep pollinator populations high in order to maintain better crop yields for a better standard of living.



Hon. Hillary Onek

Minister of Agriculture, Animal Industry and Fisheries

SUMMARY

The handbook presents information on some practices that enhance or maintain biodiversity (the diversity of life) on farmland whilst maintaining levels of food production. The practices are among the many, that farmers engage in to increase productivity of their land but may also indirectly enhance the number and diversity of wildlife including birds, bees, and butterflies and may help in maintaining soil fertility.

To date, there has been no guide for farmers providing advice in relation to farming practices that support biodiversity on farmland but also increase agricultural yields to meet the needs of a growing population. Available literature has only presented the practices without mentioning benefits to farmers and to biodiversity. This diversity of life or biodiversity is important in maintaining the health and productivity of agricultural land so that finding space for biodiversity in and around farmland can often bring with it increased yields. Trees, for example, help in soil and water conservation, and provide food and nest sites for many insects (e.g. bees) and birds some of which pollinate plants and enhance production in crops such as coffee. Insects such as dung beetles and soil dwelling organisms like earthworms help decompose waste and aerate soil leading to increased soil fertility and higher crop yields. It is vital that we develop and apply policies and practices that contribute to feeding the growing populations and conserve biodiversity for the future.

This handbook starts with a background to biodiversity and agriculture at the national level and then presents, with illustrations, a selection of different practices that can be used to maintain biodiversity on farmland while also increasing farm crop yields. The handbook focuses particularly on practices likely to be popular with, and relatively easily adopted by small scale farmers, specifically;

- Agro-forestry
- Use of organic manure
- Crop Enterprise mix
- Land fallowing
- Natural pest control methods
- Soil and Water management techniques

2. INTRODUCTION

2.1 Why the Handbook

This handbook aims to provide information to farming communities, field extension workers and policy makers on the kinds of support and practices that can be effective in conserving biodiversity on farmland without compromising yields and in some cases even enhancing yields. It is hoped that the handbook will increase awareness of the value of conserving biodiversity on farmlands.

The case studies contained in this handbook provide a general practical understanding of the issues as well as tools for extension workers, policy makers, conservationists and those involved in day-to-day farmland activities to better guide the processes that lead towards sustainable biodiversity conservation and improved food security in agricultural systems (particularly within banana-coffee systems such as those in central Uganda e.g Banana- Coffee arc around Lake Victoria).

Figure 2.1: Farmers working together for a future farmed landscape where both production and biodiversity benefit (Photograph taken in Kayunga on an Open day visit organized for Mukono farmers)

2.2 How to use the Handbook

A number of providers of agricultural advice can use this handbook as a component of their service manuals. It will help them discuss with farmers the importance of biodiversity in agricultural production and how to use good and acceptable practices and procedures to increase agricultural productivity while conserving biodiversity on their farms. Bringing about a change in practice requires helping farmers, technicians and policy makers to understand the costs and benefits of different agricultural practices with respect to their effect on agricultural yields and biodiversity.

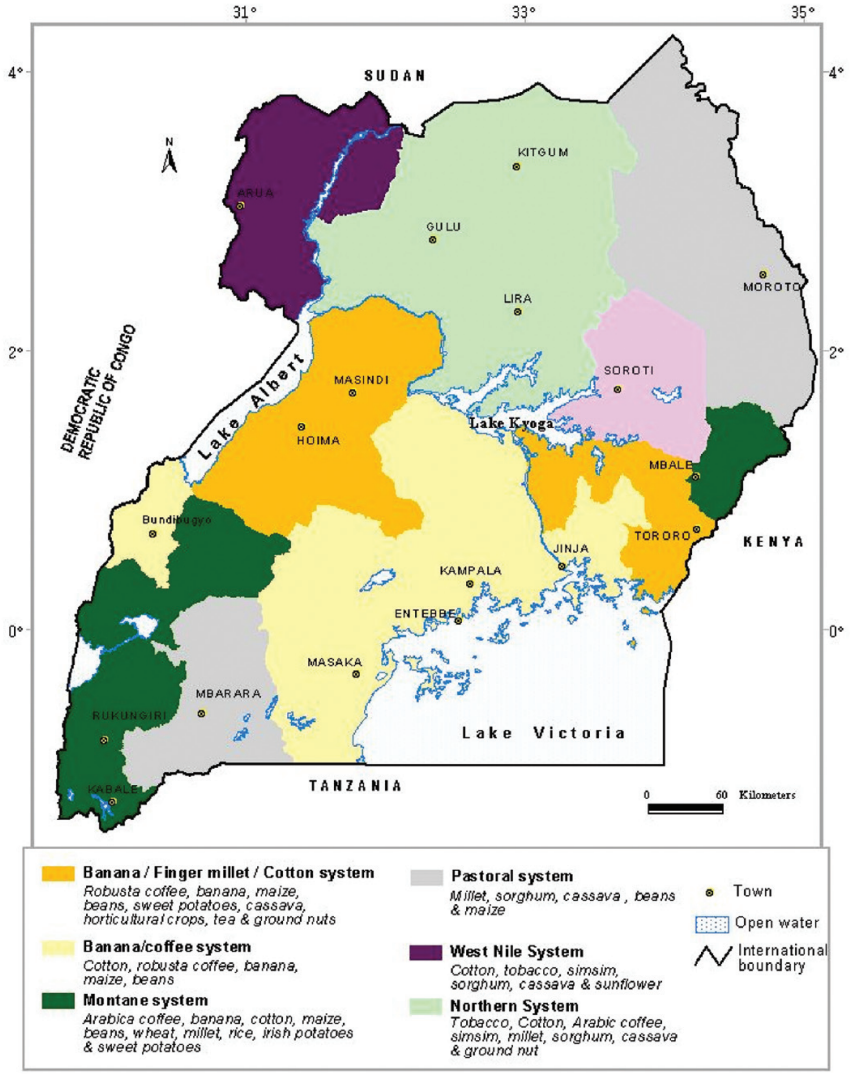
The Handbook is divided into 3 further chapters covering the following topics: Chapter 3 outlines Uganda's farming systems, the status of biodiversity and its importance to agriculture worldwide. Chapter 4 then presents a selection of different practices that promote productivity and enhance biodiversity emphasizing agricultural productivity/ benefits to the farmers. Chapter 5 presents final recommendations.

3. AGRICULTURE AND BIODIVERSITY

3.1. Introduction

Uganda has a large diversity of farming systems, human societies, and ways of managing complex external pressures on land use. Agriculture is commonly seen as in conflict with conservation and wildlife interests and intensive agriculture management is often associated with a reduction in the value of land for wildlife. In reality, improved management and the use of diversity for production are necessary components of an agriculture that both meets human needs and contributes to environmental improvement and conservation. The importance of various components of agricultural biodiversity and the contribution they make to sustainable production, livelihoods, and ecosystem health are now widely appreciated but few handbooks exist that outline how to translate this 'appreciation' into practice.

The Banana-Coffee system (as can be seen in Figure 3.1) covers the largest part of Uganda in terms of area under agriculture and this handbook specifically focuses on this system. The handbook is based upon published and unpublished case studies and experiences from Uganda and elsewhere in the world on several proven practices as a guide to help farmers increase productivity while conserving biodiversity on their farms.



(Adopted and revised from Ministry of Agriculture, Animal Industry and Fisheries 2000)

Figure 3.1: Map showing location and geographical extents of Uganda's Farming Systems

3.2 Biodiversity

Biodiversity, or biological diversity, refers to the range of different living organisms and their environments. It is often categorized or defined by three main levels: genes, species and ecosystems each linked and interdependent of the other (as is noted in Box 3.1). The focus of this handbook is on the species level (particularly birds, insects and plants) associated with agricultural land but not necessarily managed for agricultural production. This is distinct from the species often associated with the term agro-biodiversity. (See section 3.3 below)

At a global scale, Uganda is extremely rich in biodiversity, being one of the most biodiverse countries in Africa with, for example, about 1040 species of breeding birds and 1,200 butterfly species. It has 4.6% of dragon fly, 6.8% of butterfly, 7.5% of mammal and 10.2% of bird species globally recognized, many of which are associated with agricultural land (Kaihura and Stocking, 2003). Recognizing its importance, in Uganda's second report to the Convention on Biological Diversity (CBD), high priority was given to an agricultural biodiversity program.

Box 3.1: The complex links and interdependences of agriculture and biodiversity

The destruction of biodiversity by agriculture creates a vicious cycle that actually undermines agriculture, because wild species are often essential to agricultural productivity. Insects and other animals help plants reproduce, contribute to soil fertility, and regulate pest populations. Trees and plants help ensure clean water resources and control floods. Many domestic animals feed on wild plants and grasses for at least part of the year. Wild microorganisms underground break down organic matter, help aerate and drain soils and increase nutrient levels within soil; and destroy pests. Many plants require pollen from other individuals for seed sets for future growth. Bats, wild bees, and other insects are the principal pollinators of fruit trees and several major staple food crops and commercial crops including potatoes, cassava, yams, sweet potato, taro, beans, coffee, and coconut. Declines in populations of wild bees and other pollinators caused by pollution and habitat loss now threaten both the yields of major food crops and the survival of wild plant species. For example due to an epidemic of mites, a quarter of North America's wild and domestic honeybees have disappeared since 1988, with a cost to American farmers of US$5.7 billion per year.

Reference:. Scherr J. Sara and Jeffrey A. McNeely 2001 Common Ground, Common Future: Using Ecoagriculture to Raise Food Production and Conserve Wild Biodiversity Paper presented to the "Symposium on Managing Biodiversity in Agricultural Ecosystems, Montreal, Canada.

3.3 Agro-biodiversity

Agro-biodiversity refers to all crops and animals, their wild relatives, and the species that interact with and support these species, e.g., pollinators, pests, parasites, predators, vectors, decomposers, and competitors, together with the whole range of environments in which agriculture is practiced, not just crop lands or fields. It includes the variety and variability of living organisms that contribute to food and agriculture in the broadest sense, and that are associated with cultivating crops and rearing animals within ecological complexes. Pollinators are essential for seed and fruit production and their number and

diversity can strongly affect the quality and quantity of crop production. As such, these species would usually be considered under the term agro-biodiversity. The many species that simply inhabit farmland but do not directly contribute to or reduce productivity, are not usually considered under the term agro-biodiversity.

3.4 Role of biodiversity in agriculture

Putting an economic value on the role of biodiversity is not an easy task but it has been done for a few important roles such as pollination. The ecological nature and proximity of natural habitats such as a forest or wild grasslands near agricultural crops such as coffee can improve yields by about 20% because these natural habitats support key pollinator species. In this case the pollination is a so called ecological service that can be assigned as an economic value.

Box 3.2: Valuing Pollination Services

Estimates of the annual monetary value of pollination (mainly in terms of enhanced crop yields) range from $ 120 billion for all pollination ecosystem services, to $ 200 billion for the role of pollination in global agriculture alone. Conceptually, pollination is not much different from other agricultural inputs, so it should be possible to assess the costs of reducing pesticide use and selecting nesting sites and alternate floral resources for pollinators against the benefit of increased yields from higher pollination rates. Some available figures suggest that around 70% (71 of the ca 100) of crops that feed most of the world are pollinated by bees. A more recent estimate of the dependence of crop production on pollination finds that pollinators such as bees, birds and bats affect 35% of the world's crop production, increasing outputs of 87 of the leading food crops worldwide (Scherr and McNeely, 2007).

The use of shade trees ensures the survival of at least some structural and biological diversity assists in pollination and the biological control of pests and diseases. Some trees such as fruit trees like mangoes (Mangifer indica) and natives like Maesopsis eminii are planted to provide shade as well as to provide timber, medicine and food hence retaining elements of the native flora and fauna. The loss of biodiversity in increasingly intensive systems is likely to have a negative impact on production. Formerly considered self-pollinating, coffee (illustrated in 3.1) has recently been shown to have greatly increased yields where there are abundant pollinating insects. The arrival in Central America of introduced African bees has led to a significant increase in yields, in some places by over 50%. In Indonesia, fruit set of highland coffee increases with the species diversity of pollinating bees rising from 60% in the presence of three bee species to 90% where 20 bee species are present. In the above example, diversity and not abundance explained variation in fruit set. This is a clear illustration of the value of conservation because the loss of biodiversity will result in a loss of pollinators and hence the service that they provide (Donald, 2004).

Illustration 3.1: Coffee needs bees, bees need trees

An estimated 99 percent of potential crop pests are controlled by natural enemies, which include many birds, spiders, parasitic wasps and flies, lady bugs, fungi, and numerous other types of organisms. These natural biological control agents save farmers billions of dollars annually by protecting crops and reducing the need for chemical use as can be seen in illustration 3.2 birds eating caterpillars off Sweet potato leaves.

Illustration 3.2: Natural pest management

Box 3.3: Egg Plant Pollination in Kenya

In a forested landscape under development for horticultural crops in Kenya, the production of eggplant is entirely dependent on native bee pollinators. Further more, not just any pollinator will do, because eggplant can only be properly pollinated by certain bees that "buzz pollinate"; that is they bite the flower and vibrate their wing muscles at a certain frequency, such that pollen is shaken out of the small pores in the flower and can be carried to another flower to produce fruit. Without this ecosystem service, no fruit will be produced. Honey bees cannot buzz pollinate, but two species of solitary bees, which occur naturally in the forest that is being cleared for farms, are very effective pollinators. The bees only obtain pollen from eggplants because they do not produce nectar. The bees cannot therefore live exclusively on agricultural land because they also rely on remnants of nearby forests for key resources to survive, particularly in the dry seasons. Thus certain crops (in this case eggplant) need certain bees (solitary bees in this case) and bees need trees (in this case native trees) see illustration 3.1.

Reference: Scherr J. Sara and Jeffrey A. McNeely 2007, Farming with Nature; The Science and Practice of Ecoagriculture. Island Press Washington.

3.5 Farmland- options and strategies for management (farms, fields and non-crop habitats)

Biodiversity is in decline worldwide and at a global scale much of this loss can be attributed to agricultural change. Within a given agricultural landscape, farmers apply a multitude of management practices to both cropped and non-cropped lands. These practices can vary in type, intensity and frequency, as well as in their spatial and temporal scale. In landscapes dominated by agricultural crops, the most common practices involve land preparation, fertilization, agrochemical application, burning, crop rotations, soil management practices and harvesting methods. In landscapes dedicated to animal production, the prevalent practices include site preparation (for example using fire or tillage), weeding and animal management such as controlling stocking densities and, rotational patterns of grazing. Collectively, at a landscape scale, these management practices change the distribution and quality of available habitat and resources both for plants and other biodiversity.

The management and use of land, and the practices that maintain pollinators on farmland and enhance soil fertility, provide the natural capital of farmer and community livelihood strategies. Hence, programs, plans and policies that guide farmers on the best farming practices in which to engage should take that into consideration. Indeed, the Plan for Modernization of Agriculture (PMA) in Uganda, encourages farmers to "use natural resources sustainably so that you and your children can go on making a living from the land in future" (The Republic of Uganda, 2005).

Actions by all stakeholders greatly impact on the state of environment which also highly affects productivity of land as the major resource available to farmers. For example deforestation will affect a range of organisms, perhaps most visibly pollinators such as forest specialist and generalist bird species. Although in many cases only specific species may be of value in terms of increasing agricultural productivity, hence action

taken to maintain these species will often benefit others.
For example forest specialist bird species are considered to be the most sensitive of species groups to habitat disturbance and react rapidly to changes in habitat composition and management. They are typically found in forest interiors and are true forest birds, occurring in less disturbed forests or habitats. Maintaining these birds on farmland also requires maintaining a good number of medium (3-8m tall) to large trees (above 8m tall)
Forest generalists' on the other hand are species less specialized, they occur in small patches of forests, may also occur in undisturbed forests but are more regularly found in forests strips, edges, gaps. Thus maintaining some natural forest and tree cover will benefit both groups and therefore also the species that play a role in natural pest control on crops.

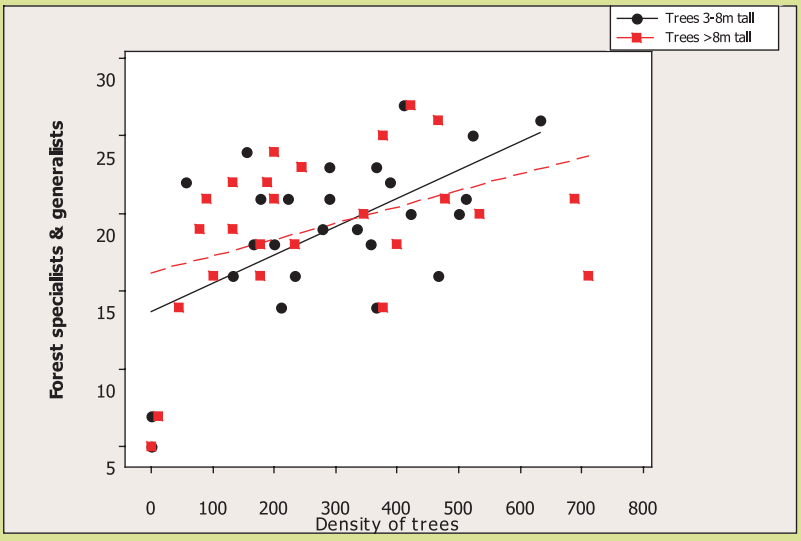


Figure 3.2: Relating diversity of forest specialists & generalist bird species diversity to density of trees per hectare in two height categories on farmlands in the 26 sites surveyed in the banana-coffee arc around L. Victoria during the COBA project

The diversity present in any agricultural production system, measured over the whole farm (ie including the cropped fields, field boundaries and adjacent non-cropped areas) depends on the biological characteristics of the local pool of species and their interactions, the effects of the physical environment and the ways in which people manage the system. Farming communities are concerned with land management issues such as water availability to plants, access to sources of fuel and fodder, control of soil erosion and land degradation, especially avoiding soil nutrient depletion and pollution of air. Farmers have generally sought to eliminate wild species from their land in an effort to reduce the negative effects of pests, predators and weeds. However, these practices often harm beneficial wild species like pollinators, insect-eating birds and other species that prey on agricultural pests.

4. Tools and methods for conserving biodiversity on farmland

When considering the needs of agricultural production and biodiversity conservation on farmland, it is useful to take into account the following;
1) Whole farm level
2) Crop habitats
3) Non-crop habitats

Farm level refers to the whole unit of a farm including the garden, livestock, apiary and poultry, whereas crop habitat refers to the specific crop plots on the garden. Non-crop habitats may be adjacent to or within farms, for instance land fallows, wetlands, forests etc. When considering the needs of biodiversity on farmland, farmers and extension advisors should be aware that:

- Agricultural systems that differ terms of the number of crop types and range of vegetation structures can be considered as falling along a gradient of intensification. At the low intensity end are areas where crops are grown under forest canopies (agroforests) and/or a diversity of crop types cultivated. The high intensity end is characterized by intensively managed areas with very few or just one crop plant (monocultures) and little or no natural vegetation.
- Changes in biodiversity result, not only from the direct actions of farmers and communities in rural areas, but also from the influences of local and national governments, private agricultural industries, consumer demands and international policies. Many of these influences are difficult to control or anticipate so there is need to be flexible and adaptive when giving and receiving advice.
- Farmers are essentially driven not by environmental concerns, but by economics, including factors such as costs relative to returns, efficiency in terms of labor and energy and use of external inputs. Thus the economic implications of any practices suggested for biodiversity must be clear and where they are beneficial or not beneficial, this needs to be highlighted.

The following section describes a number of practices that promote sustainable agriculture whilst conserving biodiversity within farmed land. These have been based on a combination of local knowledge as well as scientific research and field trials. They include ways to effectively limit natural resource degradation, integrate production of crops, trees, and animals, restore soils, control pest outbreaks, increase crop productivity and provide ecological and economic benefits to farmers. The cases presented are documented traditional practices which are known to enhance or maintain biodiversity in cropped and non-cropped habitats. Also presented are undocumented management practices that are likely to enhance, conserve and increase biodiversity on farms but for which there is less documented evidence.

Practice 1 Agro-forestry

A. Traditional Agro-forestry

Agro-forestry, the growing of trees with crops on farmland, is practiced by many farmers in Uganda. Indigenous and exotic tree species including fruit and medicinal trees are grown together with crops throughout most of the farming systems of Uganda (Figure 3.1). Agro-forestry can involve the management of selected mature trees already on the farm or the planting of new trees. This practice is believed to contribute indirectly to improving food security and consequently livelihoods of the community whilst promoting conservation of biodiversity. Under this practice, the following should be noted;

- Trees on farms should have some of the following qualities:
  - open crown/canopy,
  - nitrogen fixing,
  - quick to re-grow after pruning,
  - deep rooting,
  - resistant to drought,
  - able to provide fodder and forage,
  - easy to propagate.
- The optimal spacing of trees on farmland depends on the ultimate size of the trees and desired types of products. Trees should be sufficiently widely spaced to enable good performance of the associated crops. This will usually be achieved by following recommendations of extension advisors depending in relation to the tree species and the type of crop grown.
- Different crops have different requirements.
- The trees should be weeded along with food crops and during the first years of growth, protect trees from livestock.
- Both native and exotic trees are valuable in biodiversity conservation but native trees are known to perform better than exotic species
- It should be noted that trees on farmland provide habitats for insects, birds and butterflies which are very important in crop growth and production through pollination and predation services they provide.
- High, sustainable and profitable output from a given piece of land should be the key objective in promoting agro-forestry through extension.

Examples; *Alnus acuminate* an exotic tree species, when grown with maize helps increase productivity and is suitable for Banana-Coffee system.

Markhamia lutea, a native tree species, is suitable for the Banana-Coffee and Montane farming systems. It acts as a wind breaker and boundary marker

Albizia species helps increase coffee productivity because it is a nitrogen fixer

Maesopsis eminii a native species like some Albizia species helps in increasing the productivity of coffee and bananas. All the above provide shade for crops and habitat for pollinators which are important in increasing farmers' crop yields.

Ficus natalensis improves soil properties, provides shade for coffee and provides fodder for goats

B. Trees along boundaries

Trees along boundaries like scattered around the farm, have many uses among which are producing timber, firewood and enhancing soil fertility. Boundary trees should have the following characteristics; deep root systems and open canopy to reduce nutrient

competition and shading of food crops (often a source of wrangles with neighbors). These trees must also be well managed.

Examples:

Grevillea robusta which is a high nitrogen fixer exotic species can be grown with any crop and is suitable for all farming systems including the banana-coffee area. Others tree species such as exotic *Alnus* acuminate species as well as native *Markhamia lutea* are suitable to be grown along boundaries in the different farming systems of Uganda. *Artocarpus heterophyllus* (Ffene) is suitable for boundary planting but less so for on farm as its leaves do not decompose easily to form nutrients. Species like fruit trees (cause wrangles over ownership) and Eucalyptus (believed to drain water from soils) should not be planted along boundaries.

Benefits of Agro-biodiversity

Farmers	Biodiversity
• Provide a habitat for pollinators, and thus better yields • Improved soil fertility through nutrient recycling • Better quality crops due to shade that protects the crops from severe sun • Crops protected from damage in case of soil erosion, winds and storms • Fruits and nuts produced by some species • Enhanced income through sale of tree products • Provide security for the farmer and his/her crops • Other products like firewood, timber, medicine, fodder for animals and poles	• Provide foraging and nesting sites for a range of bird species. Often native trees provide the best insect food resources for insectivorous birds. Both native and exotic trees can provide resources for frugivorous and nectivorous species • Conservation of soil and moisture often enhances soil organisms • Native trees improve the overall level of natural diversity of plants and animals on farmland

Limitations

- Competing land use types by members of a household
- Gender conflicts on access and control of farm space
- Uncertainty of balancing economic gains verses food security
- If not properly managed, trees compete with crops and boundary trees can create disputes with neighbors. They might also harbor crop pests and diseases.
- Land shortage often promoting intensive cropping for food to the exclusion of other uses
- Farmers are skeptical about planting trees with long gestation periods
- Limited knowledge on the full economic and biodiversity benefits of agro-forestry

- Lack of secure tenure rights to land and trees can be a disincentive
- Lack of improved seeds for planting

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1. International Institute of Rural Reconstruction, 1998. Sustainable Agriculture Extension Manual for Eastern and Southern Africa. Nairobi Kenya
2. RELMA, 2003. Agroforestry handbook for the Montane zone of Uganda. Nairobi Kenya
3. Green E. Rhys, Stephen J. Cornell, JÖrn P. W. Scharlemann and Andrew Balmford. 2007. Farming and the Fate of Wild Nature www.sciencemag.org

Figure 4.1: Traditional Agro-forestry Segalye Village Nakaseke District. Tree species such as Ficus natalensis and Alnus acuminate)

Illustration 4.1: Using trees as boundary vegetation

Practice 2. Use of Manure

Maintaining soil fertility is crucial for productive and sustainable farming and requirements differ according to the different soil characteristics. Farmers use organic fertilizers to improve or maintain the fertility of soils in their gardens so as to improve the quality or quantity of plant growth.

Organic Manure

Organic manure is one of the most commonly used methods of maintaining soil fertility. It helps in binding soil particles and thus improves soil structure and texture and water holding capacity. It also exposes soil to air thereby promoting microbial activities resulting in improved soil quality.

Organic manure comes from crops grown (compost) and animals (manure) kept on farmland. Each is discussed below, based on information from Sustainable Agriculture Extension Manual {IIRR}, 1998 and The Agro-forestry handbook for the Montane zone of Uganda {RELMA}, 2003);

- **Animal Manure:** animal dung/urine and beddings make excellent organic matter for crops. Animals and birds are usually kept in homesteads but farmers usually sweep off or collect the droppings in a haphazard manner and thus do not derive the full benefit from these resources.
- In zero-grazing systems common in many Ugandan farming systems, the bedding material (grevillea trees highly recommended) which usually contain dung, droppings and urine must be removed from time to time. Many farmers do not make manure out of these beddings.
- If these droppings and beddings are mixed with the rest of the decomposable refuse from home, then high quality manure can be obtained to use in the garden to help increase crop productivity through improved soil texture and fertility.
- The manure is collected and covered with soil to prevent loss of nitrogen and left to decompose for 4 weeks after which it is ready to be applied in the garden.
- In general, manure from pigs and poultry is of better quality than manure from goats and cattle. But if cattle and goats have been fed on high quality feeds such as legumes, and improved pasture trees or shrub material, they will produce high quality manure which will be high in nitrogen.
- Manure can be enriched by mixing it, for example goats, pigs and cattle droppings can be mixed when being put in the pit. This practice is common in all farming systems.

Illustration 4.2: Collecting urine to be used as manure

- **Compost Manure:** made from either vegetative material such as crop residues, kitchen waste, other organic household waste and hedge cuttings rich in nutrients or a mixture of animal refuse and vegetative material such as crop residues that are allowed to rot together. It can be made in piles above the ground or below ground pits, the latter being preferable in a dry area or season because it conserves moisture and the former being preferred in the wet season. Compost should be placed as close to plant roots as possible. The bigger the amount of compost applied, the better the soil and crops. Compost should be applied to the crop early in the growing season so that the crop grows better

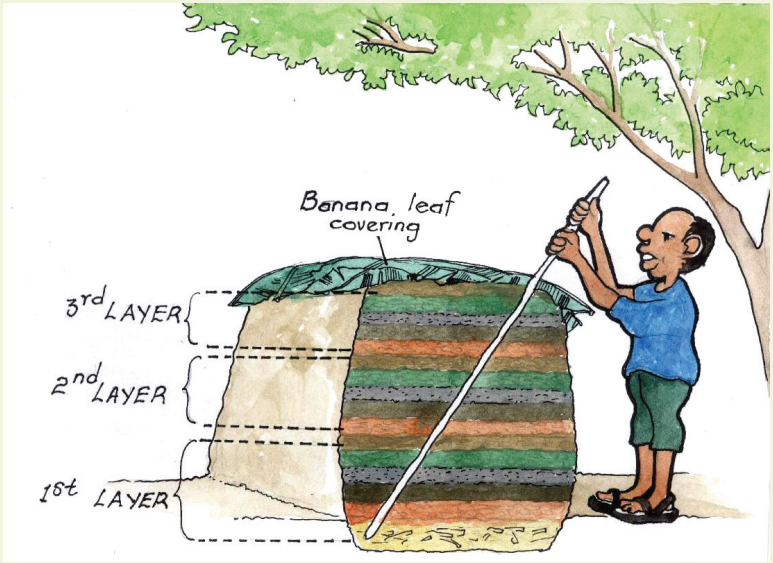

Illustration 4.3: Maize stalks (yellow), dry vegetation (orange), animal dung (dark brown), ash (grey), moist vegetation (green) and top soil (light brown)are the materials used when preparing compost in a pit and pile method.

- Each layer should start with maize stalks, on to which the following materials are added in this order; dry vegetation, animal dug, ash, green vegetation and then topsoil. To the pile or pit of manure, a long sharp stick should be driven at an angle to allow it pass through from top to bottom. The stick acts as the farmer's "thermometer".
- The "thermometer" should be pulled out from time to time to check progress of the compost. Water should be added about every 3 days depending on the weather. No water should be added if it has been raining.
- Note that the manure should be moist not wet.
- The compost should be ready after 4 weeks. Temperature can be checked by pulling out the stick to feel its warmth. If the stick feels warm, the compost is still decomposing which means it is not ready. Ready compost should have a fresh, earthy smell and contain no grass, leaves or animal manure.
- The pile can be as high as 1.5m

Benefits of Organic Manure

Farmers	Biodiversity
• Better quality and chemical free products which are on high demand in the market and may attract a premium • Higher profit due to less monetary input as manures are cheaper and easier to use • Sustainable use of land • If properly made, nutrients become readily available to plants • Reduced pollution of soil and water resources due to limited use of artificial fertilizers • Increase in crop yields due to increase in nutrients from the manure	• It improves soil water holding capacity and soil aeration hence soil biodiversity is conserved for future generations. This in turn promotes long term health of agricultural systems because of the role played in decomposition and nutrient recycling • Below ground invertebrates are often valuable prey for birds and small mammals.

Limitations

- Limited availability of organic manure, required quantities of manure not easily attained
- Collection and preparing of manure is labor intensive
- Some pests can be prevalent where manure is applied and they may damage crops
- Some farmers lack resources to buy and keep animals
- They sometimes lack skills to keep and manage productive animals

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1. International Institute of Rural Reconstruction. {IIRR}, 1998. Sustainable Agriculture Extension Manual for Eastern and Southern Africa; Nairobi Kenya
2. RELMA, 2003. Agroforestry handbook for the Montane zone of Uganda. Nairobi Kenya

Practice 3. Crop Enterprise Mix

Enterprise mix is a term used by NAADS to imply growing of two or more crops on one piece of land. In this handbook, the term is used to include the following: mixed or multiple cropping, relay cropping, row intercropping, and strip cropping.

- Crops can be planted in rows (row intercropping), at random (mixed intercropping) or in intervals. Planting in rows facilitates applying fertilizer, weeding and harvesting. It is common among most small-scale farmers in Uganda.
- Crop enterprise mixing offers farmers the opportunity to engage nature's principle of diversity on their farms.
- Spacing arrangements of plants, planting dates, and maturity dates must be considered when planning intercrops because when two or more crops are growing together, each must have adequate space to maximize cooperation and minimize competition between them. The farm however has to be well organized in order to effectively accommodate all crops.
- Intercrops can be more productive than growing pure stands and it allows some pest management benefits to be realized as a result of increased diversity (this is not to say that intercrops are not affected by pests, rather that, pure stands are more susceptible to pests outbreaks than mixed crops).
- One of the most important reasons to grow two or more crops together is the increase in productivity per unit of land.
- The production of crops is usually spread over a longer period of the year, allowing for better vegetative cover to protect the soil, and spreading the work load and income throughout the year. Systems of mixing cereal and legume crop varieties practiced by the community contribute to improved soil fertility because leguminous crops like groundnuts and sesame fix nitrogen in the soil.
- Crop mixtures and the relevant spacing should be as recommended by extension advisors.

Benefits of Crop Enterprise mix

Farmers

- Different crops are produced on a single piece of land thus variety of food available to the family potentially leading to a more balanced diet
- It optimizes production from small plots, so can help farmers cope with land shortages by utilizing the farm area more efficiently throughout the year.
- Reduces the risk of total crop loss from drought, pests and diseases hence potential increase in total farm production and profitability
- Different crops can be planted to take advantage of different seasons. For

Biodiversity

- A diversity of crops provides food and nest sites for a wide range of bird and insect species. High levels of habitat diversity are often associated with high levels of bird and insect diversity
- Presence of vegetative cover through out the year helps conserve soils and soil dwelling organisms
- Contour strip intercropping can reduce hillside erosion and protects topsoil.
- Attracts more beneficial insects, especially when flowering crops are included in the cropping system

example, crops that require a lot of water can be grown in the wet season, intercropped with drought resistant crops that can be harvested in the following dry season.
- Reduced reliance on chemical pest control methods, for example, increasing the density and uniformity of crop planting is an efficient and chemical-free way of suppressing weed growth
- Taller crops provide shade and support
- Better utilization of nutrients because of different rooting systems
- Reduces the plant diseases. The distance between plants of the same species is increased because other crops (belonging to a different family group) are planted in between.
- Minimizes labor costs on the control of weeds. A mixture of various crops gives often a better coverage of the soil leaving less space for the development of weeds.
- Provides continuous vegetative cover possibly by the use of legume based rotations or green manure
- Maintains soil fertility by recycling soil nutrients and by allowing the introduction and use of rotations between various crops, forage legumes and trees or land to remain fallow whereby grasses and shrubs become re-established
- Maintains soil bio-diversity
- Minimizes soil erosion,
- Leads to water conservation

Limitations

- The large number of different crops in the field makes weeding and harvesting difficult when using machinery
- Yields are compromised because of different spacing
- Competing land use types within a household

Figure 4.2: Cabbages grown with Banana in Nakasongola District

Figure 4.3: Poor crop mixture such as upland rice, coffee, maize and cassava deplete soil nutrients

(Photograph of a garden in Bukose Bujagali, Jinja district)

Note: Crop mixes should include a nitrogen fixing crop, legumes and crops which can easily decay hence contributing to maintaining soil fertility.

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2. International Institute of Rural Reconstruction {IIRR}. 1998. Sustainable Agriculture Extension Manual for Eastern and Southern Africa. Nairobi Kenya
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Practice 4. Land fallowing

Land left under fallow for some time regains soil nutrient levels that are commonly depleted under long periods of cultivation. For most farming systems (apart from pastoral communities) in Uganda, it is usually difficult for farmers to sacrifice production temporarily while fallowing land, mainly because of limited land but the practice has many benefits.

Fallowing to allow land to regain its fertility can be traditional or modern/improved. Traditional fallows are those left to naturally regenerate. That is trees and shrubs are left to grow on a particular piece of land for as long as the farmer can afford to leave it uncropped. Modern/improved fallowing is a type of agro-forestry practice used to allow soil to regain fertility. In order to attain soil fertility, produce good wood fuel and provide good grazing source, fallows should last at least one year.

- **Improved/modern fallow** is an agro-forestry practice used to restore the fertility of poor or depleted soils. Through continuous cultivation, plant nutrients are lost and soil texture is weakened when crops are harvested and the waste materials are not returned to the field. Planting trees or shrubs (see bullet below), and letting the land rest from cropping will help soil regain its fertility.
- Trees are planted at a spacing of 2 by 2 m. If grown from seeds or seedlings, the germinating plants require intensive weeding and protection, especially in the early stages. The fallow should be left for 1 to 3 years depending on species. Both exotic species like *Alnus acuminate, Tithonia diversifolia (*also common in hedgerows and on boundaries), *Calliandra calothyrsus, Tephrosis vogelii,* and native Sesbania sesban have been tried for improved fallows. Under ideal conditions, Alnus acuminate and *Calliandra calothyrus* can produce over 24 t/ha of good quality firewood in two years. Calliandra, Sesbania and Tephrosia may induce more than 100% increase in crop yield (Relma, 2003). All the above examples of tree species are able to accumulate Potassium and Phosphorous in higher concentrations in their plant parts compared to other plant species and are good potential sources of nutrients for soil improvement
- **Natural fallow** is the practice of simply leaving land uncultivated for some time depending on land available to each individual farmer. At the small scale farm level, the agricultural land use system is based on cultivation practices for subsistence food crop production. This subsistence system is characterized by several years of mixed food cropping without or with minimal fertilizer use followed by a fallow period of variable duration. Many factors justify the resting of pieces of land after years of cropping, with soil conditions being the

dominant influence where agriculture is intensive (Jinja, Masaka) and where there is limited labor to farm (Nakaseke).

- With natural fallows, land is uncropped and trees and shrubs are left to grow for some time ranging from 3 to 15 years. Natural areas are an integral part of agricultural systems because, apart from supporting populations of pollinators, they maintain water tables, provide clean water, reduce flood damage and provide habitat for natural enemies of crop pests. Therefore, natural areas in farms can provide key resources for biodiversity as well as restore soil fertility.
- Although this practice is recommended for all farming systems it may not be relevant in some districts like Nakaseke because of low agriculture intensity.

Benefits of fallowing

Farmers	Biodiversity
• Increased crop yields as a result of improved soils after fallowing • Increased yields as a result of presence of pollinators nearby • By products like stakes, fire wood and poles can be obtained • Provide habitat for natural enemies of crop pests which would otherwise have been on the garden.	• Land left free of chemical inputs (e.g pesticides and artificial fertilizers) is often associated with a wide range of different species of plants and invertebrates • More specifically, short term fallows often support annual plants with good pollen and nectar resources for insects and birds hence increase variety and abundance of forage for birds and bees • Short term fallows also provide good foraging habitat for many insectivorous birds since prey is abundant and accessible in the sparse vegetation • Long term fallows with trees and bushes provide good foraging and especially nesting sites for birds • Maintain water tables, provide clean water, and can reduce flood damage

Limitations

- To change land use from improved fallow to food crop production can be difficult if the fallow is overgrown.
- Limited land and hence competition for its use

Case study 1:
Mixed cropping and fallows left on farmland have been found to support a vast amount of agro-biodiversity as they provide a variety of habitats.

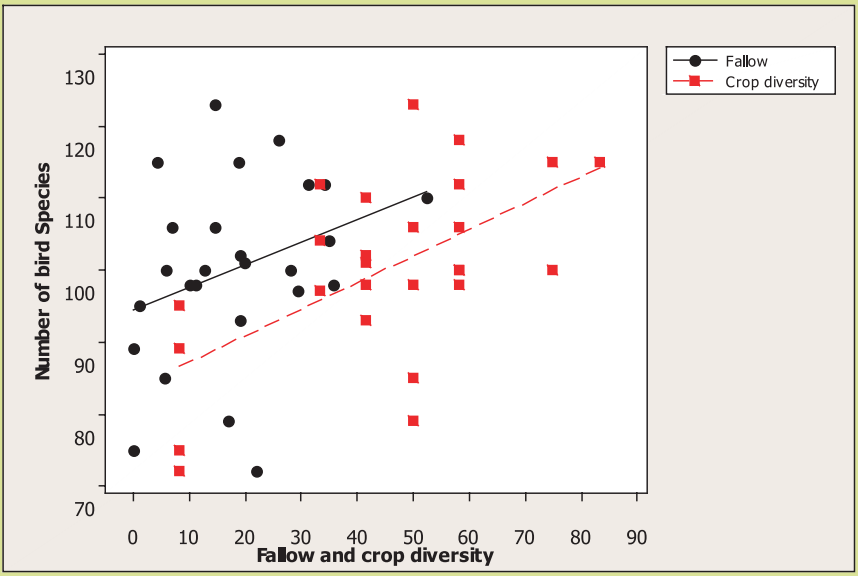

Figure 4.4: *the relationship between number of bird species (%) and the number of crop types (% crop diversity) and proportion of fallow (%) on farmlands in 26 sites surveyed in the banana-coffee arc around L. Victoria during the COBA project.*
In general farmland with a greater diversity of crops and more fallow is associated with greater species richness of birds.

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Figure 4.5: Land under natural fallow in Segalye Nakaseke District

Practice 5: Mixed Farming

The practice of rearing animals and growing crops and trees on one piece of land is referred to as mixed farming. This practice plays an important role in agro-ecological and conservation agricultural systems in enhancing or restoring agricultural biodiversity. As rural population pressure increases and less land becomes available, both crop and livestock farmers are under pressure to intensify.

- The integration of livestock and crop activities represent key ways to increase the productivity of land. Mixed farming is the backbone of modern agriculture in Uganda.
- Mixed farms often provide a range of different habitats that biodiversity needs in order to thrive in a farmed environment.
- Combining crops and livestock has the potential to maintain ecosystem function and health and therefore increased capability to absorb shocks to the natural resource base.
- The case for integrating animal and crop systems is based on the idea that by-products from the two systems are used on the same farm. Draught power, nutrient cycling, use of roughages and low quality feeds contribute to overall higher output per animal and per hectare and improved environmental quality.
- Soil fertility improvements result from the volume of organic components that circulate through the soil and plants and the animal manures that enrich the soil through long lasting carry over effects. Livestock also provides a ready means of acquiring cash to purchase inputs for crop production leading to increased output from both crop and livestock as can be noted from benefits in practice one.
- Although, the focus here has been on crops and livestock, silvopasture the system of grazing livestock and growing trees on one piece of land, could also be

viewed as a category of mixed farming. In addition to providing food and refuge for a wide range of flora and fauna, this system increases alternative sources of income such as tree products for the farmer and it provides shade for livestock. Tree species suitable for this system are native (highly recommended) Albizia spp, Milicia excelsa and exoctic acacia

Case Study 2:

A typical mixed farm in Kenya in Nyanza Province, Kisii District, Suneka Division Bomariba, has a diverse mix of crops, livestock and poultry. The farmer grows an acre of sugarcane over ca 5, ¼ acre of trees (Grivellea robusta and Eucalyptus saligna) has a woodlot, a plot of vegetables including kales, African night shade (Solanum nigrum), spider weed (Gynadropsis gynandra), cow peas (Vigna ungiculata), maize and beans. He also grows bananas on ca 0.25 acres of land, napier grass (Pennisetum purpureum) on 0.5 acres of land and has 1000 China tea (Camellia sinensis) bushes. The vegetables are used for income generation and for home consumption. He also has dairy cows, from which he sells about 20 kg of milk per day, and commercial poultry particularly using egg laying breeds. The farmer also treats the poultry manure and uses it to feed the dairy cows by mixing it with fodder. Livestock manure is used for crops and napier grass production. Nothing produced in the farm is wasted. Part of the income obtained from sale of farm produce is re-invested in the farm, while the rest takes care of family needs such as the children's and home improvement.

Source: ftp://ftp.fao.org/SD/SDA/SDAR/sard/Mixed_farming_Kenya.pdf

Benefits of Mixed Farming

Farmers

- Crops and milk/meat are produced on a single piece of land thus providing a variety of food for the family leading to a balanced diet
- It optimizes production from small plots, so can help households cope with land shortages and enhances household income
- Reduced financial inputs

Biodiversity

- Provides mixed foraging and nesting habitat for birds that favor grassland and cropland
- Provide the best alternative of using crop residues. If the stalks are incorporated directly into the soil, they act as a nitrogen trap, hence reducing the deficiencies.

Limitations

- If pressure increases, the crop-livestock systems can move towards specialized crop or livestock activities.
- Competition for land and labor between crops versus livestock

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agriculture. Island Press Washington.

There are many other practices designed to conserve soil and water as well as reduce chemical input that are likely to have positive benefits for wider biodiversity on farmland. Although there is no documented evidence of their direct wildlife benefits, these are examples of good practices that are likely to enhance and conserve biodiversity and increase or maintain crop yields.

Practice 6. Natural Crop Pest Control

Agricultural pests are defined as any organisms that harm crops or livestock so farmers seek to limit their numbers and hence the damage they cause as a way of enhancing net production.

- Improvements in the way that farmers manage their natural resources can allow many different wild species to find homes within and around farms with no reductions, and— sometimes even with increases— in crop yields.
- The effectiveness of the natural pesticides is most effective where most of the basic good agronomic practices are used e.g good soil fertility, proper ploughing and tillage, good seed selection, timely planting (when soil has proper moisture content, proper spacing and thinning, frequent weeding to reduce competition for nutrients and harboring of pests).

Below are some examples of natural pest control methods:

- Some pests such as aphids and mites can be controlled by spraying crops with water instead of chemicals. When sprayed with water, aphids and mites suck in a lot of liquid which kills them by literally causing them to burst. These pests mainly attack crops like beans, oranges, sweet potatoes and passion fruits particularly during the dry season and the method can be applied as an irrigation technique once every 2-3 days.
- The use of a combination or single plant extraction can lead to solutions that are sprayed on plants to kill or repel pests for example neem tree oil or leaf powder, lantana camara, baking powder etc. This practice has been used in the control of pests on garlic, millet and passion fruits in both the Montane and Banana-Coffee farming systems. Neem powder has also been used against rice weevils and against cow pea pests like aphids, caterpillars and pod sucking bugs.
- Cow urine (after being kept for two weeks) mixed with tithonia and lantana camara to make a liquid that can be sprayed on crops, this is common in Masaka. The liquid is sprayed on Matooke to kill banana weevil. To control pests

like bollworms , leaf miners and caterpillars in beans, cow urine should with Melia leaf powder and water for spraying on beans either in the morning before 10.00am or in the evening after 4.00pm. Cow urine mixed with water all controls army worms which are found on millet.

- Use of Ash; sprinkling kitchen ash around banana plants is a technique used by farmers country-wide to kill pests like the banana weevil without using expensive artificial chemicals. Ash when mixed with water can also be used on tomatoes to kill tomato blight, ball worms, caterpillars and nematodes. It is also effective against bean and cow pea weevils.

Benefits of Natural Crop pest control

Farmers	Biodiversity
• Less money is spent since no chemicals are bought • Crops are not exposed to chemicals which may increase their value • Effective control of pests in a safe manner	• Useful biodiversity (butterflies and bees) are protected as well as a range of other non-target invertebrates • Soil and water are protected due to non-use of chemicals

Limitations

- Frequent application of water to the crops is labor intensive
- Low water supply in some parts as well as in dry season
- Limited knowledge and skills to make and use these natural chemicals
- Limited plant materials to make the natural chemicals
- Sometimes the concoctions may not be effective

Practice 7. Soil and Water management

Soils need to be managed to reduce erosion and leaching that lead to loss in fertility. Run off water often carries off the top soil and, if not prevented, degrades the soils. Unlike water movement in unsaturated soil, which is mainly vertical, surface runoff and ground water moves mainly laterally. When the soil is exposed to the rain and the sun, it is very susceptible to soil erosion and drying out.

- To help the soil hold more water in order to protect crops for the following season from drought and pests and diseases, burning should be avoided on all farmland.

There are many ways of preventing soil erosion and retaining water on farm, some of which are;

- **Mulching** is where dry, vegetative material (usually dried grass and crop stalks) is used to cover the soil. This layer of organic material on the soil surface helps to moderate the temperature of the soil surface, reduce evaporation and moisture

loss, suppress weed growth, reduce run-off and provide plants with nutrients as the material decomposes. When crops such as vegetables grown do not give enough cover, the soil should be mulched.

- **Organic matter** when applied onto soil after preparing it as advised in practice 2 above, helps improve the structure of soil. It binds and cements soil particles because it has a high capacity to hold both water and nutrients. This makes soil thick, moist, healthy and solid so that it is not easily carried away by running water.
- **Barrier methods** such as contours, trenches, L-bridges, bunds, grass strips, terraces and ditches can be created on farm to allow water to drain into the soil slowly. Barriers trap run off water and soil particles. For the case of contours, the distance between should be small 6 to 10m for steep slopes while on gentler slopes it should be wider 10 to 20 m.

Figure 4.7 Digging a contour (Kaberamaido farmers)

- **Planting hedges along contours** can be done using seedlings or stem cuttings in single or double lines or in combination with larger trees like Maesopsis eminii, shrubs like Calliandra calothyrsus and with grasses like Napier grass (Pennisetum purpureum). Trees and shrubs help in nutrient recycling because their roots take up leached nutrients which are returned to the top soil through leaf fall. This practice is common in the Montane farming system. The abundance, distribution and types of hedges will influence biodiversity patterns by influencing animal movement. Contour hedgerow systems have been widely promoted to reduce erosion and produce organic matter for soil improvement.

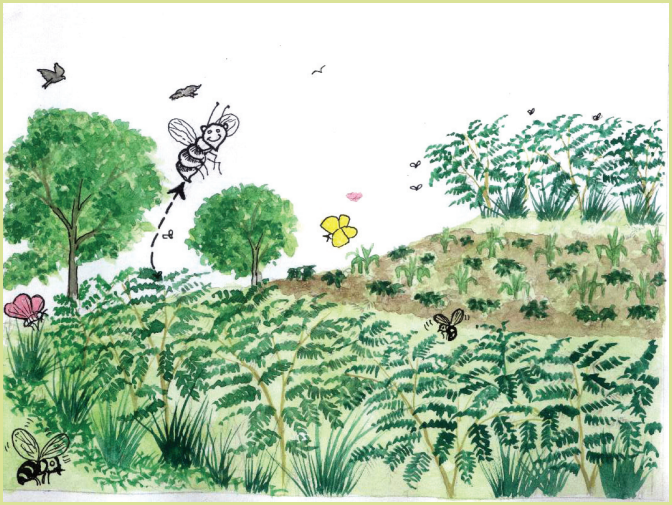

Illustration 4.4: Shrubs and napier grass planted along contours for soil and water conservation

- **Soak away pits** can also be dug in the different parts of the garden to hold run off water. These are holes of medium depth and width that can be dug in the different parts of the garden to hold rain water and allow it to sink in the soil slowly. The same grasses and shrubs as above can be planted around the pit.

Benefits of Soil and Water management

Farmers	Biodiversity
• Controlled erosion • Improved crop yields due to increased availability of moisture in the soil and conservation of soil itself • Provision of an additional range of products for example fodder, firewood, stakes and mulch • Sustainable crop production	• Enriched soils • Mulch increases soil moisture and may make soils easier to plow by birds foraging for soil invertebrates • Soil biodiversity is conserved for future generations much of which is vital for healthy agricultural systems because of the role played in decomposition and nutrient recycling

Limitations

- Mulching is labor intensive
- Mulching can introduce new pests and diseases into a field and hedges can harbor weeds and pests
- Mulch materials may not be readily available
- Trees and shrubs may compete with food crops when mismanaged
- Contour hedges are expensive and time consuming to establish and maintain

- Farmers may lack the right grasses and shrubs to plant and establish contour hedges and earth dams
- Limited knowledge and lack of materials

5. RECOMMENDATION

This handbook has presented a number of practices that are likely to promote biodiversity in farmed landscapes whilst maintaining or improving crop yields. Some of them have been tried and tested while others are based on expert and local knowledge of agricultural practices and the needs of biodiversity. There is almost certainly wide knowledge within the farming community with respect to these practices but little formal documentation them and even less encouragement to adopt them. Access to sustainably produced food of sufficient quality and quantity is a fundamental human right. The interventions/ practices presented in this handbook will help towards this aim without compromising the needs of farmers or the biodiversity. The value of many of these practices is likely to be limited to certain crop systems, soil types, climates and geographical locations. However, many already exist in small holder systems and could be applied more widely or in a slightly modified form to maximize their economic or biodiversity value. This handbook can be used to provide ideas, suggest approaches and help inform discussions between advisors to benefit farm production and biodiversity.

Narrations by farmers trained by Extension staff working with Kulika Charitable Trust Uganda

Case study 3: Farmer in Mubende

Through using organic fertilizers (compost and plant tea), I have started to grow Irish potatoes and green vegetables successfully. Compost application has helped me to plant one basin of Irish potatoes and harvest 5½ basins.

Plant tea has helped me to grow cabbages and Sukuma week (Kale) and makes Grevellia seedlings grow faster and healthily. I use tithonia to make compost and plant tea.

Many people in my locality say the plant (tithonia) is a dangerous weed because it grows vigorously, covers a wide area and tends to close the roads when it is not cut down. But people are surprised to see me planting it around my gardens and along my contour lines.

I call it a miracle weed because of the functions it fulfils for me:

- It dissolves in water very fast within seven days
- When incorporated in banana holes, it decomposes completely within 14 days and makes the hole fertile for banana planting
- It can withstand all weather conditions
- It can be used as mulch in vegetables

The key to controlling it is to ensure that it is not allowed to flower, that way it can be controlled and kept in one place. It can be used well for bush fallowing.

Farmers should also use raised beds on their farms. They are multipurpose and fit well with the idea that, **"Everything on the farm should serve more than two functions".**

- Raised beds reduce damage of crops during farm management practices like weeding
- They improve on soil drainage and aeration
- Control soil erosion (act as contours)
- Create a deep feeding area for deep-rooted vegetables e.g. carrots.

Case Study 4: Farmer in Mubende

I attended a one week workshop organized by Kulika Charitable Trust Uganda. Before I went in for training, I had a small plantation which I was unable to manage well because (I realize now) I lacked some important knowledge about farming

The following topics were taught:
a. Waste management
b. Pests and disease control
c. Goat farming
d. Bee keeping
e. Banana management
f. Compost making, application and storage
g. Manures, green manure, liquid manure, etc

After the training, we were advised to put into practice whatever we have learnt.

I bought one plot (360 x 210ft) and planted 86 banana trees. This has helped me to stabilize my saving process because I no longer buy food!

On this plantation I practice organic farming making mulch of grass and banana leaves. I have also dug trenches to trap water, which otherwise escapes. This has helped me to irrigate the plantation effectively. I am also growing beans, maize, cassava and other crops. This is a great achievement on my side!

I have planted pineapples at my home (Kibalinga), which are doing well. I also developed an idea of buying a fruit tree whenever I get salary every month, so far I have 3 avocados, 2 mangoes, 2 oranges and 2 passion fruits, which are doing well too.

Table 1: COMMON TREE SPECIES IN THE BANANA-COFFEE ZONE, THEIR LOCAL NAMES AND IMPORTANCE TO BIODIVERSITY

Botanical Name	English	Luganda	Lusoga	Biodiversity Importance Value for birds, insects and soil
Albizia spp	Albizia	Mugavu	Nnongo/musiita	Nitrogen fixer, provides nectar, shelter for birds and insects which help in pollinating crops
Alnus acuminate	Alder			Nitrogen fixer, provides nectar, shelter for birds and insects
Artocarpus heterophyllus	Jack fruit	Ffene	Ffene	Shade for birds, bees and butterflies
Calliandra calothyrsus	Calliandra		Calliandra/Mulyanyonyi	Provides nectar and pollen for birds, bees and other insects. It also can be planted as a hedge to control erosion. Its also food for livestock
Citrus sinensis	Orange	Mukyungwa		
Grevillea robusta	Grevillea, silky oak/robusta	Muttankuyege		Nitrogen fixer and provides shade for insects and birds
Maesoposis eminii	Maesopsis	Musizi	Musizi	Provides nectar and pollen for birds and insects
Markhamia lutea	Markhamia	Musambya	Musambya	Provides nectar and pollen for birds and insects, good nitrogen fixer
Milicia excelsa		Muvule		
Sesbania sesban	River bean, sesbania	Mubimba	Lutinda kyalo	Fixes nitrogen in soil
Tephrosis vogelii				Recommended for fallows its high in nitrogen fixing
Persia spp	Avocado	Ovakeddo	Ovakeddo	Provides shelter for birds and insects
Mangifer indica	Mango	Muyembe	Muyembe	Provides fruit for birds and insects
Carica papaya	Pawpaw	Papali	Papali	Provides fruits
Psidium guajava	Gauva	Mupeera	Mupeera	Provides shade and fruits for birds
Ficus natalensis spp	Ficus/Bark	Mutuba	Mugaire	Provides shade for coffee
Jambula jambusi		Jambula	Jambula/Omuziru	Provides fruit for birds

Table 2: Members of the Uganda Agro-biodiversity Working Group

Organization	Name (Contact person)
Plan for Modernization of Agriculture	Tom Mugisa
National Advisory Services	Geresom Okecho
Ministry of Water and the Environment	Steven Mugabi
National Environment Management Authority	Festus Bagoora
National Agriculture Research Organization	Sophy Musaana
Forest Resources Institute	Sam Gwail
Send a Cow	Sheila Taylor
Kulika Uganda	Magdalene A. Ogwang
Faculty of Agriculture MUK	Joy Tumuhairwe
Faculty of Forestry and Nature Conservation MUK	Philip Nyeko
Wildlife Conservation Society	
Environment Conservation Trust of Uganda	Pauline Nantongo
Uganda Export Promotion Board	Susan Bingi
UNIPA	Margaret Kaggwa
Earth Care	David Dauna
IUCN	Alex Muhweezi
Export Promotion of Organic Products	Mable Namala
Makerere University Institute of Environment and Natural Resources	Frank Kansiime, Derek Pomeroy, Diana Nalwanga and Theodore Munyuli
*Nature*Uganda	Achilles Byaruhanga and David Mushabe
Uganda Wildlife Society	Annet Nakyeyune and Olivia Nantaba

Table 3: Project partners

1	British Trust for Ornithology (BTO)
2	***Nature***Uganda (NU)
3	Uganda Wildlife Society (UWS)
4	Makerere University Institute of Environment & Natural Resources (MUIENR)
5	Danish Institute for International Studies (DIIS)
6	Royal Society for the Protection of Birds (RSPB)
7	Bournemouth University
8	Center for Agro Ecology (CAER)
9	University of Reading UK

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Special thanks are extended to Juliet Vickery (BTO), Phil Atkinson (BTO), Derek Pomeroy (MUIENR), Achilles Byaruhanga (NU), Annet Nakyeyune (UWS), David Mushabe (NU), Nantaba Olivia (UWS), Diana Nalwanga Wabwire and Theodore Munyuli(PhD Students MUIENR).

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