ASSEMENT OF AGROFORESTRY SYSTEMS PRACTICES IN MONERAGALA DISTRICT – SRI LANKA

by

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Declaration

The work described in this thesis was carried out by me at the Faculty of Appiled Sciences, Sabaragamuwa University of Sri Lanka under the supervision of Dr. J.P. Atapattu and Mr. K.P.L. Nishantha. A report of this has not been submitted to any other university to any other degree.

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Abstract

Sri Lanka has a high agriculture potential and most of the agricultural practices are carried out in the dry zone. In the dry zone, agricultural practices are based on conventional type monocrop cultivations with the use of high inputs. According to the above reason there are many negative impacts can be observed such as environmental degradation, loss of biodiversity, loss of soil fertility etc. agro forestry can be recommended to minimize these negative impacts. Different types of agro forestry practices can be seen in dry zone and many of them are not succesful.Therefore identification of socially, economically and environmentally sustainable system is needed for sustainable agricultural development in dry zone.

The research was conducted in Maneragala district in the dry zone to identify the above options. Three different agro forestry systems were selected. The study was carried out basically using a qualitative analysis method.Multioptional valuation method was used for analyzing the obtained data.

From the research, socially, economically and environmentally sustainable options were identified. The basic out comes of the research indicate that VFBAF (Village Forestry Based Agro forestry) system can be more economically feasible for large land units. Considering the long term sustainability of the environment and family health conditions the best is MHGBAF (Mixed Home Garden Based Agro forestry) system. FTBAF (Fruit Tree Based Agro forestry) system is inbetweeen these two options.

From the research it can be concluded that the objectives of farmers and the land area are the important factors for the recommendation of sustainable agro forestry option.

Content

List of figures

List of tables

Abbreviations

APAN	Asia – Pacific Agro forestry Network
CTF	Communal Tree Farm
DS	Divisional Secretariats
Edu	Education
FIOH	Future In Our Hand development fund
FTBAF	Fruit Tree Base Agro forestry
MHGBAF	Mixed Home Garden Base Agro forestry
NGOs	Non Government Organizations
SALT	Sloping Agricultural Land Technology
VFBAF	Village Forestry Base Agro forestry

Chapter 1

1.1 Introduction

Agro-forestry is the new word for an age-old practices that of having trees in the agricultural landscape. It has become more refined in meaning with a purpose of the land-use system yields both food product and a tree product at the same time each meeting the needs of the user of the system.

The modern concern for agro-forestry arose among the foresters. They saw the forested lands being threatened by a growing population demanding more food and hence by farmers seeking more land upon which to grow that food. In a predominantly agricultural country like Sri Lanka there is a strong link between population growth and deforestation. More food is need to feed/ support the increasing population and over the years the agricultural production has been increased mainly by expanding the area under cultivation (Dharmasena and Gunatilake,2002).

In Sri Lanka the area under forest cover in 1981 is generally estimated to be about 1.7 million ha of the total land area compared to 2.91 million ha in 1956 and estimate of deforestation per year for the last two decades is about 64,751ha (Pushparajah,1981). The projection estimate a further decline to 17% by the turn of this century (Jayarathna,1995).

The principal reasons for the rapid depletion of the forest resource over the last two decades are agricultural colonization and shifting or Chena Cultivations. In addition encroachment, illicit felling for timber and fuel wood and over exploitation too, have reduced both the quality and quantity of our forest resource (Pushparajah,1981).

Most of the agricultural lands of Sri Lanka are located in the dry zone. After the independence due to the population increasing and development activities such as Mahaweli Development Project and Galoya Basin Development Project the pressure on the dry zone forests increased. In the early 1980s large areas of dry zone forest were open up under land development particularly for Mahaweli programme. Therefore the forest cover of the dry zone rapidly decreased and also it reduced Biodiversity of forests because of replanting programmes using exotic monocrop type trees.

Large part of the Moneragala district is located in dry zone and it is the second largest district in the island. Owing to the rapid influx of population into the district, the natural forest cover has been drastically diminished by 70 percent during the period from 1956 to date. This is comparable from 44 percent coverage in 1956 to 23 percent in1980(Agridev,1993).During the last 30-year period these forestland has been cleared at an alarming rate (16,000 ha per year) for chena,logging and development activities.

Moneragala is one of the few districts in the island with a very high rural population (94.8%) and together with the estate population (3%). There are 73.5 percent involved in agricultural occupations. In this district almost all of the environmental problems are caused by economic activities in the rural agricultural sector (Agridev,1993).

The traditional land use pattern in the district changed ,into a commercial agriculture towards the wet zone of the district after introducing tea, rubber, coconut and minor export crops like coffee and cocoa and within the dry zone plantation of sugar cane was introduced by the government in recent years.

The major environmental problems in order of occurrence and magnitude are soil erosion, chena cultivation, encroachment of forest and water resources, deforestation Mono cropping of sugar cane and tobacco, environmental sanitation and gem-mining.

Accordingly Agro-forestry is important in solving the problem. Agro-forestry systems have been in practice in the dry zone areas from ancient times. They have been able to stabilize the dry zone farming systems in the past. However at present they have become unsustainable due to population growth and clearing of lands for agricultural production (Bandara, 1996). Hence in recent years the forestry and agricultural sector of Sri Lanka has been drastically changed to the concept of Agro-forestry. But compared to the dry zone area most of the Agro-forestry practices and research are mainly focused in wet zone. In that reason the research approach contribute Moneragala district.

1.2: Aim

The aim of the study is:

Identification of Sustainable Agro-forestry options for Moneragala district in dry zone area of Sri Lanka.

1.3: Objectives:

The identified objectives to achieve the aim are:

- To identify the introduced Agro-forestry Systems in Moneragala district.
- To assess the introduced Agro-forestry options with special reference to economic, social, technical and environmental sustainability.
- To identify the viable Agro-forestry options for dry zone area Sri Lanka.

Chapter 2
Literature review

This chapter trying to describe the definitions, advantages of agro forestry systems, development of the concept through the history, different agro forestry systems practiced in the world and their applications and finally Sri Lankan status of the agro forestry.

2.1: Definitions

Agro forestry as a sustainable management of system for land that increases overall production, combines agricultural crops and forest plants and/or animals simultaneously or sequentially and applies management practices that are compatible with the cultural patterns of a local populations (Bene et al., 1977).

King and Chandler (1978) modified the definition of the agro forestry as;" Agro forestry is sustainable land management system, which increases the overall yield of the lands, combines the production of crops (including tree crops) and forest plants and/or sequentially on the same unit of land and applied management practices that are compatible with the cultural practices of the local population".

Nair (1979) defines agro forestry as a land use system that integrates trees, crops and animals in a way that is scientifically sound, ecologically desirable, practically feasible and socially acceptable to the farmers.

Lundgreen (1982) mentioned that the " Agro forestry refers to those land use practices in which woody perennials (trees, shrubs, woody vines, bamboos, palms) are grown in association with agricultural crops or pastures, some times with livestock or other animals (e.g. insects such as bees, fish), and in which there are both ecological and economic interactions between the woody plants and the other components".

Lundgreen (1987) further status that agro forestry practice have generally focused on the mixture of tree and agricultural components on the same land such that there are significant ecological interactions in space or time between the woody and non-woody components.

Dwivedi (1992) criticized that the agro forestry is not a new system or concept. The practiced is very old. But the term is definitely new. People raised together trees, crops and animals traditionally on the same farm. The crops provided foods for livelihood. They also gave fodder. The trees gave wood for constructions for houses. They also yielded firewood. The animals provided milk and meet. They also pulled the plough and the carts. The farming system yielded almost everything, which people needed. So the agro forestry means the practice of agriculture and forestry on the same piece of land.

Chundawat et al., (1993) summarized that " *Agro-forestry is any sustainable land-use system that maintains or increases total yields by combining food crops (animal) with tree crops (perennials) and/or livestock on the same unit of land, either alternatively or at the same time, using management practices that suit the social and ecological conditions of the area.*"

Based on the above definitions agro forestry is a dynamic, ecologically based, natural resources management system that through the integration of trees in farmland and rangeland, diversities and sustain production for increased social, economical and environmental benefits for land users.

2.2: Advantages of Agro- forestry

Budowski (1998) summarized the biological,and economic and social aspects of the agro-forestry as follows.

A. Biological aspects

A large amount of solar energy is captured and a better utilization of vertical space is achieved. As well as up to a point, natural ecological models are simulated as to form and structure.

There is greater resistance against adverse rainfall conditions (both rainfall and droughts). Temperature extremes are mitigated, benefits particularly affecting plants and animals close to the ground and the lower maxima reduce the speed of decomposition of organic matter.In addition to the above factors the damage caused by the winds and practicing agro-forestry systems may reduce raindrops with high energy. This can minimized the soil erosion.

A large amount of bio mass returns to the soil as organic matter through fallen leaves, fruits, flowers and branches. There is greater efficiency in recycling nutrients because of tree roots capture nutrients that move through the soil profile or to areas far away from the annual or perennial crop plants and also they will reduced nutrients and soil losses by leaching and erosion and improve porosity, infiltration properties of soil.

Trees and their roots tend to improve the soil structure by producing a higher amount of stable aggregates and avoiding various types of hard pans and less light reach to the ground will be reduced the weeds growing on the land. Pruning of trees will be produced the mulch, which help to reduce water evaporation, add organic matter to soil and reduce the tillage.

Most trees are better able to extract available nutrients from the soil. In the case of most legumes nitrogen from the air can be fixed through the action of microorganism. As well as a greater diversity of fauna is promoted because trees provide niches for animals, birds and other beneficial predators of harmful insects or rodents and the diversity of plant species and their spatial arrangement differ the insect proliferation.

B. Economic and social aspects.

Farmers obtain at least in part of direct economic benefits from the trees that satisfy their needs. Therefore they do not need to buy these productions or transport them from far away. Trees that produce saleable wood constitute ' standing capital' an insurance against emergencies in case of immediate cash needs. As well as dependency and catastrophes associated with a single crop are overcome or mitigated, particularly in the case of irregular rain fall patterns, market fluctuations, pest outbreaks, difficulty in acquiring imported such as pesticides, fertilizers machinery and spare parts.
The economic investments required to establish tree crops may be considerably reduced because of the benefits obtained from annual crops at the early stage of the tree growth, in some cases the number of years devoted to annual crops can be increased if thinning, pruning or upper crown manipulation is undertaken and additional economic benefits can be obtained at the early stage of tree development.

The presences of the trees usually reduce the weeding cost and trees can be used to mark property boundaries. There is more flexibility to distribute the workload during the course of year. As well as wildlife can be favored and may be harvested for protein. In

addition to that some schemes allow a gradual change from destructive land-use practices towards more stable systems without diminishing productivity.

2.3: Indigenous Agro forestry systems

The indigenous knowledge on agro forestry has been discussed from different perspectives but has generally been recognized that it is the resource, which could be mobilized as local initiatives (Wickramasinghe 1995). Among the generation old agro forestry systems in the world the home garden agro forestry systems or the Kandyan home garden system of Sri Lanka came first place. Home garden agro forestry in Sri Lanka is a culturally embedded land management practice with many of the cultural features and these practices have been transmitted from one generation to the other with a unique resource base (Wickramasinghe 1994).

Wickramasinghe (1994) further stated that these traditional systems are related to numerous aspects. It provides dwellers with basic needs, food for the family, fuel wood for domestic cooking, fodder for animals, a livable environment for the organisms, medicinal products and timber. In terms of meeting family needs it is unique because unlike the other production systems it yields multiple returns.

2.4: Development of agro forestry

Agro forestry had been practiced earlier in temperate and sub-tropical countries, eg: apple ochards with pasture and sheep ,or timber trees and nuts in among cereals in Europe and North America, crops under fruit trees and olives in the Mediterranean (Huxley 1999). Huxley (1999) further state that scientific agro forestry really came into prominence in the late 1970s following the report of a team commissioned by Consultative Group for International Agricultural Research (CGIAR). In western countries the development of biological and physical sciences with the rise of industry they incentive for specialization in farming practices .The result was that traditional mixed farming and the management of natural forests moved rapidly towards the monoculture system.

Sri Lanka's once rich forest resources have been disappearing at an alarming rate throughout the twentieth century. In 1881, Sri Lanka's forests covered 84% of the island's land area falling to 71% in 1902 as commercial coffee and tea plantation expanded, by 1956 forest cover had eroded further to 44% , falling to 30% in 1992 and in 2000 Sri Lanka processed forest on less than 23% of the island (Poffenberger 2000). The forestry master plan of Sri Lanka identified the importance of protecting of the

remaining natural forest, while meeting timber, fuel wood and other non wood products from non wood resources, therefore the forest policy of Sri Lanka has been drastically changed in order to give more emphasis on conservation of forests, preservation of environment and to include a new objective to involve the local community in forestry activities through programmes of agro forestry, social forestry and community forestry (Jayarathna 1995).

Recognizing the urgency for the development of agro forestry systems the forest department is presently developing a national agro forestry plan with the assistance of the Asia-Pacific Agro forestry Network (APAN) of the Food and Agriculture Organization of the United Nations.

2.5: Experiences about agro-forestry system

Most of countries in the world have to face great problem under increasing pressure due to population exploitation and increasing conversion of forestlands to agriculture. Therefore they recognize agro-forestry is the solution.

This section briefly discusses the world experience about the agro forestry systems.

2.5.1: Agro-forestry in Australia

Wildin (1996) reported that in Australia the extent of tree clearing is one of the most striking features of the countries development and it is the main reason for land degradation and environmental problem such as soil erosion, dry land salinity, soil acidification, soil structural decline, soil nutrient degradation. Therefore agro-forestry systems are used to prevent the above problems.

They used agro forestry for , land rehabilitation, prevention of salinity, prevention sheet and gully erosion, windbreaks for protection and increase productivity of crops pasture and live stock, management of native vegetation and tree planting for conservation for wild life habitat and for commercial products other than timber and fodder (e.g.: oils, honey, and flowers). Wood lots for farm timber and commercial timber, Fodder production from trees and shrubs and also for Shelterbelts for livestock.

2.5.2: Agro-forestry in Africa.

Agro-forestry is a popular concept, as a solution to rural development needs in Africa. These can be grouped into practices involving trees with groups, tree with pastures, and trees with animals and trees nested into special places in the landscape (Rocheleau et., al 1988).

Following are the main agro forestry systems can be found in the African regeion.

a. Agro-forestry practices in cropland

One of the most widely practiced agro-forestry systems in the dry land areas of Africa. It is based on trees dispersed in cropland. Farmers plant or maintain trees their cropland to obtain valuable tree products. The trees seem to increase the production of the surrounding groups and improve the soil and water condition for crop growth.

Contour vegetation strips with multipurpose trees and tree groups,Is an agro-forestry practice in much of sub-Saharan Africa contour vegetation strips are introduced to control the soil erosion on sloping group land. These living barriers may consist of grasses, trees and shrubs. They provide the useful products such as food fodder and wood for farmers.

Multipurpose trees, grasses and other herbaceous plants grow along the edges and uncultivated spaces of soil and water conservation structures, contour bunds, ditches and bench terraces on cropland.These plant combinations are helping to stabilize and protect conservation structures from direct exposure to rain and wind while producing useful items for home use or sale.

Alley cropping or hedgerow intercropping. Most often consists of dense hedges of multipurpose tress planted in rows between wider strips of annual crops. The hedges are lopped to produce mulch and they applied to cropped areas to fertilize and cover the soil

Multistory closely spaced trees intercropped with annual plants. This arrangement is often based on shade tolerant understorey crops and on a greater diversity of tree and hedgerow species this practice is more common in dry zone of Africa both rain fed and irrigated croplands.

Practice of mulching, composting or mounding croplands with tree leaves. Case of mulching, leaves are applied directly to the soil in composting leaves and twigs are

combined with grasses in long mounds in croplands and covered with a layer of soil to decompose and crops are planted into the mounds in the next season.

b. Agro-forestry practices in pastures and rangelands

Silvopastoral systems combining woody plants with grasses and other herbaceous fodder plants are widespread through out sub-Saharan Africa.
Extensive Silvopastoral system are involve the selective protection management of naturally occurring trees and shrubs for animal fodder In addition to high protection fodder for livestock trees may provide building poles fuel wood, fruit or cash groups such as resins.

More intensive Silvopastoral system are found in natural or improved pastures in farming areas, in this case naturally occurring trees may be managed selectively or multipurpose trees and fodder shrubs may be planted in theses situation. Trees are spaced more closely and managed more intensively than in extensive systems and tree products range from timber to fruit fuel wood and high protein fodder.

c. Agro forestry practices on boundaries and border spaces

Boundary markers are different from living fences. Their main purpose is to make boundaries clear. Boundary spaces may provide a convenient site for planting productive trees and shrubs that do not fit in with other land uses elsewhere

d. Agro forestry practices along waterways

Floodplain garden are located in isolated depression along the flatter and more stable portions of river and stream banks or on the edges of lakes and ponds. These are including trees shrubs woody vines as well as vegetable crops medicinal plants species and root crops.

Multipurpose trees, shrubs, and grasses planted to stabilize rock and wooden structures for erosion control across gully channels. These sites are highly productive because of the control drainage of surface and sub surface water in to the filled section behind the structures. Timber firewood and fodder are produced from woody plants and developed small fruit and vegetable plots.

Multipurpose trees and tree crops also established with grasses on the sloping banks of streams, gullies or channels protect the soil on the slope, to shade the water causes and to provide fuel wood fodder fruit or other product.

e. Agro forestry practices in home compound

Agro forestry practices in home gardens can range from a few trees and shrubs in a small vegetables and herbs garden to a dense multistoried plot of fruits vegetables herbs and cash crops and trees planted for timber fuel wood and fodder home garden represent the main cultivated fruits and a major sources of food and cash in come especially for a poor family with little arable land.

Decorative and shelter planting around houses, They also include agro forestry practices such as fruit bearing vines mixed with large ornamental tree or vegetable gardens combine with flowering and decorative trees.

f. Agro Forrest practices in forest, woodlands and woodlots

Taungya agro forestry system, it combines the establishments of new forest plantation with food and cashed crops. This system has applied in dry land Africa for the rehabilitations of grazing lands and the establishments of the wood lots. This approach reduces cost of reforestation as well as forest development over the long term.

Woodlots, Usually involves more intensive management of the trees and other plants in small areas. Introducing multipurpose trees enriches Existing wood lots. Herbaceous crops or animals. New agro forestry wood lots are designed to produce fuel wood and fodder provide a more diverse mix of products and services and sustain the soil and water recourses of the site.

2.5.3: Agro-forestry in Philippines

Home gardens, commercial crops under shade of trees growing Agricultural crops with commercial trees, silvo-pastoral practices Communal Tree Farm programme (CTF), Sloping Agricultural Land Technology (SALT)are very common in Philippines .
Bandyopadhyay (2001), described home gardens are an important land use and Agro Forest practices in the Philippines , they consist of an intimate mixture of as many as 34 woody species 40 herbaceous species. These home gardens are predominantly coconut based. The home gardens in the Philippines can be classified as agro-silvo-pastoral system.
Farmers have integrated crops with livestock. Small holder farmers depend on tree fodder and crop residues for agricultural lands CTF programme is aimed at reforesting marginal and sub marginal forest lands and providing employment to subsistence upland farmers including shifting cultivation (Bandyopadhyay.2001). The programme envisages the participants to establish agro forestry tree farms. Trees may be established single or intercropped with fruit and agricultural cash crops. Livestock and fish production may also be undertaken and also considering the variable socio-economic and edaphic condition, two more versions of SALT have evolved (Bandyopadhyay.2001). SALT-11 integrates goat production by cultivating agricultural and fodder crops and provides space for an alley of agricultural crops. The ratio of agriculture crops.tres and fodder is 40:20:40.

2.5.4: Agro Forestry in Vietnam

Home gardens silvotishery and silvo- pastoral practices are very common.
Bandoyopadyay (2001) described two types of home gardens are recognized. One for the fait delta lands and another for sopina land in hills and mountains. In these gardens multipurpose trees and planted for fruit and fuel wood, timber, vegetable bean species and medicinal plants are also grown under trees and bee keeping may also be adopted. The lowest ground is used for rice fields and fishponds. Silvofishery is more popular southern Vietnam In the low- lying areas, mangroves and tree species adapted to saline soil, acid sulphate soil and acid sandy soil are combined with fisheries. It has been found by experience that shrimp raised in prepared ponds covering about 29 percent of the mangroves areas can maintain productivity of the forest as well as the shrimps Mangroves forest act as shelter belt and provide timber, fuel wood and raw material for paper.

2.5.5: Agro Forestry in Indonesia

Home gardens are impotent land –use and agro forestry practice in Indonesia (Bandyopadhyay 2001) the number and type of tree species vary between home gardens depending on socio-economic factors and also vary between and with in provinces. Major food crops are upland rice, maize vegetable, coconuts and fruit trees. Major cash crops are fruits beverages and vegetables a number of trees are grown for timbers and fodders.
Farmers raise cattle, buffalo, goats, seeps, poultry and fish with in the home gardens.

2.5.6: Agro forestry in south Asia

Agro-forestry system being practiced in Bangladesh, India, Bhutan, Nepal, Pakistan, Sri Lanka .This section briefly introduced the agro forestry systems which was practiced in Bangladesh and India.

A. Bangladesh:

Shifting cultivation practiced on hill slopes in being replaces by sedentary mixed.agro-forestry and horticulture systems (khosla and kaushal 1993). Homestead gardens built on mounds are also very common in Bangladesh. A wide variety of fruit bearing tree species, timber species, fuel wood trees and bamboo are grown on homestead. They provide fuel, food, fodder and other materials

B. India:

Trees on fallow lands, taungya, shifting cultivation in the east silvipasture system in the desert and hills horticulture with silviculture or agriculture in plains and mountains, complex multistoried systems in the south are most widely practiced agro-forestry system in India (khosla and kaushal 1993)

2:6: Agro forestry practices in Sri Lanka

Fourteen types of agro forestry practice were identified as being in use in Sri Lanka.

Table 2.1 ago forestry practices in Sri Lanka (source: UP-OFI link project 1991-1995)

Number	Type of practice
1	Cropping phase of shifting cultivation (chena cultivation)
2	Follow phase of shifting cultivation (chena cultivation).
3	Cropping phase of taungya (co- operative reforestation).
4	Trees on plantation tree cropland. Sub divided into multipurpose trees on plantation tree crop land (inter cropping with coconut, inter cropping with rubber, shade trees in tea and shade trees in coffee and cocoa and tree crop on plantation tree cropland multicropping rubber with tea).
5	Crop on plantation tree crop land (intercropping with coconut and intercropping with rubber).
6	Home gardens (kandy forest gardens, home gardens).
7	Live fences (kandy forest gardens, home gardens, strip plantings).
8	Boundary planting (strip planting).
9	Windbreaks (strip planting).
10	Alley cropping (alley cropping, intercropping with coconut).
11	Contour hedgerows (slopping agricultural land technology
12	Plantation grazing (agro forestry practices with a livestock component).
13	Fodder banks (agro forestry practices with a livestock component).
14	Farm woodlots

Important agro forestry systems shown in the table briefly discuss in the following section.

2:6:1: Shifting cultivation (chena)

Shifting cultivation (chena) is widely practiced traditional system of farming in the dry zone (Ranasighe 1991). It refers to unirregated rainfed annual crops cultivation based on slashing and burning of forest, Scrub or grassland. While in the traditional form it involves shifting from one plot to the next and the following of the abandoned plot with

cultivation for substance, transitional form is now common with either very short periods of follow often with a commercial orientation (Gelbert 1988).

Research conducted by the university of peradeniya (1991-1995) reported that 1.2 millions ha of land predominantly in the dry zone, that is 18.5% of the total land area of the country are subject to some form of chena cultivation making it the largest use of agricultural land in Sri Lanka and it has been estimated that as much as 80% of the countries rainfed grains, pulses and vegetables are grown on this land.

2:6:2: Taungya

Shifting cultivation has been harnessed to some extent by the forest department in various form of Taungya in which people are paid to plant and maintain trees in the establishment phase of forest plantation and allowed to intercrop. Ranasinghe (1991) reported the teak plantations in the dry zone were established by this method and trees and field crops are grown together for about tree years. Priority is given to the trees and land was leased out to farmers allowing them 2 ha each and incentives were given for the success for the teak planting.

2:6:3: Multilayered tree gardens

The most widespread agro forestry practice in Sri Lanka is the multilayered tree garden, found all districts of Sri Lanka (Nuberg et al., 1994). These are variously referred to as home gardens and forest gardens. University research and agro forestry development in Sri Lanka 1991,19995 reported home gardens are socio economically important at both the household level and the national economy and it has been estimated that;

-A quarter of the countries fuel wood supply comes from home gardens.

-Horticultural production which is from home gardens has an annual value of Rs 20 billion equivalent that of rice.

-Soil erosion rate are much smaller under tree garden.

-There is a total area of one million ha covered by home gardens in Sri Lanka which represent 15% of the total land area of the country.

2:6:4: Kandyan forest gardens

The system is usually practiced on small homestead in a few districts (kandy, Kurunegala and Matale). In the mid country and similar systems are found in other Southeast Asian countries. But the Sri Lankan version tends to have a greater variety of crops, and to give better returns in cash crops and subsistence produce (Ranasinghe 1991). These are the traditional system of mixed perennial cropping which has been practiced for several centuries. The crops include a number of economically valuable trees such as spices, frits, medicinal plants and timbers.

2:6:5: Alley cropping

Alley cropping is an alternative method to chena farming and it involves nutriant recycling processes through bio mass addition (Senevirathna Banda 1995).
Alley cropping or hedge row inter cropping can be proposed as environmentally sound, ecologically stable and sustainable farming systems which can replace or improver the traditional system of shifting cultivation (Gunasena et al ., 1991). Gunasena (1989) reported that the long term experiments of alley cropping. The leguminous trees, Gliricidia sepium showed better growth than leacaena leucocephala especially during prolonged droughts and the loppings of the alley crops and the crops deciduas were returned to the same plots at end of each season and they changes in the soil nitrogen and organic matter content in the soil.

2:6:6: conservation farming

Conservation farming which is being practiced mostly in the dry part of Sri Lanka and it is designed to conserve soil natural resources (surface and sub oil fertility, and water from direct rain fall) and promote the natural recycling of forest vegetation (Ranasinghe 1991).

2:6:7: Community forestry

A community forestry project was under taken by the forest department with the aid of the Asian Development Bank (ADB), the basis of this project was to involve the communities in the establishment, management and protection of tree crops (Ranasinghe 1991).

The project included intensification and establishment of community woodlots, home gardens as schools. Beatification, soil conservation, dust control, noise control and shelter from wind are the expected results from them.

Agro forestry is a popular concept. Therefore different research was done and they defined many definitions. Through those researches they identified the value and advantages of agro forestry. But studying the history, many years ago ancient farmers shows these characters and they develop the concept. Most of the countries have been practiced the agro forestry. As Sri Lanka is a tropical country, we have a good potential for that. In Sri Lanka different agro forestry systems were practiced by government and NGO's. Both in the wet zone and dry zone area the sustainability of the systems are less. Therefore the research was targeted to identified the sustainable agro forestry option to Monaragala district.

Chapter 3

Materials and Methodology

This chapter discusses the study sites, the method used to collect the preliminary data and the method used for analysis.

3.1: Study Sites

Three sample areas were selected for the research randomly to represent three different agro forestry systems. Flowing figure shows the study area.

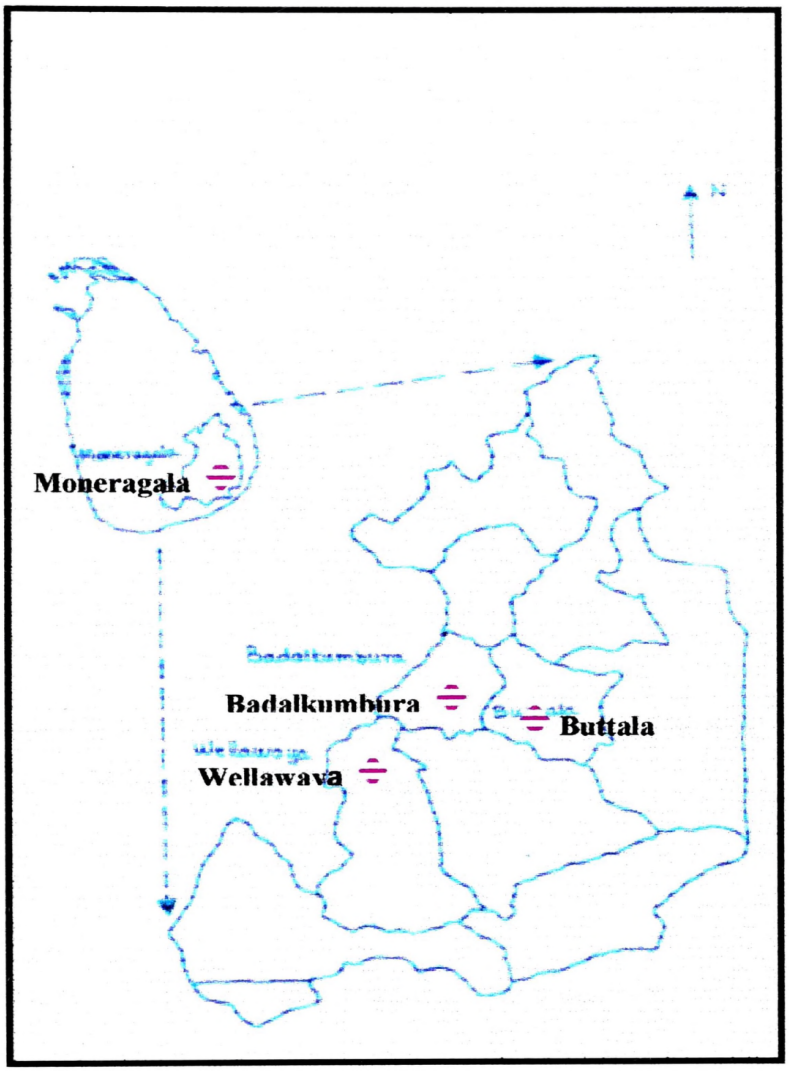

Fig 3.1: Study area

3.2: Time duration

This research was carried out from November, 2003 to February, 2004.

3.3: Basic research method used

Basic research method was done by literature review, base line survey and questionnaire survey.

a. Literature review

The data about the agro forestry systems were obtained from the Post Graduate Institute of Agriculture in Peradeniya, Gami Sewa Sevana Galaha and FIOH Badulla.

b. Base line survey

The baseline survey was carried out through the Field visits, discussions with resource persons in villages and personal communications.

c. Questionnaire survey

The questionnaire was designed to collect Social, Economical and Environmental impact of the above projects (please see appendix 1).

3.4: Hypothesis

According to the objectives these hypothesis were constructed.

- There are practiced agro forestry systems in Moneragala district.
- Socially, Economically and Environmentally sustainable agro forestry systems are in the Moneragala district.

- Socially, Economically and Environmentally viable options can be identified through the existing agro forestry systems.

3.5: Required data

Following table shows the Social, Economical and Environmental data required for the study.

Table 3.1: Social, Economical and Environmental data required for the study.

Social	Economical	Environmental
Awareness	Income	Forest cover
Willingness	Expenditures	Diversity
	Amount of land use	Soil condition
		Manure application
		Weedicide application

3.6: Method of Analysis

Analysis method mainly based on the qualitative analysis therefore, Multioptional Valuation Analysis were used to analysis the different features in different agro forestry systems.

3.7: Expected shortcomings and preventing measures used

i).The farmers do not like to give actual figures about their income. Therefore the income was calculated based on their expenses.

ii) People were rural and isolated. They relucted to give real answers to the researcher.Therefore the study was carried out with support of the officials who engaged in the different projects.

Chapter 4

Results and Discussion

This chapter analysis the collected data to test the hypothesis.

There are practiced agro forestry systems in Moneragala district, based on the agronomic factors, social factors, economic factors and implementing agencies, following farming systems were identified. Following table shows the three different agro forestry systems practiced in moneragala district.

Table 4.1: Three different agro forestry systems identified in moneragala district.

Agronomic factor	Social factor	Economic factor	Implementing agency	Name of the system
Perennial trees, annual crops and vegetables.	Female target	zero input	NGO	MHGBAF
Fruit trees	Male target	High input	Agricultural department	FTBAF
Teak plantation with short term crops and vegetables	Male target	High input	Forest department	VFBAF

Detail features of the different farming systems are follows.

4.1: Mixed Home Garden Base Agro forestry system (MHGBAF).

Fig 4.1: Mixed Home Garden Base Agro forestry system

This project is facilitated by Future In Our Hand (FIOH) development found .Thirteen families were participating the project. All the farmers participating the project live in Dickyaya (Buttala DS division). The project was started in year 2001. The duration of the project is three years.

4.2: Fruit Tree Base Agro forestry system (FTBAF).

Fig 4.2: Fruit Tree Base Agro forestry system

The project is facilitated by Agriculture Department. 20 families were participating the project. Farmers participating the project live in Kalagahakiula, Helatuntala and Madukotanaraw (Badalkubura DS division). It was started in year 1999.

4.3: Village Forestry Base Agro forestry (VFBAF).

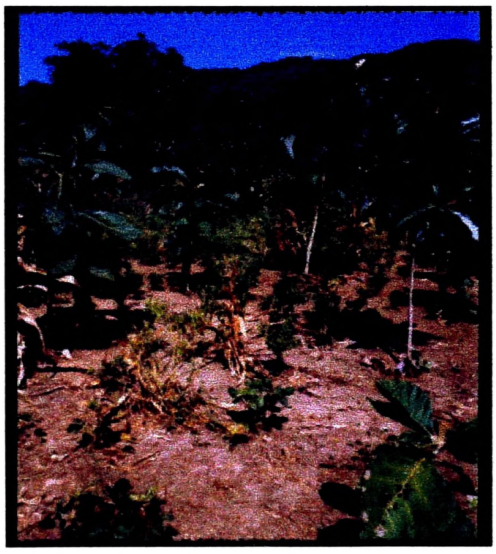

Fig 4.3: Village Forestry Base Agro forestry

Forest department facilitates the project. 14 families were participating the project and they live in Anapallama (Wellawaya DS division) and the project was started in year 2001.

Socially, Economically and Environmentally sustainable agro forestry systems are in the Moneragala district and following graphs shows the detail features of each system with respect to social, economical and environmental factors.

4.4: Social factor analysis:

According to the fig: 4.4 highest percentages of families shows high awareness on MHGBAF system. FTBAF system and VFBAF system included in to intermediate category. The reason was the assistant delivered from coordinators and social mobilisers of the NGO (FIOH), who had been involved in MHGBAF system. The responsibilities of them were educating, motivating and monitoring the activities of the farmers. The farmers involving in to the MHGBAF were having a record book, which mentioned their daily agricultural practices, observations and results. The social mobilisers used to visit the farmer's lands twice a week and farmers have divided into two small groups and they held group meetings in every week. The government officials of the FTBAF and VFBAF were not maintained close contact with farmers compared with the MHGBAF.

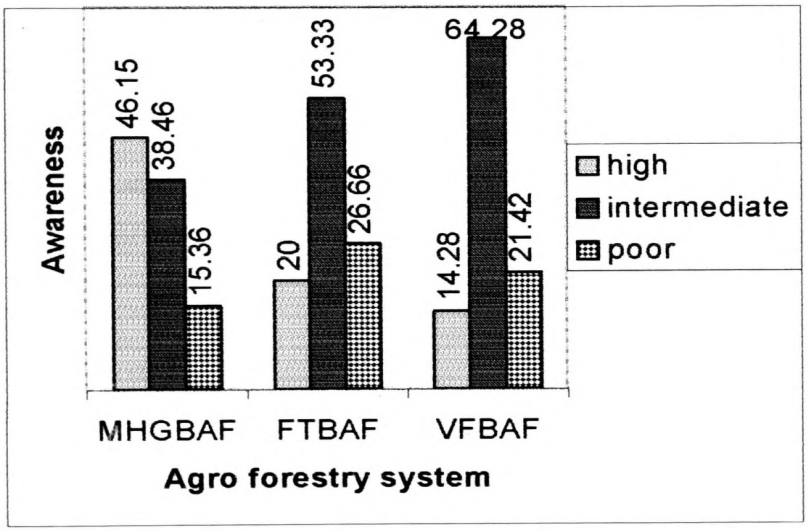

Fig 4.4: Relationship between percentages of Awareness and Agro forestry system

The education level of the farmers involving in to each project was compared in figure 4.5. In MHGBAF system and FTBAF most of the people include in to secondary education level.

The education level of the farmers involving in to each project was compared in figure 4.5. In MHGBAF system and FTBAF most of the people include in to secondary education level. VFBAF system was recorded poor education level. Therefore, it is assumed that there is no relationship between awareness and education level of the target group.

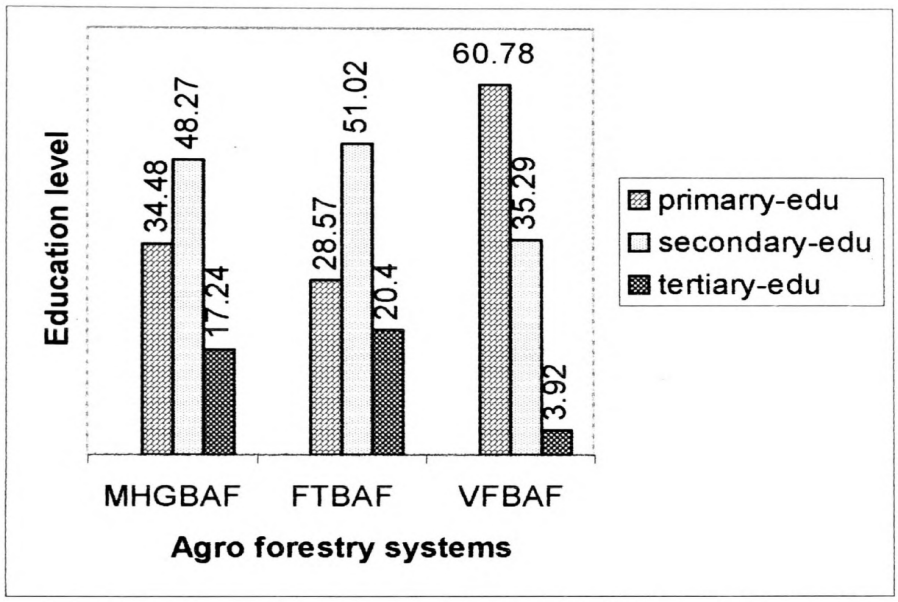

Fig 4.5: Relationship between highest Awareness level and Education level (Percentages).

According to the Figure 4.6, participation of the female to the MHGBAF system was 80%. In FTBAF system there was no significant difference between gender participation to the project. 90% of the males were participating to the VFBAF system, because the field works of this project were very hard for the female when comparing to the other projects.

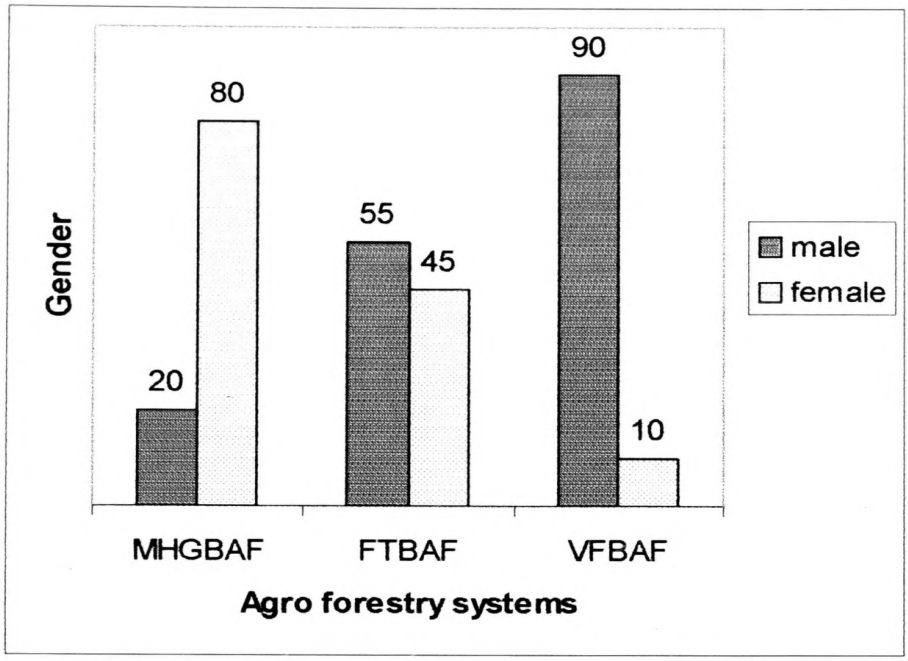

Fig 4.6: Relationship between awareness and gender group

Fig: 4.7 show that the willingness of farmers to maintain MHGBAF and VFBAF was higher than the FTBAF system. In the MHGBAF system, the farmers obtain the vegetables, fruit and medicine, which needed for their daily consumption from the system. In the VFBAF, incentives for the maintenance of the system were given by the Forest Department. But the willingness for FTBAF system has been depleted, as a result of the low profit at the market.

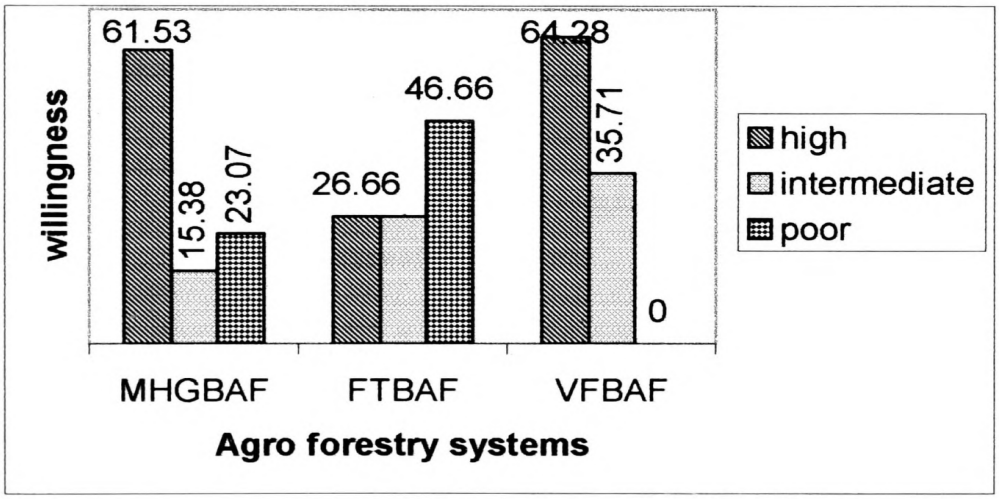

Fig 4.7: Relationship between willingness and agro forestry system

It could be identified in fig 4.8, when comparing the three systems; more Youngers (age 25-35) were used as the target group with MHGBAF system. But in the FTBAF and VFBAF systems age range of >45 people were significant.

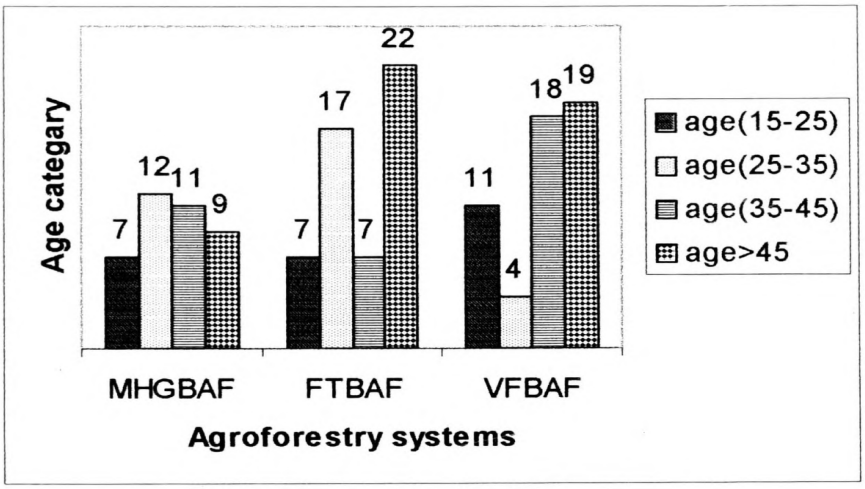

Fig 4.8: Relationship between willingness and age category

Fig: 4.9 shows that FTBAF and VFBAF systems were used as the main income source of the family.

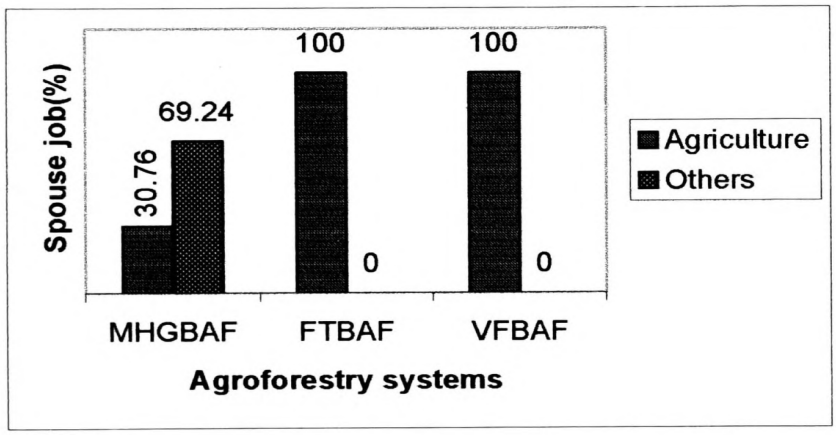

Fig 4.9: Relationship between willingness and spouse job

4.5: Economic factor analysis:

According to the fig 4.10, VFBAF system had the highest mean income well as the highest mean expenditure. MHGBAF system shows the least mean income and expenditure. FTBAF system was at the middle range of mean income and mean expenditure.

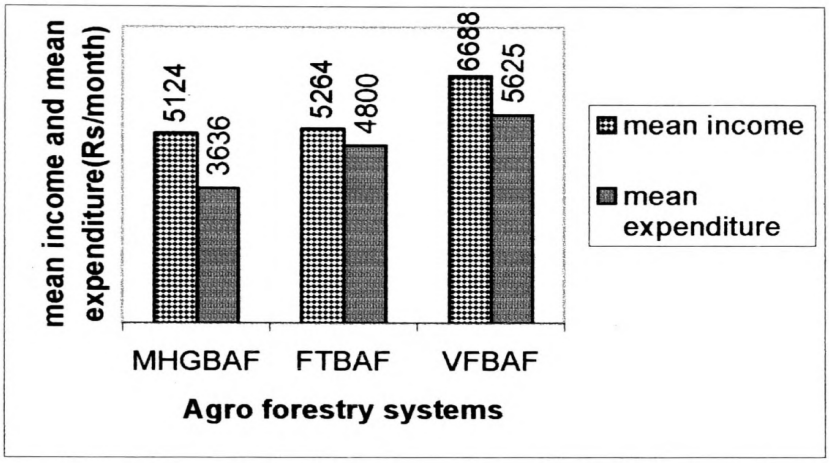

Fig 4.10: Relationship between mean income and expenditures (per month)

According to the fig 4.11 comparatively high profit gain from MHGBAF system, FTBAF system and VFBAF system gain low profits. The reason was MHGBAF system is a zero input base system and they used wormy culture, organic farming techniques and own seeds and planting materials.

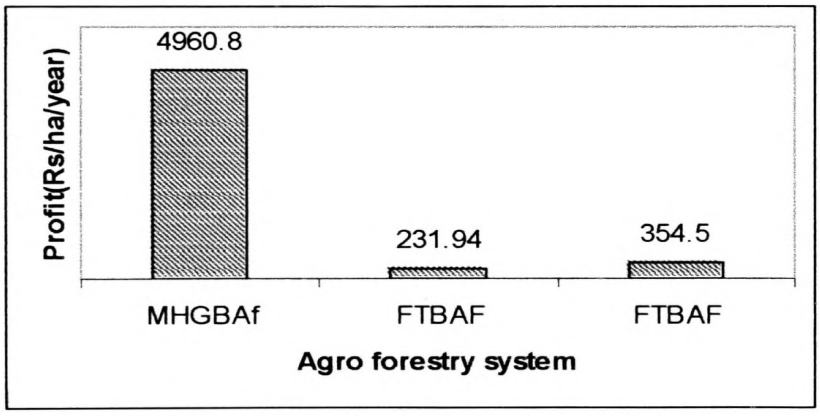

Fig 4.11: Relationship between profits of each agro forestry systems.

According to the fig 4.12, In MHGBAF system there is no expenditures for manures and weedicides. VFBAF system the expenditure only for the weedicides but the FTBAF system the expenditure for both cases was the reason for increasing their mean expenditure.

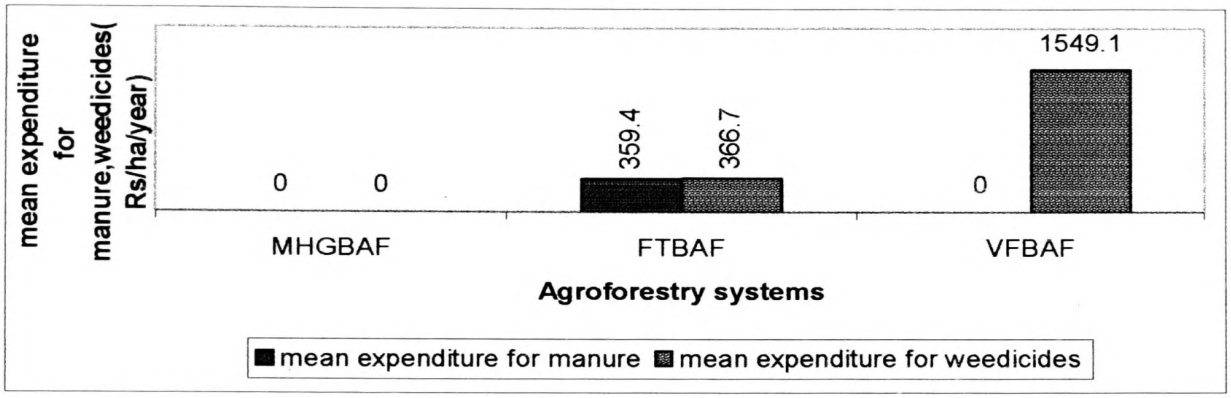

Fig 4.12: Relationship between mean expenditures for manure and Weedicide usage per month and different agro forestry systems.

According to the fig: 4.13, the land area of VFBAF system and FTBAF system was higher than MHGBAF system. But income from the MHGBAF system was comparatively high.

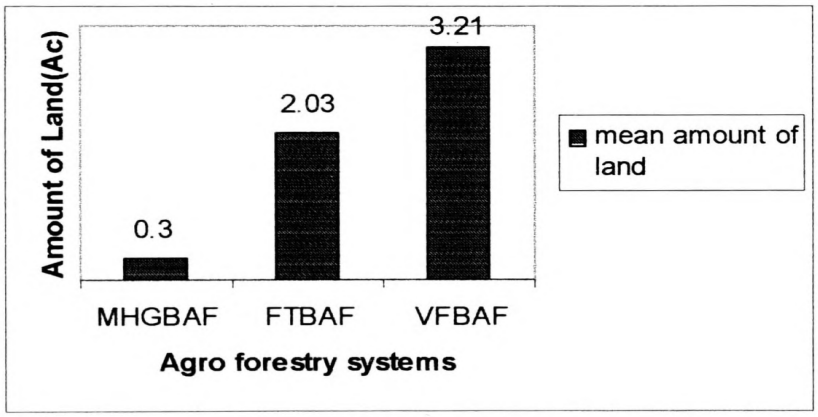

Fig 4.13: Relationship between mean amount of land usages and different ago forestry systems.

with respect to the economic factor MHGBAF system is the most economically effective land use system because it is a cyclic moddle therefore they used own seeds and planting materials but FTBAF system they have to wait without any harvest due to that they have to faced the uneconomic gaps and they have to bye planting materials from the market, therefore they have to invest more money for planting materials because it is a linear model. VFBAF system partially linear wel as partially cyclic, therefore with respect to the economic value VFBAF system can be placed into in between MHGBAF system and FTBAF system. Any linear moddle is an unsustainable and cyclic moddle is sustainable, it is a proven principle.

MHGBAF mainly used for self consumption but they used traditional varieties, therefore high demand can be expected from future. FTBAF system totally depends on the price of the fruits and VFBAF system is short term.

4.6: Environmental factor analysis

According to the categorization, Fig: 4.14 show that forest cover of VFBAF System was belonging to the very good category. But other system was not showed significant difference.

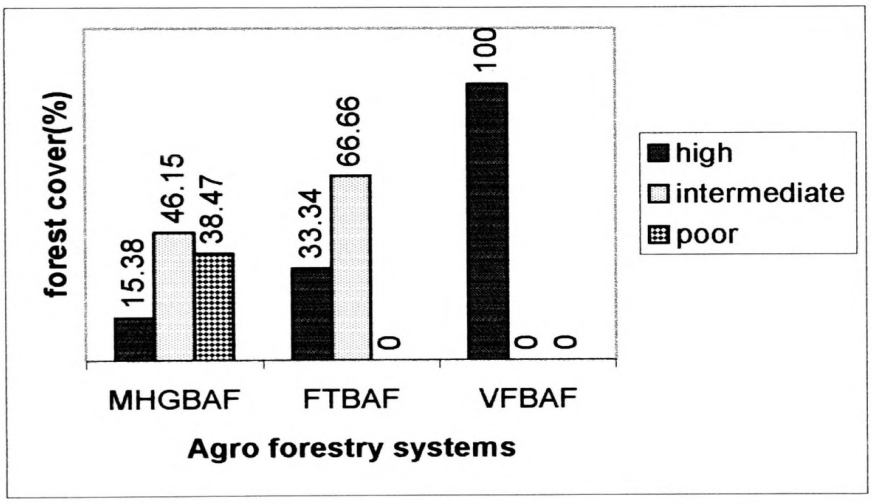

Fig 4.14: Relationship between forest cover and agro forestry system

Diversity of the tree species of the systems can be plotted as fig: 4.15.

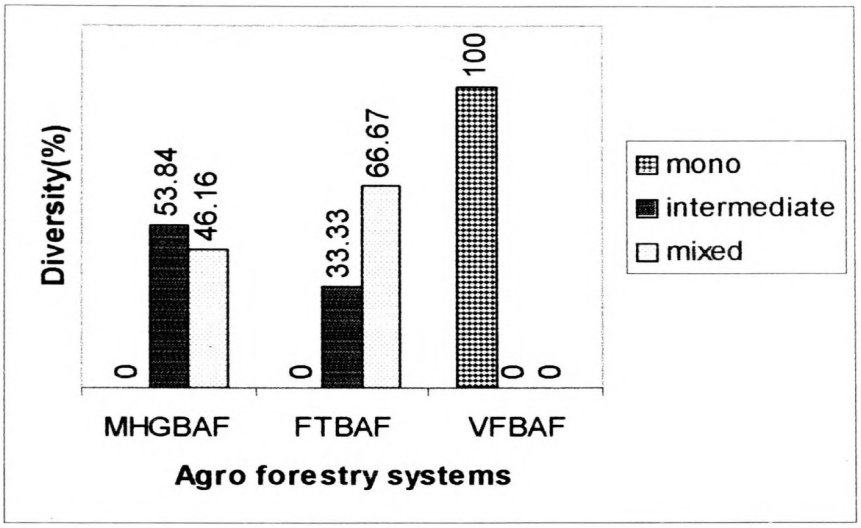

Fig 4.15: Relationship between tree species diversity and agro forestry system.

In MHGBAF system can be observed high biodiversity therefore can be obtain different type of productions like fruits, vegetables, green leaves, crops etc.Accordingly risk and uncertainty of price can be minimize in this system, but other two systems depend on limited number of verities therefore risk and uncertainty is very high.

Interview revealed that the soil conditions of MHGBAF and FTBAF system were at the very good category. Because they had the ownership of these lands and they trying to the land keep in fertile condition. But in the VFBAF system the soil condition has been degraded, because these lands were owing to the Forest Department.

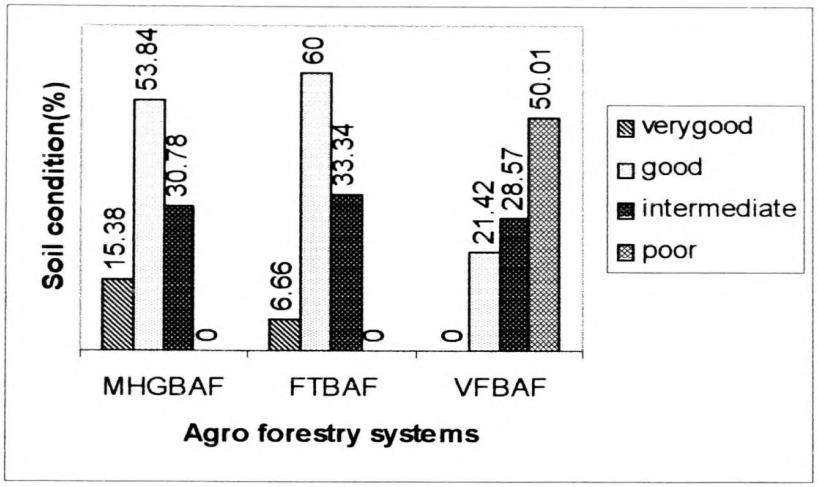

Fig 4.16: Relationship between soil condition and agro forestry system

According to the fig: 4.17 manure application for the VFBAF system was not recorded. In MHGBAF system were used only the natural manures such as wormy wash and organic matters, because most of the families used these lands for the own consumption. But other systems were used for the commercial purposes.

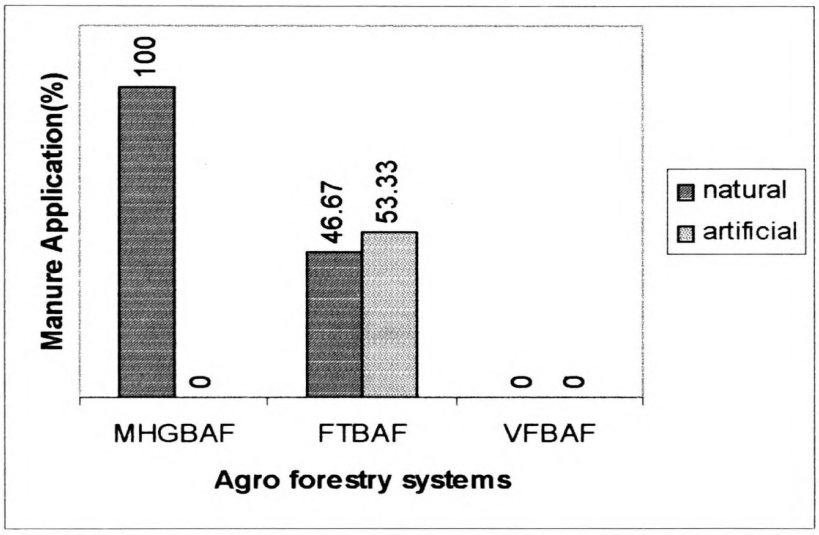

Fig 4.17: Relationship between manure application and agro forestry system

Weedicides application of the systems showed that in the VFBAF systems was included in to the good category, because maintenance cost for the lands was given by the Forest Department.

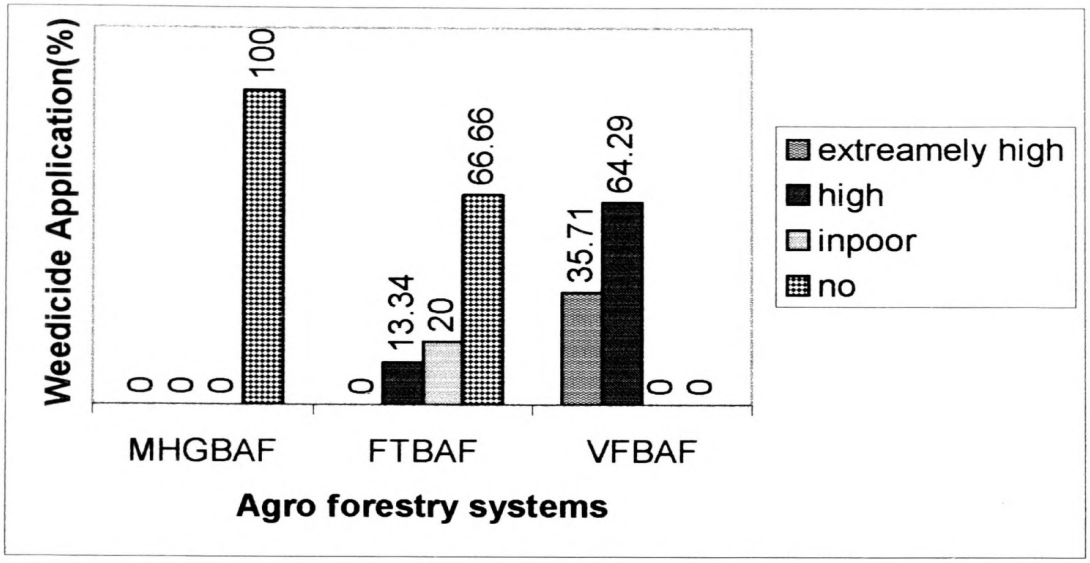

Fig 4.18: Relationship between weedicide application and agro forestry system.

Socially, Economically and Environmentally viable options can be identified through the existing agro forestry systems. Each and every farming system there are negative and positive factors with respect to sustainability. Following table shows the social economical and environmental sustainability factors of different farming systems.

Table 4.2: Assessment of sustainability options of different farming systems.

Identified option	**Reason**
Family based system	We can use females and kids for helping the system and can used more incentive methods like organic farming technology, wormy culture.
Selection of crops	Consider the FTBAF system there was a problem of selection of crops in this system because we couldn't find any factories in this area therefore farmers

	have to transport their products to urban areas. Due to that they can't compete with Colombo, Kaluthara and Gampha farmers because they have to pay high transport cost as welas the high post harvesting damages.
Type of crop verities	MHGBAFsystem they cultivates traditional verities and these are more resistant to the pest, disease and environment and other two systems were used highbred verities and they are low resistant to those factors.
Moddle of the system	Cyclic moddle is more economically sustainable than the Linear moddle because MHGBAF system is cyclic type system and it is the most economically sustainable system.
Farming system	There is a trend for organic products and those products can sell for high price.
Land area	MHGBAF system is the most economically effective land use system, which can be applied for the small land units. VFBAF system may be more economically feasible for large unit of land.
Income level of the farmer	Short-term monocrop system is better for highest income gaining in short period. Poorest of the poor MHGBAF system is the best farming system because it is a zero input base system and also to over come the wishes cycle of the malnutriants

	MHGBAF system is the best.
Land ownership	To environmental sustainability land ownership should give to the farmer.
Situation of the farming system	When we start the agro forestry system resident place and farm land should be in the same land unit because we can have a high awareness on the system.
High biodiversity	these systems were consist with different canopy levels, high root systems, different type of crop varieties etc.It help to soil fertility, environmental sustainability and economic sustainability.
Soil condition	Most erodable land areas VFBAF is the best farming system and MHGBAF system is more suitable for fertile land units.

Chapter 5

Conclusion and Recommendation

With respect to the social factors there was no relationship between farmer's education level and the sustainability of the agro forestry options practices.

This study clearly shows that, willingness of the government working with males was very high but comparing with the females it is difficult to change the attitudes of males towards the intensive agro forestry practices. Agro forestry systems using female groups may be more effective and efficient way to achieve sustainability.

Should be a family based system.

Have to select the crops with self seed production and planting materials.

Should be consider the crop selection and crop varieties.

From the research it can be concluded that, before introducing the agro forestry options to the area it should be clearly identified objectives and area of lands owned of the target group.

To environmental sustainability land ownership should give to the farmers.

When we introduced the new systems must do the market analysis and should participate the third party to support the farmers in the market.

If any one can derive the three systems may be the best, but should have more research.

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Appendix

Questionnaire:

A: Social details:

1. Family description:

- No of members of the family
-Age
-Education level
-Type of occupation (farming, temporary, government, others)
-Subsidies

2. Land usage:

-Type of land
-Amount of land
-Type of agro forestry system
-Perennial varieties
-Annual crop and vegetable varieties
-Cultivation pattern
-Time duration

B: Economic details:

1 .Family expenses (approximately) for/annual:

-Food
- Education
- Heath
-Constructions
-Agriculture-seedlings
    -ground preparing
    -manure application
    -weediside application
    -pesticides application

2. Fammily income/annual:

-From agro forestry system
-Amount
-Time duration

C: Environmental details:

1. Usages of fuel wood (from forest/from agro forestry system)
2. Soil conditions (before AFsystem and after AF system)
3. Perenials trees (before AFsystem and after AF system)
4. Annual crops and vegetables (before AFsystem and after AF system)
5. Soil organisms (before AFsystem and after AF system)
6. Siol erosion (before AFsystem and after AF system)
7. Type of pests (before AFsystem and after AF system)
8. Type of weeds (before AFsystem and after AF system)
9. Land preparation method (before AFsystem and after AF system)
10. water supply/amount and frequency (before AFsystem and after AF System)

D: Human attitude:

-Practical (yes/no)
-Economical (yes/no)
-Main ambition (yes/no)
-Future expectations (yes/no)

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