REHABILITATION & ECOLOGICAL RESTORATION R & D FOR MARGINAL & DEGRADED LANDSCAPES AND SEASCAPES

A Research Compendium
FOR MARGINAL UPLANDS

Department of Environment and Natural Resources
Ecosystems Research and Development Bureau

FOREWORD

Through the years, quite a number of research information and technologies in forest, horticultural tree species and agronomic crops have been generated to improve degraded and marginal upland areas. This compendium specifically presents data on different species suitable for agroforestry, their biophysical characteristics, fruit and seed technology, nursery techniques, cultural management practices, pests and diseases and control measures, plantation establishment and management strategies. It also provides an array of erosion control strategies for sloping lands.

This compendium is ERDB's attempt to provide a selection of appropriate upland rehabilitation strategies for ERDB regional counterparts and other interested agencies/entities. May this compendium serve as reference guidebook in promoting the restoration of degraded upland areas.

MARCIAL C. AMARO, JR., CESO III
Director

PREFACE

This Research Compendia on Rehabilitation and Ecological Restoration R & D Technologies for various Ecosystems was published through the efforts of the Ecosystems Research Development Bureau and its regional research field counterparts, *i.e.* Ecosystems Research and Development Sectors. Research information was gathered from all Regions including those from recent books and the internet. Ecosystems studied include: critical watersheds, degraded mine waste areas, volcanic debris laden areas, marginal grasslands and uplands, damaged urban and coastal sites.

While research and technology information generated in the past years have proliferated, the changing needs of time require that recent technologies be collated, integrated, analyzed and synthesized as a basis of decision-making in verifying the effectiveness and efficiency of said technologies. Managers and developers particularly in degraded areas need vital source of broad set of information from which to choose from. This manual hopes to be a meaningful guide to hasten rehabilitation efforts in these areas.

EVANGELINE T. CASTILLO, *Ph. D.*
National Program Leader/Coordinator
Rehabilitation Banner Program

ACKNOWLEDGEMENT

The Project Leader would like to extend gratitude and appreciation for the participation, support, and assistance extended by various agencies and group of people, namely:

- The ERDB for the funds provided to pursue this research undertaking;
- To Directors Adeluisa G. Siapno and Marcial C. Amaro for their encouragement for the completion of this compendium;
- Forester Gregorio D. Reyes for the trust and confidence to do the work;
- Dr. Aleli M. Luna for the unwavering support;
- Dr. Evangeline T. Castillo, National Training Coordinator for her technical expertise and valuable suggestions;
- Ma. Vienna O. Austria and For. Josephine B. Tanudtanud for the help in gathering secondary data.
- Forester Lourdes DC Reyes, Salvacion T. Orobia, Rowena C. Payuan, and Lorlina A. Calderon for their research assistance;
- To Adrian del Mundo and Darrel Solis for their assistance in preparing the illustrations;
- The ERDS focal persons and technical staff for providing substantial information; and
- The staff of various agencies for the access in their facilities particularly their library such as the Cavite State University, Forest Management Bureau, UP Diliman, UP College of Forestry, International Institute for Rural Reconstruction, Ateneo de Manila University, and Asian Development Bank.
- Finally, to Marita W. Briz, Lauro B. Rueda, Natalia P. de Leon, Famela J. Bonsol, Christian Noel M. Dotimas, Maila P. Melodillar, and Maria Aurora G. Gutierrez for their assistance in the final reproduction of this Compendium.

LYNLEI L. PINTOR
Project Leader

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDIX TABLES

INTRODUCTION

The Philippines has a total land area of 30 million hectares. Out of the country's land area, an estimated 14.9 million hectares are classified as uplands (Tacio, 2005). An area is considered upland if it has a slope ranging from 18 percent upward. Upland areas generally encompass grassland and forest ecosystems. They are important support systems of the upstream-downstream continuum, giving life to the lowland and coastal ecosystems.

In terms of biophysical characteristics, uplands are prone to erosion due to their rugged topography, considered varied, infertile and marginal soil, dry land particularly during summer due to insufficient supply of water, high temperature, complex farming systems, abundance of weeds and pests, and unpredictable field conditions (Agroforestry Kit, undated).

On the socio-economic aspect, upland areas have been characterized to have a rapid increase in population. Farming could be described as dependent on rainfall, with limited infrastructures, lacking in effective marketing systems, and having almost no credit and financing structures. Employment for farmers is seasonal, earning them meager income.

Limited employment opportunities in the lowland lead most of the Filipinos to migrate in upland areas resulting in the rapid increase in upland population. According to the Washington-based World Resources Institute (WRI), reasons for migration also include downturns in economic growth, limited access to land, inequitable land distribution, widespread poverty, resettlement programs, and timber exploitation policies.

Regardless of migration pattern, migrants have common socio-economic characteristics. Upland dwellers are the "poorest of the poor" having an annual income of PhP2,168.00. Their inadequate diet leads to malnutrition (Guerrero, 2000). They are least educated, least hopeful, and considered the most neglected by the Philippine government in terms of exerting effort for their agricultural development (Philippine Lumberman, 1995). Moreover, they subsistence-oriented and have complex land tenure status. Labor in the farm is confined within the family.

Farming has become the primary occupation of migrants in rolling and steep slopes of the uplands. Their intention was to convert these areas into productive farmlands. Such activities have resulted to the decrease in the country's forest cover as a result of continuous cutting of trees in these fragile areas.

Cultivation in upland areas increased from 582,000 hectares in 1960 to more than 3.9 million hectares in 1987 (WRI, 1995). After 10 years, Tacio (2005) revealed that more than six million hectares of forest lands in upland areas became denuded and unproductive due to heavy cultivation. Report shows that 74 percent of the uplands are actively used for subsistence farming. Farmers practice slash-and-burn agriculture to meet the needs of their family. The cutting and burning of trees without incorporating soil conservation management strategies result in land degradation (DA, DENR, DOST, and DAR 2004).

Heavy cultivation in upland areas lead to soil erosion. Soil erosion is considered as the most common type of land degradation affecting the soil physico-chemical and biological properties. In fact, a total of 13, 559,429 hectares have been affected by erosion. The loss of topsoil makes the land less suitable to crop production or total loss of soil productivity and reduction in water retention capacity (DA, DENR, DOST, and DAR, 2004). It also increases the cost of food production.

It has been reported that 20 percent of the eroded materials go to rivers, reservoirs, and irrigation canals (Rev. Watson, 2005). Likewise, upland areas under heavy cultivation cause landslides and floods destroying lives and property. It is essential to reinstate the fertility and productivity of degraded lands through application of soil and water conservation measures (DA, DENR, DOST, and DAR, 2004). Hence, rehabilitation of marginal upland areas is highly imperative in order to save the remaining upland areas in the country and meet the growing needs of increasing population.

OBJECTIVES

To compile information on vegetative and engineering measures in rehabilitating marginal upland areas;

To identify the species suitable in marginal upland areas;

To ascertain the biophysical requirements, seed technologies, nursery techniques, and other cultural management practices, pests and diseases control strategies of various species for marginal upland areas.

DESCRIPTION OF UPLAND ECOSYSTEM

Sixty percent of the total land area of the Philippines is classified as uplands. With slopes of 18 degrees or more, such upland areas are vulnerable to soil erosion especially when denuded of their forest cover (Guerrero, 2000). For Tacio (2005), around 14.9M hectares or half of the country's land area of 30M hectares are classified as uplands. The uplands are zones where agriculture and forestry are practiced on rolling to steep land, with slopes ranging upward from 18%.

The uplands are continuously pressured by increasing population as more lowland people migrant to these areas. The uplands is the ecological and social frontier where the battle for future survival of the Filipino society will be fought (Sajise, 2005).

The natural resources of the uplands provide a livelihood for people, through land uses such as agriculture, forestry, field sports, tourism and recreation. The upland ecosystem also provides us with natural resources such as clean water which we use in our daily lives. The wild nature and ruggedness of the uplands provides open-air recreation and enjoyment for people, and their natural beauty is one of the main attractions for our tourism industry.

These habitats occur with a variety and combination of species in a range of mosaics in the uplands over extensive areas (biodiversity.gov.uk.).

DESCRIPTION OF MARGINAL UPLAND AREAS

The uplands have become marginal due to increase in upland population together with forest exploitation. Other factors that contributed to the degradation include land tenure arrangements, uncontrolled exploitation of forest, shifting cultivation, conversion of agricultural lands, overgrazing, improper agricultural practices, construction of road networks, land clearing for national infrastructures, indiscriminate burning, mining and natural calamity. Thus, the upland is no longer capable of sustaining productivity to support the needs of human society (Sajise, 1986 as cited by DENR, IIRR, and Ford, 1992).

Marginal upland areas are no longer covered with tropical rainforest vegetation. Agricultural activities in upland areas became a contributory factor in the depletion of forest resources. Acidity, low nutrient content, and loss of nutrients due to erosion, leaching, and volatilization are the characteristics of soils in marginal upland areas (Malab, undated). Soil resources have been exploited causing the degradation of upland agricultural land. At present, it is characterized by barren denuded hills and mountains mainly vegetated with cogon and brush. Only few trees remain in this area. The marginal upland areas consist of classes of areas such as cultivated/open areas/forest, grassland, cultivated mixed grassland, eroded areas, and other barren areas (DENR, IIRR, and Ford, 1992).

Fig. 1. Sample of marginal upland area.

REHABILITATION STRATEGIES

VEGETATIVE MEASURES

I. Agroforestry

Agroforestry is known to protect upland environment and enhance biodiversity (PCARRD, 2003). It is an effective technology to rehabilitate and manage degraded upland areas (Villanueva, 2005). In fact, it is being used as a national strategy because it enhances sustainable development in upland areas thereby promoting people empowerment and social justice. Agroforestry has the potential to conserve and increased crop productivity. The potential is based on two premises such as protective (ecological) and productive roles of agroforestry (Villanueva, 2005). The ecological role is based on the benefits that trees give to the soil and the microenvironment. It involves soil and water conservation, improvement of microclimate, and resistance to pests and diseases. Agroforestry's productive role is about improving the upland ecosystem, conserving it and consequently sustainable productivity through time (Lasco, 1999).

Fig 2. Sample of agroforestry farming system

Ia. Definition of Agroforestry

Agroforestry is a technology for sustainable land-use for the management of upland areas with physical and chemical soil constraints (Malab, undated). For Nair (1993), agroforestry is a land-use system involving integration of trees, agricultural crops, and livestock, simultaneously or sequentially to increase productivity of plants and animals in a sustainable manner under conditions of low levels of technology inputs and marginal lands.

Fig. 3. Agroforestry at Bagong Silang, Los Baños, Laguna

Ib. Characteristics of Agroforestry

Agroforestry is more complex ecologically and economically than mono-cropping. Its cycle is more than one year which involves two or more plant species where one is a woody perennial, has two or more outputs, and interactions exist among woody and non-woody components (Lasco, 1999).

Ic. Criteria for Agroforestry System

Productivity should increase crop production and land productivity. There must be combination of crops and technologies to achieve optimum product-output mix. It is expected to achieve high yield, reduce inputs, and increase labor efficiency.

Agroforestry should be sustainable providing the needs of men and at the same time conserving the productive potential of the resource base through time. Soil and water conservation strategies should be applied to maintain and conserve land fertility. Components of sustainability in agroforestry include ecological, social, and economic.

Agroforestry should be acceptable to the farmers for them to adopt the technology. Socio-cultural norms and traditions, beliefs, and customs should be taken into consideration.

Id. Classification of Agroforestry Systems

A. **Agrisilviculture**

Agrisilviculture is a combination of trees and agricultural crops integrated on the same land. This includes multistorey systems, alley cropping systems, improved fallow system, taungya system, trees that serve as trellis of climbing crops, and windbreaks.

Forms:

A.1. Multistorey Systems

The system is characterized by mixing various species creating at least two layers of canopy. The upper canopy consists of light-demanding species while the understorey is composed of shade-tolerant species.

Multistorey system can be developed in an existing monoculture plantation. The main tree crop is planted with wide spacing to allow light in shade-tolerant crops.

The series of canopy layers protect the soil against rainfall reducing soil erosion and surface runoff. On the other hand, the upper layer of the tree canopy reduces penetration of light in the crops planted underneath. Thus, it is advisable to plant shade-tolerant crops underneath. Pruning or thinning of overstorey trees should also be done when necessary.

Fig. 4. Sample of multi-storey system with gabi planted underneath.

Places	Trees and Crops
Surigao del Sur	Falcata, coffee, lanzones, durian, abaca, bagras and corn.
Cavite and Batañgas	Fruit trees, coffee, taro, ginger, rice, corn, sweet potato, vegetables, African daisy, pineapple, arrowroot
Candelaria, Quezon	Citrus, coffee, jackfruit, mango, anonas, avocado, sinegue-las, taro
Laguna	Coffee, citrus, banana, taro, rice, corn, vegetables, lanzones
Tiwi, Albay	Coffee, cacao, alnus, ipil-ipil
Bicol	Banana, cassava, camote, rice, taro, peanut, sweet potato, ramie, hot pepper, ginger, pineapple, papaya, coffee, ca-cao, lanzones, abaca, jackfruit, rimas, buri, santol, citrus, avocado, mango, macopa, guava, tiesa, balimbing, chico, caimito, rambutan, atis, black pepper
Leyte	Mungbean, peanut, palay, corn, sorghum, cassava, sweet potato, taro
Davao City	Black pepper, papaya, cacao, pineapple

A.2. Taungya System

This is a long established approach. A land-use practice that offers a complete and culturally integrated approach to rural development, diversified and sustainable agroforestry.

To establish a taungya system, a piece of land is cleared and planted with tree seedlings. At the same time, food crops are planted among the trees. The food crops can be farmed for a duration of 2-3 years depending on how quickly the tree canopy develops. After three years, the trees remain on the land until they are harvested and then the system can be repeated.

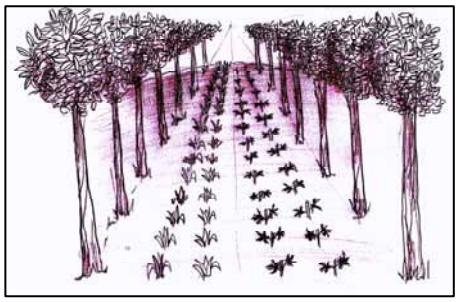

Fig. 5. A sample of a taungya system.

A.3. Trees Along Boundaries

The system involves planting of multipurpose trees and shrubs around the farm which provide protection and valuable products. Trees also serve as fence and boundary for the farmers' property.

Species Used

Common Name	Scientific Name
Agoho	*Casuarina equisetifolia*
Teak	*Tectonis grandis*
Yemane	*Gmelina arborea*
Cashew	*Anacardium occidentale*
Cacao	*Theobroma cacao*
Bamboo	*Bambusa blumeana*
Banana	*Musa sapientum*
Pineapple	*Ananas comosus*
Ochra	*Hibiscus esculentus*
Sweet potato	*Ipomoea batatas*
Mustard	*Brassica juncea*
Sugarcane	*Saccharum officinarum*
Cassava	*Manihot esculenta*
Corn	*Zea mays*
Papaya	*Carica papaya*

A.4. Alley Cropping System

Alley cropping is a system effective in the context of soil and water conservation. It increases soil nitrogen, helps control weeds, serves as windbreak, helps achieve higher yields of annual crops grown between hedges of leguminous shrubs over conventional cropping system, and provides livestock feed and firewood.

The system involves planting of hedgerows along contours and agricultural crops in the alleys formed between hedgerows. The hedgerows are composed of wood perennials to prevent soil erosion and reduce the speed of surface runoff.

To start farming using the alley-cropping system, select a flat to gently sloping topography that is less productive for food crop production. After clearing and weeding, layout the rows of trees/shrubs and food crops in an east-west direction with a 5-m distance in between rows of tree crops, 1 m in between tree and food crops, and 25-150 cm in between individual tree plants. Distances always depend on the type of plant to be grown. Cultivate only the rows where tree and food crops will be planted.

During the planting season, plant trees and crops. Allow first the tree crops to grow for a period of one year while normal farming operations is being done on the food crops.

Prune the tree crops on the second year either quarterly or every two months at 0.5 m height. The pruned leaves and stems will serve as mulch for food crops.

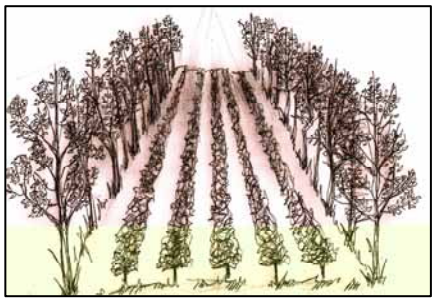

Fig. 6. An illustration of alley cropping.

Samples of Alley Cropping:

***Leucaena*-Based Alley Cropping**

The University of the Phillippines Los Baños launched a corn/ *leucaena* farming technology that minimizes soil erosion and increases corn yields. *Leucaena* seeds were planted at 30 cm between hills and 50 cm between rows, forming a double-row contour hedge 4 m apart. Five rows of corn are planted between the hedgerows. The first cutting of leucaena was made after six months while pruning was done at 45-60 day intervals.

Leucaena leaves used for mulching have a nitrogen efficiency of approximately 33 percent. Once the leucaena has decomposed, the nutrients become available to the crop.

Desmanthus-Based Alley Cropping

Desmanthus virgatus can be planted as a component of alley cropping systems. The plots consist of 1-m wide contour hedgerows (3 rows of Desmanthus planted 10 cm apart with 40 cm between rows) separated by alleys 5 m wide where corn and mungbean are grown in sequence. Hedgerows can be pruned every 45 - 60 days to provide green manure for the alley crops. In Desmanthus-based alley cropping, a 99% reduction in annual mean soil loss and a 75% decrease in runoff are expected (Comia *et al.* 1994).

Gliricidia-Based Alley Cropping

A row of Napier grass can be planted between two rows of Gliricidia seedlings. The hedgerows follow the contour of the erosion plots with 50 cm x 50 cm between rows and hills, respectively, to form a 0.5-m wide hedge. Grow corn as the first crop in the 5-m wide alleys between the hedgerows followed by peanut. Prune the hedgerows every 45-60 days to minimize shading. The branches can serve as green manure/mulch to other crops. In this system, the annual soil loss from the alley cropping plots is lesser compare with the traditional practices.

B. Improved Fallow System

Farmers undergo fallow period after 4-5 years of continuous cultivation to allow the farm to rejuvenate. Instead of waiting for the time to revegetate, leguminous nitrogen-fixing multipurpose tree species are planted.

Species Used

Common Name	Scientific Name
Alnus	*Alnus japonica*
Akleng parang	*Albizia procera*
Alnus	*Alnus nepalensis*
Acid ipil-ipil	*Leucaena leucocephala*
Calliandra	*Calliandra calothyrsus*
Duhat	*Syzygium cumini*
Dapdap	*Erythrina orientalis*
Gmelina	*Gmelina arborea*
Giant Ipil-ipil	*Leucaena pulverulenta*
Guava	*Psidium guajava*
Kariskis	*Albizia lebbekoides*
Kadios	*Cajanus cajan*
Karikut-rikut	*Desmodium gyroides*
Katurai	*Sesbania grandiflora*
Kakauate	*Gliricidia sepium*
Kamachile	*Pithecellobium dulce*
Langil	*Albizia lebbek*
Malabalatong	*Flemingia macrophylla*

Common Name	Scientific Name
Mahogany	*Swietenia macrophylla*
Malunggay	*Moringa oleifera*
Neem	*Azadirachta indica*
Raintree	*Samanea saman*
Rensonii	*Desmodium rensonii*
Sineguelas	*Spondias purpurea*
Thailand shower	*Cassia siamea*
Corn	*Zea mays*
Upland rice	*Oryza sativa*
Sweet potato	*Ipomoea batatas*
Cassava	*Manihot esculenta*
Gabi	*Colocasia esculenta*
Pineapple	*Ananas comosus*
Peanut	*Arachis hypogaea*
Papaya	*Carica papaya*

This strategy uses leguminous fallows to accumulate N in the biomass and recycle it into the soil. It also acts as a break crop to smother weeds and to improve physical and chemical properties of the soil. It also increases availability of nitrogen through N2 fixation by trees. The other essential nutrients such as P could be cycled to some degree through plant biomass and returned to the soil during litter decomposition. In the process, it converts nutrients to more available forms (Kwesiga *et. al* 2002).

Improved fallows enhance household welfare through increase in yields while requiring the same land and labor inputs as farmers' main cropping strategy without using fertilizer.

Improved fallows provide benefits in terms of reduced risk from drought, increased fuelwood, and other by-products. It improves soil physical properties which reduce soil erosion and enhance the ability of the soil to store water. Fallows also help reduce pressure on woodlands for fuelwood.

Forms:

B.1. Naalad Farming System in Naga, Cebu

The *balabag* system or the fallow-till rotation is an indigenous agroforestry technology among Naalad farmers in Naga, Cebu combining agricultural and forestry crops in the same unit area. The land is cleared of perennial crops by cutting, then cropped, fallowed, cleared, and cropped again (Pulhin, 1983). Fallowing restores soil fertility. The area is compartmentalized to allow rotational cropping and fallowing, so that when one-half of the farm is under fallow using *Leucaena* the other half produces main crops.

When the yield start to decrease gradually, cropping moves to where the fallow area has been cleared of *Leucaena* trees. The branches are placed along the contours using *Leucaena* stumps as support to form barriers. Branches with leaves are placed along the base of the strips to reduce the velocity of runoff water. The remaining leaves are then scattered over the soil surface and allowed to decompose. The *Leucaena* fallow-balabag rotation has the same function of recycling nutrients and adds biologically-fixed nitrogen to the system.

Fallow Species Used by Ibalois and Ilocanos in Benguet

Buho (Schizostachyum *lumampao*), anos (*Schizostachyum lima*), tibig (*Ficus sp.*), fern (*Cyathea sp.*), rattan (*Calamus sp.*), akleng parang (*Abizia procera*);

C. Silvipastoral System

It is a land management system in which forest species are used for the production of wood and livestock. It refers to situations in which fodder or shrubs and or/pasture grasses serve as alley crops, protein banks/cut-and-carry fodder production system involving woody perennials, live fence system, and tree-crop grazing system.

Forms:

C.1 Live Fence System

Live fence system is a form of agroforestry to demarcate a boundary by planting trees and/or shrubs with close spacing and fixing

wires on it (ICRAF-Huxley, 1997). This kind of system is being used by poor farmers who do not have sufficient capital to purchase barbed wire. Live fences/live barriers/hedges are thicker, more densely spaced fences to protect their crops. It includes different species that do not need barbed wire for support (Budowski, 1987). Trees/shrubs with foliage that are palatable to livestock are grown to enclose the grazing animals. The trees serve as live fence, and at the same time, the low-lying branches of the trees as fodder supplement. Live fence serves as natural barrier to control movement of animals and people from entering into the farm and proven to provide farmers with numerous benefits. Live fence provides fuelwood, fodder and food, act as wind breaks to protect cropland, or enrich the soil. Live fences around the farm can also act as nutrient traps, preventing loss of nutrients that could be lost through surface runoff.

Farmers should plant stakes using a species that is easy to root. *Gliricidia sepium* is usually being planted as live fence post because of its large stem cuttings root. It has also multiple uses such as forage, green manure and as a rat poison. Farmers plant large (1.5-2.0 m) stakes of *Gliricidia sepium* which take root within a month. The shoots grow for a period of 6-10 months before farmers cut them back. Subsequent prunings can be done every 4-8 months. Shoot pruning at intervals of 6-8 months result in woody sprouts suitable as stakes. Thus, farmers can have many live stakes as fence posts.

Fig. 7. Photo showing live fence system with grazing animals.

Fig. 8. Photo showing live fence system planted with different kinds of plant species.

C.2 SALT 2

SALT-2 comprises a half-hectare goat-based agroforestry wherein 40 percent is used for agriculture, 40 percent for livestock, and 20 percent for forestry. This technology can minimize erosion and improve soil fertility.

SALT-2 is classified under the agro-silvipasture scheme of agroforestry integrating production of fuelwood from hedgerows, agricultural crops, livestock, and forage.

In establishing SALT-2, first locate and develop the contour lines by using an A-frame. Establish hedgerows and grow food and cash crops on the upper half of the farm. Develop a forage garden in half of the area. Construct a goat barn in between the boundary of the forage garden and agricultural area. Maintain the farm regularly by cutting the hedgerows 0.5-1 m from the ground when they start to shade the crops. Replant missing hills of hedgerows.

D. Agrisilvipastoral Systems

The most intensive form of land management, are systems in which the land is managed concurrently for the production of agricultural and forest crops and for rearing of domesticated animals. In addition, there are many agricultural practices associated with forest that strictly do not fall under the above categories. These include, collection of non-timber forest products from forests, growing trees around wetlands and other water bodies in which fish culture is practiced, apiculture with trees, and multipurpose woodlots, etc.
Forms:

D.1 Multistorey System with Free Grazing

The system is similar to the multistorey under agrisilvicultural system except that there are grazing animals. It is composed of coconut and lanzones mixture, with cattle grazing under the trees. This kind of system is observed in Laguna and Quezon provinces.

Species Used

Common Name	Scientific Name
Guinea grass	*Pannicum maximum*
Napier grass	*(Pennisetum purpureum)*
Setaria	*Setaria sp.*
Vetiver grass	*Vetiveria zizanoides*

E. Contour Tillage

Contour tillage is applied on sloping lands. This reduces runoff, soil erosion and nutrient loss. A contour is an imaginary line connecting points of equal elevation, perpendicular to the direction of slope. Different plants can be established along the contour lines. Contour tillage may involve soil traps, bench terraces, and hedgerows (Malab, undated).

Conservation tillage results in a much shorter turn-around period between two croppings. This is very crucial in areas where rainfall duration is short as it takes advantage of the residual soil moisture at the end of the rainy season.

The crop residue cover reduces evaporation, prevents the growth of weeds, increases soil organic matter content, stimulates soil life (flora and fauna) and sequesters carbon.

F. Cover Crops

Cover crops are grown to prevent soil erosion and water loss. They also increase soil fertility, improve soil structure because it can provide up to 30 tons of organic matter/hectare, increase soil organic matter, and suppress weed growth. Cover crops help retain moisture particularly during dry season. Other benefits include animal fodder, fuelwood, food and additional income. Short-term crops belonging to the legume family are planted under trees during fallow periods.

Cover crops can be interplanted or relay-planted with corn or other grain crops. It can also be planted alone in the cropping cycle. Plant cover crops under the trees or as a fallow crop.

Species Used

Common Name	Scientific Name
Kokoa, Velvet bean	*Mucuna pruriens*
Batao, Lablab bean	*Dolichos lablab*
Jack bean	*Canavalia ensiformis*
Sword bean	*Canavalia gladiate*
Kadios, Pigeon pea	*Cajanus cajan*
Sun hemp	*Crotolaria sp.*
Tahori rice bean	*Vigna umbelata*
Paayap black bean	*Vigna unquiculata*
Sigarillas	*Psophocarpus teragonolobus*
Winged bean	*Psophocarpus palustris*
Tropical kudzu	*Pueraria phaseoloides*
Ubi	*Dioscorea alata*
Camote	*Ipomoea batatas*

G. Hedgerows

Hedgerows are an indigenous practice in some Asian countries. It improves soil fertility, soil moisture, soil structure, and water infiltration. Nitrogen-fixing trees/shrubs, grasses, agricultural crops, and fruit trees are planted in rows along the contour. Hedgerows prevent soil erosion because they help slow down rainwater thereby trapping the soil.

Species Used

Common Name	Scientific Name
Villosa	*Acacia villosa*
Red Calliandra	*Calliandra calothyrsus*
White Calliandra	*Calliandra tetragona*
Fireball	*Calliandra haematocephala*
Thailand shower	*Cassia siamea*
Antsoan dilao	*Cassia spectabilis*
Fire tree	*Delonix regia*
Rensonii	*Desmodium rensonii*
Dapdap	*Erythrina poeppigiana*
Flemingia	*Flemingia macrophylla*
Kakawate	*Gliricidia sepium*
Acid ipil-ipil	*Leucaena diversifolia*
Ipil-ipil	*Leucaena leucocephala*
Kupang	*Parkia roxburghii*
Butterfly	*Piliostigma malabaricum*

H. Contour Strip Cropping

This cropping system involves growing of a soil-exposing and erosion-permitting crop in strips of suitable widths across the slopes on contour, alternating with strip of soil-protecting and erosion resisting crop. Contour strip cropping shortens the length of the slope, checks the movement of runoff water, encourage desiltation and increases the absorption of rainwater by the soil. Further, the dense foliage of the erosion-resistant crop prevents the rain from beating the soil surface directly. It is advisable to rotate the strip planting by showing a non-resistant crop, following an erosion-resistant crop and vice-versa.

I. Terracing

Terrace is a leveled section of a hilly cultivated area, designed as a method of soil conservation to slow down or prevent the rapid surface runoff of irrigation water. A strategy of cultivating the soil and growing crops on a level of ordinarily narrow plain with steep front.

Terracing is considered labor intensive and expensive in terms of land-levelling processes. Draft animal power and a scraper/scoop are needed to help in moving the soil. The scraper has a blade made of wood or metal with a handle attached and a rope attached to the top of the blade.

Forms:

I.1 Bench Terrace

To establish a bench terrace, mark two contour lines on a hillside with the aid of an A-frame. The distance along the slope varies. The more gentle the slope, the more that the contour lines should be further apart. Generally, the vertical distance is 1 m.

Remove the soil from the upper half of the strip using hand tools or draft animals. Continue doing this until such time that the area above the midline and the soil piled below the midline are leveled.

Establish the riser (front of the level area) such as it slants back toward the hillside. The riser should have 15-45 degrees angle depending on the soil type and the height of the riser. Plant the riser with grasses for further riser stabilization.

Excavate a small canal at the base of the terrace to carry off excess rain water during heavy rains. This saves the terrace from being washed away.

Create a slope slightly upward at the new front area of the terrace. Develop a small mound or lip on the top of the riser at the front of the terrace. This prevents the water from washing over the front and eroding the riser.

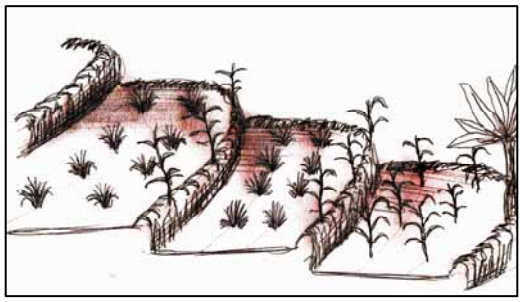

Fig. 9. An illustration of a bench terrace

ENGINEERING MEASURES

I. Soil Barriers

Barriers can either be made of wood, rocks, logs, and branches across the slope. These are placed against wooden stakes driven into the ground. Grasses and other materials are placed on the upper side of the barrier to act as a sediment trap. The width of the cropland between barriers is 4-8 m. The soil barriers slow down runoff thereby act in the retention of sediments behind the fences.

Fig. 10. An illustration of soil barriers which is a combination of different plants with wooden stakes.

II. Soil Traps

Check dams and trenches built in diversion ditches or waterways serve as soil traps. A check dam slows down the flow of water and allows soil particles to settle. It is made of *Gliricidia* stakes, bamboo, rocks, and logs to harvest soil eroded from the upper slope.

Trenches are constructed to trap soil along the waterways, prevent widening and deepening of gullies, and reduce the velocity of runoff in gullies. To make trenches, one has to dig 1-2 m above the check dam. Dimensions also include: 0.8 m depth, 1.0 m length and 0.5 m width. This can also be built at the lower portion of the field. This can trap soil and store water. The accumulated soil is returned to the farm lots.

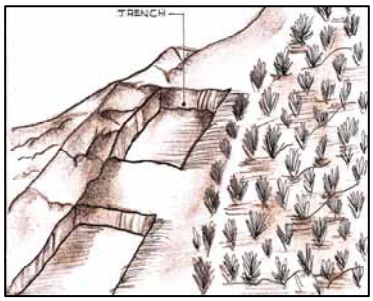

Fig. 11. A check dam as soil trap.

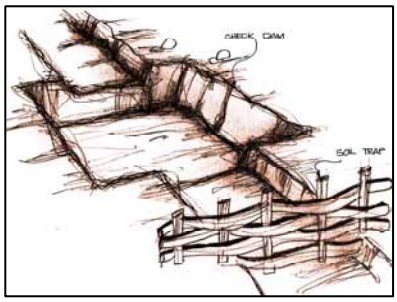

Fig. 12. Trench as soil trap.

This Compendium provides numerous research reference materials to properly raise recommended/suitable agroforestry species (forest trees, grasses, agricultural crops, and fruit-bearing trees) as shown in Appendices. Specifically, it includes aspects on biophysical requirements, seed technologies and nursery techniques, pests and disease control, and field plantation cultural management techniques.

REFERENCES

Agpaoa, A. C. *et al.* 1975. Manual on Reforestation and Erosion Control for the Philippines. German Agency for Technical Cooperation Ltd. (GTZ). West Germany. 569 pp.

Agroforestry, Seed Technology and Nursery Management.1988. A Training Manual Published by Institute of Agroforestry, UPLB, College, Laguna.

Anonymous. 1989. Workshop to Develop and Agroforestry Technology Information Kit. November 4-13, 1989. IIRR, Silang, Cavite, Philippines.

Anonymous. 1982. The Philippine Recommends for Reforestation. Technical Bulletin Series No. 49. PCARRD, Los Baños, Laguna.

Baconguis, S. R. and L. I. Canete-Ranes .Canopy International. 26(6); 3, 11 N-D 2000 1971. Plants of the Philippines. Science Education Center, University of the Philippines p. 4 & 174.

Brown, F. G. 1968. Pests and Diseases of Forest Plantation Tree. Clarendon Press, Oxford, UK.

Bumatay, E. C., E. J. M. Mende and J. Quimio. 1995. The Effect of Hardening Arrangement on Beds on the Growth of *Acacia mangium, Acacia auriculiformis* in the Nursery. Proceedings of the International Symposium on Recent Advances in Tropical Tree Seed Technology and Planting Stock Production held on Haad Yai, Thailand on June 12-14, 1995.

Dano, A. M. and P. C. Atega. 1999. Soil and Water Conservation Structures: Lessons from ERDB-DENR Experience. In Proceedings of the 1st Asia Pacific Conference on Ground and Water Bioengineering for erosion control and slope stabilization. Manila Phil 19-21 April 1999.

DENR Recommends No. 2b and 14 (2000 & 2005) ERDB Publication.

DENR Recommends. 2000 & 2005. Reforestation Packet Series 2b and No. 14.

DAS, Someswar, 1984. Nursery and Plantation Management: A Training Manual, 1988. Published by Institute of Agroforestry, UPLB.

Dayan, M. dP. 2004. DENR Recommends #14 Fungal Diseases of Forest Tree Seeds and Control Measures: A Guidebook.

Dayan, M. dP., R. S. Reaviles, and V. dP. Abarro. 2005. Forest Tree Seeds: A Phenological Guidebook. ERDB-DENR, College, Laguna.

DENR-ERDB.1998. Development and Management of Forest Plantation. A Guidebook. College, Laguna.

De Guzman, E. R. M. Umali and E. D. Sotalbo. 1986. Guide to Philippine Flora and Fauna. Dipterocarps and Non-Dipterocarps. Natural Resources Management Center. UPLB, College, Laguna.

Delos Santos, A.E. 1980. Agoho: An Alternative Cash Crop. Canopy International.

ERDS-CAR-DENR. 1994. Soil and Water Conservation through Vegetative Measures. Technology Transfer Tips. Vol. 1, No. 1. Baguio City. 19 pp.

Flores, E.M. 2002. *Samanea saman* (Jacq.), Merr. In: J.A. Vozzo (ed) Tropical Tree Seed Manual. Agriculture Handbook 721. USDA Forest Service, Washington, D.C.

Hensleigh, T. E. and Holaway, B. K. (eds). 1988. Agroforestry Species of the Philippines. AJA Printing, Malabon, Metro Manila, Philippines.
ICRAF. 1980. Agroforestry Species: A Crop Sheet Manual. Kenya.

Kumar, P., Aranthanarayana, A. K. and Sharma, S.N. 1987. Physical and mechanical Properties of *Acacia auriculiformis* from Karnataka. Indian For. 113: 567-573.

Maun, M. M. 1970. *Albizia falcataria* in Nueva Viscaya Plantation. Department of Agriculture & Natural Resources, Bureau of Forestry. Occasional Paper No. 39. pp 1-20.

Munez, P.S. and L.G. Nagpala. 1983. Bareroot Agoho wildlings successful Growth in San Jose, Occidental Mindoro. Canopy International.

Mauricio, L. S. 1990. Practical Methods of Fruit Collection. RISE 2 (1-10).

Mosquito, M. G. 1990. *Acacia auriculiformis*. An Afforestation Species Used in the RP-Japan Forestry Development Project Watershed management. Proceedings of the Symposium Workshop on Emerging Seeds Technology for Agroforestry Species held at CEC, Los Baños, September 6-7, 1989.

NAS. 1980. Firewood Crops, Shrubs and Tree Species for Energy Production. Washington, DC. USA

Nasayao, E.E., E. M. Germano, R.E. Dabuet and M.E. Barillo, A.M. Lumacad, N.E. Racho. 1996. Terminal Report of ACIAR PN 9208. Tree Establishment Technologies in the Philippines. ERDS-DENR Region VIII, Tacloban City, Philippines. 123 p.

Newman, V. 1989. Effect of Pretreatment on Germination of *Acacia mangium*. Forest Research Center, Sabah, Malaysia.

Orallo, C. A. and A. V. B. Lopez. Sylvatop Philipp For. Res. J. 1981 6 (1) pp. 33-37

Pests and Diseases of Forest Plantation in the Phil. A Guidebook Series No. 154/1995. PCARRD-DOST, National Forestation and Development Office, Center for Environment and Natural Resources DENR

Pinyopusarerk, K. 1990. *Acacia auriculiformis*: an annotated bibliography. Winrock International Institute of Agricultural Development, Australian Centre for International Agricultural Research, Canberra. Australia. 154pp.

PCARRD-DOST and NPCO-DENR.1991. Improved Reforestation Technologies in the Philippines.

PCARRD-DOST, FMB-DENR-, DA, UPLB-CFNR-FDC-ENFOR. 1999. Guidelines for Watershed Management and Development in the Philippines. Los Banos, Laguna. 241 pp.

Ragupathy, S. et al. 1989. Recent Development of Acacia Planting. ACIAR Proceedings No. 82 pp. 274-780.

Ramilo, V.C. 1980. Seed, Nursery and Plantation Technologies of Giant Ipil-ipil (*Leucaenaa leucocephala* (Lamb.) de Wit). Term paper presented for Advance Nursery and Plantation Technologies Graduate Course. UPLB College of Forestry, College, Laguna

Philippines.

Report of the Fifth Meeting of the Seed Technology and Materials Exchange Working Group. Chiang Mai, Thailand June 9-12, 1993.

Research Information Series on Ecosystems (RISE) 1991. Drought-resistant Species. Vol. 3 No. 2. ERDB, College, Laguna

Research Information Series on Ecosystems (RISE) 1989. Rain tree and Ilang-ilang. ERDB Vol. 1 No. 10 (December). ERDB, College, Laguna. pp. 2-11.

Research Information Series on Ecosystems (RISE). 1989. Reforestation Species: Mollucan Sau (*Albizzia falcaria*) Japanese Acacia (*Acacia auriculiformis*). Vol. 1 No. 4 ERDB, College, Laguna. Pp 15-22.

Research Information Series on Ecosystems (RISE). 1992. Distribution and Site Requirements of Some Reforestation Species. Special Issue No. 4. ERDB, College, Laguna 12 pp.

Sadjad, S. 1993. Some Inofrmation on Seed Technology of *Parasarianthes falcataria, Acacia mangium, Shorea pinanga, Swietenia macrophylla* and *Peronema canescens*. Proceedings of the 5th WG Meting held in Chiang Mai Thailand on June 9-12, 1993.

Staples, G.W. and C. R. Elevitch. 2006. *Samanea saman* (rain tree), ver. 2.1. In: Elevitch, C.R. (ed). Species Profiles for Pacific Island Agroforestry. Permanent Agriculture Resources (PAR), Honolulu, Hawaii. pp. 1-15.

Technology Transfer Series. 1996. *Acacia auriculiformis*. Vol. 8 No. 3. ERDS-DENR Region VIII, Tacloban City 24 pp.

Technology Transfer Series. 1994. Seed Technologies and Plantation Techniques for Mahogany, Narra, Rain tree and Yemane, ERDS Region V. Vol.2 No. 2. 54 pp.

Technology Transfer Series.1993. Gall-rust of Mollucan sau [*Paraseriathes falcataria* {L.} Nielsen] in Central Visayas: Strategies for Prevention and Control. ERDS Region 7. Vol 4. No. 1. 21 p.

The Philippines Recommends for Reforestation. 1992. Philippine Council for Agriculture, Forestry and Natural Resources Research and Development, Los Baños, Laguna. Series No. 49-A. 113 pp.

The Philippines Recommends for Pines. Technical Bulletin Series No. 54. ISSN, Philippine Council for Agriculture, Forestry and Natural Resources Research and Development, Los Baños, Laguna.

Thomson, L. A. J. 2006. *Pterocarpus indicus* (narra), ver. 2.1. In: Elevitch, C. R. (ed.). Species Profiles for Pacific Island Agroforestry. Permanent Agriculture Resources (PAR), Honolulu, Hawaii. Pp. 1-15.

Welgas-Briz, M.W. 1995. Effects of different seed treatments, temperature, and light on germination, and light intensity on initial growth of seedlings of *Acacia auriculiformis* A. Cunn. Ex Benth. MScF Thesis. University of New Brunswick, Fredericton, N.B. 110 pp.

APPENDICES

Appendix Table 1. Leopold Matrix of Species for Rehabilitation of Marginal Upland Areas.

	ELEVATION RANGE (M)			DROUGHT TOLERANCE				Ph		
	0-1000	0-1500	0-2000	G	M	E	P	Act	Wt	Nac
Acacia auriculiformis	x			x	x	x		x	x	x
Acacia mangium Willd.	x			x	x	x				
Albizia lebbekoides	x			x	x	x		x	x	
Albizia procera (Roxb.) Benth		x		x	x			x	x	x
Alnus maritima		x		x	x			x		
Albizia falcataria		x						x	x	
Alnus japonica		x		x	x			x	x	x
Azidirachta indica A. Juss										
Calliandra calothyrsus		x		x	x				x	x
Casuarina equisetifolia L.		x			x	x			x	
Cajanus cajan	x			x	x			x	x	
Eucalyptus camaldulensis			x					x		
Flemengia macrophylla					x			x		
Gliricidia sepium			x	x	x			x	x	x
Leucaena leucocepha	x			x	x			x	x	
Melia dubia	x								x	
Piliostigma malabaricum (Roxb.)	x			x				x	x	
Pinus kesiya Royle ex Gordon			x						x	
Pithecellobium dulce (Roxb.)			x	x	x			x	x	x
Pterocarpus indicus		x		x	x			x	x	x
Samanea saman		x		x				x	x	
Sesbania grandiflora		x		x				x	x	
Trema orientalis	x									

Appendix Table 2. Biophysical Requirements of Species Suitable for Marginal Uplands Rehabilitation

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Acacia auriculiformis	Twisted pod, flat and undulating when ripe with small black seeds encircled with orange funicle from which they are suspended after pods open.	December to January and March to April	Climb the tree and handpick or clip the pods (after they turn brown od before they open) with pruning poles.	Orthodox	49,500 seeds/kg	Sun dry the pods: extract seeds manually. Dry the seeds under shade to reduce moisture content to 7%
Anthocephalus chinensis Rich Ex Walp	Fruits are united and embedded in receptacle			Recalcitrant seeds	18,000,000- 26,000,000 per kg	Involves air drying, crushing, and sieving to separate seed from chaff. Fruits are soaked in the open until rotted, ground by hand into a thick slurry, air dried, and passed through a series of sieves. This procedure improves seed purity up to 98%, and germination success.
Acacia mangium	Fruit is a dark brown, crinkled and soiled pod that partially opens when ripe; the small seeds 2.5 mm long and 4mm wide, hang by ornage fleshy funicles.	February to April or November to December	Collect seeds directly from the tree when they become gray and open up by cutting the pods from the branches with a long bamboo pole.	Orthodox	Fruiting is prolific. Individual trees in a 14-year-old plantation produce as much as 1 kg of seed per year. The average is 0.4 kg.	

PLANT NAME	FRUIT					
Scientific Name /Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Albizia procera	Flattened pod, dehiscent, 10-20cm long and 1.8-2.5cm broad; changes from green to deep red or reddish brown on maturity each pod contain 6-12 seeds, 5mm x 6mm wide plat, elliptical to nearly orbicular.	April and November	Climb the tree and handpick or clip the pods (after they turn brown od before they open)	Orthodox	200,000/liter	Extract the pods in sack then dry in the sun for a short time and remove debris by winnowing
Albizzia lebbek	The fruit is a flat brown pod 10–20 cm long and 2–2.5 cm broad, containing several seeds inside.				7,000 to 10,500 seeds/ kg	Seeds can be collected from March to June. When properly dried, they can be stored in jute sacks at room temperature for five years.
Alnus nepalensis						The cones are easily collected by handpicking from the branches. The seeds are spread on iron sheets or cement floor under the sun until the scales open. The seeds are winnowed to clean them. After drying, seeds should be stored in an airtight container at 7oC in the refrigerator for one year.

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Alnus maritima (Thumb.) Steud	Fruit is a cone with a diameter of 15 cm and above and opens when dry and the small winged seeds are released.		Collect cones using bamboo pole to cut the branchlets with the fruit, and handpick the fruit	Intermediate months with germination	122,000 seeds/kg 22,000 seeds/li	
Anacardium occidentale	With edible nuts and shell contain resinous oil. The fruit consists of a fleshy, red or yellow, pear-shaped receptacle, at the distal end of which is borne a hard-shelled, kidney-shaped ovary or nut.	Trees bear at 3 to 10 years and continue to 30 to 50 years of age flowering.				
Anacardium occidentale	With edible nuts and shell contain resinous oil. The fruit consists of a fleshy, red or yellow, pear-shaped receptacle, at the distal end of which is borne a hard-shelled, kidney-shaped ovary or nut.	Trees bear at 3 to 10 years and continue to 30 to 50 years of age flowering.				
Azidirachta indica A. Juss	Fruit is green, smooth, ellipsoidal drupe, 1.25 - 1.8 long, greenish yellow when ripe, having a bitter sweet pulp, with one or two seeds. Flowers and fruit stink after the rain.	June-July; December-January	Climb the tree and directly handpick matured fruits when the drupe turns yellowish-green, or use a pruning pole to pick the fruit	Intermediate	3,300/kg	Depulp seeds properly by macerating in tap water. Air dry the seeds for 2 days before sowing.

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Annona muricata	Fruits are ovoid to irregular oblong, to 20 cm long, dark green, covered with short spines, fleshy, and juicy. Seeds are black.	Production starts 3 - 5 years in a seedling tree and occurs year-round.				
Artocarpus heterophyllus	Fruit is green turning yellow when ripe, fleshy, oblong to 60 cm long, the rough surface with numerous punctuate tips.					
Carica papaya	Fruit is melon shaped or spherical to oblong (depending on the variety), 5 to 30 cm long, usually with thinner rind and larger cavity than that of females. Fruits occur from just below the growing point to 1m below on the trunk.	11 to 14 months of age	Hands can reach the fruits. Farmers pick all fruits showing a tinge of yellow at apical end.		44,000 - 68,000/kg.	Remove the gelatinous envelope. In some cases, seedlings are started in the nursery by sowing seeds in seed plots or individual containers.
Citrus microcarpa	The fruit is usually small and round, ranging from 3.0 to 3.0 inches in diameter. The rind may be thin or thick. The fruit is round, about 2 cm to 4.5 cm in diameter, and greenish - yellow in color.	Fruit bearing may be attained in 2 - 3 years.		recalcitrant		
Cajanus cajan	The pod is 7 cm long and 1 cm wide, hairy, and contains 2 - 7 seeds.	Harvesting - November			16,000kg	Seed pods are picked by hand. Threshing the seed from the stem requires a strongly constructed machine such as double-cylinder pea and bean threshers. The seed is then winnowed, graded and stored in air tight containers.

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Cassia spectabilis	The pod is rigid and cylindrical, brown 20-30cm long and 08-1.0 cm wide and green initially turning black once ripe. The seed is 4-5mm, small brown and pointed by the apex.		Seed pods are picked by hand. Threshing the seed from the stem requires a strongly constructed machine such as double-cylinder pea and bean threshers. The seed is then winnowed, graded and stored in airtight containers.	Orthodox	46,628/kg or 56,271 / l	
Cocos nucifera	Fruits are ovoid, subglobose, maybe obscurely 3 angled, and are 15 - 25 cm long. The outer covering is a thick fibrous husk. A bony endocarp ios lined with albumen and has 3 eyes at the apical end. Four types occur in the Philippines.					Fruits mature 12 months after flowering. The tree flowers year round. Seed have short viability and should be planted after a 2 week ripening period
Coffea arabica	Berries are oblong about 15mm long, turning either red or yellow.	December to February				
Durio zibethinus	The fruit is ellipsoid or somewhat spherical, very large, being 15 - 25 cm long, and weighing as much as 3kg or more; it is covered by a hard shell with hard, sharp pines. The shell breaks open into 5 parts to which the flesh adheres. In each section of the fruit there are 2 - 6 very large seeds covered by flesh. The flesh is soft and whitish, and has somewhat the consistency of cheese and the odor of bad smelling cheese.					

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Eucalyptus camaldulensis	Fruit is capsulated, 4mm long and 6 mm wide. It changes from light green to grayish brown on maturity. Seeds is very light (1.0 mm - 1.5 mm) and very light	May-August	Climb the tree and use bamboo pole with hook or scythe	Orthodox	348,000 seeds/kg	Extract seeds manually when the upper valve opens and mature fruits are dried
Flemingia macrophylla (Willd.) Merr			Strip pods from the stem by hand	Orthodox	4,500-97,000 seeds/kg	Harvest pods before the discharge of seeds. At maturity, the pods turn brown and split, discharging the seeds
Gliricidia sepium	The fruit/pod is light brown, narrowly oblong to oblanceolate, 10-14cm long and 1.5-2.0cm wide. It is flat, hanging, 1-2 each inflorescence and dehixcent. Each pod contains 6-8 seeds. When mature and dry the pod opens and releases seeds. The seed is disc-shaped, yellow to dark yellow, 7-11mm in diameter.	April-May Feb-March Jan-Feb	Climb the tree and handpick the mature pods before they open or use a bamboo pole with a scythe to pick the fruit	Orthodox	7,706 /kg	Sundry the pods to open then extract the seeds manually. Dry the seeds in the shade until MC is 7-8%
Gmelina arborea	Fruit is drupe. Grows well in poor soil.					
Gnetum gnemon Linn.	Fruits are produced in small clusters, 2.3 5 to 3.5 cm long, oblong with smooth red skin. Seed is enclosed in fleshy covering about one mm thick. Seedcoat is thin and brittle and separates readily from the seeds					

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Leucaena leucocephala	Translucent and green when young, the pods redden and harden with age, eventually splitting along both edges to eject their 15-30 seeds. The flat, shiny brown, teardrop shaped seeds have an impervious, waxy coat and must be treated to ensure quick and uniform germination	All year round	Collect the pods before the seeds dehisce using bamboo pole with scythe	orthodox	18,000-22,000 / kg	Sundry the pods to open or thresh the pods after drying by placing the pod and bit to release the seeds. Remove all the fruit pulp and other impurities by winnowing
Melia dubia	Fruits are smooth , yellow and 1.5 cm long. Inside the fruit is a hard stone or kernel containing 2-5 slender dark brown 8mm long	September-November (zamboanga); August-November (Leyte)	Climb mother trees and pick the fruits or use bamboo pole with scythe.	Orthodox	2,722 seeds/kg	Carefully crack the seeds prior to germination
Moluccan sau	Fruit in pod form is dehiscent, 10-13cm long and 1.5-1.8cm wide; pod is light brown to brown when ripe, and contains 15-20seeds; seed is bean-shaped, 5-8mm long and 2.5-3.0 mm wise, grayish green with smooth but hard seed coat	Nov (lSur); Jun (Nvizcaya); Dec-Feb (Mt. Makil-ing,LB); Oct-Dec (s. Kudarat); Oct-Nov (Agusan)	Seeds are collected when pods are mature wherein color is from green to light or dark brown. The pods can be gathered by climbing up the tree using clipper attached to a long pole or with the use of bamboo pole with hook. Collect only the matured dark brown pods while still unopen and attach to the tree.	Orthodox	15000-22000	Sundry the pods to release the seeds. Then, air-dry the seeds up to 6-7% MC before the stor-age.
Persea americana	Fruits are large; 7 to 20 cm long and 7 to 10 cm diameter. Maybe round, oblong, pear shaped or bottle necked. The skin varies from yellowish green to dark green or maybe tinged with purple. It can be shiny or dull, smooth or rough, thin and papery, thick and brittle, or thick or leathery.		Flowering is in March in the Manila area . In Manila and Ilocos fruits mature from June to September; in some other areas from January to March. Seeds remain viable for only a few days unless stored at just above freezing. There are 9.25 seeds / kg			

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Pilliostigma malabaricum	In pod form, indehiscent, linear often curved rather thick, 17-34cm X 2-3cm with corky veined pericarp; seed 10-30/ pod, albuminious, oblong, 0.3-0.5cm X .2-.5cm X .2-.3cm, dark brown	February to April (Regions 3, 5) and June - July (Region 8)	Climb the tree and handpick the pods. Use bamboo pole with scythe to cut the branchlets with pods.	Orthodox	12,000 - 12,200 seeds/kg	Bit or cut the pod to open then manually extract the seed
Pithecellobium dulce	Pod is twisted up to 15 cm long, green, turning pinkish brown to red when ripe, splitting at the suture. Seeds are 6 - 8 and dark brown.	August - Oct	Use bamboo pole with scythe to collect the branchlets with ripe fruit/ pod	Orthodox	5,500-8,800 seeds/kg	Manually extract the seeds
Psidium guajava	Fruit globose to ovoid or obovoid, 4 - 5 cm long, green, turning yellowish when ripe, somewhat aromatic, the pulp is pink or nearly white.					
Pinus kesiya Royle ex Gordon	Female cones are borne at the tip of the growing shoots, male cones are borne at the lateral sides of the twigs of lower branches, seeds are oval, dark brown in color, 5 7 mm long with a deciduous wing up to 2 cm long and 8 cm wide.				55000-63000 seeds/kg	
Samanea saman	Fruit is straight and fleshy, up to 20 cm long, the mesocarp is sweet and pulpy.	Aug - Dec	Collect from the ground the newly fallen fruits	Orthodox	4,000-7,700/kg	Sundry the pods for 2-3 days, extract the seeds manually then airdry the seeds for 2 wks to attain 7-8%MC

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Swietenia macrophylla	Its fruit are large and conical, its seeds are light chest brown.					
Theobroma cacao	Fruit is hard, oblong, with pointed tip, to 30 cm long, brown purple or yellow when ripe with many seeds. The seeds are numerous and embedded in whitish pulp.					
Trema orientalis					22,700 seeds	Macerate the fruits in running water

Appendix Table 2. Biophysical Requirements continued...

	Germination			Method of Sowing
Scientific Name	Media	Treatment	Sterilization	Sowing
Acacia auriculiformis	Fine sand using seed boxes or plastic trays: 1:1:1 ordinary garden soil, dried compost and coir dust	Soak seeds in boiling water for 3-4 minutes then in tap water overnight; for stored seeds, soak the seeds in boiling water leaving them to cool and soak in 24hours; for newly collected seeeds, soak the seeds in tap water overnight. Immediately sow seeds which start to open, otherwise cut a little out of the seed-coat with a nail clipper or a sharp knife.	Sterilize potting medium for at least 4hours at 80-90°C	Push the seeds just below the soil surface. A mulch of grass can be applied after sowing to protect soil and seed from large water droplets. Remove the mulch when seed has germinated. Water once a day using fine mist spray/ sprinkle. 25-50% shading after transplanting.
Anthocephalus chinensis **Rich Ex** Walp				Direct sowing is not very successful because of the small-sized seeds and the sensitivity to drought, excessive moisture and direct sun.
Albizia falcataria	Seed pods are collected when they turn brown at the end of the dry season.	They are dried in the sun (or in warm air) for 24-48 hours and broken either by 10 minutes of turning in a cement mixer with heavy wooden blocks or by heating in a commercial thresher. The seeds are then sieved clean of pod debris and winnowed by hand or machine to remove chaff. The bright orange funicles remain attached to most seed.	Treated seeds are broadcasted on prepared seed beds and are covered with sand/soil. When the first pair of leaflets emerge, the seedlings are transplanted into plastic bags. Seed of high germinability can be sown directly in plastic bags.	Once dried placed in an air tight container.. Seeds germinate poorly unless the impervious seed coat is pierced so that the endosperm and embryo can take up water. This is achieved by boiling some water, removing it from the heat source, and immediately pouring in the seed. After 30 seconds, the hot water is removed and replaced by tap water. The seed is then allowed to soak overnight. Boil water and pour it over the seed, 1 part seed to 10 parts water. After 30 seconds to 1 minute, remove seeds and place in tap water; then soak overnight, remove, and dry.

	Germination			Method of Sowing
Scientific Name	Media	Treatment	Sterilization	Sowing
Acacia mangium	Seed pods are collected when they turn brown at the end of the dry season.	They are dried in the sun (or in warm air) for 24-48 hours and broken either by 10 minutes of turning in a cement mixer with heavy wooden blocks or by heating in a commercial thresher. The seeds are then sieved clean of pod debris and winnowed by hand or machine to remove chaff. The bright orange funicles remain attached to most seed.	Treated seeds are broad-casted on prepared seed beds and are covered with sand/soil. When the first pair of leaflets emerge, the seedlings are transplanted into plastic bags. Seed of high ger-minability can be sown directly in plastic bags.	Once dried placed in an air tight con-tainer.. Seeds germinate poorly unless the impervious seed coat is pierced so that the endosperm and embryo can take up water. This is achieved by boil-ing some water, removing it from the heat source, and immediately pouring in the seed. After 30 seconds, the hot water is removed and replaced by tap water. The seed is then allowed to soak overnight. Boil water and pour it over the seed, 1 part seed to 10 parts water. After 30 seconds to 1 minute, remove seeds and place in tap water; then soak overnight, remove, and dry.
Albizia procera		For stored seed, soak seeds in boiling water for 5 seconds and then remove from direct heat, then soak in cool		Sow the seeds in seed boxes, seedbeds or directly in polyethylene bags
Albizzia lebbek		Seed germination could be enhanced by soaking in boiling water for 5-15 seconds and cool for 24 hours. Seeds could be sown directly in plastic bags or seedbeds with 1:1 soil-sand media. If seeds are sown on seedbeds, trans-plant the germinants to the plastic bags upon reaching 5 cm in height.		

	Germination			Method of Sowing
Scientific Name	Media	Treatment	Sterilization	Sowing
Alnus nepalensis				Usually propagated by seeds. It can also be propagated thru suckers, cuttings and by coppicing. Seed treatment is not required. Direct sowing is effective. Germination of fresh seeds begin from 10 to 13 days after sowing and is completed in 17-22 days. The seeds can germinate, grow and develop on all types of soil. The average germination is from 30 to 55%. Sowing is done from January to February but the best is in the latter part of January. The method of sowing is by broadcasting evenly in well-prepared seedbeds. The seeds should be covered with fine soil.
Alnus maritima (Thumb.) Steud	Broadcast the seeds, gently press into the soil and cover with a layer of fine sand up to 1.5 cm thick. The soil in the seedbed must be loose and well drained, application of a surface layer of mulch is advisable, and avoid excessive shading.	Sterilize the soil by cooking	Spread evenly the seeds in the seed box, cover with a newspaper or cogon grass then water it moderately. Daily watering at day time is needed until germination	
Anacardium occidentale				

	Germination			Method of Sowing
Scientific Name	Media	Treatment	Sterilization	Sowing
Azidirachta indica A. Juss	1:1:1 ratio of OGS, sand and organic matter	Soak seeds in tap water for 24 hrs; clean the seeds under running water and air dry under the sun in 2-3 days	Sterilize media for 4-8 hours	Broadcast freshly collected seeds in prepared seedbed, cover with a thin layer of 0.5-1.0 cm of sand and mulch with straw before watering
Annona muricata				
Artocarpus heterophyllus				
Calliandra calothyrsus	1:1:1 rario ordinary garden soil, compost, and sand	Boiling water is poured over seeds, allowed to cool then soaked in tap water for 24 hours.		
Carica papaya		Seeds need to be dried and dusted with fungicide. Dipping for 15 seconds in hot water at 158º F (70º C) and then soak for 24 hrs in distilled water after removal from storage will improve germination.	Sterilization can also be achieved by using trans-parent plastic mulch.	
Citrus microcarpa			Use sterilized soil to avoid nematode infestation and damping off or hemaph-rodite forms should be preserved during thinning	Sow seed 1" inch deep in porous well-drained soil in a 3" - 4" inch cup. After 1-2 weeks transplant into larger 1/2 to 1 gallon pot/bag. Transplant into ground or large pot within 2 - 4 months.
Cajanus cajan			The seeds were surface sterilized by soaking in 1% (v/v) sodium hypochloride (NaOCl) solution for 5 min and then rinsed several	Seeds may be broadcast or sown in rows with plant spacings of 40–200 cm × 20–180 cm.

	Germination			Method of Sowing
Scientific Name	Media	Treatment	Sterilization	Sowing
Cassia spectabilis		Nick or cut the seed coat and soak the seeds on 0.02% fungicide solution overnight and soak the seeds in tap water overnight; place the seeds in boiling water and allow them to soak		
Cocos nucifera	prefers soils that are well suited to growth of corn			
Coffea arabica				
Durio zibethinus				
Eucalyptus camaldulensis				Broadcast seeds and cover with sand enough to cover the seed or mix seeds with sand and broadcast. Cover the seedbed with a mulch of grass to protect the seeds against larger water droplets. Water well the seeds to prevent drying out.
Flemingia macrophylla (Willd.) Merr		Soak seeds in boiled water for 2-3 minutes, gently stirring the seed for the duration. Pour off the hot water, replace with cool water and soak for 12 hrs. Germination occurs in 7-14		For large areas, method of sow seeds in rows 90 cm apart with a seed planted every 10-20 cm. For hedgerows, have minimal space between plants within the row for erosion control.
Gliricidia sepium	Plastic trays or seedboxes with fine sand 1:1:1 ratio of sand, top soil and dried orgnic matter.	Soak in hot water and allow to cool overnight		Sow the seeds in seedbeds spaced at 5-10cm apart within rows and 10-20cm apart between rows to allow root pruning and easier transplanting. Cover the seeds with a thin layer of soil.

	Germination			Method of Sowing
Scientific Name	Media	Treatment	Sterilization	Sowing
Gmelina arborea				
Gnetum gnemon Linn.				
Leucaena leucocephala	1:1:1 top soil, dried humus and coir dust	Soak the seeds in concentrated sulfuric acids (H_2SO_4) for 30 minutes, wash in tap water or in running water, then soak in tap water overnight	Sterilize the potting medium in sterilizing pad for 3-4 has at 80-90°C	Sow the pretreated seed in tray using drill method at 1cm apart and 2cm in between lines then cover the seeds thinly with the fine medium. In seed-beds, broadcast or sow using drill
Melia dubia	1:1 ratio of fine sand and garden soil	Crack the seeds and soak overnight		Sow the seeds in plastic trays in plastic trays or seedbed
Moluccan sau	1:1 ratio of ordinary garden soil (OGS), fine sand, dried humus.	Germination of the seeds can be hastened by soaking in boiling water for 5-15 seconds and soaking the pretreated seeds in tap water for 24 hours. Pretreated seeds can be sown directly in 4 x 6" polyethylene plastic bag or in seedbed.	Sterilize the soil for 7-8hours at 1800C with intermittent spraying of water before putting in seed boxes. Disinfect soil before seeding. Drench soil with dilute emulsion of Thiram or Captan (3-6li/sq.m of soil).	Broadcast, press gently into the soil and then cover by a layer of fine sand up to 1.5 cm thick. The soil in the seedbed must be loose and well-drained, apply mulch into the surface layer and avoid excessive shading
Persea americana				
Pilliostigma malabaricum	3 layers of paper towel in trays,1:1:1 OGS, sand or coir dust and dried humus in plastic trays. Seedbed with OGS, sand or coir dust	Nick the seed coat and soak in tap water overnight. Soak the seeds in boiling water for 3-3 minutes then soak in tap water overnight	Resistant to damping off and sterilization of the sowing medium need not to be done	Sow the seeds using drill method

	Germination			Method of Sowing
Scientific Name	Media	Treatment	Sterilization	Sowing
Pithecellobium dulce	3:1 ratio of clay loam and fine sand	For large volume of seeds, soak newly selected seeds in tap water overnight. For small volume of seeds, cut or nick the seed coat and soak in tap water overnight, for stored seeds, soak the seeds in boiling water for 3 minutes	Resistant to damping off, sterilization of potting medium is not necessary	Drill the seeds in the tray and cover thinly with the medium. For hedges, sow seeds in site, spaced 15 cm apart in two rows 30 cm apart
Psidium guajava				
Pinus kesiya Royle ex Gordon	Top soil/garden soil+river sand (ratio - 1:1 or 75 top soil, 25 river sand)	For thick seed coat, (break the seed coat then soak in hot water overnight; For thin seed coat soak in water for at least 3-5 hours.	Cook the soil or pour hot water	Use a screen to broadcast the seeds in the bed then cover it with newspaper.
Samanea saman	1:1:1 top soil, sand and dried organic matter	Nick or cut the seedcoat and soak in tap water overnight or in 0.02% fungicide solution-100% germination soak the seeds in concentrated H2SO4 for 30 mins., wash in running water, then soak in tap water or in 0.02% fungicide overnight	Sterilize the medium for four hours at 80-90 degrees C in sterilizing pad. Let the medium cool off then place in trays for sowing of seeds	Sow the seeds in trays with 1:1:1 topsoil, sand and dried organic matter or in trays with moistened paper towel; if to be sown in seedbeds, space should be 10 x 10cm up to 2cm depth. For direct sowing, sow 1 seed per bag
Swietenia macrophylla				
Theobroma cacao				
Trema orientalis		Soak seeds in tap water at temperature range of 35-38OC of for 5 to 10 minutes; or soak the seeds in GAA (Giberellic acid) in agar at 500 ppm or refrigerate at 2oC for 3-4 months		

Appendix Table 3. Seed Technologies for Various Species Suitable for Rehabilitation of Marginal Uplands.

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Acacia auriculiformis	Twisted pod, flat and undulating when ripe with small black seeds encircled with orange funicle from which they are suspended after pods open.	December to January and March to April	Climb the tree and handpick or clip the pods (after they turn brown od before they open) with pruning poles.	Orthodox	49,500 seeds/kg	Sun dry the pods: extract seeds manually. Dry the seeds under shade to reduce moisture content to 7%
Anthocephalus chinensis Rich Ex Walp	Fruits are united and embedded in receptacle			Recalci-trant seeds	18,000,000- 26,000,000 per kg	Involves air drying, crush-ing, and sieving to sepa-rate seed from chaff. Fruits are soaked in the open until rotted, ground by hand into a thick slurry, air dried, and passed through a series of sieves. This procedure improves seed purity up to 98%, and germination success.
Acacia mangium	Fruit is a dark brown, crinkled and soiled pod that partially opens when ripe; the small seeds 2.5 mm long and 4mm wide, hang by ornage fleshy funicles.	February to April or November to December	Collect seeds directly from the tree when they become gray and open up by cutting the pods from the branches with a long bamboo pole.	Orthodox	Fruiting is prolific. Individual trees in a 14-year-old plantation produce as much as 1 kg of seed per year. The average is 0.4 kg.	

PLANT NAME	FRUIT					
Scientific Name /Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Albizia procera	Flattened pod, dehiscent, 10-20cm long and 1.8-2.5cm broad; changes from green to deep red or reddish brown on maturity each pod contain 6-12 seeds, 5mm x 6mm wide plat, elliptical to nearly orbicular.	April and November	Climb the tree and hand-pick or clip the pods (after they turn brown or before they open)	Orthodox	200,000/liter	Extract the pods in sack then dry in the sun for a short time and remove debris by win-nowing
Albizzia lebbek	The fruit is a flat brown pod 10–20 cm long and 2–2.5 cm broad, contain-ing several seeds inside.				7,000 to 10,500 seeds/kg	Seeds can be collected from March to June. When prop-erly dried, they can be stored in jute sacks at room tem-perature for five years.
Alnus nepalensis						The cones are easily collected by handpicking from the branches. The seeds are spread on iron sheets or cement floor under the sun until the scales open. The seeds are winnowed to clean them. After drying, seeds should be stored in an airtight container at 7oC in the refrig-erator for one year.

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Alnus maritima (Thumb.) Steud	Fruit is a cone with a diameter of 15 cm and above and opens when dry and the small winged seeds are released.		Collect cones using bamboo pole to cut the branchlets with the fruit, and handpick the fruit	Intermedi-ate months with ger-mination	122,000 seeds/kg 22,000 seeds/li	
Anacardium occidentale	With edible nuts and shell contain resinous oil. The fruit consists of a fleshy, red or yellow, pear-shaped receptacle, at the distal end of which is borne a hard-shelled, kidney-shaped ovary or nut.	Trees bear at 3 to 10 years and continue to 30 to 50 years of age flowering.				
Anacardium occidentale	With edible nuts and shell contain resinous oil. The fruit consists of a fleshy, red or yellow, pear-shaped receptacle, at the distal end of which is borne a hard-shelled, kidney-shaped ovary or nut.	Trees bear at 3 to 10 years and continue to 30 to 50 years of age flowering.				
Azidirachta indica A. Juss	Fruit is green, smooth, ellipsoidal drupe, 1.25 - 1.8 long, greenish yel-low when ripe, having a bitter sweet pulp, with one or two seeds. Flowers and fruit stink after the rain.	June-July; December-January	Climb the tree and directly hand-pick matured fruits when the drupe turns yellowish-green, or use a pruning pole to pick the fruit	Intermedi-ate	3,300/kg	Depulp seeds properly by macerating in tap water. Air dry the seeds for 2 days before sowing.

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Annona muricata	Fruits are ovoid to irregular oblong, to 20 cm long, dark green, covered with short spines, fleshy, and juicy. Seeds are black.	Production starts 3 - 5 years in a seedling tree and occurs year-round.				
Artocarpus heterophyllus	Fruit is green turning yellow when ripe, fleshy, oblong to 60 cm long, the rough surface with numerous punctuate tips.					
Carica papaya	Fruit is melon shaped or spherical to oblong (depending on the variety), 5 to 30 cm long, usually with thinner rind and larger cavity than that of females. Fruits occur from just below the growing point to 1m below on the trunk.	11 to 14 months of age	Hands can reach the fruits. Farmers pick all fruits showing a tinge of yellow at apical end.		44,000 - 68,000/kg.	Remove the gelatinous envelope. In some cases, seedlings are started in the nursery by sowing seeds in seed plots or individual containers.
Citrus microcarpa	The fruit is usually small and round, ranging from 3.0 to 3.0 inches in diameter. The rind may be thin or thick. The fruit is round, about 2 cm to 4.5 cm in diameter, and greenish - yellow in color.	Fruit bearing may be attained in 2 - 3 years.		recalcitrant		
Cajanus cajan	The pod is 7 cm long and 1 cm wide, hairy, and contains 2 - 7 seeds.	Harvesting - November			16,000kg	Seed pods are picked by hand. Threshing the seed from the stem requires a strongly constructed machine such as double-cylinder pea and bean threshers. The seed is then winnowed, graded and stored in air tight containers.

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Cassia spectabilis	The pod is rigid and cylindrical, brown 20-30cm long and 08-1.0 cm wide and green initially turning black once ripe. The seed is 4-5mm, small brown and pointed by the apex.		Seed pods are picked by hand. Threshing the seed from the stem requires a strongly constructed machine such as double-cylinder pea and bean threshers. The seed is then winnowed, graded and stored in airtight containers.	Orthodox	46,628/kg or 56,271 / l	
Cocos nucifera	Fruits are ovoid, subglobose, maybe obscurely 3 angled, and are 15 - 25 cm long. The outer covering is a thick fibrous husk. A bony endocarp ios lined with albumen and has 3 eyes at the apical end. Four types occur in the Philippines.					Fruits mature 12 months after flowering. The tree flowers year round. Seed have short viability and should be planted after a 2 week ripening period
Coffea arabica	Berries are oblong about 15mm long, turning either red or yellow.	December to February				
Durio zibethinus	The fruit is ellipsoid or somewhat spherical, very large, being 15 - 25 cm long, and weighing as much as 3kg or more; it is covered by a hard shell with hard, sharp pines. The shell breaks open into 5 parts to which the flesh adheres. In each section of the fruit there are 2 - 6 very large seeds covered by flesh. The flesh is soft and whitish, and has somewhat the consistency of cheese and the odor					

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Eucalyptus camaldulensis	Fruit is capsulated, 4mm long and 6 mm wide. It changes from light green to grayish brown on maturity. Seeds is very light (1.0 mm - 1.5 mm) and very light	May-August	Climb the tree and use bamboo pole with hook or scythe	Orthodox	348,000 seeds/kg	Extract seeds manually when the upper valve opens and mature fruits are dried
Flemingia macrophylla (Willd.) Merr			Strip pods from the stem by hand	Orthodox	4,500-97,000 seeds/kg	Harvest pods before the discharge of seeds. At maturity, the pods turn brown and split, discharging the seeds
Gliricidia sepium	The fruit/pod is light brown, narrowly oblong to oblanceolate, 10-14cm long and 1.5-2.0cm wide. It is flat, hanging, 1-2 each inflorescence and dehixcent. Each pod contains 6-8 seeds. When mature and dry the pod opens and releases seeds. The seed is disc-shaped, yellow to dark yellow, 7-11mm in diameter.	April-May Feb-March Jan-Feb	Climb the tree and handpick the mature pods before they open or use a bamboo pole with a scythe to pick the fruit	Orthodox	7,706 /kg	Sundry the pods to open then extract the seeds manually. Dry the seeds in the shade until MC is 7-8%
Gmelina arborea	Fruit is drupe. Grows well in poor soil.					
Gnetum gnemon Linn.	Fruits are produced in small clusters, 2.3 5 to 3.5 cm long, oblong with smooth red skin. Seed is enclosed in fleshy covering about one mm thick. Seedcoat is thin and brittle and separates readily from the seeds					

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Leucaena leucocephala	Translucent and green when young, the pods redden and harden with age, eventually splitting along both edges to eject their 15-30 seeds. The flat, shiny brown, teardrop shaped seeds have an impervious, waxy coat and must be treated to ensure quick and uniform germination	All year round	Collect the pods before the seeds dehisce using bamboo pole with scythe	orthodox	18,000-22,000 / kg	Sundry the pods to open or thresh the pods after drying by placing the pod and bit to release the seeds. Remove all the fruit pulp and other impurities by winnowing
Melia dubia	Fruits are smooth , yellow and 1.5 cm long. Inside the fruit is a hard stone or kernel containing 2-5 slender dark brown 8mm long	September-November (zamboanga); August-November (Leyte)	Climb mother trees and pick the fruits or use bamboo pole with scythe.	Orthodox	2,722 seeds/kg	Carefully crack the seeds prior to germination
Moluccan sau	Fruit in pod form is dehiscent, 10-13cm long and 1.5-1.8cm wide; pod is light brown to brown when ripe, and contains 15-20seeds; seed is bean-shaped, 5-8mm long and 2.5-3.0 mm wise, grayish green with smooth but hard seed coat	Nov (lSur); Jun (Nvizcaya); Dec-Feb (Mt. Makiling,LB); Oct-Dec (s. Kudarat); Oct-Nov (Agusan)	Seeds are collected when pods are mature wherein color is from green to light or dark brown. The pods can be gathered by climbing up the tree using clipper attached to a long pole or with the use of bamboo pole with hook. Collect only the matured dark brown pods while still unopen and attach to the tree.	Orthodox	15000-22000	Sundry the pods to release the seeds. Then, air-dry the seeds up to 6-7% MC before the storage.
Persea americana	Fruits are large; 7 to 20 cm long and 7 to 10 cm diameter. Maybe round, oblong, pear shaped or bottle necked. The skin varies from yellowish green to dark green or maybe tinged with purple. It can be shiny or dull, smooth or rough, thin and papery, thick and brittle, or		Flowering is in March in the Manila area . In Manila and Ilocos fruits mature from June to September; in some other areas from January to March. Seeds remain viable for only a few days unless stored at just above			

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Pilliostigma malabaricum	In pod form, indehiscent, linear often curved rather thick, 17-34cm X 2-3cm with corky veined pericarp; seed 10-30/pod, albuminious, oblong, 0.3-0.5cm X .2-.5cm X .2-.3cm, dark brown	February to April (Regions 3, 5) and June - July (Region 8)	Climb the tree and handpick the pods. Use bamboo pole with scythe to cut the branchlets with pods.	Orthodox	12,000 - 12,200 seeds/kg	Bit or cut the pod to open then manually extract the seed
Pithecellobium dulce	Pod is twisted up to 15 cm long, green, turning pinkish brown to red when ripe, splitting at the suture. Seeds are 6 - 8 and dark brown.	August - Oct	Use bamboo pole with scythe to collect the branchlets with ripe fruit/ pod	Orthodox	5,500-8,800 seeds/kg	Manually extract the seeds
Psidium guajava	Fruit globose to ovoid or obovoid, 4 - 5 cm long, green, turning yellowish when ripe, somewhat aromatic, the pulp is pink or nearly white.					
Pinus kesiya Royle ex Gordon	Female cones are borne at the tip of the growing shoots, male cones are borne at the lateral sides of the twigs of lower branches, seeds are oval, dark brown in color, 5 7 mm long with a deciduous wing up to 2 cm long and 8 cm wide.				55000-63000 seeds/kg	
Samanea saman	Fruit is straight and fleshy, up to 20 cm long, the mesocarp is sweet and pulpy.	Aug - Dec	Collect from the ground the newly fallen fruits	Orthodox	4,000-7,700/kg	Sundry the pods for 2-3 days, extract the seeds manually then airdry the seeds for 2 wks to attain 7-8%MC

PLANT NAME	FRUIT					
Scientific Name / Common Name	Morphological Description	Calendar	Methods of Collection	Type	Seed Count	Method of Extraction
Swietenia macrophylla	Its fruit are large and conical, its seeds are light chest brown.					
Theobroma cacao	Fruit is hard, oblong, with pointed tip, to 30 cm long, brown purple or yellow when ripe with many seeds. The seeds are numerous and embedded in whitish pulp.				22,700 seeds	Macerate the fruits in running water
Trema orientalis						

Appendix Table 3. Seed Technologies continued...

	Germination			Method of Sowing
Scientific Name	Media	Treatment	Sterilization	Sowing
Acacia auriculiformis	Fine sand using seed boxes or plastic trays: 1:1:1 ordinary garden soil, dried compost and coir dust	Soak seeds in boiling water for 3-4 minutes then in tap water overnight; for stored seeds, soak the seeds in boiling water leaving them to cool and soak in 24hours; for newly collected seeeds, soak the seeds in tap water overnight. Immediately sow seeds which start to open, otherwise cut a little out of the seed-coat with a nail clipper or a sharp knife.	Sterilize potting medium for at least 4hours at 80-900C	Push the seeds just below the soil surface. A mulch of grass can be applied after sowing to protect soil and seed from large water droplets. Remove the mulch when seed has germinated. Water once a day using fine mist spray/sprinkle. 25-50% shading after transplanting.
Anthocephalus chinensis Rich Ex Walp				Direct sowing is not very successful because of the small-sized seeds and the sensitivity to drought, excessive moisture and direct sun.
Albizia falcataria	Seed pods are collected when they turn brown at the end of the dry season.	They are dried in the sun (or in warm air) for 24-48 hours and broken either by 10 minutes of turning in a cement mixer with heavy wooden blocks or by heating in a commercial thresher. The seeds are then sieved clean of pod debris and winnowed by hand or machine to remove chaff. The bright orange funicles remain attached to most seed.	Treated seeds are broadcasted on prepared seed beds and are covered with sand/soil. When the first pair of leaflets emerge, the seedlings are transplanted into plastic bags. Seed of high germinability can be sown directly in plastic bags.	Once dried placed in an air tight container.. Seeds germinate poorly unless the impervious seed coat is pierced so that the endosperm and embryo can take up water. This is achieved by boiling some water, removing it from the heat source, and immediately pouring in the seed. After 30 seconds, the hot water is removed and replaced by tap water. The seed is then allowed to soak overnight. Boil water and pour it over the seed, 1 part seed to 10 parts water. After 30 seconds to 1 minute, remove seeds and place in tap water; then soak overnight, remove, and dry.

	Germination			Method of Sowing
Scientific Name	Media	Treatment	Sterilization	Sowing
Acacia mangium	Seed pods are collected when they turn brown at the end of the dry season.	They are dried in the sun (or in warm air) for 24-48 hours and broken either by 10 minutes of turning in a cement mixer with heavy wooden blocks or by heating in a commercial thresher. The seeds are then sieved clean of pod debris and winnowed by hand or machine to remove chaff. The bright orange funicles remain attached to most seed.	Treated seeds are broad-casted on prepared seed beds and are covered with sand/soil. When the first pair of leaflets emerge, the seedlings are transplanted into plastic bags. Seed of high ger-minability can be sown directly in plastic bags.	Once dried placed in an air tight con-tainer.. Seeds germinate poorly unless the impervious seed coat is pierced so that the endosperm and embryo can take up water. This is achieved by boil-ing some water, removing it from the heat source, and immediately pouring in the seed. After 30 seconds, the hot water is removed and replaced by tap water. The seed is then allowed to soak overnight. Boil water and pour it over the seed, 1 part seed to 10 parts water. After 30 seconds to 1 minute, remove seeds and place in tap water; then soak overnight, remove, and dry.
Albizia procera		For stored seed, soak seeds in boiling water for 5 seconds and then remove from direct heat, then soak in cool		Sow the seeds in seed boxes, seedbeds or directly in polyethylene bags
Albizzia lebbek		Seed germination could be enhanced by soaking in boiling water for 5-15 seconds and cool for 24 hours. Seeds could be sown directly in plastic bags or seedbeds with 1:1 soil-sand media. If seeds are sown on seedbeds, trans-plant the germinants to the plastic bags upon reaching 5 cm in height.		

	Germination			Method of Sowing
Scientific Name	Media	Treatment	Sterilization	Sowing
Alnus nepalensis				Usually propagated by seeds. It can also be propagated thru suckers, cuttings and by coppicing. Seed treatment is not required. Direct sowing is effective. Germination of fresh seeds begin from 10 to 13 days after sowing and is completed in 17-22 days. The seeds can germinate, grow and develop on all types of soil. The average germination is from 30 to 55%. Sowing is done from January to February but the best is in the latter part of January. The method of sowing is by broadcasting evenly in well-prepared seedbeds. The seeds should be covered with fine soil.
Alnus maritima (Thumb.) Steud	Broadcast the seeds, gently press into the soil and cover with a layer of fine sand up to 1.5 cm thick. The soil in the seedbed must be loose and well drained, application of a surface layer of mulch is advisable, and avoid excess-	Sterilize the soil by cooking	Spread evenly the seeds in the seed box, cover with a newspaper or cogon grass then water it moderately. Daily watering at day time is needed until germination	

	Germination			Method of Sowing
Scientific Name	Media	Treatment	Sterilization	Sowing
Azidirachta indica A. Juss	1:1:1 ratio of OGS, sand and organic matter	Soak seeds in tap water for 24 hrs; clean the seeds under running water and air dry under the sun in 2-3 days	Sterilize media for 4-8 hours	Broadcast freshly collected seeds in prepared seedbed, cover with a thin layer of 0.5-1.0 cm of sand and mulch with straw before watering
Annona muricata				
Artocarpus heterophyllus				
Calliandra calothyrsus	1:1:1 rario ordinary garden soil, compost, and sand	Boiling water is poured over seeds, allowed to cool then soaked in tap water for 24 hours.		
Carica papaya		Seeds need to be dried and dusted with fungicide. Dipping for 15 seconds in hot water at 158º F (70º C) and then soak for 24 hrs in distilled water after removal from storage will improve germination.	Sterilization can also be achieved by using trans-parent plastic mulch.	
Citrus microcarpa			Use sterilized soil to avoid nematode infestation and damping off or hemaph-rodite forms should be preserved during thinning	Sow seed 1" inch deep in porous well-drained soil in a 3" - 4" inch cup. After 1-2 weeks transplant into larger 1/2 to 1 gallon pot/bag. Transplant into ground or large pot within 2 - 4 months.
Cajanus cajan			The seeds were surface sterilized by soaking in 1% (v/v) sodium hypochloride (NaOCl) solution for 5 min and then rinsed several	Seeds may be broadcast or sown in rows with plant spacings of 40–200 cm × 20–180 cm.

	Germination			Method of Sowing
Scientific Name	Media	Treatment	Sterilization	Sowing
Cassia spectabilis		Nick or cut the seed coat and soak the seeds on 0.02% fungicide solution overnight and soak the seeds in tap water overnight; place the seeds in boiling water and allow them to soak		
Cocos nucifera	prefers soils that are well suited to growth of corn			
Coffea arabica				
Durio zibethinus				
Eucalyptus camaldulensis				Broadcast seeds and cover with sand enough to cover the seed or mix seeds with sand and broadcast. Cover the seedbed with a mulch of grass to protect the seeds against larger water droplets. Water well the seeds to prevent drying out.
Flemingia macrophylla (Willd.) Merr		Soak seeds in boiled water for 2-3 minutes, gently stirring the seed for the duration. Pour off the hot water, replace with cool water and soak for 12 hrs. Germination occurs in 7-14		For large areas, method of sow seeds in rows 90 cm apart with a seed planted every 10-20 cm. For hedgerows, have minimal space between plants within the row for erosion control.
Gliricidia sepium	Plastic trays or seedboxes with fine sand 1:1:1 ratio of sand, top soil and dried orgnic matter.	Soak in hot water and allow to cool overnight		Sow the seeds in seedbeds spaced at 5-10cm apart within rows and 10-20cm apart between rows to allow root pruning and easier transplanting. Cover the seeds with a thin layer of soil.

	Germination			Method of Sowing
Scientific Name	Media	Treatment	Sterilization	Sowing
Gmelina arborea				
Gnetum gnemon Linn.				
Leucaena leucocephala	1:1:1 top soil, dried humus and coir dust	Soak the seeds in concentrated sulfuric acids (H2SO4) for 30 minutes, wash in tap water or in running water, then soak in tap water overnight	Sterilize the potting medium in sterilizing pad for 3-4 has at 80-90°C	Sow the pretreated seed in tray using drill method at 1cm apart and 2cm in between lines then cover the seeds thinly with the fine medium. In seed-beds, broadcast or sow using drill
Melia dubia	1:1 ratio of fine sand and garden soil	Crack the seeds and soak overnight		Sow the seeds in plastic trays in plastic trays or seedbed
Moluccan sau	1:1 ratio of ordinary garden soil (OGS), fine sand, dried humus.	Germination of the seeds can be hastened by soaking in boiling water for 5-15 seconds and soaking the pretreated seeds in tap water for 24 hours. Pretreated seeds can be sown directly in 4 x 6” polyethylene plastic bag or in seedbed.	Sterilize the soil for 7-8hours at 1800C with intermittent spraying of water before putting in seed boxes. Disinfect soil before seeding. Drench soil with dilute emulsion of Thiram or Captan (3-6li/sq.m of soil).	Broadcast, press gently into the soil and then cover by a layer of fine sand up to 1.5 cm thick. The soil in the seedbed must be loose and well-drained, apply mulch into the surface layer and avoid excessive shading
Persea americana				
Pilliostigma malabaricum	3 layers of paper towel in trays,1:1:1 OGS, sand or coir dust and dried humus in plastic trays. Seedbed with OGS, sand or coir dust	Nick the seed coat and soak in tap water overnight. Soak the seeds in boiling water for 3-3 minutes then soak in tap water overnight	Resistant to damping off and sterilization of the sowing medium need not to be done	Sow the seeds using drill method

	Germination			Method of Sowing
Scientific Name	Media	Treatment	Sterilization	Sowing
Pithecellobium dulce	3:1 ratio of clay loam and fine sand	For large volume of seeds, soak newly selected seeds in tap water overnight. For small volume of seeds, cut or nick the seed coat and soak in tap water overnight, for stored seeds, soak the seeds in boiling water for 3 minutes	Resistant to damping off, sterilization of potting medium is not necessary	Drill the seeds in the tray and cover thinly with the medium. For hedges, sow seeds in site, spaced 15 cm apart in two rows 30 cm apart
Psidium guajava				
Pinus kesiya Royle ex Gordon	Top soil/garden soil+river sand (ratio - 1:1 or 75 top soil, 25 river sand)	For thick seed coat, (break the seed coat then soak in hot water overnight; For thin seed coat soak in water for at least 3-5 hours.	Cook the soil or pour hot water	Use a screen to broadcast the seeds in the bed then cover it with newspaper.
Samanea saman	1:1:1 top soil, sand and dried organic matter	Nick or cut the seedcoat and soak in tap water overnight or in 0.02% fungicide solution-100% germination soak the seeds in concentrated H2SO4 for 30 mins., wash in running water, then soak in tap water or in 0.02% fungicide overnight	Sterilize the medium for four hours at 80-90 degrees C in sterilizing pad. Let the medium cool off then place in trays for sowing of seeds	Sow the seeds in trays with 1:1:1 topsoil, sand and dried organic matter or in trays with moistened paper towel; if to be sown in seedbeds, space should be 10 x 10cm up to 2cm depth. For direct sowing, sow 1 seed per bag
Swietenia macrophylla				
Theobroma cacao				
Trema orientalis		Soak seeds in tap water at temperature range of 35-38OC of for 5 to 10 minutes; or soak the seeds in GAA (Giberellic acid) in agar at 500 ppm or refrigerate at 2oC for 3-4 months		

Appendix Table 4. Nursery Techniques and other Cultural Management Practices of Species Suitable for Rehabilitation of Marginal Uplands.

PLANT NAME						
Scientific Name	Method	Time	Container Size	Medium/Ratio	Micro-organism	Dosage
Acacia auriculiformis	Lift the seedlings when a pair of leaves is already formed	2-3 weeks after emergence of pair of leaves or when few lateral roots arise	4"x6" polyethelene bags	Sterilized OGS, coir dust and dried humus	VAM mycorrhiza; Rhizobium or Rhizobium +Azobacter	5g (1full soft drink cap) placed halfway in the bag, then transplant germinant and fill bag with the medium
Acacia mangium	Pricking is done using pointed sticks when a pair of leaves are formed; do in the shaded area to avoid drying of	3 weeks after emergence	4"x6" polyethelene-bags	1:1:1 ratio of sand, topsoil and dried compost	Mycovam and Rhizobial inoculants	
Albizia procera	Prick 2 weeks after sowing		4"x6" polyethelene bags	OGS, sand and coir dust. Ratio: 1:1:1	Mycorrhizal inoculant	5g mycorrhizal inoculant suited to the species . Apply halfway of the potting medium, then add the remaining half, fill the bag
Calliandra calothyrsus			4' X 6" polyethelene bag	Placed the sterilized medium in the bag	Rhizobial inoculant	Dissolve 40 gram gum arabic in 100 ml warm water allow to cool
Gliricidia sepium	Prick the germinants when a pair of leaves is already developed	2-3 weeks after sowing	4"x6' polyethelene bags	1:1:1 potting mixture of OGS, sand or coir dust and dried organic matter	Mycovam	5g mycovam is inoculated in half filled polybag then fill the bag with potting medium
Leucaena leucocephala	Prick the germinants when a pair of leaves is already developed		4" X 6" polyethelene bag	Potting mixture of OGS, dried humus and coconut coir dust with 1:1:1 ratio	Rhizobial inoculant	In pellet form or capsulated form in the center of the potting medium in plastic bag

PLANT NAME						
Scientific Name	Method	Time	Container Size	Medium/Ratio	Micro-organism	Dosage
Melia dubia	Prick when the germinants attained a height		4 X 6" polyethelene bag	1:1 ratio of fine sand and garden soil		
Moluccan sau						
Pilliostigma malabaricum	Transfer in 4 X 6" bags with 1:1:1 OGS, dried humus and coir dust	Anytime of the day in shaded area	4" X 6" plastic bags	1:1:1 OGS, sand or coir dust, dried OM	Mycorhyzal inoculation	Place 5g in the center of the plastic bag half filled with the medium. Then fill up the bag with the medioum before transplanting of germinants
Pinus kesiya Royle ex Gordon	Use stick or hard object to dig the germinants to lessen the disturbance of the root system		6"x8"x0.003 poly-ethelene bags			
Trema orientalis	Seed the sown in paper towel, can be transferred when the hypocotyl is twice the size of the seeds. Transfer the germinants from seed-boxes as seed bed when a pair of leaves is already developed.	Anytime of the day in shaded area	4 X 6" plastic bag		Mycorrhizal inoculant	Add 5 g in each bag half way of the potting medium, then add the other half of the medium .

Appendix Table 4. Nursery Techniques continued….

PLANT NAME	TRANSPLANTING & OTHER PRACTICES				FERTILIZATION/AMENDMENTS	
Scientific Name	Grading	Re-potting	Root Pruning	Spacing	Basis	Form
Acacia auriculiformis	plant only those healthy and vigorous seedlings	When first pair of leaflets emerges, transplant into perforated plastic bags; keep in shade up to 3 months	On bigger / large size seedlings		If the analysis of the potting medium lacks the essential nutrients for development soil amendment like fertilizer application is necessary by	Add fertilizer to the potting mix approximately 2 grams, 5 and 1 gram of Urea, Solophos and Muriate of Potash, respectively.
Acacia mangium	Plant only those healthy and vigorous seedlings	Transplant the seedling carefully in 4"x6" bag with the medium and inoculant after 12 days when a pair of leaves developed and about 5cm in height				
Albizia procera	Prick the vigorous germinants/ seedlings of the same size	Transplant seedlings into the containers when a pair of leaflets developed 5 days after germination	Root pruning is necessary 1-2 times per month, by cutting all the roots growing outside the			Apply NPK 15-15-15 after 2 weeks when new leaves have developed to improve seedling growth
Calliandra calothyrsus	Select only vigorous seedlings	Transplant seedlings from nursery at about 4-6 months, spaced at 2m x				
Gliricidia sepium				Arrange the seedlings in rows to prevent toppling over which may damage the newly transplanted seedlings	Apply fertilizer and other soil amendment if the analysis of the potting medium lacks nutrient (NPK) requirements	

PLANT NAME	TRANSPLANTING & OTHER PRACTICES				FERTILIZATION/AMENDMENTS	
Scientific Name	Grading	Re-potting	Root Pruning	Spacing	Basis	Form
Leucaena leucocephala						
Melia dubia		When the seedlings reach an average of 10cm				Apply 4 gms NPK at 3cm pot bottom
Moluccan sau		Transplant seedlings when they reach 20-25 cm in height with good fibrous root system				
Pilliostigma malabaricum				Arrange the seedlings in rows to prevent top-pling over which may damage the newly transplant	Apply complete fertilizer if the nutrient analysis of the potting medium lacks the major elements	Apply 0.5gm of complete fertilizer (14-14-14) per seedling at the time of pot-ting and then 1gm of NPK per seedling, two to four weeks after transplanting
Pinus kesiya Royle ex Gordon		Do 2-3 months after sowing or when they are				
Trema orientalis	Select only vigor-ous seedlings of the same size			Place the plastic bags with seed-lings in rows so as to prevent the toppling over the bag which may cause injury to		

Appendix Table 5. Pest and Disease Control Strategies in the Nursery and Plantation for Species Suitable for Marginal Uplands.

PLANT NAME	SEED				NURSERY	
Scientific Name	Pest & Diseases	Causal Pathogen	Control Measure(s)	Pest & Diseases	Causal Pathogen
Acacia auriculiformis	Seed diseases	Isiodiplodia theobromae Colletotrichum gloesperoides •Macrophoma phaseolina •Aspergellus flores/ niger	After pre-treatment, soak the seeds in 0.02% solution overnight	Powdery mildew	*Oidium spp.*
Acacia mangium	Seed diseases	Pestalotia sp. Fusarium moneliforme Aspergellus flavus/niger	Soak seeds in 0.02 fungicide solution overnight or coat the seeds with fungicide at 4g/fg seeds	Powdery mildew	*Oidium maildew*
Albizia procera		*Fusarium solani Lasiodiplodia theobromae Colletotrichum gloesperoides, Pestalotia spp. ocrophoma phaseolina Aspergellus app ,F. Monoliformis, penecillium spp.*	Apply fungicide on seeds using slurry method; soak seeds overnight in fungicide solution after pre-treatment		
Anacardium occidentale					
Calliandra calothyrsus				Damping off	*Pythium Phytopthora and Rhizoctomia*
Carica papaya					
Cassia spectabilis		*Fusarium moniliforme*	Soak the pretreated seeds in 0.02% fungicide solution overnight		
Cocos nucifera					
Coffea arabica					

PLANT NAME	SEED			NURSERY	
Scientific Name	Pest & Diseases	Causal Pathogen	Control Measure(s)	Pest & Diseases	Causal Pathogen
Gliricidia sepium	Seed diseases	*Fusarium solani, Lasiodiplodia theobromae*	Soak seeds in fungicidal solution for 2 hours prior to sowing		
Leucaena leucocephala	Seed storage fungi	*Asperigillus spp. Penicillium spp C. gleosperoide s F. moniliforme Phomopsis*	Coat seeds with fungicide before sowing	Damping off	*Colletotrichum gleoessporiodes, Fusarium, Phoma. Chaetomium*
Pilliostigma malabaricum	Seed storage fungi	*Asperigillus flavus A. niger Penicillium spp*	Soak seeds in fungicide before sowing		
Trema orientalis					

Appendix Table 5. Pest and Disease Control continued….

PLANT NAME	SEED		NURSERY	
Scientific Name	Control Measure(s)	Pest & Diseases	Causal Pathogen	Control Measure(s)
Acacia auriculiformis	Observe sanitation; Spray Dithane M-45 or Captan emulsion every 2 weeks; proper disposal of infected leaves to prevent spreading of disease	Powdery mildew	*Oidium spp.*	Observe sanitation; spray
Acacia mangium	Avoid overcrowding in the nursery; spray any contact fungicide once infection is observed	dieback	Colletotrichum Fusarius spp. ; Pestalotia spp.	Avoid tree injury; if injured, apply fungicide in affected areas
Albizia procera		White rot fungus	Ganoderma lucedera	Observe sanitation; burn infested roots and stems; avoid damage or injury to roots and stems
Anacardium occidentale		Common pests are corn silk beetle, rice weevil, sawtooth grain weevil, twig bore root and stem borer. Tea mosquito, shoot and blossom webber, leaf miner, ants, thrips, mealy bugs, and rodents. Common diseases are pink disease, damping off, and anthracnose.		
Calliandra calothyrsus	Sterilize the pooting medium for 4 hours at 50 - 90°c to kill the fruiting structures of the soil-borne fungi	Leaf-defoliators; Stembore; and Tussock moth on flowers	Leucocephalis errorata and Sahyadrassis malabaricus (Philippines)	Apply any insecticide that can control the larval stage of the moth and leaf defoliator
Carica papaya		Phytophthora blight (Phytophtora palmivora) causes small, water soaked, discolored spots on the susceptible to invasion. Later stages cause girdling and mortality. A white fungal fruiting mass releases the spores which invade the trees and fruit.		Control fungal problems by removal and destruction of infected plants and fruit. Spray with copper sulfate or Dithane M-45 fungicides. Avoid planting in clay or waterlogged soils.

PLANT NAME	SEED			NURSERY
Scientific Name	Control Measure(s)	Pest & Diseases	Causal Pathogen	Control Measure(s)
Cocos nucifera		Coconut beetles are found tunneling in the soft crown at dusk, leaving holes in the peduncles and bilaterally symmetrical cuts on leaflets.		Control maybe mechanical (hand picking larvae from decaying trunks), chemical, or biological (using parasitic green mucardine fungus).
Coffea arabica		Many pests and diseases afflict coffee. The major insect pests include defoliators, berry and shot hole borers, termites, and mealy bugs. Major diseases are leaf rust, leaf spot, coffee berry disease, and stem canker.		Spraying is generally recommended to control insect pests. Most diseases can be controlled by proper farm sanitation, pruning, maintaining fertile soil, and using resistant planting stock.
Gliricidia sepium		Leaf spot	Cercospora sp.	
Leucaena leucocephala	Dry bthe seeds to MC of 6-7% before the storing the seeds in the refrigerator. Soak the pretreated seeds in fungicide solution	Leaf spot	Camptomeris leucaenae (S & D Sydow)	Spry any contact fungicide at 3 g/ lire of water at bi weekly interval. Remove the infected parts and burn.
Moluccan sau		Gall rust	Uromycladium tepperanium	Plant healthy and resistant seedlings
Persea americana		Major pests are borers , scale insects, mealy bugs, and fruitly. Major diseases are root rot, anthracnose, Cercespora spot, stem end rot, sun blotch, and scab.		
Trema orientalis		Tree harbors defoliating insects Lepidoptera species) ,Shoot borer	Lepidopteron insect or moth	Spray any insecticide to insects that attack the leaves or shoot

Appendix Table 6. Field Plantation Cultural Management Techniques of Species Suitable for Marginal Uplands.

PLANT NAME	SEED NURSERY		PLANTING		
Scientific Name	Clearing	Staking	Hole Size	Spacing	Planting procedure
Acacia auriculiformis	Clear the whole area of brush by strip or clear brushing. Ring-weed the transplanting spot at 1 meter diameter. Digging a planting hole much bigger than the pot is advisable				Remove potting bags, dig holes slightly bigger than the potting bags to accommodate the 10cm x 40cm plastic bag
Acacia mangium Willd.	Clear the whole area of brush by strip or clear brushing. Ring-weed the transplanting spot at 1 meter diameter. Digging a planting hole much bigger than the pot is advisable			3 x 3m	
Albizia procera (Roxb.) Bentham	Prepare the site by brushing or clear brush any existing vegetation		Hole should be enough to accommodate the seedlings in plastic bag and dried organic matter that will be added to the hole before	2x2 and .75 cubic meter (3m x 0.5m x 0.5m) and staggered trenches	
Albizia procera	Prepare the site by brushing or clear brush any existing vegetation				Insert the seedling (without the polyethelene bag) into the planting hole and see to it that the root collar is in level with the ground surface. Fill up the hole by putting back the topsoil
Albizia falcataria (L.) Fosberg or Paraserianthes falcataria (L.) Nielsen	Clear grass and other vegetative cover at the time of planting as this species is a poor grass competitor during its				

PLANT NAME	SEED NURSERY		PLANTING		
Scientific Name	Clearing	Staking	Hole Size	Spacing	Planting procedure
Cajanus cajan			20cm diameter x 8cm depth	2x2 spacing is to be applied for the immediate effect on degraded soil	Remove the bags completely before planting the seedlings in the holes. Cover the seedlings with the topsoil and apply mulching material to prevent drying of the newly transplanted seedlings.
Calliandra calothyrsus					
Cananga odorata (Lam.)				3m x 3m	
Carica papaya			Hole should be enough to accommodate the seedlings in plastic bag and dried organic matter that will be added to the hole before outplanting	2x2 and .75 cubic meter (3m x 0.5m x 0.5m) and staggered trenches	Totally remove the bag before planting. Cover the seedlings with dried organic matter or a mixture of top soil taken from ordinary garden soil and dried organic matter
Durio zibethimus				5m X 5m	Remove the bag completely before planting
Gliricidia sepium	Flatten first the site to ease in the lay outing				
Leucaena leucocephala			3 to 4 times wider than the size of the plastic bags		
Melia dubia				Plant tillers at 10-15 cm apart. They should not be planted too far apart as they would not form a hedge in a short period of time	Before transporting, the slips from the nursery to the field, cut the tops off about 15-29cm above the base, and the roots 10cm below the base. Plant the tillers along the contours which were previously laid out before the planting activity. Two to three tillers are normally used

PLANT NAME	SEED NURSERY		PLANTING		
Scientific Name	Clearing	Staking	Hole Size	Spacing	Planting procedure
Moluccan sau	Clear grass and other vegetative cover at the time of planting as this species is a poor grass competitor during its early stage of development				
Trema orientalis	For over burden soils, put stakes and flatten the place where trenches are to be made.				

Appendix Table 6. Field Plantation continued...

PLANT NAME	PLANTING		CARE AND MAINTENANCE
Scientific Name	Timing	Soil amendments	
Acacia auriculiformis	Outplant the seedling when it reaches the height of 8-10 inches	Apply complete fertilizer 1 week after planting and every 6 months thereafter at the rate of 130 grams/seedling. If the soil is found to be deficient of potassium, add 90 grams of Muriate of Potash	Cut infested trees, in stands where small numbers of trees are affected, place "trap logs" at different places within the stand, debark the logs and burn them (barks)
Acacia mangium Willd.	Transplant seedlings in the field when they reach 25-30cm in height and at the onset of rainy season	Apply fertilizer in a diameter of 0.5m. In slopes, dig a hole 0.20-0.30m above the seedling and apply fertilizer. Do replacement planting after 2-4 weeks. Conduct weeding and fertilizing.	Conduct ring weeding during the first six months after planting 1/2 away from the base of the seedlings.
Albizia procera (Roxb.) Bentham			
Albizia procera	Outplant the seedling when it reaches the height of 8-10 inches	Apply complete fertilizer 1 week after planting and every 6 months thereafter at the rate of 130 grams./seedling. If the soil is found deficient of Potassium, add 90 grams of Muriate of Potash	Conduct regular weeding and brushing of the plantation during the first two years
Albizia falcataria (L.) Fosberg or Paraserianthes falcataria (L.) Nielsen			Conduct complete weeding and three spot weedings during the first year after planting. Do occasional elimination of vines if necessary.
Cajanus cajan	Outplant at the onset of rainy season	Farm manure and topsoil from other areas	Closely monitor pest and diseases, apply mulch in case of long dry season and water outplanted seedling.
Calliandra calothyrsus			Conduct complete weeding and three spot weedings during the first year after planting. Do occasional elimination of

PLANT NAME	PLANTING		CARE AND MAINTENANCE
Scientific Name	Timing	Soil amendments	
Cananga odorata (Lam.)	Transplant seedlings in the field when they reach 25-30cm in height and at the onset of rainy season	Apply fertilizer in a diameter of 0.5m around the seedlings. In case of planting on slopes, dig a hole 0.20-0.30m above the seedling and apply the fertilizer. Do replacement planting after 2-4 weeks. Conduct weeding at the same time as fertilizing.	Conduct ring weeding during the first six months after planting 1/2 away from the base of the seedlings.
Carica papaya	At the onset of rainy season	Fill up the planting hole with compost especially in stony and rocky areas	Per seedling, apply 50g of NPK in a diameter of 0.5m around the seedlings after 1 month and a second application of 100 f after 2-3 months, and at the end of the rainy season. In case of planting on slopes, dig holes 0.20-0.30m above the seedlings and apply the fertilizer. Replacement planting can be carried out after 2-4 weeks
Durio zibethimus	Outplant seedlings at the onset of the rainy season		Conduct periodic monitoring on the occurrence of any competetive weeds, pests and diseases and survival of seedlings.
Melia dubia	Outplant the tillers at the onset of the rainy season		Trim to a height of 30-50cm during the wet season to encourage the tillering and prevent shading the crops. Conduct weeding whenever necessary to produce maximum tillering

A RESEARCH COMPENDIUM FOR DAMAGED MARGINAL UPLANDS

COMPENDIUM SYNTHESIZERS

EVANGELINE T. CASTILLO
Program Leader

LYNLEI L. PINTOR
Project Leader

ERDB COMPENDIUM COMPILERS

MA. VIENNA O. AUSTRIA

JOSEPHINE B. TANUDTANUD

Ecosystems Research and Development Bureau
Department of Environment and Natural Resources
College, Laguna 4031
May 2010