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CAFRI

2022

TRAINING MANUAL FOR
AGROFORESTRY
ENTREPRENEURSHIP
BUILDING OF RURAL YOUTH



**Training Manual for
Agroforestry Entrepreneurship
Building of Rural Youth**

This publication is part of FAO-NRAA Technical Cooperation Project (TCP) on Support Implementation of National Agroforestry Policy by Enhancing Tree Cover & Production of Wood.

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सत्यमेव जयते

Foreword

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Agroforestry as a land-use system has the potential to strengthen the nation's response to the current economic & ecological challenges by producing food, fuel and fibre in an eco-friendly manner. Principally, agroforestry is the deliberate inclusion of woody perennials (including trees, shrubs and bamboo) along with agricultural crops and/ or livestock on the same piece of land. This tree- based food production system is an optimal approach to reaching maximum yields on the principles of resource use efficiency and ecological harmony. It also fits well with the important agenda of Sustainable Development Goals (SDG) 2030, one of which is efficient & sustainable "land-use". Agroforestry plays a substantial role in contributing to at least 12 out of 17 SDGs, realizing which the Government of India formulated the National Agroforestry Policy in 2014, the first of its kind anywhere in the world.

Upgrading of the agroforestry to universal scale warrants participation of various institutions & organizations and, therefore their capacity building assumes importance. Promoting participatory research and identifying drivers of change in different contexts can further accelerate the pace of scale-up. There is also a large potential for innovation in relation to extension services by using social marketing in effecting behavioural changes, and introduction of practices and products, *i.e.* creation of demand to render agroforestry as demand-led initiative.

The now available digital technology could as well be optimally blended with manpower based extension for greater efficiency in delivery of services.

Pursuant to the Union Government's comprehensive policy on agroforestry, several ministries & departments, and their agencies have stepped in with concerted efforts to promote agroforestry as an initiative for negotiating climate-change associated risk alongside reconciliation of economic needs of the farmers & ecological rejuvenation at the ecosystem level.

It is in this context, that National Rainfed Area Authority (NRAA) collaborated with the Food & Agriculture Organization (FAO-India) of the United Nations, ICAR- Central Agroforestry Research Institute (CAFRI), Jhansi, and the Indian Institute of Forest Management (IIFM), Bhopal in planning for and implementing a Technical Cooperation Project (TCP), called "Support implementation of National Agroforestry Policy (NAP) by enhancing tree cover & production of wood".

This TCP broadly addresses two critical issues, inclusive of i) designing and recommending a facilitative extension module; ii) delineation & development of tradable parameters for the selected timber & non-timber species identified in the states of Uttar Pradesh & Karnataka.

The agroforestry extension framework along with a ready reckoner including a training manual & workbook developed by ICAR-CAFRI encompasses a robust approach for adoption of appropriate agro- forestry extension strategies across the country. The extension training module developed covers all the processes involved in agroforestry form end to end – nursery (pre-planting) to planting & production to post-harvest management.

As regards the tradable parameters, the Report developed by IIFM, Bhopal suggests simple to adopt and easy to replicate traits, that are feasible for physical & online trade. This is facilitative of promoting the sustainable & viable use of selected timber & non-timber species in both the states. Further, there exists scope for replication of the same in other states too.

This Study is a unique attempt for promoting the agroforestry based on robust extension & appropriate post-harvest practices. This approach is expected to have a distinctive impact on the understanding and interpretation of agroforestry operations by grass root level functionaries individuals and farmers.

The effort has been cooperative & coordinated, and therefore the outcome is suitably applicable at field level. The results can be expected to generate substantive interest at government level, which envisions to scale up agroforestry as a peoples programme.

I place on record the sincere effort and innovative approach brought to bear upon this unique project.


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Message

The National Agroforestry Policy adopted in 2014 made India a trend setter in agroforestry research and implementation. The policy called for the development of dedicated agroforestry extension framework to boost the sector in different states. ICAR-Central Agroforestry Research Institute (ICAR-CAFRI) got the opportunity to develop the Agroforestry Extension Framework in collaboration with FAO and NRAA through several rounds of consultations with important stakeholders. The extension framework envisages capacity building and strengthening of existing extension machineries such as KVK's, VVK's, ATMA and state agricultural departments, and the institutional arrangement made for implementing the objectives of Sub-Mission on Agroforestry (SMAF). It was felt necessary to have a Training Manual to have complete exercise of extension mechanism from field to market. ICAR-CAFRI alongwith other associates brought out this capacity building and training manual that can be used for training the extension personnel across the country to boost agroforestry.

This agroforestry training manual contains a holistic plan for developing agroforestry in different states and highlightings the designs and agroforestry models for farmers' field. Further, the document emphasizes the entrepreneurship aspects and value chain development with regard to agroforestry. In the process, the role of ICT applications in agroforestry extension have been detailed. As a backup, various initiatives of the Government of India for agroforestry development have been highlighted along with other supporting information on the package of practices, biodiversity, and propagation techniques of agroforestry species.

The document has been prepared as a part of Letter of Agreement under the FAO Technical Cooperation Programme (TCP/IND/3710) on "Support Implementation of National Agroforestry Policy by Enhancing Tree Cover & Production of Wood".

It is believed that this Technical Manual shall benchmark the capacity building manual activities for different stakeholders and help effective implementation of agroforestry projects and programmes in India for ensuring livelihood and environmental securities *per se*.

- Director, ICAR-CAFRI

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We are grateful for the financial support provided by the Food and Agriculture Organization of the United Nations (FAO) and National Rainfed Area Authority (NRAA), Govt. of India in the form of Letter of Agreement under the Technical Cooperation programme (TCP/IND/3710) on "Support Implementation of National Agroforestry Policy by Enhancing Tree Cover & Production of wood, owing to which, the ICAR-Central Agroforestry Research Institute enabled this capacity building and training manual. The information compiled in this document is from individual/institutional experiences and secondary information sources on the promotion of agroforestry. Our effort has been to bring all available information for its utility to develop one single document for anyone to have it as a ready reckoner for capacity building of agroforestry extension workers.

The guidance received from Dr. Ashok Dalwai, CEO, NRAA; Shri Tomio Shichiri, FAO Representative in India, Dr. S.K. Chaudhari, Deputy Director General (NRM), Indian Council of Agricultural Research; Dr. S. Bhaskar, Assistant Director General (AA&CC) and Dr. B.P. Bhatt from NRM Division of ICAR HQ; Shri Illias Animon, Forestry Officer, FAO Regional Office of the Asia Pacific, Shri B. Rath, Technical Expert (WM), NRAA, Ministry of Agriculture & Farmers Welfare, Shri R.B. Sinha, Senior Policy Advisor (Natural Resources), FAO, Dr. Konda Reddy, Assistant FAO Representative in India and Dr. Divya Shah, NRM & Biodiversity specialist, FAO, Ms. Athira Sobhana, Project Associate, FAO, is thankfully acknowledged. The comments received from experts from FAO, NRAA and independent consulting experts - Prof. Dr. Atul, Dr. V.V. Sadamate and Dr. B. Lakshmi, ASCI, Hyderabad have helped in improving the document. The information available in the public domain of various internet sites, authors, institutions, and publications used in this manual are thankfully acknowledged. In all, I thank all those who directly or indirectly contributed to the implementation of activities under this Letter of Agreement including the State Forest Departments, State Agricultural Universities and KVKs.

- Director, ICAR-CAFRI

Abbreviations and acronyms

AFB	Adaptation Fund Board
ATMA	Agricultural Technology Management Agency
AFPs	Agroforestry Products
AGRISNET	Agricultural Resources Information System and Networking
AA&CC	Agronomy, Agroforestry and Climate Change
CCEA	Cabinet Committee on Economic Affairs
CEO	Chief Executive Officer
CSCs	Common Service Centers
CICs	Community Information Centers
CAFRI	Central Agroforestry Research Institute
DoA&C	Department of Agriculture & Cooperation
DST	Decision Support Tools
DG	Director General
DNA	Deoxyribonucleic acid
ES	Expert Systems
FPO	Farmer Producers Organization
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographical Information Systems
GPS	Global Positioning System
HQ	Headquarter
HDBP	High Density Block Plantation
ICFRE	Indian Council of Forestry Research and Education
InDG	India Development Gateway
ICT	Information and Communication Technology
ICRAF	International Centre for Research in Agroforestry
JFM	Joint Forest Management
KVK	Krishi Vigyan Kendra
LDPFL	Low Density Plantation on Farm Lands
MAPs	Medicinal & Aromatic Plants
MNRE	Ministry of New and Renewable Energy
MoPNG	Ministry of Petroleum and Natural Gas
MPTs	Multipurpose Tree
NAP	National Agroforestry Policy
NABARD	National Bank for Agriculture and Rural Development
NIE	National Implementing Entity
NMSA	National Mission for Sustainable Agriculture
NRAA	National Rainfed Area Authority
NCCF	Network for Certification of Conservation of Forests
NPK	Nitrogen, Phosphorous, And Potassium

NTFPs	Non Timber Forest Produces
NDQPM	Nursery Development for Quality Planting Material
PBP	Peripheral and Boundary Plantation
PLP	Potential Linked Credit Plan
QPM	Quality Planting Material
RIDF	Rural Infrastructure Development Fund
RRB	Regional Rural Banks
SMART	Specific, Measurable, Attainable Relevant, and Time Bound
SWOT	Strengths, Weaknesses, Opportunities, and Threats
SMAF	Sub-Mission On Agroforestry
TCP	Technical Cooperation Program
TSP	Tribal Sub Plan
VKCs	Village Knowledge Centers
VRCs	Village Resource Centers
SATCOM	Satellite Communication
SCP	Special Component Plan
SAU	State Agricultural Universities
TGA	Total Geographical Area

1. Agroforestry Upscaling & Entrepreneurship Building of Youth

Agroforestry is defined as a land use system which integrate trees and shrubs on farmlands and rural landscapes to enhance productivity, profitability, diversity and ecosystem sustainability. It is a dynamic, ecologically based, natural resource management system that, through integration of woody perennials on farms and in the agricultural landscape, diversifies and sustains production and builds social institutions.

Every landowner will have different personal and production goals for an agroforestry development, and an individual's plan for his/her land will be different from someone across the country, state, or even across the road. To accommodate these differences, this training manual has been developed to provide a set of tools that one can use to make informed decisions in creating a profitable agroforestry business. In addition to identifying available resources, site conditions and marketable agroforestry plant species, getting through the steps and filling in the Workbook forms and practical skill development figures on each aspect will help to explore and articulate skilful values and attitudes in an individual.

Establishing agroforestry systems such as multi-storied home gardens, with species that are valued for domestic use and for sale in domestic and national / international markets as well as for soil protection and soil regeneration, offer a good alternative to harvesting from natural forests. This training module will equip the youth and extension officers with a comprehensive set of tools with which to train others in agroforestry practices and its entrepreneurship development. It has two goals. One goal is to help youth and farmers in action-oriented agroforestry entrepreneurship, employment generation programmes. The other goal is to provide communities with the skills required for practising livelihoods that have a benign, or ideally, a beneficial, impact on the natural resource world.



2. Planning and Developing Agroforestry Plan



An agroforestry development intervention is based on the capability of land, personal goals, business goals and land stewardship objectives. These goals and objectives are re-assessed and changed as new information is obtained during the planning and initiation of an agroforestry development. Agroforestry practices often involve various fields *e.g.*, forestry, agriculture, animal husbandry, horticulture, soil science, marketing *etc.*, you may have to augment your personal knowledge. Developing a plan may seem tedious at the beginning, but the long-term benefits far outweigh the difficulties of plan creation. By having a plan, landowners can better envision how to successfully integrate an agroforestry practice to their farm. And the planning process also will help develop a familiarity with the management required to reach the goals, objectives, benefits and economics desired. The best way to ensure success is by thoughtful and honest planning.

Why Plan?

The development of a plan for integrating agroforestry practices to the farm system is as important as the actual establishment of the practice itself. Planning – and the development of a timeline - will help maximize the chances for the success of the agroforestry practice. Planning will not only assist in understanding how the practice and its placement on the landscape can accomplish specific on-farm goals, but also will provide assistance in identifying market opportunities for products that may be grown in the practice. Diagnosis precedes treatment or Design.

The culmination of the planning process is the development of a 5-year management and activities schedule. This final, yet very important step, will help line out the inputs needed over time to keep the agroforestry practice a meaningful and productive component of the farm system for years to come.

Coupled with the field workbook exercises this manual is designed to help to guide through the various stages of creating a plan for agroforestry development area(s), and to assist in gathering information on:

- Objectives and priorities.
- Personal resources (*e.g.*, labour, equipment, buildings, animals, plants).
- Climate, soil conditions and physical features.
- Current land use.
- Land available to practice agroforestry.
- A non-timber plant inventory (for woodland only).
- Market conditions for potential products.

Together with the field workbook exercises, the steps will help to identify what agroforestry products can be grown on the land, which of these products can be sold profitably, and how to develop basic business and marketing strategies. The time put into researching, preparing, and following the plan is an investment in the future agroforestry success.

The steps presented in the following pages – designed to guide in creating an agroforestry plan – are often inter-related, and information gathered in one step will likely make impact on information gathered in other steps. For this reason, the creation of your plan will likely require you to revisit (and expand) each step as you learn more and develop new ideas.

Note: The sequence of steps has been organized to help in developing an agroforestry plan logically. One need not complete each step in the order it is presented. One may prefer to gather information in a way that best suits individual's circumstances.

Personal Assessment

2.1. Step 1: Initial Objectives and Priorities

Landowners exploring multiple uses for their property face many preliminary decisions. Not least, if one have a number of different objectives for an area, some may seem to be in conflict. The choices each landowner makes reflect a set of individual values and attitudes. The personal and business goals of an individual become the criteria for assessing the different possibilities for his/her land.

Land management objectives and priorities will be specific to the circumstances and the area to be developed for agroforestry. However, among other possibilities, you may want to:

- Develop a new source of income from unproductive land (diversification).
- Reduce costs of an existing farm or forest operation.
- Develop a source of long-term income.
- Develop a source of short-term income while awaiting longterm income from timber.
- Reduce property taxes.
- Protect or improve environmental conditions.
- Increase grazing opportunities.

Turn to the Workbook and complete the table of initial objectives and priorities. Remember that these initial objectives may change as you learn more about your land and your agroforestry business. After you finish this assessment, you will be able to weigh your objectives against what you can actually produce on each area of your land. **Step 2: Evaluate Personal Resources** In addition to your land base, your agroforestry development will require the input of other personal resources. An evaluation of the resources available to you will help determine which agroforestry options are best suited to your operation. An evaluation should include: Management and labour availability – Periods during which you are not busy (between or after harvests) and the periods during which labour and management time will be committed to other activities. (See field workbook 1.1 Exercise Step 1).

2.2. Step 2: Evaluate Personal Resources

In addition to your land base, your agroforestry development will require the input of other personal resources. An evaluation of the resources available to you will help determine which agroforestry options are best suited to your operation. An evaluation should include:

2.2.1. Management and labor availability

Periods during which you are not busy (between or after harvests) and the periods during which labor and management time will be committed to other activities

2.2.2. Equipment and buildings

Buildings and equipment, including machines and hand tools, that can be used for this development.

2.2.3. Livestock

Your operation may already have cattle, sheep or other animals.

2.2.4. Plant material

Your own sources of seed, seedlings, cuttings and larger trees.

2.2.5. Other materials

Resources such as sawdust or shavings, manure and straw for mulch.

List these personal resources, as well as anything else that you consider of importance, in the table (See field workbook 1.2 Exercise Step 2)

Biophysical Site Assessment

2.3. Step 3: Identify Current Land Uses

List the present uses of each area of your land and the products you harvest, and record them in your Workbook. These uses could include:

- Residential
- Recreational
- Farming (which crops)
- Grazing (type of livestock)
- Timber production
- Non-timber production
- Environmental use

See field workbook 1.3 Exercise Step 3 and Sub-Exercises are also very important.

2.4. Step 4: Map Area(s) for Agroforestry Development

An agroforestry development may include all of your land or only specific areas, such as existing woodlands, open field or logged over area. In either case, identifying objectives and making decisions will be much easier if you break your land into separate development areas with similar current uses and site conditions (such as soil, moisture and existing plants). Steps in the Workbook, including the sketch map, should be completed for each separate development area. Pages of the Workbook can be copied for this purpose.

2.4.1. Further steps needed for each agroforestry development area :

- Draw a sketch map of the area you are targeting for agroforestry development. Using the legend provided in the Workbook, indicate boundary lines, main geographic features, houses, other buildings and roads.
- Identify and measure the area approximately, marking these measurements on the sketch. This will help determine planting requirements and potential crop production.

Step 3 gives an opportunity to provide information on land use in greater detail, and by thinking about land uses, you may decide to modify your sketch map.

2.4.2. Why Assess Your Land?

Assess climate, soil and physical features on each site on which you intend to develop an agroforestry practice. These assessments will allow you to determine:

- Which plants you can successfully grow on each site.
- Limitations to planting and growing these plants.
- The most effective management practices.

Assessments can be as detailed as you want, or as required by the project. The introduction of long-term or special-needs crops such as black walnut trees requires a different level of site assessment than the planting of a shallow-rooted annual crop. Even if you plan to begin small, with a few tree seedlings on a fence line and a small planting of medicinal herbs, you should still assess the limitations and potential of your land.

The information provided here, and the accompanying form in the Workbook, gives a basic site assessment. More detailed assessments require added time, equipment and expertise. They are only worth doing if it will help with a critical aspect of your agroforestry development. For most developments, they are not necessary (See field workbook 1.4 Exercise Step 4).

2.5. Step 5: Climate Assessment

Climate on your site ultimately determines what you can grow on your land. Combining this data with the information provided in Appendices 2 and 3 of the Training Manual will establish the range of possibilities for your agroforestry practice. Most information sources, and suppliers of seeds and plants, list the minimum hardiness zone for particular plants (See field workbook 1.5 Exercise Step 5).

2.6. Step 6: Soil Assessment

2.6.1. Soil Texture and Composition

Mineral soils are particles of rock or minerals produced from rock by weathering and other geological processes. Sands and gravel are the largest particles, while clay and silt soils contain the smallest particles. The finer textured soils hold more water and dry out more slowly. Organic soil layers or horizons are derived from decaying vegetation, usually in a thin layer above mineral soils. Where found in a sizable layer, they tend to retain both water and nutrients.

2.6.2. Soil Depth

Soil depth determines the rooting capability of the plants you may wish to grow. In particular, forest soils can be quite shallow, requiring extra care in management. You will notice distinct layers as you dig down and you may come across restricting layers such as:

1. Stones and rock outcrops that can interfere with digging and cultivation, and can reduce the nutrient and water-holding capacity of the soil. Rock outcroppings are areas with very little soil; and
2. Hardpan, a hardened layer below the surface of the soil that can prevent penetration of water and roots. Additional soil features that may be problematic include: fragipans, claypans, abrupt textural changes and general discontinuity. Deep-rooted plants will be severely impacted by hardpan.

Note and record in the Field Workbook the approximate percentage of rock fragments in the soil (stoniness), and depth and type of any restricting layers.

2.6.3. Soil Moisture

Soil moisture, which is a key to the establishment and growth of plants, is closely linked to soil texture. The spaces (pores) between soil particles hold water and air needed by plants for good growth. Generally, coarser soils are well-drained and are often dry for longer periods, while soils with finer textures hold more water and are likely to remain moist longer. Other factors, such as ground water level or the presence of an impermeable layer that restricts drainage, also determine soil moisture.

As you dig your pit, is the soil dusty and dry? Does water seep into the bottom of the hole? Often, the time of year and recent weather will influence soil moisture.

2.6.4. High Water Table, Standing Water or Flooding

Areas such as wetlands and parts of riparian zones which remain fully saturated for extended periods of time are of special concern. These areas are sensitive to access development and machine use, and are important for wildlife habitat and other environmental values. You will need to identify these areas of your land and plan to use especially careful management. Access may be limited for all or part of the year

In your Workbook table and on your sketch map, it is important to note any: Wetland features, evidence of flooding, areas that experience overland flows or standing water during spring runoff, and areas with continual seepage or high water table.

Both very wet or dry conditions pose challenges for planting and management. However, some plants are particularly adapted to one or the other of these extremes (see Annexure 8.1to8.3 for a listing of suitable plants). Note the moisture conditions of various portions of your proposed development area on both your sketch map and in your Workbook table.

2.6.5. Nutrients

The availability of nutrients in the soil affects the quantity and quality of products produced. You can undertake a soil test to determine the soil pH (acid/alkaline balance), specific nutrient levels, and recommendations for various crops. In your Field Workbook the status of soil nutrients that you have determined and attach any lab reports. (See field workbook 1.6 Exercise Step 6)

2.7. Step 7: Physical Features (Terrain)

The physical features are closely related to – but also different from – the soil characteristics described in Step 6. For ease-of-use, physical features are described separately from soil characteristics. However, the information you generate through each step is entered into the Field Workbook. This allows you to easily see the relationships between physical features and soil characteristics. There are several physical features that can influence your capability to produce particular crops on a site.

Aspect refers to the direction toward which the site slopes (if any). South and southwest-facing slopes are usually warmer and drier than those facing north, and naturally support different plant communities. Terrain relief refers to whether the site is steep, flat, sloped, rolling, gullied or broken (steep slopes between benches). This will influence access and machine capability, water management, cold air drainage and other microclimate factors. Frost pockets are one additional feature to consider. Cold air flows downhill and pools in low areas. The resulting localized frosts can damage delicate flowers and shoots that start to grow early in the spring. Even crop plants correctly chosen for your hardiness zone can be affected. Assess low areas on your land for potential frost pockets. Avoid these areas for frost-sensitive plants. Sloped or bench land that has good air drainage is a better choice.

Enter your observations of the physical features mentioned above in your Field Workbook table and on your sketch map (See field workbook 1.4, 1.7 Exercise Step 4 and 7).

2.8. Step 8: Timber and Non-Timber Forest Crop Inventory

If you want to practice agroforestry in woodland areas, this step will help you inventory the variety of plants growing on your land – everything from trees to herbs on the forest floor. The inventory of trees described here is restricted to their potential production of non-timber products (*e.g.*, medicinal, florals) and their interactions with other plants (*e.g.*, shade, moisture, nutrients). A non-timber vegetation inventory can be used to help create a list of 'best bets' – plants that can be successfully grown on your land, and will also help you decide how to manage your woodland efficiently and productively (*i.e.*, managing competition for sun, water and nutrients).

If you own more than a few acres of land, you should sample your land base, using inventory plots to obtain a 'best approximation' of the vegetation. Sampling is an excellent compromise between doing nothing (and having a very limited picture of your land) and trying to do the impossible: Counting every tree, shrub and herb on your property.

2.8.1. Preparing Your Inventory

An inventory should give you a timely snapshot of your land; it should not take too long, nor should it be too difficult. Inventory plots are the sites where you record information about vegetation and other features on your land. They form a pre-determined portion (or percentage) of the larger area you're interested in sampling. Multiplying your plot data by the number of plots that would fit in the larger area will give an estimate of what you would find if you actually measured everything. Size of inventory plots depends on what you're trying to survey and the vegetation cover on the plot. In your forest vegetation survey, you will actually take two separate surveys from the same plot center. This is because you need to collect information about two very different types of vegetation: Trees; shrubs and other smaller plants.

2.8.1.1. Tree inventory

The tree inventory described here is only intended to determine the non-timber resources available.

2.8.1.2. Number of trees and species

Record the number of trees of each species found at the plot. This will assist in determining what non-timber products can be obtained, and what plants can be grown under the canopy.

2.8.1.3. Condition of trees

Helpful in determining whether marketable non-timber products can be harvested. Also helpful in assessing the possible function as a windbreak.

2.8.1.4. Crown closure

The degree of canopy closure will determine the conditions for raising or enhancing shade-loving species in the under story.

2.8.2. Non-timber Inventory

Begin your inventory by identifying and listing all the harvestable non-timber species found in the plot on your plot sheet. Include plants that provide good browse if you intend to graze the area. For each species, record the following:

2.8.2.1. Total number of plants for each species

Where possible/feasible, count the number of individual plants of each species found in the plot. This will be easier on an open forest floor than it will be on dense sites. You may choose to record sites like the latter simply as 'dense coverage.' This is one of those instances where judgment calls come in. Even an approximate number could be useful in developing a harvesting plan.

2.8.2.2. Estimate of the percentage cover for each species

How much of the plot do you think the species covers? Provide an estimate to the closest 10%.

2.8.2.3. Proportion of harvestable vs. non-harvestable individuals

The aim here is estimate the amount of harvestable individuals for each species (none, 20%, 50%). Your decisions will be based on factors such as size, color, and insect or other damage. If many of the plants are not harvestable in their current condition, cultural practices such as fertilization and pruning may be available that would improve product quantity and quality.

2.8.3. Using Your Inventory

First, make sure all areas inventoried are marked on your map(s). Next, you need to take the raw data from your inventory (plot sheets), compile it, and present it in a useful format. That means taking the information from your sample plots and organizing the information, so it represents your entire development area.

2.8.4. Trees and/or other resources per acre

Among your survey information, you have recorded the number of each plant species that appears in each inventory plot. Now you want to convert that number into the number of plants per acre. This is done using the plots per acre factor. The plot information is then extrapolated to one acre and multiplied by the total acres.

Once you know the approximate number of plants of a given species per acre you have a fairly good idea of the plant resources you have on your land. Record the information in the tables (See field workbook 1.8 Exercise Step 8).

Agroforestry Development Ideas

2.9. Step 9: Agroforestry Development Ideas – Brainstorming

After reading the Training Manual, one will probably come up with some ideas for agroforestry developments on your property. Once you have done this, it is time to engage in some brainstorming. In addition, check out Annexure 8.1 to 8.3 (Trees, Shrubs and Grasses and Forages for Agroforestry) in the Training Manual to develop additional ideas.

Brainstorming is the process of putting ideas down on paper as they come into your head. List them all and don't try to self-censor the ideas. You can reduce this list to 'best bets' later. Input from family and friends, as well as ideas from neighbouring landowners, can help generate useful ideas. This is also a point at which expert advice may expand the list of possibilities. For additional assistance consult the Additional Resources that are listed at the end of every section.

For each development area, sort the list by practice and record this information in the corresponding Workbook form. In general, more intensive agroforestry practices (e.g., forest farming) are suited for smaller units of land, while the more extensive practices (e.g., Silvipastoral) are suited to larger units of land (See field workbook 1.9 Exercise and Sub-exercises Step 9).

2.10. Step 10: Listing 'Best Bets'

The intent of this short but important step is to create a list of potential crops that can be grown on your land. This list of 'best bets' will be based on the information you have gathered so far – including land and personal resources, site conditions and current land use – combined with the plant information provided in Annexures 8.6 and 8.7 of the Training Manual.

Perhaps the easiest way to approach this list is by first determining what plants can grow under the climatic, soil and physical conditions that occur in each of your agroforestry development areas. Plants you already cultivate on your land, plants revealed by your non-timber inventory, and crop ideas you have developed while gathering information will all form part of this list.

You can add substantially to the list by looking at Appendices 2 and 3 in the Training Manual to see what other plants can be successfully grown on your site, and what products can be made from them. You want this list to be as extensive as possible, so you can consider the widest possible range of options.

Your list can be refined by considering the resources at your disposal (e.g., labor, buildings, equipment) at different times of the year. These factors will limit the crops and crop combinations you can grow. Finally, you can

further refine your list by revisiting the objectives you have for your land, such as income diversification, reduction of land taxes or environmental protection.

The list of 'best bets' you make in this part of your Workbook should include all the plants that can grow on your land, and the products that can be derived. Make sure you include timber products that can be made from trees you would plant as part of an agroforestry development. If you have done a timber inventory – in addition to the non-timber vegetation inventory – list those possible timber products as well.

Along with the briefs given in the Training Manual, the following steps will help you develop a marketing strategy, or marketing plan. Each step contains directions needed to complete corresponding sections in your Workbook. You should note that every part of every step might not apply to your situation (See field workbook 1.10 Exercise and Sub-exercises Step 10).

Evaluate the 'Best Bets' in the Context of the Industry

2.11. Step 11: SWOT Analysis

Having analysed the current situation of your farm with respect to objectives and priorities, personal resources, site assessment and vegetation inventory, and brainstormed ideas of agroforestry practices, you can use that information to identify Strengths and Weaknesses, Opportunities and Threats or a SWOT analysis for the crops you think may produce. This can be helpful in defining and clarifying the issues you need to address in the rest of the planning process.

As per brief given in the Field Workbook it will help in identifying strengths and weaknesses, you will be focusing on factors internal to your business. Opportunities and threats refer to the external environment of your business. The plan you will develop will be shaped by both internal and external factors; it will build on your strengths and minimize the impacts of your weaknesses while at the same time be responsive to the opportunities and threats your environment offers.

In the SWOT Analysis worksheet, summarize the internal strengths and weaknesses and the external opportunities and threats for your business as you identify them today. Consider all aspects: natural, physical and human resources, marketing, operations and finances (See field workbook 1.11 Exercise Step 11).

2.12. Step 12: Porter Five Forces Model

The Five Forces Model (developed by Dr. Michael Porter of Harvard University) serves as a good framework for assessing different industries you would like to get in. The Five Forces Model identifies coordination and control aspects of an industry and provides a guideline for understanding the resources and relationships needed to be successful in a market. The model is presented in more detail in the – Marketing Principles. Using the information and examples provided in the Field Workbook, use the following ideas to evaluate the chosen crops in the context of the industry:

- Identify barriers to entry.
- Identify suppliers/bargaining power of suppliers.
- Identifying buyers/bargaining power of buyers.
- Identify substitutes.
- Identify competitors and their competitive advantages.

See field workbook 1.12 Exercise and Sub-exercises Step 12.

2.13. Step 13: Revising Your "Best Bets"

In Step 11 of your agroforestry plan, you identified the plants that can grow on your land, and which you can produce with the resources you have available.

After a thorough analysis using the SWOT Analysis and Porter Five Forces Model, the list of 'best bets' can be refined to include those plants and products you think have the best market potential. When selecting a list of marketable 'best bets,' consider

- How difficult is it to enter the market?
- Is the required supply available?
- Are there buyers nearby?
- What is the demand for the crop, relative to supply?
- How does harvesting and selling these crops fit in with the rest of your production system? For example, will the crop(s) require big inputs of labor during an already busy period?
- Is investment of resources (labor and capital) likely to provide an adequate return?
- How does that return compare to other possible crop/product options

Where possible, use your vegetation inventory information to list the approximate volumes of the crops you have for sale. For crops not yet planted, you should estimate how much you'll be able to sell so you have an idea of how much to plant (See field workbook 1.13 Exercise Step 13).

Your marketing strategy is about defining your customer or target market and tailoring your product, pricing, distribution and promotion strategies to satisfy that target market.

Marketing Strategy for 'Best Bets'

2.14. Step 14: Select and Describe Target Market(s)

Your first task in building a customer strategy is to identify your target market. Target markets are most commonly characterized as either individual households or businesses. Begin your target market research by developing a customer profile. Customer profiles can help you determine if a market segment is large enough to be profitable. Break your target market up into segments based on differences in their geographic location, demographic characteristics, social class, personality, buying behaviour or benefits sought (See field workbook 1.14 Exercise Step 14).

2.15. Step 15: Adding Value to Products

As you think about the products your business will offer, try to describe them in terms of the value they will bring to your customers. List all value-added opportunities and identify 'pros' (how it will benefit the needs of each customer segment) and 'cons' (e.g., costs, risks) for each of them. Identify also unique characteristics that will differentiate your product from competitors. Define each product to address specific needs for each market segment (See field workbook 1.15 Exercise Step 15).

2.16. Step 16: Getting Products to the Buyer

Now that you have a customer and product in mind, your next task is to identify how to move or distribute products from your farm to the customer's house or store shelves. Distribution strategies typically describe:

- Location – Where will you sell your product?
- Distribution – Which sales channels will your product follow?
- Transportation – How will your product reach the buyer?

See field workbook 1.16 Exercise Step 16

2.17. Step 17: Setting the Price

In general, pricing strategies are based on two factors: Prevailing market prices and your costs. In the long run, your price has to cover your full costs – including production, marketing and promotion – as well as a return for your time and investment. Try to identify prevailing market prices for similar products if they exist; learn about what customers are willing to pay and what prices your competitors charge. Also identify and document all your production, marketing and promotion costs. Decide how you want to price your product for each market segment. Do you want to undermine the competition by offering a lower price? Can you set a high price that reflects your quality image or market demand? Are you simply looking to cover costs? Do you have power to set a price? How sensitive is demand to price changes? Take all these aspects into consideration and try to establish a realistic price or price range for each product (See field workbook 1.17 Exercise Step 17).

2.18. Step 18: Promoting Your Products

Promotion is very important to gain product recognition among customers. Promotional strategies often are built around a “message.” The message that you deliver about your product or business is just as important as the product itself. Equally important is how and when you deliver that message through the use of advertising tools and media. Consider also the costs of each promotion method (See field workbook 1.18 Exercise Step 18).

Agroforestry Practice Design and Management

2.19. Step 19: Revisit Your Objectives and Priorities

The first step in developing your agroforestry plan was to outline your initial objectives and priorities for your land-based business. Since then, you have gathered considerable amounts of information that will likely change at least some of those original goals. Record your revised objectives and priorities in the space provided in the Workbook (See field workbook 1.19 Exercise Step 19).

2.20. Step 20: Detailed 'Best Bets' Crop Information

To develop the most functional and profitable agroforestry practices, you should know as much as possible about each plant you intend to grow. You will have gathered much of this information while filling out your Workbook, using your land assessment, plant inventory (where appropriate), market research, Annexures 8.1 to 8.3 of the Training Manual, and possibly your own additional research.

Important information includes the biological requirements of each plant, the agroforestry practices they can be adopted, what other plants (and animals) they are compatible with, labour requirements for harvesting, potential volumes, value-added opportunities, and useful market information.

The table provided in the Workbook may include categories of information you do not have. You can exclude these or take extra time to find the information. There is also extra space for additional information you consider important but not specifically listed here (See field workbook 1.20 Exercise Step 20).

2.21. Step 21: Designing Your Agroforestry Practices

Now is the time to arrange your plants into agroforestry practices that best meet the management objectives you outlined in Step 19. The information on each plant crop, and the management information provided earlier in this chapter, will allow you to design and manage agroforestry practices that best meet your objectives. Fill in a table in the Workbook for each agroforestry practice you intend to develop. Remember that price and marketability are not the only criteria for selection of the plants you will include in your agroforestry practices. Some plants may be chosen because they provide valuable ecological functions to your agroforestry practice, such as trees for shade and windbreaks, or legumes for nitrogen fixation. (See field workbook 1.21 Exercise Step 21)

Building an Agroforestry Development Plan

The purpose of building an agroforestry development plan is to create a schedule of the work that needs to be done in the years ahead to fully develop your agroforestry area(s). Your completed Agroforestry Development Plan will include specific tasks, time-lines and labour projections for each agroforestry practice on a year-by-year basis. The Development Plan is the final step in Field Workbook and will form the practical basis for your agroforestry development. You will no doubt change and adapt your work projections in the years ahead, but a good Development Plan will form a clear starting point and help focus your management efforts.

The Development Plan includes two distinct parts:

- A five-year plan outlining specific tasks for each agroforestry practice.
- A yearly activity plan, broken down into specific tasks for each month.

2.22. Step 22: A Five-Year Management Projection

Your five-year management projection is a schedule of the work you plan to undertake in the next five years to develop your agroforestry practices. The specific tasks and timelines you prepare will form the basis for your yearly activity schedule

Don't worry too much about getting absolutely everything right on the first pass. Your plans will change over time and you can go back and adjust your projections accordingly. For now, you are mainly interested in conceptualizing the overall operation on paper

The five-year management projection has four sections:

- Area: Size of the area to be managed.
- Practice: Agroforestry practice and its associated products.
- Year: Year that you want the management activity to take place.
- Management Objective: Specific objective you hope to accomplish.

Use the template provided in the Workbook to create your own five-year management projection (See field workbook 1.22 Exercise Step 22).

2.23. Step 23: Yearly Activity Schedule

The yearly activity schedule describes specific tasks that need to be done, when and by whom. This is the document you will use to plan your work schedule on a month-by-month basis. A good yearly activity schedule will allow you to identify potential time and business conflicts, and ensure you avoid overlapping seasonal activities that could create shortages of labor and resources.

A yearly activity schedule – one for each agroforestry practice – has five sections:

- Crop Plant: The plants that you have decided you can grow and market.
- Management Objectives: A record of objectives, transferred from your five-year projection.
- Task and Time of Year: A list of specific tasks that must be accomplished to achieve each objective, including timelines associated with each task.
- Materials: Estimates of seed, seedlings, fertilizer, fencing, animals, feed and other items necessary for corresponding tasks.
- Labor and Equipment: A record of labor and equipment needs (if any) for each of the specific tasks.

Like the five-year management projection, your yearly activity schedule will likely change as you learn more. Remember to leave yourself plenty of time to complete all the work. As landowners well know, most tasks take longer than expected. The yearly activity schedule will also be helpful in costing the materials, labor and equipment necessary for the cash flow projection of your business plan (See field workbook 1.23 Exercise Step 23).



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3. Developing and Designing Agroforestry Models at Farmers' fields



The deliberate growing of woody perennials on the same unit of land with agricultural crops and/or animals, either in spatial mixture or in temporal sequence

- Involves two or more species of plants and/or animals, at least one of which species is a woody perennial
- Contains complex interactions among species' components that are suited to the needs of environmental and human systems
- Always has two or more outputs

Agroforestry systems are classified into two levels:

3.1. Agroforestry at plot or farm level:

Agroforestry activities or practices related to the day-to-day management of an agroforestry system, such as hedgerow planting of leucaena (*Leucaena leucocephala*) or planting of rubber (*Hevea species*) seedlings in a multi-strata agroforestry system (See field workbook 2.1 Figure 1). At farm level, agroforestry can be managed through regular spacing and irregular spacing depending on the owner's preferences and goals.

Generally, at plot or farm level, agroforestry systems can be classified into two types

3.1.1. Simple agroforestry Systems

The agroforestry systems usually have no more than five tree species, annual crops (rice, maize, vegetables, forage herbs) and/or vegetatively propagated species (bananas, cacao, coffee). The trees also serve as shade for companion crops, forming a single layer of canopy (See field workbook 2.2 Figure 2). Spacing between individual plants is either regular or random. The expected benefits from the system are focused on the economic aspects of the main commodity. The best-documented forms of simple agroforestry are alley cropping, taungya, woody hedgerows, windbreaks.

3.1.2. Complex agroforestry Systems

The agroforestry system usually contains more than five tree species besides the main commodity crop or crops. Besides yielding products (fruit, timber, spices), the trees also serve as shade for companion crops and form multiple layers of canopy (See field workbook 2.3 Figure 3).. Spacing between individual plants is usually irregular and management of the system is usually extensive. The characteristics and functioning of complex agroforestry systems are close to those observed for natural forest ecosystems, either primary or secondary, that is, providing economic (tangible products) benefits and ecosystem services (carbon sequestration, water regulation, prevention of soil erosion and landslides, and habitat for endemic animals and plants). In some cases, farmers enrich their simple agroforestry systems with other tree or shrub species and other crops and transform them into complex agroforestry systems.

A further specification by experts classifies agroforestry systems according to the following criteria (Figure):

3.1.2.1. Structural basis

Structural basis refers to the composition of the components, including spatial arrangement of the woody component, vertical stratification of all the components, and temporal arrangement of different components.

3.1.2.2. Functional basis

Functional basis refers to the major function or role of the system, usually furnished by the woody components. These can represent a service or be of a protective nature, for example, windbreak, shelterbelt, soil or water conservation.

3.1.2.3. Socioeconomic basis

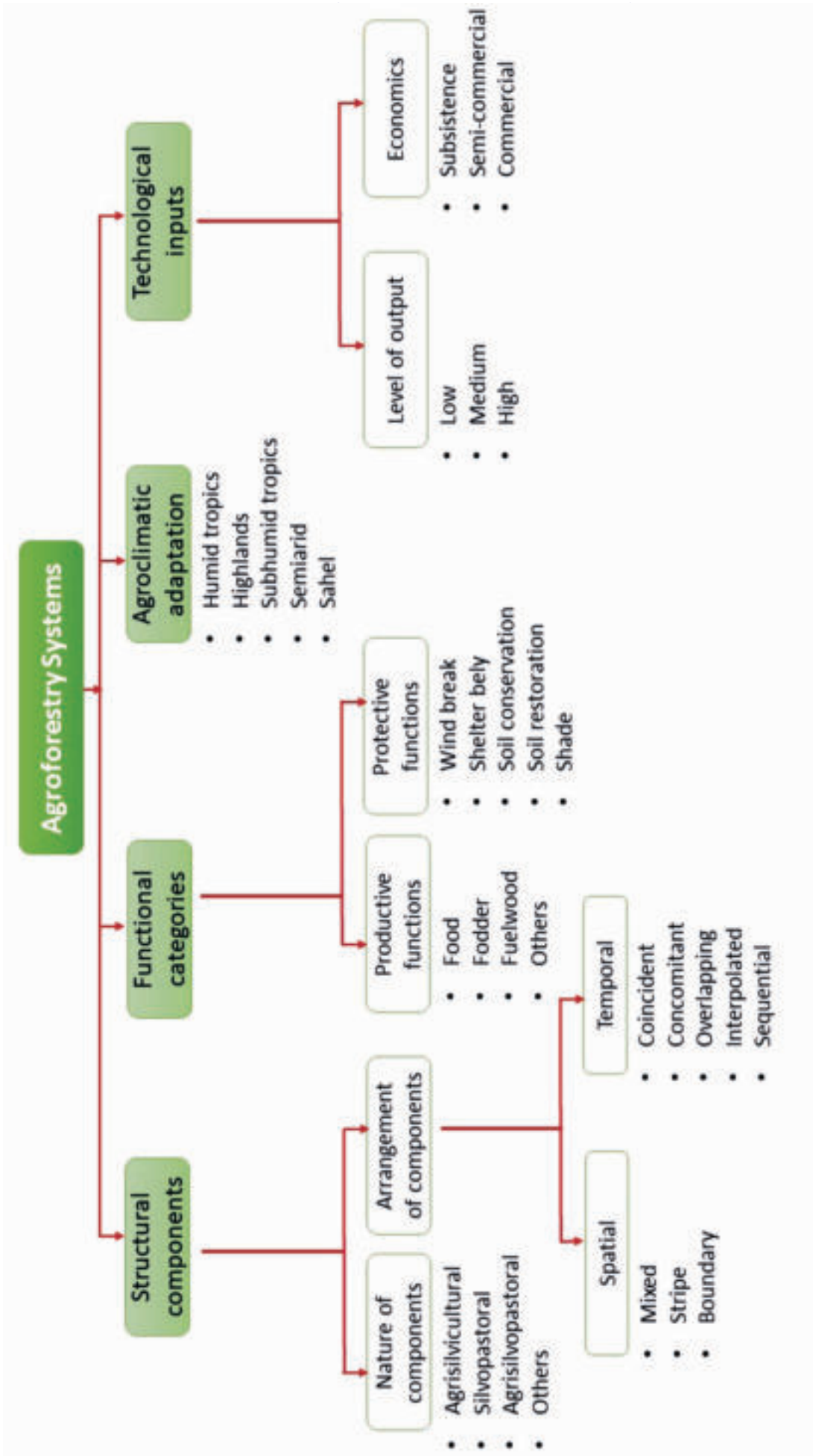
Socioeconomic basis refers to the level of inputs (low to high), intensity or scale of management, and commercial goals, for example, subsistence, commercial, or intermediate.

3.1.2.4. Ecological basis

Ecological basis refers to the environmental condition and ecological suitability of a system, based on the assumption that certain types of systems can be more appropriate for certain ecological conditions. There are separate sets of agroforestry systems for arid and semiarid lands, tropical highlands and lowland humid tropics

3.2. Agroforestry at landscape level:

Agroforestry is a land-use system that interacts with other land uses to provide livelihoods for local people as well as environmental services in the landscape. The structure of an agroforestry system can also be defined in terms of its components and their expected roles (See field workbook 2.4 Figure 4).. This classification considers the composition of the components, including a spatial mixture of the perennial woody component, vertical stratification of the component mix and a temporal arrangement as shown above (or See field workbook 2.5 Figure 5). Examples of this classification are found in table:



3.3. Examples of Agroforestry Systems

System	Components	Examples
Agrisilviculture (See field workbook 2.6 Figure 6).	Trees with crops	● Shifting cultivation
		● Improved fallow
		● Taungya
		● Home-garden
		● Alley cropping (See field workbook 2.7 Figure 7).
		● Multipurpose trees and shrubs on farmland
		● Crop combinations with plantation crops
		● Shelterbelt
		● Windbreak (See field workbook 2.8 Figure 8).
		● Soil conservation hedge (See field workbook 2.9 Figure 9).
		● Rotation woodlot
		● Boundary marking
		● Riparian buffer
Silvipastoral (See field workbook 2.10 Figure 10).	Trees with pasture and livestock	● Protein bank
		● Trees and shrubs on rangeland or pasture
		● Live fences of fodder trees and shrubs
		● Plantation crops with pasture and animals
		● Agrisilvipastoral Trees with crops and livestock
		● Multi-story system with free grazing
		● Alley cropping with pasture grasses and agricultural crop
		● Woody hedgerows
Other systems (See field workbook 2.11 Figure 11).	Trees with insects Trees with fishery	● Aqua-forestry
		● Apisilviculture
		● Sericulture
		● Mushrooms with mixed tree species
		● Multipurpose woodlot

This concludes that agroforestry is agriculture with trees. Thus, it describes practices developed and employed by farmers over many centuries to cultivate trees on farmland in different combinations with crops and livestock. From a purely agricultural perspective, agroforestry is about recognizing and promoting trees on a farm. From a strict forestry perspective, it is about recognition and rights for tree-based systems and livelihoods that farmers have created and can expand with appropriate support from relevant forest management techniques. Nevertheless, agroforestry is an amalgam of agriculture and forestry, rather than treating these as separate land uses, institutions, policy domains and fields of science. This integration is achieved through a landscape approach. Most importantly, apart from bio-geophysical perspectives, agroforestry can be an entry point for speeding the progress of achieving social, economic, welfare, market and environmental stewardship. For further details the supporting information is given in the Annexure to strengthen the development and upscaling and capacity building of agroforestry for the youth and the farmers.

The practical exercises in field workbook will provide the basic guidance for trainers to design and deliver training that will help individuals or organizations increase their knowledge, skills and experience in agroforestry development and decision making for adoption of a particular system (See field workbook 2.12 Figure 12).. In addition, the exercises contained in the workbook are designed to help participants foster the understanding and basic skills necessary to support farmers in developing effective and efficient agroforestry practices).

4. Young Farmer Entrepreneurship for Agroforestry Value Chain



4.1. Farmers as Entrepreneurs

An entrepreneur is any person who creates and develops a business idea and takes the risk of setting up an enterprise to produce a product or service which satisfies customer needs. Entrepreneur refers to the person and entrepreneurship defines the process. Both men and women can be successful entrepreneurs; it has nothing to do with gender. All entrepreneurs are businesspersons, but not all businesspersons are entrepreneurs.

Can small-scale farmers become entrepreneurs? Yes. Small-scale farmers all over the world have shown a remarkable ability to adapt. They look for better ways to organise their farms. They try new crops and cultivars, better animals, and alternative technologies to increase productivity, diversify production, reduce risk – and to increase profits. They have become more market-oriented and have learned to take calculated risks to open or create new markets for their products. Many small-scale farmers have many of the qualities of an entrepreneur.

For small-scale farmers to become entrepreneurs they need all of these qualities and more. They need to be innovative and forward-looking. They need to manage their businesses as long-term ventures with a view to making them sustainable. They need to be able to identify opportunities and seize them. Some small-scale farmers do have these qualities, but they still focus on maintaining their traditional way of life. Their production decisions are based on what they need -- not on what is possible.

The farmer-entrepreneur produces a clear picture in his mind of what is possible and the future he wants. He knows that what is possible is determined by the market. The farmer-entrepreneur is always looking for new opportunities. He knows that new opportunities are found in the market. The farmer-entrepreneur wants to make profits. He knows that profits are made in the market. An entrepreneurial farmer has the initiative, drive, capacity and ability to take advantage of opportunities (See field workbook 3.1 Exercise 1).

4.2. Understanding basic concepts of entrepreneurship

The word “Entrepreneurship” is derived from the French verb *entreprendre* which means “to undertake”. Entrepreneurship, value chains and market linkages are terms that are being used more and more when talking about agriculture and farming. Many small-scale farmers and extension organisations understand that there is little future for farmers unless they become more entrepreneurial in the way they run their farms. They must increasingly produce for markets and for profits. Becoming more entrepreneurial can be a challenge for small-scale farmers. They will need help from extension workers and other institutions. What is an entrepreneur? An entrepreneur is someone who produces for the market. An entrepreneur is a determined and creative leader, always looking for opportunities to improve and expand his business. An entrepreneur likes to take calculated risks, and assumes responsibility for both profits and losses. An entrepreneur is passionate about growing his business and is constantly looking for new opportunities. Entrepreneurs are also innovators. They always look for better and more efficient and profitable ways to do things. Being innovative is an important quality for a farmer-entrepreneur, especially when the business faces strong competition or operates in a rapidly changing environment.

In order to be successful, an entrepreneur should have the following qualities:

4.2.1. Opportunity-seeking

An opportunity is a favourable set of circumstances that creates a need for a new product, service or business. It includes access to credit, working premises, education, trainings *etc.* An entrepreneur always seeks out and identifies opportunities. He/she seizes an opportunity and converts it into a realistic and achievable goal or plan.

4.2.2. Persevering

An entrepreneur always makes concerted efforts towards the successful completion of a goal. An entrepreneur perseveres and is undeterred by uncertainties, risks, obstacles, or difficulties which could challenge the achievement of the ultimate goal.

4.2.3. Risk Taking

The best entrepreneurs tend to:- Set their own objectives where there is moderate risk of failure and take calculated risks Gain satisfaction from completing a job well Not be afraid of public opinion, scepticism Take responsibility for their own actions

4.2.3.1. Importance of risk-taking

Build self-confidence Create a feeling of leadership Create strong motivation to complete a job well An entrepreneur needs to consider the following issues before taking a risk. Is the goal set realistic? How big is the potential reward for this risk? How big is the potential loss? What is the probability of failure with this risk

4.2.4. Demanding for efficiency and quality

Efficiency Being efficient means producing results with little wasted effort. Quality refers to: The ability of a product or service to meet a customer's expectations for that product or service.

4.2.5. Information-seeking

Successful entrepreneurs do not rely on guesswork and do not rely on others for information. Instead, they spend time collecting information about their customers, competitors, suppliers, relevant technology and markets. Gathering relevant information is important to ensure that the entrepreneur makes well informed decisions.

4.2.6. Goal Setting

A Goal - is a general direction, or long-term aim that you want to accomplish. It is not specific enough to be measured. It is large in scope, not necessarily time-bound, and is something that people strive for by meeting certain objectives which will hopefully add up to eventually achieving the goal. Objectives - are specific and measurable. They can be output objectives, or they can be attitudinal or behavioural. But most of all, they can be measured. They are concise. They are specific. Think of the word object." You can touch it, it's there, it's actual, and it's finite. An entrepreneur must have a goal and an objective which is specific, measurable, attainable relevant, and time bound (SMART).

4.2.7. Planning

Planning is making a decision about the future in terms of what to do, when to do, where to do, how to do, by whom to do and using what resources. An effective entrepreneur therefore usually plans his/her activities and accounts as best as they can for unexpected eventualities.

4.2.8. Persuasion and networking

Persuasion is a way of convincing someone to get something or make a decision in your favour Inducing or taking a course of action or embracing a point of view by means of argument, reasoning, or entreaty; to convince to succeed in causing a person to do or consent to something; to win someone over, as by reasoning or personal forcefulness to cause to believe; to induce, urge, or prevail upon successfully. Business Networks In a business environment where we are in, we network with customers, suppliers, competitors, various firms, different organisations, government offices and family, etc Factors that affect persuasion and networking Socio-cultural background and perceptions Communication skills (both verbal and non-verbal). Negotiation skills.

4.2.9. Building self-confidence

Self-confidence is the state of being certain that a chosen course of action is the best or most effective given the circumstances. Confidence can be described as a subjective, emotional state of mind, but is also represented statistically as a confidence level within which one may be certain that a hypothesis will either be rejected or deemed plausible. Self-confidence is having confidence in oneself when considering a capability. Overconfidence is having unmerited confidence-believing something, or someone is capable when they are not.

4.2.10. Listening to others

An entrepreneur does not simply impose his/her idea on others. Rather, he/she listens to other people in their sphere of influence, analyses their input in line with his/her own thinking and makes an informed decision.

4.2.11. Demonstrating leadership

An entrepreneur does not only do things by him/herself, but also gets things done through others. Entrepreneurs inspire, encourage and lead others to undertake the given duties in time.

See field workbook 3.2 Exercise 2 which will help in analysing and interpretation of the information collected in this aspect. The field workbook 3.3 Exercise 3 will help in development of the entrepreneurship characteristics action plan and the 3.4 Exercise 4 will strengthen the entrepreneurial skills.

4.3. Generating a business idea**4.3.1. What is a business idea?**

Every business is born from an idea. Business ideas should come from observation, to find a potential opportunity, or try to forecast what people or other businesses might want. Business ideas are sometimes developed from someone's education and past experience. It should be known that by considering your natural talent you might find the seed for a good business idea. It is an idea about what products you are going to offer, what services you are going to provide or what goods you are going to sell; where and how you are going to sell them and who are you going to sell them to.

A successful business meets the needs of its customers. It gives people what they need or want. Your business idea will tell you; Which need your business will fulfil for its customers. What product or service your business will sell. Who your business will sell to. How your business is going to sell its products or services

Business ideas are identified through positive, creative thinking. They can come from different sources such as ideas built on local resources, local needs, local activities, interests and hobbies.

4.3.2. What Makes A Good Business Idea?

A good business idea is one that is based on; A product or service that customers want A product or service you can sell at a price customers can afford and which will give you a profit The knowledge of skills you have or you can get The resources and money you are able to invest. All good businesses begin with a good idea that has been well thought through. How do people find good business ideas? A field workbook exercise will be helpful in this regard.

4.3.3. SWOT Analysis

One method people often use to decide which the most suitable business idea is the SWOT analysis. It helps you focus on possible problem areas and potential advantages of each idea. S-trengths W-eaknesses O-pportunities T-hreats

4.3.4. Inside the business

To analyse the strengths and weaknesses of a business an entrepreneur should look inside the planned businesses. What will the business be good at and what are its weaknesses?

1. Strengths are the specific positive aspects, which will give your proposed business an advantage over similar business ventures and competitors. It could be that you propose to offer a better quality product or to have a location, which is located near your customer.
2. Weaknesses on the other hand are specific aspects that your business will not be good at. Perhaps your costs will be high because your business is located far from suppliers and you will have to pay more for transport

4.3.5. Outside the business

To analyse the opportunities and threats of your proposed business entrepreneur should look outside the business *i.e.* the external environment. What aspects of the external environment will benefit the business and what aspects will negatively affect the business?

3. Opportunities are on-going potential developments around you that will be good for your business. It could be that the demand for the product you are proposing will increase because of the influx of tourists.
4. Threats are probable events that may affect your business negatively. For example, the business idea could be so simple that other people may start similar businesses in your area and reduce your share of the market.

See field workbook 3.5 Exercise 5 will help to find out some successful business ideas of the trainees himself/herself by using the 3.6 Exercise 6 information of business ideas form. This will result in understanding and developing the SWOT analysis by using .3.7 Exercise 7. .

4.4. Developing A Business Plan

Business plan Definition: A business plan is a written summary of your proposed business. It includes information about the plans, operations and financial details, its marked opportunities and strategies, as well as the entrepreneur's personal background.

4.4.1. Why business planning is necessary?

Business plans show you if the business can expect to make a profit in the future. It shows what money to expect to come into and out of the business. For instance, if your costs are expected to be high, there would be need to increase prices. A plan will be able to identify parts of the business that require improvement. In so doing, one will be forced to think about every part of the business. To work out a plan, one must therefore think carefully about everything that affects the business. A business plan makes it possible to access a bank loan because most banks are interested in knowing the expected sales, costs and anticipated profits as well as cash flows before offering a loan. It forces you to think deeply and plan every detail properly before you start your business. It helps you to determine the direction you want to move in. A business plan serves as a map against which you can determine your process. A business plan provides details of resources required and can be given to potential investors/financiers. A business plan indicates chances for success and potential critical points. For checklist for business plan please refer the field workbook (See field workbook 3.8 Exercise 8).

4.4.2. Market Analysis

A market is an area of potential exchange, *i.e.*, there are potential buyers (customers), and people who are willing to sell products or services. Prices are affected by the forces of demand (of products) and supply (by sellers). A product is anything that can be offered to a market for buying, use or consumption that might satisfy a want or need, for example, eggs, coffee, and mangoes. A service is performed when one group offers something to another. A service is not tangible and does not result in ownership of any kind. Examples include training services and public transport services

4.4.3. Market research

Market research is conducted in order to collect information, which enables you to make the right decision on the marketing of your product/service. The main focus within this activity is to find out as much as possible about people's buying habits and your competition. Market research is a systematic, objective collection and analysis of data about a particular target market, competition, and/or environment, often conducted as the first step in identifying the viability of business ideas. It always incorporates some form of data collection whether it is secondary research (often referred to as desk research) or primary research which is collected direct from a respondent (See field workbook 3.9 Exercise 9).

4.4.4. Financial Analysis

The financial analysis includes the Budget having the Income and Expenditure and what category has the surplus or deficit amount to complete the analysis to plan the enterprise accordingly.

4.4.4.1. Budget

Every enterprise must have a budget. A budget is a calculated estimation of the value or price of the project and is always composed of the expenses – the costs of the project – and the income – the resources brought into the project to cover the expenses. Without a budget, it is impossible to control the project, and it is impossible to know if it is feasible. If you do not know how much it costs you will not know how much you need.

4.4.4.2. Income

Include all sources of funds necessary for the project (your resources, participants' contributions, grants, materials and services donated or loaned and amount requested from backers). Estimate the rental cost of material loaned or donated by sponsors. The total amount requested must be made clear (and must not exceed the maximum usually granted). Calculate total receipts. This figure must be higher than total expenditure (otherwise there will be no profit).

4.4.4.3. Expenditure

List all expenses connected with the project. Estimate the cost of all outgoings (in the currency specified on the form). Your estimate must be realistic (show how you have arrived at the final sum). Expenditure must correspond to the anticipated programme of activities. Estimate the rental cost of any material loaned by the private sector and include it under expenditure (and receipts). Calculate your total expenditure.

A sample of format of budget is given in the Field Workbook (See field workbook 3.10 Exercise 10).

4.5. Resource mobilisation

To mobilise resources effectively, consideration must be given to three elements, which together are referred to as a resource mobilisation framework. The three elements of the framework are 'resources', 'mechanisms' and 'resource providers'. If necessary, define each of these three and clarify their meaning by providing some examples.

Resources - Money is one of the key resources that all projects need to be able to function and carry out their work. However, there are other resources that are also useful to starting a business. Examples include skills training, staff, inputs (e.g. seeds, tools, land etc). **Resource mechanisms** - Resource mobilisation mechanisms are the ways that resources can be mobilised from resource providers. Mechanisms are the actual processes of requesting or getting resources – for example, writing proposals, holding fundraising events, selling services, selling products, face-to-face meetings, etc. **Resource providers** – Resource providers are the sources of funds and include banks, micro-credit agencies, government agencies and charitable organisations.

4.5.1. Owner's Equity

This is the private money one puts into the business. It is sometimes called risk capital because if the business fails, you lose this money. Investing your own money in a business is risky; however it puts less pressure on the business rather than borrowing. Investing your own capital may be risky but it shows that you have faith in your business idea. This can encourage others to invest with you. If you don't have enough capital you can try and find a partner who may be interested in the same business idea. A partner may or may not work in the business but can invest money in it. Ensure you have clearly-defined terms of partnership to avoid unnecessary misunderstanding later

4.5.2. Loans

A loan for start-up capital refers to borrowed money which you will pay back at a later date with interest. The loan may be paid back in full in one or several instalments depending on the agreement. A loan inherently puts significant pressure on the business due to the requirement to pay it back. The more you borrow the more you pay in terms of interest and instalments. You may borrow money for: Land and buildings. Equipment. Working capital. These are some of the possible requirements when applying for a loan for details refer the Field Workbook.

4.5.3. Grants

A grant is an allowance that a government or organisation gives to support small business creations in the country. Government and non-governmental organisations sometimes give grants to potential entrepreneurs to support them in starting small businesses. Further information on accessing funding through grants is covered in a later session.

4.6. Realistic Planning

Milestone-planning for the realisation of your business will have an essential influence on the financing and risks associated with the business. Planning helps you to think your way through all the aspects and to analyse the effects of individual steps in implementation. However, realistic planning is not simple, more so when founding a new business. In spite of this, attempt to carefully sketch the individual steps needed to implement the business plan. In this way, you gain credibility from your backers and business partners and enhance the chances of success for your business.

Four simple rules can help simplify realistic planning for you:

4.6.1. Subdivide the tasks into packages

Since there is a great deal of detailed work to be carried out when setting up a business, there is always the danger of losing sight of the big picture. Thus you should always organise the individual activities in “packages.” The business plan should, however, not contain more than ten such packages; you can specify them further at a later date. A concrete objective is to be set for each package

4.6.2. Ask the experts

Make use of the expertise of specialists in order to underpin major steps in planning. Marketing specialists, for example, could show you how long it will take to develop and conduct a given campaign.

4.6.3. Set priorities

Every planning concept comprises a series of events and assumptions that in some cases run in parallel and are linked with one another. Certain activities can, if delayed, endanger the entire project – similar to assembly line production that comes to a halt, if certain parts are lacking. Activities such as these are referred to as the “critical path.” You should devote particular attention to them in your planning.

4.6.4. Reduce risks

Try to schedule activities that will reduce risks at the beginning of the implementation. You could, for example, carry out a market survey immediately or just shortly after market entry. If you do not carry out such surveys or polls until a later point in time and find that there are not enough customers for your product, all your previous work may have been in vain:

The contents of a Business Plan is given in the Field Workbook (See field workbook 3.11 &3.12 Exercise 11 &12).

4.7. Marketing

4.7.1. What is marketing?

Marketing is the effort to identify and satisfy customers' needs and wants. It involves finding out who your customers are, what they need and want, the prices, the level of competition. It involves the knowledge and all the processes you undertake to sell your product.

Marketing answers the following questions: Who are my customers? What are my customer's needs and wants? How can I satisfy my customers'? How do I make a profit as I satisfy my customers?

4.7.2. The 4 P'Sof Marketing

4.7.2.1. Product

Product refers to goods/services produced for sale, the product /service should relate to the needs and wants of the customers Some important questions you need to ask yourself include What products/services do I sell? Why did I decide to sell these products? Do I have the products customers want? Do any of my products not sell well? Do I stock products that do not sell well?

4.7.2.2. Pricing

Pricing refers to the process of setting a price for a product/service. Your prices must be low enough to attract customers to buy and high enough to earn your business a profit To set your price you need to; Know your costs. Know how much customers are willing to pay. Know your competitors price. Know how to make your prices more attractive.

4.7.2.3. Place

Place means the different ways of getting your products or services to your customers. It is also referred to as distribution. If your business is not located near your customers, you must find ways to get your

products/services to where it is easy for customers to buy. You can distribute your products to your customers through; Selling directly to the consumers of the products. Retail distribution and wholesale distribution

4.7.2.4. Promotion

Promotion means informing your customers of your products and services and attracting them to buy them. Promotion includes advertising, sales promotion, publicity and personal selling. Use advertising to make customers more interested in buying your products or services. Some useful ways of advertising include signs, boards, posters, handouts, business cards, pricelists, photos and newspapers. You can use sales promotion to make customers buy more when they come to your business, you could also; Ensure you maintain attractive displays. Let customers try new products. Have competitions Give demonstrations Sell complementary products (products that go together

4.7.3. The Marketing Process

4.7.3.1. Marketing Research

Before starting a business, it is absolutely important to know the market conditions, in which the business will be operating: What are the customer needs? Who is the competitor? What are the prices at which products and services are sold? These are only some of the questions that need to be clarified before starting. So, after having come up with a brilliant idea, you need to check if it can work in the market. You need to carry out a market survey. The main focus within this activity is to find out as much as possible about your potential customer's buying habits and competition What do they buy? Where do they buy? Why do they buy from XY? When do they buy? How much do they buy? Which price do they pay? What are their preferences? Do they get any extras?

4.7.3.2. Costing and Pricing

Costing is the ability to set your prices and making financial plans. One need to calculate the cost of manufacturing or providing your products or services. Costs are all the money needed to operate your business. Costing is the way you calculate the total cost of making or selling a product, or providing a service. It will allow you to calculate the net profit you can make from your business.

4.7.3.2.1. Importance of costing

To determine what price you should sell your product/ service To evaluate how much profit/loss your business is making To know which items cost too much so that you can develop alternative ideas. To find out how much each product/service costs Costing helps your business to: Set competitive prices for your goods and services. Reduce and control costs Make better decisions about business. Plan for future needs of the business.

4.7.3.2.2. Types of costs

Fixed costs These are costs that do not change with the level of production. They are incurred even if no production takes place *e.g.* rent of premises. Direct cost Direct cost refers to costs which are directly connected with the production of products or services. Examples include the cost of raw material, stock, cost of labour (wages), transportation and handling expense. Variable costs These are costs that are directly related to the level of production. They increase or decrease in direct proportion to the level of production. For example: raw materials, stock, cost of packaging, transport, handling of goods and electricity (if machines are used). . Indirect cost These are costs that relate to the running of the business but not directly to the production process. Examples include maintenance costs, equipment, electricity and interest on the loan

4.7.4. Product Pricing

Pricing is the monetary value of a product or services that you charge to cover your total costs (direct and indirect costs) and profit that you desire on each unit of product or service. Price is important in all business ventures. This is because it determines the profits that the entrepreneur will make. In setting the price, one has to make marketing mix decisions, estimate the demand curve, calculate the cost, understand the environmental factors, set pricing objectives and determine the selling price.

A formula that articulates how to estimate the selling price is:

Selling price = cost of goods sold/unit + Operating costs/Unit + Desired profit/ unit

4.7.4.1. Factors that influence pricing

Nature of the market: open market with little competition - abundant supply and low demand normally means low prices, and vice versa 2. Consumer demand for a product; customers generally buy more of a product when prices are low. 3. Costs in the distribution channel; If a product is sold through a middle person, the price charged will be affected by how that middleperson treats the product.

Once the influences on price have been considered, the entrepreneur must develop goals for the product price. These goals could be to maximise profits, maximise sales volume or establish a competitive position. After all of

the above factors have been considered, the process of setting the product price begins. It requires research and careful consideration.

4.7.4.2. Breakeven Analysis

A breakeven analysis is used to determine the volume of sales your business needs to start making a profit. The breakeven analysis is especially useful when you're developing a pricing strategy, either as part of a marketing plan or a business plan.

$$\text{Break Even} = \frac{\text{Fixed costs}}{\text{Revenue per unit} - \text{Variable cost per Unit.}}$$

4.7.5. Price-setting and profit calculation

Profit is net income and is calculated from the total earnings after expenses are considered. Profit is the money a business makes after accounting for all expenses. Making profit is the goal of every for-profit company Revenue: the total amount of sales during a specific period, including discounts and returned merchandise. Price: the sum or amount of money or its equivalent for which anything is bought, sold, or offered for sale. Sales Volume: quantity or number of goods sold or services rendered in the normal operations of a firm in a specified period Expenditure: actual payment of cash or cash-equivalent for goods or services.

Some simple formulas;

$$\text{Profit} = \text{Revenue} - \text{Expenditures}$$

$$\text{Revenue} = \text{Price} \times \text{sales volume}$$

$$\text{Expenditure} = \text{Material} + \text{Labour} + \text{Transportation}$$

$$\text{Price} = \text{Cost} + \text{Profit}$$

4.7.6. Ways to Increase Profit

In order to increase profit one or both of the following must be done: Increase Revenue. Reduce Expenditure. Revenue can be increased by taking measures on the marketing mix. The marketing mix is a planned mix of controllable elements of a product's marketing plan commonly termed as 4P's: product, price, place, and promotion. These elements are adjusted until a right combination is found that serves the customers' needs while generating optimum revenue.

(See field workbook 3.13 to 3.15 Exercise 13 to 15).

4.8. Record Keeping

4.8.1. What are Records?

Records refer to the information created, received and maintained as evidence by an organisation or person, in pursuance of legal obligations or in the transaction of business. For instance, a receipt book is a record of cash entering coming into a business or organisation.

Record Keeping is a systematic process of compiling similar or related information resulted from business activities or operations into one document and storing it in files/folders (accepted formats) for the purpose of tracking and assessing the performance or operations of a business.

Why do we need to keep records?

To help find and solve problems in a business To control business capital, especially cash To show the direction of the business To plan for the future Records allow businesspeople to oversee expenditures, costs, and profit Records help to analyse business development over time

Tools for record keeping

Record-keeping tools are critical to a successful business, and should be put in place before the business is launched. These tools help to ensure that documents are stored safely and methodologically. Each type of document should be stored separately, for example: Daily sales record Credit sales Receipt book Cashbook Profit and loss statement (income statement) Cash flow statements Fixed assets registration Stock taking

During the training how to keep the Daily sales record form, Receipt book, Cashbook, Stock Control, Profit or loss statement and Cash flow statements will be undertaken as given in the Field Workbook.

4.8.2. Savings

4.8.2.1. What is Savings?

Savings are money or other assets kept over a period of time, usually not to be consumed immediately but in the future. Savings can be kept in a bank or any other safe place where there is no risk of loss, spending or making profit. Savings can be done through Small but regular deposits – this happen when someone has decide to sacrifice current consumption (use of assets, e.g. of money and goods) in order to increase the availability of

assets for future consumption. It therefore, involves postponing expenditures in order to accumulate a sizeable amount of resources for future use. Automatic deductions from salaries, wages or income - this type of saving is not voluntary. It is a system used by most employers under the labour law.

4.8.3. Advantage of saving

To provide for specific needs in the future To have access to monetary or other assets whenever needed To ensure financial independence To make one's own resources inaccessible for others without one's approval To safely store surplus To acquire skills for proper money management and self-discipline To qualify for certain types of loans.

4.8.4. Investments

These are monetary assets purchased in the hope that they will generate income, reduce costs or appreciate in the future. In short, investment means the use of money to make more profit in the future.

4.8.5. Personal Budget

A personal budget is a finance plan that allocates future personal income towards expenses, savings and debt repayment. How to prepare a personal budget for saving purposes Identify your sources of income and how much you earn from each source Add up to get total income per month. Track all your expenses daily, weekly or monthly Then divide them by categories For daily expenses, multiply each by four to get monthly expenses and add them to get a monthly total for daily expenses Take the total income per month and subtract the monthly total for daily expenses. The difference can be taken as savings. If the difference is negative or the expenses exceed the income then: Cut back your expenses Adjust your expenses.

(See field workbook 3.16 to 3.19 Exercise 16 to 19).

4.9. Developing extension support and Producer Organization

Extension support for entrepreneurship requires considering a number of points in addition to traditional extension planning. Some of these are: Have a list of the knowledge, skills, attitudes and behaviour of effective entrepreneurs; Create opportunities to incorporate entrepreneurship issues into farm extension programmes and plans; Focus on learning-by-doing approaches; Encourage farmer-to-farmer exchanges particularly linking potential farmer-entrepreneurs with successful, established farmer-entrepreneurs; Develop an effective and deliberate mentoring system.

When developing new farm business enterprises, it is important that extension workers think carefully about what would be required to implement these enterprises. If the extension services in the area do not have the relevant expertise, extension workers are an important link through which farmers obtain the necessary support including access to finance. This could involve acting as a broker between farmers and linking them to finance programmes or agricultural banks, suppliers, markets and others in the value-chain.

4.9.1. Developing a Producer Organization

Producer organisations can make useful contributions to developing entrepreneurship among farmers. On a practical level, they can help by: Providing information and other advisory and capacitybuilding services; Strengthening market (bargaining) power through supporting horizontal and vertical integration and facilitating coordination among producers; Creating a foundation for profits through collective storage and processing; Representing farmers' interests in policy negotiations and dialogue with other agribusiness stakeholders and local, regional and national authorities; Providing technical assistance to their members to meet quality standards and possible certification criteria.

In terms of helping foster entrepreneurship, producer organisations can help by: Providing a safety net and encouragement to take risks; Creating opportunities for farmers to share ideas and test them out among farmers with similar production systems and circumstances; Providing opportunities for 'weaker' farmers to learn from 'stronger' farmers in a safe environment; Encourage members to reinvest profits into their farm businesses and into new opportunities in the value chain.

Through producer organisations, small-scale farmers can link with other farmers and stakeholders along value chains. To be effective, the process requires dialogue, both amongst the farmers and between their representatives and other stakeholders along the value chain including other producers, processors, marketers, consumers and business associations.

4.9.2. Supporting Partnerships and Networking

In the changing agricultural environment, farmers need reliable and economical supplies of raw materials, production inputs and equipment and must ensure they have sufficient products of appropriate quality to capture better markets. Often they cannot easily do these things on their own. Group purchasing and collective marketing are examples of farmers working together to gain advantages not available to individuals. Partnerships and networks can be developed among farmers and with other role-players in the value chain.

These roleplayers can help farmers access information on markets, government policies and technologies, enter outside markets, and obtain training, extension, credit and marketing services. Success in market-oriented farming improves greatly when farmers have strong partnerships with and linkages among role-players in the value chain. Many farmers will need help developing partnerships and networks.

4.9.3. Joint ventures

Joint ventures can be set up between farmers, cooperatives and agribusiness companies anywhere along the value chain including the input, production, grading and processing, and marketing stages. Farmer-entrepreneurs will need to consider the form these arrangements will take, depending on the commodities selected, how long it takes to fulfil its purpose and the level of integration. For single commodities, a simple production contract is often sufficient. When working with a range of commodities or when the development period is long, a joint venture may be the best option. The joint venture must add value to the farmer's business.

4.9.4. Vertical coordination

Vertical coordination is collaboration up and down the stages of the value chain, including input supply, production, processing, and marketing to serve a strategic objective. When farmer-entrepreneurs see that vertical coordination will strengthen their farm businesses, strategic partnerships will be formalised through contracts between two or more independent businesses.

4.9.5. Platforms and forums

Platforms and forums can be used by farmers to meet producers from different areas and other role-players in the value chain to learn from one another. They can use them to learn more about their competitors and as forums for negotiations and planning collective activities. Meetings can be arranged on a product basis and can include government, chambers of commerce, private businesses and NGOs. Extension workers helping farmers develop partnerships, must reflect carefully on the most effective design for these bodies and the surest way to initiate and sustain them and how to encourage the farmers to champion the initiatives – and how to support their evaluation of partnerships in terms of the value they will add to their farm businesses.

(See field workbook 3.20 to 3.22 Exercise 20 to 22).



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5. Developing Quality Planting Material - Tree Nurseries



Nurseries are essential for anyone interested in establishing agroforestry systems. They are the starting point for the tree that will take on a life in the field. Farmers can use nurseries to propagate seedlings either by vegetative methods or by seed. Careful planning and design of a nursery is important if high quality seedlings that will yield the best results in the field are to be raised. This section provides the necessary technical information to establish such a productive and healthy nursery.

5.1. Site Selection

The first and most important step in building a successful nursery is to find a suitable site for it. There are various criteria to keep in mind when selecting the site. (See 4.1 and 4.2 figure 1 and 2 in the field workbook). It should:

- be close to a stream or near a readily accessible source of water such as a well
- be in an area that is easily accessible and convenient to get to (such as close to the house or the farm)
- have good soil, sand and compost or manure, or be convenient to a source of these things
- be reasonably flat or terraced (a large slope will make it difficult for the seedlings to stand upright and will be prone to water flow that can destroy the seedlings)
- be large enough to accommodate the plants (roughly 10m x 10m for every 5,000 plants), and to provide areas for working, for seedbeds, and for storage of soil and organic material
- have shade in the work area to protect both workers and plants
- have a fence, ideally a living fence and be located in an area that is protected from strong winds

5.2. Nursery Layout and Preparation

Once the site has been selected, clear away any stumps, roots or large stones that might interfere with the location of the seedlings. If the site has a steep slope (greater than ten degrees), level or terrace it. Make terraces at least 5m wide to allow enough space for seedlings or seedbeds. To prevent erosion and runoff, plant binding grasses on terrace edges. Once this is done, it is important to build a fence around the nursery to keep out strangers and animals and to provide some shade. Plan the layout of the nursery so that there is a suitable place for seedbeds, potted seedlings, soil, sand, compost or manure, and a work area with shade. Construct seedbeds as given in field workbook. As a general guide, make seedbeds about 80-100cm wide so that you can reach all the seedlings when weeding and watering. Make walkways between rows of potted seedlings wide enough for comfortable access. To facilitate counting and to provide for better management, arrange pots in even numbers (for example, in groups of 10 or 20 pots wide and 50 or 100 pots long). If possible, orient the rows of plants lengthwise east to west so that all plants in the rows receive uniform amounts of light (See 4.3 figure 3 in the field workbook).

5.2.1. Seed Collection and Viability Test

After the site is selected and prepared the next step is to collect or buy the seed of the desired tree species to be planted. When fruit is ripe, collect seeds from at least 30 mature, healthy, vigorous trees i.e., plus trees. Store seeds in a cool, dry place to avoid loss of viability. Remember that some seeds can be stored for much longer than others and some cannot be stored at all. To check seed viability, carry out the following simple test. (See 4.4 figure 4 in the field workbook) Cut a rectangular plastic container lengthwise so that the closed face lies flat on a table. Lay wire mesh over the open face of the container, and lay cotton or cloth on the mesh. Soak the cloth or cotton with water and lay about 100 seeds on the material. Keep the cloth constantly wet by spraying it with water when necessary so that the seeds remain moist. Leave the seeds like this until they begin to germinate. Count how many seeds germinate. If you laid 100 seeds on the germination tray and only 25 germinated, the germination rate is about 25 per cent. In this case, plant four seeds in each pot.

5.2.2. Calculating the Seed Requirement

To calculate seed requirement, a farmer should know the number and species of trees needed, the size of the area to be planted and the desired spacing between the trees. Farmers should also know how many seeds are there in 1kg for the particular species being planted, and the germination rate of that species. Conducting the test above can establish the germination rate. Let's look at an example and calculate the amount of seed required. A farmer wants to plant a green manure bank measuring 1,000m x 500m with let's say tree species name (A).

All the trees must be at least 2m apart. That is, the spacing is to be 2m x 2m. Tree species name (A) has 7,000 seeds per kilogram. The seed the farmer wants to use has a 70 per cent germination rate. Note that the amount of seeds required will depend on the number of seedlings to be planted out and that this will partly depend on the shape of the block of land and whether or not trees can be planted right on the boundaries of the land. In most cases, the calculation will be close to accurate if you divide the total area of land (in this case, 1,000m x 500m, or 500,000m²) by the amount of space needed by each tree (in this case 2mx2m, or 4m²).

Area = 1,000 x 500m = 500,000 m² Spacing = 2m x 2m = 4m² Seedlings needed = Area/Spacing = 500,000m²/4m² = 125,000. Additional seeds needed to make up for the 30% of seeds that will not germinate = 30% x 125,000 = 37,500. Total number of seeds needed = 125,000 + 37,500 = 162,500 As there are 7,000 seeds per kilogram, the required 162,500 seeds will weigh 162,500/7,000kg = 23.21kg Therefore, a total of 23.21 kg of seeds is required for the area to be planted.

5.2.3. Seed Treatment

To improve and speed up germination rates, use one of the four treatments described below. for more details on water treatment methods as given in workbook) After treatment, plant the seeds immediately.

Cold water treatment: Place seeds in a cloth or sock and immerse in cold water for 12-48 hours. 2. Hot water treatment: Boil water in a pot and remove from the heat for 10 to 15 minutes. Place the seed in a cloth or sock and soak in the water for up to two days. 3. Boiling water treatment: Boil water in a pot and remove from the heat. Put the seed in a cloth or sock and place in the water for two minutes. Pour out the hot water and replace with cold water. Leave the seeds immersed for up to two days. 4. Scarification: Use sandpaper to scarify the end of the seed coat where the root will emerge. (Generally, this end has an indentation.) Be careful not to damage the seed itself (See 4.5 figure 5 in the field workbook).

5.2.4. Soil and Organic Material Preparation

Plant growth is highly dependent on the texture and nutrient content of the soil. Soil texture can range from sticky clay to gritty sand. Sticky clay is not good for drainage and aeration. Sandy soil does not retain enough water and nutrients for optimal plant growth. The best soil for most seedlings is neither sticky nor sandy but somewhere in between, allowing for retention of water, good drainage, and aeration. To get such texture, it may be necessary to adjust the soil content. If the soil is hard clay, add compost and sand in proportions of 2:2:1 (soil: compost: sand). If the soil is medium-textured, add both compost and sand in proportions of 1:1:1. If the soil is sandy, add only compost at a ratio of 1:1. Organic material in soil provides the nutrients essential for good plant growth. The two most common sources of organic material for use in the nursery are compost and animal manure (See 4.6 & 4.7 figure 6 & 7 in the field workbook).

5.2.5. How to Make Compost

Compost is the name given to organic matter (such as vegetables, fruit, leaves and grass) that has been broken down by bacteria, insects and fungi into a nutrient-rich material. Compost can be used by plants as fertilizer. The process of making compost can take from 40 days to four months. To make compost, gather a number of different organic materials, such as grass, fruit skins, vegetable matter, sugar cane, corn or rice husks, weeds, or leaves from leguminous plants. Break or chop the material into small pieces (1-2cm). Put the pieces in a pile. Pour water on the pile (the microorganisms that are working on the pile of organic waste and turning it into compost rely on water and oxygen to survive). Turn the pile every few days and sprinkle it with water every so often to keep it from drying out. It should remain moist but not soaked. Over watering it can kill the microorganisms. The content of the pile should be about 50 per cent water. When you squeeze a clump with your hand, it should feel wet but water shouldn't drip out.

There are two types of microorganisms that digest the organic material both of which raise the temperature of the pile. The first type raises the temperature to 50 degrees centigrade. After this, the temperature will autonomously increase to 65 degrees centigrade, at which point the first organisms will die off and organisms adapted to high heat will take over and continue to break down the materials. These temperature-tolerant organisms will raise the temperature to a peak of 70 degrees centigrade. The longer the temperature stays at 55-65 degrees centigrade, the faster the compost will be made.

One system for making compost that is recommended by the World Agroforestry Centre, formally called the International Centre for Research in Agroforestry (ICRAF), is called the 'three bed system'. To construct this system, you will need some wood or bamboo sticks. First, make a rectangular frame about 30cm high, 1.5m wide and 3m long. (See 4.8 figure 8 in the field workbook). Lay the bamboo or wooden poles on the frames to form a base leaving hole big enough for air to pass through for ventilation but not so big that the organic matter and compost can fall through. Be careful not to use material that rots quickly, or the bed will collapse. Make three of these frames side by side about 1m apart. Pile the chopped organic waste onto two beds to a height of about 1m, leaving the centre bed empty for now. (See 4.9 figure 9 A in the field workbook).in workbook). After a week, check the temperature of the piles by sticking your hand in them. Check them again in about two weeks; they should have cooled down. With a pitchfork, mix each pile so that it becomes loose and the material at the bottom is exposed to the air. After two more weeks, remove the outside layer of material from each pile and put it on the centre bed (See 4.9 figure 9 B in the field workbook). Over time, remove all material from the outer layer of the piles and place it on the centre bed on top of the other material. Continue to do this until all the material has been moved from the outer beds to the center bed (See 4.9 figure 9 C in the field workbook). Mature compost

will have only about one-fifth of the volume of the original organic material from which it was made. You can now begin the process again by placing fresh organic material on the outside beds. After about four weeks, move the material from the centre pile to a storage area and leave it to mature. When it is mature, you should not be able to see any chunks of organic matter (such as bark or leaves) in the pile. To check that the compost is ready to use, wait until the compost is light brown and looks like ground coffee. Then put two handfuls of moist compost into a plastic bag and leave it in a cool, dark place for 24 hours. Open the bag. If there is no gaseous smell, the compost is ready. If there is a gaseous smell, leave the pile for a few more days and then test again. If compost is used before it is ready, it may burn the plant or it may lack the essential nutrients required by the plant for healthy growth.

5.2.6. How to Prepare Manure

Manure is also an important source of plant nutrients and can be added to soil to improve both texture and fertility. Types of animal manures differ in the amount of nutrients they contain. Chicken manure has a higher nitrogen, phosphorous, and potassium (NPK) content than any other domestic manure, with a 20:16:9 NPK ratio. Sheep and goat manure have a ratio of 19:7:20; cattle manure has an NPK ratio of 12:3:9; and pig manure has a ratio of 10:7:8. Prepare and test manure in the same way as you prepare and test compost (refer to section 4.7). Test for readiness after six to ten weeks.

5.3. How to raise Seedlings

Seedlings can be started in three ways. They can be raised in a seedbed and when sufficiently mature, planted out in the field; they can be germinated in a seed box, transplanted to a pot and then planted in the field; or they can be sown in a pot and then planted in the field. All three ways have advantages and disadvantages. Bare-rooted seedlings (those from seedbeds) are easier to transport to the planting site, require less care in the nursery and are cheaper because there is no need for pots. However, they need more space and time in the nursery and are at risk of damage and death when the roots are exposed to the air after being removed from the seedbed. Similarly, germinating seeds in a seed box and then pricking them out and transplanting them in a pot can often cause the roots to be damaged. The seedlings may also experience shock from being transplanted and as a result, growth may slow down. Finally, while plants sown in pots are heavier to transport to the planting site and their roots require careful pruning, they are often easier to care for and will be healthier when ready for planting in the ground. It is important to select the method most suitable for the species being grown.

5.3.1. Making and Using Seedbeds

To make a seedbed, collect some tree branches or bamboo poles with a combined width of about 20cm. Lay them down to make a box frame about 60cm wide, 15cm high and 1m long (See 4.10 figure 10 in the field workbook). Raise the branches/poles 1cm off the ground so that a machete blade can be passed underneath when pruning the roots, and secure the poles with pegs. Fill the frame with good potting soil so that the soil reaches the top of the frame. Make furrows 10cm apart along the length of the seedbed. Leave a 5cm space between the outer row of seedlings and the frame. Sow seeds about 5cm apart from each other in the furrows. Cover the furrows with soil to a depth of no more than two-thirds the thickness of the seeds. Water the seedbed and cover with mulch.

5.3.2. Making and Using Seed boxes

Construct a seed-box with dimensions of about 60cm x 60cm and 10cm deep. Make holes in the bottom of the box and raise the box on legs to allow for drainage. To provide some stability and to prevent ants from climbing the legs and attacking the seedlings, stand the legs in cans filled with water. Cover the bottom of the box with a 3cm layer of gravel and then fill the box with a rooting medium made of equal parts of soil, sand, and compost (See 4.11 figure 11 in the field workbook). Pour boiling water over the filled box to sterilize it. Make furrows in the soil, place seeds in the furrows (or broadcast the seeds evenly) and cover them with a fine layer of soil. Water the box to keep the contents constantly moist.

5.3.3. Making and / or Using Seedling Pots / Poly bags

Polythene pots can be used for potting seedlings. The important thing is that the container should be sufficiently durable to last two to three months. The bottoms of the pots may be open or closed. However, open ones are preferred as they drain better and are less likely to cause root deformities. If you are using open-ended pots, wet some soil until it is sticky and push it to the bottom of the pot, filling about 2cm at the bottom. This will make a compact seal and prevent the soil falling through the pot. After this is done, fill the pot to the top with potting soil (See 4.12). The soil will settle, leaving about a 0.5cm gap at the top, which will retain water when the pots are watered. Insert a stick into the centre of the soil in the pot to the desired depth (two-thirds the diameter of the seed) and plant the seed in the hole. Water the pot to keep the soil moist. Now a days using polybags is very common and easy to use but ensure they should be perforated.

5.3.4. Shade

Seedlings need to be shaded from extreme heat. As the plants grow larger and become stronger, the amount of shade should be slowly reduced, so that when it is time for planting out they are 'hardened' and can survive on their own without shade. (See 4.13 figure 13 in the field workbook) Thatch, large leaves, bamboo mats can all be used to provide shade. The shade provided should not be so dense that no light can enter. One method for hardening plants is to expose the plants to full sunlight for one hour per day, then for two hours, then three hours and so on until the plants no longer need shade. Another method is to cut the shade in the nursery by half after three to four weeks. After another two to three weeks, remove the shade completely.

5.4. Pricking Out and Transplanting

If germinating seedlings in seedbeds or seed-boxes and then transplanting them into pots, the seedlings should be 'pricked out' once their first two true leaves have developed. This will generally be when the seedlings are about three to five weeks old and around 3-8cm tall. The night before transplanting, water both the soil in the pots and the seedlings in the seedbeds or seed-boxes. When transplanting, work in a well shaded area as direct sunlight can kill the pricked-out seedlings very quickly. Make a hole in the soil in the pot deep enough for the seedling root, making sure that the hole is straight. Throw away any poor-quality seedlings. Loosen the soil around the seedling and hold the leaves upward. Squeeze the leaves gently together and pull the seedling out of the soil (See 4.14 figure 14 in the field workbook). Now place the seedling in the pre-prepared hole in the pot, making sure it is straight. Water the pots immediately after transplanting and place under the constructed shade.

5.4.1. Hardening Off and Planting Out

Before trees can be successfully planted in the field, they should be hardened off. This means that they should gradually be given less water and less shade, so that by the time they are ready for planting they will be able to withstand the natural environment with minimal care. Once the shade has been gradually removed, gradually reduce watering from twice to once per day. This should be done four to six weeks before planting out. After another week, reduce watering to once every other day until the time for planting out. It is also important to increase root pruning to once a week before planting out (See 4.15 figure 15 in the field workbook). Do not plant out any plants that look deformed or unhealthy. Throw them away.

Plant out at the start of rains and ideally on a wet day. Plant out during the early morning or evening to avoid extreme heat. Most trees are ready for planting out when the stems of the trees are equal in length to the roots, and both stems and roots are about 20cm long. Carry the potted seedlings to the site and remove the pot by cutting off the bottom 1cm of the pot and making a slit down the side. For seedlings in seedbeds, remove the seedlings by cutting squares around them and carefully lifting them and the square of soil out of the bed (See 4.16). Keep the seedlings moist and wrapped in leaves or put in a basket and cover with a wet cloth to protect them from the sun. At the site, dig holes measuring 30cm deep and 30cm in diameter. Place the subsoil and the topsoil in two different piles. Mix the topsoil with equal amounts of manure and put the mixture back in the bottom of the hole. Place the seedling at the center of the hole, keeping the root collar level with the ground. Replace the subsoil at the top of the hole and pack the soil firmly around the seedling. Water the seedling. Add mulch to prevent weeds from establishing and water evaporating. If necessary, construct a small enclosure around the tree to protect it from browsing animals (See figure 16 of the field workbook).

5.4.2. Root Pruning

Root pruning helps to produce robust root systems and to prevent roots growing into the ground in the nursery. Three methods for root pruning are discussed here. The first is root pruning in the seedbed. To prune the root in this situation, use a machete or long blade to cut vertical rows through the soil between all seedlings in the bed. After this, run the machete along the ground under the seedbed from all four sides. For seedlings in pots, simply move the pots every once in a while. This will prohibit any root growth. (See figure 15 of the field workbook) Prune the root every two to three weeks and three to four days before planting out. The third method of root pruning is air pruning. Only some species can be pruned in this manner so the farmer should test this with a small amount of seedlings first. Make a platform with wire mesh laid on some brick or logs (See 4.15 figure 15 in the field workbook). Lay the seedlings on top of the mesh. As soon as the roots make contact with the air, they cease growing vertically and form fine lateral roots.

5.5. Seedling Management

To see how to manage the seedling it is most important to make the periodic movement of the pots/polybags, protecting the seedlings by making enclosures. This will strengthen the planning methods and precaution is to be taken that the planting is done in an appropriate manner (See 4.17 to 4.19 figure 17 to 19 in the field workbook). However, it is very important to Water new seedlings twice a day. As climate and soil differ from place to place, seedlings raised in some areas may require more (or less) watering than seedlings raised in other

places. The general rule is to give plants enough water to maintain turgidity in the leaves. If the leaves begin to wilt, they are not being watered enough. To avoid over watering, allow the soil to dry out slightly before watering again. It is best to water in the early morning or late afternoon when it is cool. Water so that the soil becomes completely wet and water begins to run out the bottom of the pot. Weeding plants in the nursery is also important. Weeds compete for the nutrients and water that the seedlings need to thrive. Clear weeds often and discard the weeds in a compost pile. To control pests, keep things tidy, sterilize equipment before use, and destroy diseased plants. Some natural, plant-based products can also be used to minimise insect and fungi attacks. Some common ones which can be easily used by farmers are suggested below:

- **Neem (*Azadirachta indica*)** This tree can be used as a fungicide, insecticide and bactericide. Wash and remove the husks of mature seeds and allow the seeds to dry completely. Take 12 handfuls of seeds and grind into a fine powder. Mix the powder in 12 litres of water and soak overnight. Strain the liquid and apply.
- **Custard apple (*Annona Squamosa, A. muricata*)** This fruit can be used as an insecticide. Collect two handfuls of seed and dry them. Grind the seeds into a fine powder and mix with 4 litres of water. Soak overnight. Strain the liquid and apply.
- **Chilli pepper (*Capsicum frutescens*)** This can be used as an insecticide. Collect two handfuls of chillies and dry them. Grind the chillies into a fine powder and mix with 2 litres of water. Soak overnight. Strain the liquid and apply.
- **Gliricidia (*Gliricidia sepium*)** Roots, seeds, and leaves can be used as an insecticide or to prevent rats from eating seedlings. Mix 300g of dry plant material with 1 litres of water and soak for 24 hours. Strain the liquid and apply.
- **Papaya (*Carica papaya*)** This can be used as a fungicide. Finely chop 1kg of dry leaves and mix with 1 litres of water and soak overnight. Dilute with 4 litres of water and apply to the soil and to the bottom of leaves.
- **Garlic and onion (*Allium sativum, A. cepa*)** This mixture can also be used as an effective pesticide. Mix 500g of finely chopped material in 10 litres of water. Allow to ferment for one week. Dilute with another 10 litres of water and apply to the soil.

5.6. Vegetative Propagation Technique

There are several different methods used for asexual or vegetative propagation of plants. Some of the most common methods are explained below. Note that here 'rootstock' refers to local trees that are used for their root system because they are adapted to the local soil, climate, and pests. These rootstocks are often grafted or budded with 'scions', which are usually branches or other vegetative material taken from trees that bear improved varieties of fruits, are resistant to fruit diseases, or yield more than the rootstock variety (See figure 20-24).

5.6.1. Wedge grafting

1. Cut the top from the rootstock leaving a flat surface. On this flat surface cut a vertical incision in the shape of a wedge.
2. Cut a scion tip in the form of a wedge so that it can fit in the cut on the rootstock
3. Insert the scion into the rootstock.
4. Wrap a plastic strip around the union to keep the two pieces secure.
5. Cover the scion with a plastic bag to retain moisture.
6. Remove the plastic bag when new buds begin to grow.
7. Remove the plastic strip and plant the seedling (See 4.20 figure 20 of the field workbook).

5.6.2. T-budding

1. Select the bud to be used and make an upward cut starting 2cm below the bud and ending about the same length above.
2. Make a horizontal cut on the bark of the rootstock.
3. Make a 2.5cm long vertical cut up to the horizontal cut forming a T shape.
4. Lift the bark with the blade and insert the bud so that it fits tightly in the groove.
5. Cut any excess ends so that the bud fits well in the groove.
6. Wrap the bud with plastic strip to secure it, leaving the bud exposed.
7. After the bud has set (usually four to six weeks), remove the tape.

5.6.3. Chip-budding

1. Make a 5mm deep cut at a 45 degree angle into the scion about 2.5cm below the bud.
2. Starting about 2cm above the bud, make a downward cut to meet the first cut.

3. Make a similar cut on the rootstock and throw away the piece cut out.
4. Place the bud in the groove that was cut in the rootstock.
5. Tie the bud in place with plastic strip.
6. Remove the plastic tape after the bud has set usually four to six weeks (See 4.22 figure 22 of the field workbook).

5.6.4. Air Layering

1. Cut a ring from the bark on a selected branch so that cambium is exposed.
2. Apply a ball of soil in a plastic sheet to the area where the bark was removed and secure tightly OR bend the branch to the ground, covering the exposed area with soil from the ground and securing it in place so that the branch remains covered with soil.
3. After roots have developed, cut the branch below the area that is covered with the soil and plastic.
4. Unwrap the branch and plant (See 4.23 figure 23 of the field workbook).

5.6.5. Cuttings and Truncheons

1. Cut one-year-old branches into cuttings (about 15-40cm long and 3-10mm diameter for cuttings and 80-120cm long and 15cm diameter for truncheons). It is best to do this when trees are resting, which is usually in dry or cool periods.
2. Cut a branch a few centimeters below a node at an angle. If it is available, dip the end in rooting hormone.
3. Remove some of the leaves and cut the remaining leaves in half so that there is less surface area for water loss.
4. Plant cuttings in sterilized sand immediately, and plant truncheons directly in the field after digging a suitably sized hole.
5. Water well to keep the soil moist until roots develop.
6. After the roots have grown dense enough, transfer the seedling into plastic pots or in the case of truncheons let them continue to grow where they are (See 4.24 figure 24 of the field workbook).

5.7. Certification of Quality Planting Material

5.7.1. Identification of source of planting material

Genetically superior trees at the mature stage of growth and with the flowering cycle documented should be used for multiplication in accredited nurseries. Establishment of clonal and seed orchards at the nurseries or State Forest Departments, research institutes, and agricultural universities should be used as these institutes ensure that tested seed and clones are available for mass propagation. Correct identification of tree species should be done by an acknowledged expert in tree taxonomy. A panel of such experts are appointed and made accessible to the accrediting agencies. The use of DNA barcoding for precise identification is a modern technology that can be further developed and used to confirm the species identity

5.7.2. Certification Procedure

The nursery, after having identified the species and specific clones for propagation in its premises, obtains and maintains the necessary documentation attesting to the species and clonal identity. If procured from research organizations/agricultural universities/State Forest Department or other agencies, the certificate will be provided with the exchange of plant material. The procedure for Certification of QPM is presented in the field workbook. Clearly labelled clones will be maintained in the seed/clonal orchard and used for multiplication. Any of the popular sexual/clonal propagation methods can be used for mass propagation. This includes propagation through seed, rooted stem cuttings, branch cuttings, layering, grafting, rhizome offsets and tissue culture. Macro-proliferation of the resulting planting stock is a method that can be followed to maintain stocks for many cycles. State forest department will help in the accreditation of the nurseries. Accredited Nurseries will issue certificates for quality planting material they produce. Such planting material will carry labels (see format in in the field workbook) that declare the essential information that gives an assurance to the tree grower of the quality. Tree planting stock carrying the label of "Certified Quality Planting Material" sold from an Accredited Nursery will ensure: 1. Correct species identity 2. Uniform and established clonal identity 3. Disease and pest-free material 4. Plant quality and health

Quality Planting Material (QPM) of agroforestry species is a prerequisite for developing a farmer enterprise. And, to support this, nationally accepted guidelines are in place by each State Forest Department to ensure production and supply of QPM. National Accreditation System for Bamboo Nurseries and Certification of Quality Bamboo Planting Material (GOI 2018b) is being used by state forest department along with the Greening India Scheme. The guidelines presented here, and format given in field workbook are focussed for Multi-Purpose Tree Species (MPTS), planted or tended by farmers and exempted from felling and transit regime by the

state governments (list is given in the field workbook of Sample Guidelines - 4.25 Indicative List as Provided by the M.P. Forest Department for Quantitative Standards of Seedlings Plantation) for promotion under agroforestry in different agro-ecological regions of the country.

Another NGO initiative is The Network for Certification of Conservation of Forests (NCCF) it is a non-profit organisation established in January 2015, registered under the Societies Registration Act, 1860 to have a globally aligned Forest and Trees outside forests certification scheme developed within India. Contact link is <https://www.nccf.in/trees-outside-forest-certification-standard/>. NCCF is to address the concerns for sustainable management of forests, biodiversity and plantations, agroforestry models, at the same time making the Indian wood and forest fibre-based industry globally competitive ensuring raw material sustainability.

5.7.3. Certification under Greening India Scheme

The State Forest Department will be the nodal agency for enabling production and availability of QPM. It will either produce the QPM on its own or through collaborative arrangements with forestry/agricultural research organizations/Forest Development Agencies/farmers below poverty line /tree growers' cooperatives and Panchayats. Individuals/private entrepreneurs including farmers below poverty line / interested in setting up their own nurseries will be encouraged to set up satellite nurseries. Such individuals/entrepreneurs/farmers should be registered under provisions of relevant local acts and rules at the time of application. The profit generated on sale of QPM will be ploughed back to nodal FDA for creation of revolving fund for future sustenance of the nurseries. Illustrative guidelines for establishment of satellite/high-tech nurseries in Greening India Scheme (See 4.26 to 4.33 of the field workbook).



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6. Developing Agroforestry Technologies



This section provides technical information on how to set up a number of agroforestry model technologies by utilizing QPM as produced in the accredited nurseries and that offer a variety of benefits. This section is divided into two parts based on the types of technologies described. There are technologies that offer multiple benefits for farmers including fodder, timber and fruit production and there are technologies that conserve water and soil and improve the fertility and structure of soil. Remember that almost all technologies will have more than one benefit, and that many will have a number of benefits. Ideally, agroforestry technologies should be combined into a system using a variety of tree species, so that farmers can reap a number of benefits at the same time such as helping to restore the landscape, providing essential products, improving diet, supplementing income and establishing the successful agroforestry entrepreneurship.

6.1. Multiple Use Tree Technologies

Trees are an essential part of our lives. By planting trees in agroforestry systems, we can get the most out of trees to fulfil our needs in the form of live fences, fuel, fodder, food, medicine, green manure and specific products such as rubber, dyes and oils. Ideally, agroforestry systems should include a variety of tree species, so that farmers can reap a number of the benefits described above while helping to restore the landscape, and at the same time improving food security and income. This will reduce the need for harvesting from the natural forest, and for subsistence hunting (See 5.1 figure 1 in the field workbook).

6.2. Living Fences

Farmers can grow trees on farms in the form of 'living fences'. Many farmers build fences around their yards to demarcate their land, to keep domestic and wild animals away from their houses and crops, and to enclose domestic animals for household or commercial purposes. Fences made from sawn timber and wire have many disadvantages. Firstly, over time, the wood rots and needs to be replaced. Secondly, the materials are costly. Thirdly, natural resources need to be exploited to provide materials. Finally, the fence offers no secondary benefits to the farmer besides those of fencing. 'Living fences' (fences made from growing trees) are an excellent alternative to 'dead' fences. They require little exploitation of natural resources, are cheaper to establish and maintain, provide all the primary benefits of dead fences, and, in addition to acting as fences, provide secondary benefits, such as green manure, fodder, fruit, and fuel wood.

To establish an effective living fence that delivers the benefits of trees while acting as a fence, use species that form a dense mass and/or have thorns. Such species create a tight, impenetrable barrier to animals. Having selected your species, demarcate your fence line. Sow seeds of the desired species every 20cm. Plant seedlings every 40cm, or plant truncheons about 1m apart and 30-50cm deep until the line is complete. Some species may need to be protected from grazing animals until they are large enough to withstand such grazing. This is usually about one year. The trees in the living fences should be trimmed to about 50-75cm high after the second or third year to promote lateral growth, and thus ensure a denser hedge. Trim the sides of the hedges as well to minimise excessive unwieldy growth. Some of the trees in the fence may be left to grow upwards so that they yield poles and fruit (See 5.2 figure 2 in the field workbook).

6.3. Fodder

Trees grown on farms in agroforestry projects can also provide fodder for domestic animals such as buffalo, cows, pigs and goats. Providing for these animals is important as they generate income, supplement the household diet with meat and dairy products, and provide a source of manure for the garden. Buffaloes are also excellent draught animals that can be used to plough fields and carry heavy loads. Fodder banks are a cost-effective way of feeding cattle while also providing secondary materials such as fuel wood and small poles.

Fodder trees can be planted on a plot of land set aside for their production, they can be grown on the boundary of the farm, playing a secondary role in land demarcation. Fodder can be grown in the form of grass, and trees and grass can be grown in a mixed stand (See 5.3 figure 3 in the field workbook). In order to establish fodder trees on a plot of land allocated specifically for this purpose, plant trees 0.9m x 0.9m apart. If trees are interplanted with grass, plant trees 0.9m apart with alleys of 4.5m between tree rows. Plant the desired grass species with 0.9m x 0.45m spacing in the alleys. Start pruning the fodder trees in the second growing season when the height of the trees has reached at least 1m. The number of times per year that the trees can be pruned depends on the secondary use of the trees. If, for example, the farmer wants to grow poles from the fodder trees, they should be pruned only once per year. However, fodder can be cut from the trees daily as needed.

When deciding how many trees to grow for fodder, keep in mind that growing cattle need about 12 per cent crude protein in dry form for normal growth. Good quality grass usually contains about 8 per cent crude protein in dry form and an optimal grass/legume mixture contains about 20 per cent crude protein with high calcium content. Cattle usually require about 2 per cent of their body weight in dry forage or 8 per cent fresh material per day. So if a cow weighs 500kg, it should be fed about 10kg of dry fodder each day.

6.4. Woodlots

Wood and bamboo is an essential commodity in many households around the world and is of particular importance in rural areas. Many rural families rely on these for fuel, for building or repairing homes, for making

tools, and for making furniture and various other household items. Many people harvest timber from the forest or buy it from a company that either grows trees on a plantation or harvests them from natural forest. In order to avoid destroying natural forest and to minimise the high costs of purchasing timber, farmers can plant timber trees on their land. Woodlots on farms can also provide an alternative to illegal timber extraction from the forests, which is a common way by which locals increase incomes and meet domestic demands for wood.

To decide what trees to plant in order to supply the household with fuel and timber products (such as buildings, tools and furniture), the farmer should first determine what the timber is needed for. He or she will then need to find out what species are suitable for this use (or combination of uses) grow easily and quickly in the region. How the trees are planted will depend on their end use. If they are going to be used for poles, then the trees should be planted close together. In general, this promotes self-pruning and limits lateral branch growth, resulting in tall, straight poles.

With closer spacing, many more poles can be produced on the same plot of land. If trees are going to be produced for fuel, some side branching may be desirable, so trees can be spaced a bit farther apart. If trees are being grown to produce large timber for construction or furniture, larger spacing is required to allow enough room for satisfactory growth. Small diameter poles are produced with a spacing of 1.8m x 1.8m, medium-sized poles or firewood with a spacing of 3.6m x 1.8-3.6m, and large diameter timber for construction and furniture with a spacing of 5m x 5m (See 5.4 figure 4 in the field workbook). The rows of trees should be alternate. Plant out the seedlings and manage the lot accordingly. Harvest the trees when they reach the desired size and replant or wait for regrowth if the trees are coppiced or pollarded (See 5.5 figure 5 in the field workbook).

6.5. Multipurpose Tree (MPTs) Gardens

Trees offer many benefits to human communities. They provide materials to build and make houses, fences, bridges, animal shelters, furniture, tools, artwork, paper, rope, clothing, musical instruments and so on. Trees also provide fuel, fodder, food for humans, medicine, green manure and specific products such as rubber, dyes and oils. They offer food, shelter and homes for birds and primates, food for herbivores, hunting grounds for carnivores, and microhabitats for amphibians and reptiles. They also protect soil from erosion, and waterways from sedimentation. Trees also help to protect and improve air quality and limit the 'greenhouse effect'.

Multipurpose tree gardens can both help to restore the landscape for biodiversity and ecological service reasons and improve the household's diet and income. Farmers can plant their farm with an integrated system of trees so that they support each other and deliver the environmental benefits found in a natural forest. An ecologically healthy farm will be more productive than one in which the natural ecological systems are degraded. To establish a multipurpose tree garden, first make a brief survey of the local forest to get an idea of the composition of species and space between trees that exists naturally in the area, and to understand the mutual relationships between local plants and animals. Plant a mix of species in a pattern that encourages different animals and birds to frequent the garden. This promotes biodiversity by reducing fragmentation of natural forest and creating possible land bridges between forest areas. It also provides a way of supplementing the household's income and diet. Plant the trees so that they can co-exist and do not compete with each other for light, nutrients, or water – for example, not too close together

To work out what species of trees to plant in the tree garden, write a list of what final products are desired and what species grow naturally in the forest, promote biodiversity, and provide ecosystem functions that are important to the area. From this list, select species that can grow on the land available and in different canopy levels and tolerance of shade and light. The mix may include exotic species selected for greater economic and household value, though care should be taken that these species are not likely to invade the natural forest. Some farmers may mix fruit trees with nitrogen fixing trees and trees providing medicine, ground crops and/or timber. There are many combinations to choose from (See 5.6 figure 6 in the field workbook).

6.6. Orchards

Orchards are another agroforestry system that can offer farmers both food and an income. When planting, space seedlings according to the desired width of the tree crown for optimal fruit production. To encourage growth, place manure in the planting hole before planting, and apply fertilizer occasionally. Prune back the branches of the canopy to maintain a uniform structure that is easy to manage (See 5.7 figure 7 in the field workbook).

6.7. Taungya

Taungya agroforestry system involves intercropping young tree seedlings that will eventually become a woodlot or orchard, with growing agricultural crops (See 5.8 in the field workbook). The trees selected may also contribute to soil improvement. Intercropping can continue until competition for light makes it no longer possible. (This may mean several seasons.) After this, trees are left as pure stands, with no additional agricultural cropping until after the trees are harvested.

5.8. Systematic Tree Intercropping

Similar to taungya, intercropping of trees with crops can provide farmers with food while also providing them with various other products, such as fuel wood, poles, fruit, and fodder. The trees planted may also improve the soil. However, unlike taungya, systematic tree intercropping involves continued cropping of trees with crops. Instead of abandoning the agricultural crops once the trees compete too much for light, the trees themselves are pruned, so that the two can thrive simultaneously. Plant trees throughout the field at a spacing of 10m x 10m and, as the trees grow larger, thin them so they are about 20m x 20m apart so that they do not compete with the crops. Prune the canopy as well to limit shade on the crops below (See 5.9 to 5.14 figure 9 to 14 in the field workbook).

6.9. Watershed Management

In many rural areas throughout the world, trees are cleared to make room for growing food crops. This is an important and vital practice for the survival of all humanity. However, the over harvesting of forests and the bare land left behind can create a number of problems. In addition to the loss of materials for uses such as medicine, fuel, construction, and diet, there can also be environmental problems that threaten human communities. For example, degradation of forestland on sloped areas causes irreversible damage to farms and poses a threat to human lives. When heavy rains rush over the exposed land that has no trees to cover and bind the soil, high levels of soil erosion occur. Erosion on farms leads to both a loss of nutrients in the soil (and a consequent decrease in crop yields) and sedimentation of waterways (and a consequent decrease in the abundance of aquatic life). To make up for a decrease in productivity, farmers may shorten fallow periods and clear more of the forest to provide more agricultural land. This is often the start of a vicious cycle. Increased clearing leads to increased erosion, which leads to loss of productive land and the need for more clearing. At the same time, the intense floods that follow clearing threaten many lives and homes. Furthermore, sedimentation of rivers may poison the water for humans and kill the fish and animals that depend on the rivers.

Fortunately, it does not have to be a choice between land for agriculture and land for trees. Agroforestry allows for both to exist at the same time in a way that provides benefits for humans, other living things and the environment. Agroforestry can help to conserve soil and water, and improve the quality and nutrient content of the soil, thereby reduce the need to cut down the forest and allow for the replanting of slopes. For farmers currently using swidden agriculture, technologies such as terracing, contour hedgerows, improved fallow, and alley cropping offer increased soil fertility and better soil and water conservation. These improvements increase crop yields and food security while decreasing the need to abandon exhausted fields and cut forests for new, more productive land (See 5.15 figure 15 in the field workbook).

6.9.1. Making and Using an A-Frame

An A-frame is an essential tool in preparing the land for many of the agroforestry technologies mentioned in this manual. It enables a farmer to mark the slope, or contour of the land, so that it can be used in a way that minimises erosion

1. Find three wooden poles, two that are 3m long and one that is 2m long, some string (about 5m), and a stone about the size of a fist (See 5.16 figure 16 A in the field workbook).
2. Tie the two 3m poles together at the top.
3. Tie the 2m pole across the two longer poles about 1m from the bottom, to form an A.
4. Tie the string to the structure at the point where the two longer poles (legs) are fastened together, so that it hangs about 5-10cm below the horizontal pole.
5. Tie the other end of the string to the stone. (See 5.16 figure 16 B in the field workbook).
6. Calibrate the A-frame by standing it on a level surface. Mark the point where the string passes through the center of the horizontal pole. Mark the two spots made by the legs of the frame on the ground. Reverse the position of the A-frame legs. If the string now passes through the same spot on the horizontal pole, this is the midpoint. If it differs, mark the midpoint between the area the string is hanging in now and the area it hung the first time. This is now the midpoint (See 5.16 figure 16 C in the field workbook).
7. Drive a stake into the ground at the highest corner of the field and place one of the legs of the A-frame next to it.
8. Hold this leg in place and move the other leg around until the string hangs over the midpoint. Drive another stake into the ground at this point.
9. Hold the second leg in place and pivot the first leg around until the string again hangs over the midpoint. Drive a stake into the ground at this location. Continue this process until you reach the other side of the field. You will now have a line of stakes on ground with the same contour (See 5.16 figure 16 D in the field workbook).

10. Move downhill from the first stake to the position of the next contour. This will be approximately 10-15m below the first contour but will vary according to the slope.
11. Repeat steps seven to ten above and work your way across the field.
12. Continue to mark contours across the field by repeating steps seven to ten at intervals down the slope

6.10. Contour Plantations

Contour plantations are suitable for controlling the flow of water and minimizing erosion on deep porous soil. (See 5.16 figure 16 C in the field workbook) This agroforestry technology can be adopted as per the brief details given below:

1. Make a drainage canal at the top of the farm that gradually winds down the slope at a one degree angle. This canal will cross and link with the out flow ends of the contour, which run across the slope. The drainage canal should empty out into a gully carrying the excess water away from the farm. The depth and width of the drainage canal may vary according to slope and average rainfall but may be about 0.5m wide.
2. Build check dams in the drainage system to slow down water flow by driving stakes into the ground across the width of the drainage canal. Cuttings or truncheons can be used to make a living check dam. Weave split bamboo between the stakes. Start at the top of the canal and work down. (See 5.17 in the field workbook)
3. Dig soil traps about 0.5m above each check dam and about 0.8m deep and 1m long. The soil should be removed from the trap periodically and placed in the field (See 5.17 in the field workbook).
4. Using an A-frame, mark contour lines on the field.
5. Dig out the soil on the contour line creating contour canals about 50cm wide x 30cm deep and place the dug out soil on the top edge of the canal, creating a mound (See 5.17 in the field workbook).
6. Plant grass and leguminous trees on the mound for stabilization and, when pruned, for fodder or green manure (See 5.17 in the field workbook).

6.10.1. Bench Terracing

While this technique is very time and labour intensive, it is also the most effective way to minimise erosion.

1. Using an A-Frame, mark contour lines on the field.
2. Starting from the bottom of the field, identify a midpoint between the two lowest contour lines (See 5.18 in the field workbook).
3. Cut a level 50cm depressed "bench" along the lower contour line to place the soil from above the midpoint on.
4. Remove the topsoil from the area below the midpoint and set aside for later placement on the surface of the terrace.
5. Cut the soil from above the midpoint and begin to lay it on the "bench" (See 5.18 in the field workbook).
6. Build a mound on the bench so that its height is level with the midpoint and it slopes upwards towards the hillside.
7. Continue to remove the soil from above the midpoint and to place it below the midpoint until both sides are level (See 5.18 in the field workbook)
8. Build a contour canal below the mound at the bottom of the now level step.
9. Plant grass on the slope of the mound and leguminous species on the top part for fodder or green manure (See 5.18 figure 18DA in the field workbook).
10. If the farm is in a rocky area, the mound can be made as a rock wall.

6.10.2. Contour Vegetation Hedgerows

This technology is particularly good for hard soils.

1. Using an A-frame, mark contour lines in the field.
2. Build furrows or contour marker ridges on the contour line and align the crop ridges to the marker ridges. Align the upper half of the area between two marker ridges to the top marker ridge and the lower half of the area to the lower marker ridge.
3. For vetiver grass, dig out clumps of vetiver from the soil and cut the leaves so that they are about 20cm long and the roots are 10cm long. Plant 10-15cm apart (See 5.19 figure 19 in the field workbook).
4. For Napier grass, dig out clumps from the soil and plant the clumps on the contour line at a 45 degree angle and at a depth of 8-10cm so two nodes are buried. Space clumps 20cm apart.
5. Trim the grass to a height of 40cm to encourage tillering and avoid shading. The cut grass can be used for multiple purposes such as thatching and making of brooms.
6. Plant leguminous trees above the furrow lines 2m apart.

6.11. Alley Cropping

This system is used to improve the structure and nutrient content of soil and to control erosion while providing secondary products to the farmer such as fuel wood and sometimes, fodder. Alley cropping involves growing trees that improve the fertility of the soil (such as leguminous species) with annual crops (such as rice or maize). Directly sow leguminous species 20cm apart on the sides or top of ridges. Thin to one plant per hole so that there is one plant every 40-60cm. For larger trees, plant one seedling every 1m). On flat land, plant the rows 5.5m apart; on steep land about 4.5m apart. Prune the hedges when they reach about 1m in height, which is usually during the second growing season. Cut the branches with an upward slant to avoid fungal growth. Prune a second time if and when the shrub begins to shade the crop and inhibit its growth. Prune a final time just after the crop is harvested. Distribute the green manure in the furrows and on the ridges of the field, and cover with soil if possible (See 5.20 figure 20 in the field workbook). This system is used to improve the structure and fertility of soil and to conserve water while providing secondary products such as fuel wood. Fast-growing, nitrogen-fixing trees are grown throughout a field while cultivation is abandoned. Sow seeds throughout the fallowed field at a spacing of 90cm x 45cm, or plant seedlings at a spacing of 90cm x 90cm (See 5.21 figure 21 in the field workbook). After two to three years, cut the trees off at ground level and incorporate the material into the soil. Agricultural crops may be intercropped in the first year while shrubs are small.

6.12. Under sowing

This system is also used to improve the structure and fertility of soil while providing secondary products such as fuel wood. In this system, fast growing leguminous trees are interplanted with an agricultural crop about a week or two after the crop has been planted. See 5.22 figure 22 in the field workbook) The tree is cut down and incorporated into the soil as green manure just before the next sowing season.



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7. ICT Tools and Applications in Agroforestry Extension



The ICT term includes all technical terms that are used for handling information and facilitating communication, including computers, network hardware, communication lines and all the necessary software. In other words, ICT is comprised of information technology, telephony, electronic media and all types of processes and transfer of audio and video signals and all control and managing functions based on network technologies.

Successful design of agroforestry practices hinges on the ability to pull together very diverse and sometimes large sets of information (*i.e.*, biophysical, economic and social factors), and then implementing the synthesis of this information across several spatial scales from site to landscape. Agroforestry, by its very nature, creates complex systems with impacts ranging from the site or practice level up to the landscape and beyond.

Computer-based Decision Support Tools (DST) help to integrate information to facilitate the decision-making process that directs development, acceptance, adoption, and management aspects in agroforestry. Computer-based DSTs include databases, geographical information systems, models, knowledge-base or expert systems, and 'hybrid' decision support systems. These different DSTs and their applications in agroforestry research and development are described in this manual. Although agroforestry lacks the large research foundation of its agriculture and forestry counterparts, the development and use of computer-based tools in agroforestry have been substantial and are projected to increase as the recognition of the productive and protective (service) roles of these tree-based practices expands. The utility of these and future tools for decision-support in agroforestry must take into account the limits of our current scientific information, the diversity of aspects (*i.e.* economic, social and biophysical) that must be incorporated into the planning and design process, and most importantly, who the end-user of the tools will be. Incorporating these tools into the design and planning process will enhance the capability of agroforestry to simultaneously achieve environmental protection and agricultural production goals.

7.1. ICT tools

There are following ICT tools which are being used in extension programs: Expert Systems Geographical Information Systems (GIS) Remote Sensing Applications in Agriculture, Forestry etc Global Positioning System Applications in Agriculture, Forestry and Agroforestry e-Extension / cyber Extension e-Governance.

7.2. Expert Systems

ES is defined as “a computer program designed to model the problem-solving ability of a human expert”. It is also defined as “a system that uses human knowledge captured in a computer to solve problems that ordinarily require human expertise”. It is a computer application that solves complicated problems that would otherwise require extensive human expertise The idea behind creating an ES is that it can enable many people to benefit from the knowledge of one person *i.e.* the expert. Capabilities of Expert Systems is to explore impact of strategic goals; Impact of plans on resources; Integrate general design principles and manufacturing limitations; Provide advice on decisions; Monitor quality and assist in finding solutions and look for causes and suggest solutions

7.3. Geographical Information Systems (GIS)

A Geographical Information System (GIS) is a system for capturing, storing, analysing and managing data and associated attributes, which are spatially referenced to the Earth. GIS is a software tool that allows users to create interactive queries, analyse the spatial information, edit data, maps and present the results of all these operations. GIS technology is becoming essential tool to combine various maps and remote sensing information to generate various models, which are used in real time environment. GIS is the most important and useful system for decision making in Agricultural, Forestry and Agroforestry sector by the functionaries. The GIS will help ascertain the ground level realities with the help of spatial data obtained from various resources. GIS can integrate data from various sources such as Remote Sensing Data and Image with that of data of land records and agricultural, forestry census. GIS applications can be used in agri-based, forestry-based enterprise to ascertain the scope of activities and monitoring of activities

7.4. Remote Sensing Applications in Agroforestry

Remote Sensing (RS) is a technology that provides the means to collect and use geographic data to assist in the development of agriculture, forestry and agroforestry. Remote Sensing in the most generally accepted meaning refers to instrument-based techniques employed in the acquisition and measurement of spatially organized or geographically distributed data on some properties such as spectral, spatial, physical of an array of target points of objects and materials from a distance from the observed target without physical contact. Remote sensing of the environment by geographers is usually done with the help of mechanical devices known as remote sensors.

Remote sensing is an important tool to provide important information on soils, land evaluation, land degradation, crop distribution, crop growth, availability of water resources *etc.* Crop Production Databases Crop growth and yield determination Crop Monitoring Use of GIS in combination with remote sensing enhances the decision-making in the following ways; Process identification to enable comparison of different acquisitions through time. Identification of agricultural and other development problems. Evaluation of possible technical interventions for conservation or reclamation measures. Monitoring of soils, water, and land degradation processes.

7.5. GPS Applications in Agroforestry

The Global Positioning System (GPS) is a satellite-based radio-navigation system established by the government and has been made available to the public community. All our mobile devices are embedded with this system. Navigation, surveying and integration with Geographic Information Systems (GIS) are just a few of the fields which have seen the successful application of GPS Technology. GPS is a complex system which can be used to achieve positional accuracies ranging from 100 m to a few millimetres depending on the equipment used and procedures followed.

7.6. e-Extension / Cyber Extension

Cyber extension means “using the power of online computer networks with the help of communication channels to deliver the content in the form of text, graphics, audio and video either passively or interactively to facilitate dissemination of agricultural technology” Cyber Extension is an important mechanism to support the Extension functionaries. The cyber extension bridges the communication gap between the four pillars of Extension system - The Research, Extension, Marketing and Farmers.

Need for e-extension: To accelerate agricultural, forestry and agroforestry growth, To expand knowledge resource, To facilitate better information access, To supplement inadequate technical manpower, For stronger research-extension – Client system linkage, To develop efficient feedback mechanism, For cost-effective extension delivery, To develop knowledge managers, To ensure gender equity in technology transfer process, To empower small and marginal farmers, To serve the farm stakeholders beyond technology transfer role.

Cyber extension tools are: E-Mail, Interactive Expert Systems on Crop Pests and Diseases, INTERNET browsing for Extension Information, Video Conferencing, Call Centers; SATCOM Networks, Discussion Groups and News Groups, Electronic Monitoring system.

7.7. Information needs of farming community:

There is a lot of information need of the farming community. However, the following are the critical ones for the farming community: Access to warehouse, markets with prevailing price information, Access to (government information on) schemes, subsidies, modern agricultural methods, best practices, soil testing, seeds, plantlets, fertilizers, pest control, Facilities for grading agricultural produce and ensuring correct price for their produce Logistics support, cost sharing possibilities, Access to micro credits, Agri Insurance support/faster claim processing.

7.8. e-Governance

e-governance refers to the use of Information and Communication Technology (ICT), particularly web based applications, to provide access to and deliver information / service to the public, business, other agencies and governmental entities faster, cheaper, easier and more efficiently. e-Governance is defined as the “application of electronic means in (a) interaction between government and citizen and between government and businesses as well as (b) in internal government operations to simplify and improve democratic, government and business aspects of governance.

Benefits of e-governance: 1. Faster, easier, more convenient service 2. Convenience, Near to Home, more services at one place 3. Faster processing, shorter wait, shorter queues at Government offices 4. Less number of trips to government offices 5. Better interaction environment; No harassment 6. Reduced transport cost 7. Avoids wage loss for daily-wage earners 8. Better quality service 9. More accurate and legible documents, easy recovery from errors, 10. Lesser corruption, increased transparency and 11. Improved access to offices

7.9. e-Extension initiatives: websites, portals, e-learning resources and ICT projects

In order to ensure access to all, the VKCs are located in public buildings (Panchayats, SHG building, Community Hall, School, Farmers and Fishermen Associations, Women Self-Help Groups, Community Based Organization, etc.). The information content is developed in close interaction with the local people in a bottom-up manner. Various initiatives are as follows:

- Village Knowledge Centres (VKCs)
- Village Resource Centres (VRCs)
- Community Information Centres (CICs)
- Common Service Centres (CSCs) Scheme
- WEB Portals - AGRISNET (Agricultural Resources Information System and Networking)
- DACNET (Department of Agriculture and Co-operation Network) is an e-governance project;
- India Development Gateway (InDG) is a nationwide initiative of the Department of Information Technology, Government of India

Kisan is a comprehensive Agricultural Portal initiated by the Nagarjuna Fertilizers and chemicals Ltd., in South India. iKisan addresses the Information, Knowledge and Business requirements of various players in the Agriculture arena viz., Farmers, Trade channel partners and Agri Input/Output companies.

The e-Krishi project, Market driven Agricultural Initiative through IT enabled Agri Business Centres in Kerala, addresses the existing gap in agriculture information flow and transaction management.

Digital Green (DG) is an ICT based research project for the production and dissemination of locally relevant agricultural information through participatory video and mediated instruction.

e-Sagu was a ICT based personalized agro-advisory system in which rather than on site visit of crops the agricultural scientists deliver the advice by getting the crop status in the form of digital photographs and other information

Soochna-Se-Samadhan is an initiative to use the power of voice as the primary means of information dissemination. It facilitates the exchange of critical and timely information among marginalised communities so that it helps in improving their quality of life. It aims to provide connectivity, content and capability via a phone-based service.

7.10. ICTs for Market Information and Agri-Business

AGMARKNET The project is about empowering farming community with the knowledge of latest commodity prices and arrivals information through innovative usage of ICT by networking agricultural produce wholesale markets in the country.

ITC's Agri Business Division, one of India's largest exporters of agricultural commodities, has conceived *eChoupal* as a more efficient supply chain aimed at delivering value to its customers around the world on a sustainable basis. The *eChoupal* model has been specifically designed to tackle the challenges posed by the unique features of Indian agriculture, characterised by fragmented farms, weak infrastructure and the involvement of numerous intermediaries, among others.

7.11. Telephone / Mobile Telephony

Farmer Call Centre (Kissan Call Centre) The Department of Agriculture & Cooperation (DoA&C), Ministry of Agriculture and Farmers Welfare, Govt. of India launched Farmer Call Centres on January 21, 2004 across the country to deliver extension services to the farming community. The purpose of these call centres is to respond to issues raised by farmers, instantly, in the local language. There are call centres for every state which are expected to handle traffic from any part of the country. Queries related to agriculture and allied sectors are being addressed through these call centres. The Farmer Call Centre is a synthesis of two hitherto separate technologies namely, the Information and Communication Technology (ICT) and the Agricultural Technology. Both have their specialized domains and work cultures. To optimally utilize the strengths of both these systems, it was proposed to take full advantage of professionally managed Call Centre mechanism and dovetail it with the specialized Subject Matter Specialists knowledge of Agricultural Scientists and Extension Officers, so as to facilitate its reach to the farming community. The use of ICT tools and service has been well appreciated by the farmers who have said such a service by the Farm Science Centre is just in the nick of time when farmers have their crops ready for market. The number of farmers coming to the Farm Science Centre is growing day by day.

To achieve more success in agroforestry entrepreneurship development specially to attract youth in participatory, partnership mode, the use of IT tools will need to focus on the following main activities which have to be carried out on focused basis : Exploitation of the tools and services. Building a collaborative working environment. Planning the architecture for development, teaching and training. Implementing the e-learning environment. Designing the multimedia tools to make the system accessible for learners and trainers.



8. Initiatives of GOI for Development of Agroforestry



Agroforestry has significant potential to provide employment to rural and urban population through production, industrial application and value addition ventures. Current estimates show that about 65% of the country's timber requirement is met from the trees grown on farms. Agroforestry also generates significant direct and indirect employment opportunities. Given the fact that land holding size in India is shrinking, tree farming combined with agriculture is perhaps the only way forward to optimize the farm productivity and thus, enhancing livelihood opportunities of small farmers, landless and the rural women.

Agroforestry may become an important tool to build resilience of farmers and rural people against threats of climate change and natural calamities. The report of the Task Force of Planning Commission in 2001 identified a potential of 10 million ha irrigated lands that could be brought under commercial agroforestry and 18 million ha of rainfed areas that could be developed through subsistence agroforestry. By taking up agroforestry in rainfed areas, it is envisaged that there can be poverty alleviation of 30 million people. The current approximate area under agroforestry is estimated to be 25.32 million ha (*i.e.* 8.2% of the TGA of the country).

8.1. National Agroforestry Policy - NAP 2014

The President of India launched the much-needed National Agroforestry Policy 2014 (NAP 2014) during the World Congress on Agroforestry organised during February 2014 at New Delhi. India is the first country in the world to have a National Policy on Agroforestry. The major objectives of the NAP-2014 are as under:

- Encourage and expand tree plantation in complementarity and integrated manner with crops and livestock to improve productivity, employment, income and livelihoods of rural households, especially the small holder farmers.
- Protect and stabilize ecosystems, and promote resilient cropping and farming systems to minimize the risk during extreme climatic events.
- Meet the raw material requirements of wood based industries and reduce import of wood and wood products to save foreign exchange.
- Supplement the availability of agroforestry products (AFPs), such as the fuel-wood, fodder, non-timber forest produce and small timber of the rural and tribal populations, thereby reducing the pressure on existing forests.
- Complement achieving the target of increasing forest/tree cover to promote ecological stability, especially in the vulnerable regions.
- Develop capacity and strengthen research in agroforestry and create a massive people's movement for achieving these objectives and to minimize pressure on existing forests.

8.1.1. Strategy of NAP-2014

To achieve the above objectives, following strategies are outlined in the NAP-2014. Establish an Institutional Setup at National level to promote Agroforestry. Simplify mechanism / procedure to regulate the harvesting and transit of agroforestry produce within the State and other States forming an ecological region. Development of a sound database and information system. Investing in research & development, extension and capacity building and related services. Improve farmers' access to quality planting material. Certification of nurseries, seeds and other planting materials for agroforestry. Providing institutional credit and insurance cover for agroforestry. Facilitating increased participation of industries dealing with agroforestry produce. Strengthening farmers' access to markets for tree products, improving marketing infrastructure including market information. Incentives *viz.*, input subsidy, interest moratorium *etc.* to farmers for adopting agroforestry. Promoting sustainable agroforestry for renewable biomass based energy for meeting various energy needs for irrigation, motive power, farm machines and processing industry.

8.2. National Sub-Mission on Agroforestry

The policy recommendation led to setting up a Sub-Mission on Agroforestry (SMAF) under National Mission for Sustainable Agriculture (NMSA) and made operational from 2016-17 with an outlay of Rs. 935.00 crores for four years. During 2016-17, a budgetary provision of Rs. 75 crore was made for Sub-Mission on Agroforestry with major components as (i) Nursery Development for quality planting material (NDQPM) for small, big & hi-tech nurseries (ii) Peripheral and Boundary Plantation (PBP) for '*Har Med Par Ped*' (iii) Low Density Plantation on Farm Lands (LDPFL) with 100 to 500 plants/ha (Strips/ Staggered) (iv) High Density Block Plantation (HDBP) with 500 to 1500 plants/ha (Blocks/intermediate blocks). (v) Capacity Building & (vi) Demonstration of agroforestry models to bridge the yield gap. The most essential part of this SMAF was the condition *i.e.*, all States to notify/ share their liberalized transit regulation for availing the benefit of the scheme. Eight (8) States shared their notifications and funds were released to these States.

8.2.1. Beneficiaries:

Farmers would be supported financially to the extent of 50% of the actual cost of the interventions (limited to 50% of the estimated cost as indicated in the Cost norms) for the respective interventions. Farmers

groups/Cooperatives and Farmer Producers Organization (FPO) can also avail the benefit of the programme but the assistance can be accessed as per norms and provisions applicable to the individual farmers. At least 50% of the allocation is to be utilized for small, marginal farmers' of which at least 30% should be women beneficiaries/farmers. Further 16% and 8% of the total allocation or in proportion of SC/ST population in the district will be utilized for Special Component Plan (SCP) and Tribal Sub Plan (TSP), respectively. Farmers must have a soil health card to get the benefit under the programme.

8.2.2. Agroforestry Interventions

The Sub-Mission has following broad interventions:

1. Nursery Development for quality planting material (NDQPM): Assistance shall be given for nurseries (small, big & hi-tech nurseries) for producing quality planting material to meet the requirement of planting material. Eligible components and pattern of assistance for NDQPM is given at Annexure-I
2. Peripheral and Boundary Plantation(PBP): To make potential use of the area occupied by these bunds around the periphery of the farmers fields, tree species can be grown as peripheral/boundary plantations to add more income to the farmers' basket. This will not only make effective use of the precious land for livelihood support but also for generating additional income opportunities to the farmers. It will also help in stabilising the bunds and reducing soil erosion.
3. Low Density Plantation on Farm Lands (LDPFL) : Low Density Block Plantation (HDBP) ranging from more than 100 plants/ha to more than 500 plants/ha without sacrificing the yield of the existing crops/cropping systems, shall be incentivized at the proportionate rates as applicable to per plant expenditure.
4. High Density Block Plantation (HDBP): High density Block Plantations on farm lands(HDBP) will be supported as a complementary source of income to the farmers. Differential planting densities ranging from more than 500 plants/ha to 1500 plants/ha as intermediate blocks / strip plantations /wind breaks would be supported. Farmers can take up block plantation in waste and degraded land not suitable for growing crops to make productive use of these land in creating livelihood and income opportunities for them. In addition, the tress will help in enriching the soil and making it fertile & more productive thereby bringing land under crops in times to come.
5. Capacity Building & Trainings: Capacity Building and Training will be one of the important interventions of the sub-mission. Activities like training of farmers/field workers with a view to ensure growing quality planting material, skill development, awareness campaign, Publications, Information sharing, exposure visits at national and international levels, seminars/Workshops at national/international levels etc. would be supported under this. States can utilise up to 5% of the allocated funds for capacity building and training activities.
6. Demonstration of Agroforestry Models: Specific projects for demonstration to bridge the yield gap and for extension purposes on area specific innovative agroforestry models by SAUs/ICAR Institutes/CAUs/CSIR/ICFRE institutes/State Government/other National & International level agencies/organizations will be supported particularly in the field of climate resilient agroforestry system & studies on carbon foot print, carbon sequestration, nitrogen fixation etc. with the approval of Project Sanctioning Committee on case to case basis.

8.2.3. Implementing agency

In most of the state the State Forest Department is the implementing and nodal agency, if they are not the implementing department, will be actively associated in planning & implementation of the programme. Additional area taken up under plantation would be periodically intimated to State Forest Department to appropriately accommodate in their Wood Development Plan for issue of licenses to processing industries.

8.3. Institutional finance in agroforestry

Institutional finance in agroforestry has not been at par with its potential due to the lack of awareness of technical and economic data on different agroforestry models, and the technoeconomic parameters required by financial institutions (FI) to evaluate finance needs and viability of the projects. Similarly, very little has been done in developing and popularizing insurance products for agroforestry ventures, however the agriculture crop insurance mechanism can be taken as initiative for supporting allied sector of agroforestry. Lack of awareness, unavailability of products suitable to growers, high cost of premium and unclear procedure of claim settlements are reported to be the factors responsible for this poor state of affairs.

8.4. National Policy on Biofuels-2017

India is the second most populous country and also one of the fastest growing country in the world. Huge amount of energy is a prerequisite for the development of a country like India. The energy can be divided into 2 forms mainly- primary and secondary energy. Primary energy implies power requirements to run its industries, and light its houses and offices, while secondary needs imply energy requirements for all the transportation it

requires – of its people and goods. To fulfil secondary energy requirement of India, petro-crude import is required to meet more than 80% of transport fuel requirements. This makes too much burden on India's economic insecurity, economic losses and environmental degradation. Currently, the focus of country is ensuring energy security in urban as well as in rural areas

Recently Biofuels policy has been moved from Ministry of New and Renewable Energy (MNRE) to Ministry of Petroleum and Natural Gas (MoPNG) and it is currently in the process of reviewing the “National Policy on Biofuels 2009”. As this policy can play important role in rural development, plantation and agri-residue can become alternate source of income to farmers. This is also the aim of central govt. to double the farmer's income by 2022. Biofuel is also a renewable and clean source of energy, so it would be an effective tool in handling the climate change mitigation goal. It is an alternative source of energy, so it will reduce the exchequer burden due to petroleum products import. It will help in solving the rural energy problem of India.

8.4.1. Plantation under NBP (National Biofuel Policy)

Plantations of trees bearing non-edible oilseeds will be taken up on Government/community wasteland, degraded or fallow land in forest and non-forest areas. Contract farming on private wasteland could also be taken up through the Minimum Support Price mechanism proposed in the Policy. Plantations on agricultural lands will be discouraged.

There are over 400 species of trees bearing non-edible oilseeds in the country. The potential of all these species will be exploited, depending on their technoeconomic viability for production of biofuels. Quality seedlings would be raised in the nurseries of certified institutions/organizations identified by the States for distribution to the growers and cultivators.

In all cases pertaining to land use for the plantations, consultations would be undertaken with the local communities through Gram Panchayats/Gram Sabhas, and with Intermediate Panchayats and District Panchayat where plantations of non-edible oil seed bearing trees and shrubs are spread over more than one village or more than one block/taluk.

8.4.2. Financial mechanism under NBF (National Biodiversity Fund)

Plantation of non-edible oil bearing plants, the setting up of oil expelling/extraction and processing units for production of bio-diesel and creation of any new infrastructure for storage and distribution would be declared as a priority sector for the purposes of lending by financial institutions and banks. National Bank of Agriculture and Rural Development (NABARD) would provide re-financing towards loans to farmers for plantations.

Financial incentives, including subsidies and grants, may be considered upon merit for new and second generation feedstocks; advanced technologies and conversion processes; and, production units based on new and second generation feedstocks. If it becomes necessary, a National Biofuel Fund could be considered for providing such financial incentives.

8.5. Joint Forest Management (JFM) - National Forest Policy

As per the provisions of National Forest Policy 1988, the Government of India, vide letter NO.6.21/89-PP dated June 1, 1990 issued guidelines to the state governments for involving local communities in the protection and development of the degraded forests. Based on this, the JFM programme has now been widely adopted in twenty two states of the country. These states are Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Gujarat, Himachal Pradesh, Haryana, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Mizoram, Nagaland, Orissa, Punjab, Rajasthan, Sikkim, Tamil Nadu, Tripura, Uttar Pradesh and West Bengal. The primary objective of JFM is to provide a visible role to the local communities in planning, management and protection of forests and to give them a share in the benefits from these forests. On operational parameters, JFM is a concept of developing partnership between forest department and fringe forest user groups on the basis of jointly defined roles and responsibilities. JFM in India is gradually emerging as a powerful tool of sustainable forestry. It recognises the livelihood and sustenance needs of the people through the principle of 'care and share'. The concept of JFM has been interpreted in various ways but the basic element in this concept is to establish grass-root community-based institutions for protection and management of the forests. The programme aims at empowering local people for their active participation as partner in the management of forest resources and sharing the benefits derived from its protection and management. The JFM approach optimises the returns, minimises conflicts and links the forestry development works with over all development of the land-based resources. It also aims at acquiring technical and managerial capability available at the grassroots level.

8.6. National Bamboo Mission

Bamboo was termed as 'Green Gold' during 2018-19 budget and a Re-structured National Bamboo Mission with an outlay of Rs. 1290 crore to promote bamboo sector in a holistic manner was announced by Finance Minister. For 90 years Bamboo - taxonomically a grass - was registered as a tree in the Forest Act, but the Indian Forest (Amendment) Ordinance, 2017 has axed bamboo from a list of plants that also included palms, skumps, brushwood and canes. The government promulgated the amendment to exempt bamboo grown in non-forest areas

from definition of tree. This decision would be great leap in the direction for doubling the farmers' income. Restructured National Bamboo Mission approved by the Cabinet Committee on Economic Affairs (CCEA) on 25-04-2018. The Mission envisages promoting holistic growth of bamboo sector by adopting areabased, regionally differentiated strategy and to increase the area under bamboo cultivation and marketing. Under the Mission, steps have been taken to increase the availability of quality planting material by supporting the setting up of new nurseries and strengthening of existing ones. To address forward integration, the Mission is taking steps to strengthen marketing of bamboo products, especially those of handicraft items.

8.7. NABARD's Business involvement under Forestry/Agroforestry

In addition to extending refinance support to financial institutions, particularly the Commercial Banks and RRBs for various forestry and wasteland development viz., farm forestry, agroforestry (involving user industries), industrial plantation (through Forest Development Corporations), wasteland afforestation since 1982, NABARD -National Bank for Agriculture and Rural Development has widened its business involvement in the sector through its different products as follows:

8.7.1. Rural Infrastructure Development Fund (RIDF)

Through RIDF, NABARD has supported 2871 projects amounting to loan sanction of Rs. 1562.62 crores (which is 0.52% of the total RIDF loan) for Forest Development & Management in 10 States (as on 30 September, 2017).

8.7.2. Umbrella Programme on Natural Resource Management (UPNRM)

Through UPNRM, projects have been supported for Farm Forestry, Agroforestry, Non Timber Forest Produce (NTFP) and Medicinal & Aromatic Plants (MAPs). For this sector, 26 projects (which is more than 10%) out of 237 projects were sanctioned. The total assistance has been more than Rs. 55 crores out of a total of Rs. 486 crores.

8.7.3. Credit Potential Mapping by NABARD

NABARD prepares Potential Linked Credit Plan (PLP) for all districts in the country every year. The PLP is intended to provide insight on the potential for development in different sectors of the rural economy, a road map to banks for extending credit to important sectors/sub sectors/activities in the district and for Government departments and various developmental agencies to provide necessary infrastructure and linkage support for the development of various sectors and also converge their plans with that of banks thereby facilitating increased credit flow and overall development. The credit potential assessed for 2016-17 in respect of Forestry and wasteland development was Rs. 3307.21 crores and has been projected at Rs. 3750.18 crore during 2017-18.

8.7.4. NABARD for Adaptation Fund under UNFCCC

NABARD has been accredited as National Implementing Entity (NIE) for Adaptation Fund in July 2012 and is the only NIE for India. Adaptation Fund Board (AFB) has so far sanctioned 5 projects submitted by NABARD and also endorsed one concept note with total outlay of USD 9.8 million. Allocation for India under AF is US\$ 10 million per year, however, due to fund constraint the same is not now restricted to USD 10 million per country on an interim basis. Most of the projects are having agroforestry and other plantation activities as main components to increase the adaptive capacity of the farmers. Following projects are directly related to forestry sector:

Enhancing adaptive capacity and increasing resilience of small and marginal farmers in Purulia and Bankura Districts of West Bengal; Building Adaptive Capacities of Small Inland Fishermen Community for Climate Resilience and Livelihood Security in Gandhwati (tribal) block of Dhar district in Madhya Pradesh. Climate Proofing of Watershed Development Projects in the States of Rajasthan and Tamil Nadu" focuses on climate-proofing of 20 watersheds in Tamil Nadu and Rajasthan. Climate smart actions and strategies in North Western Himalayan region Building Adaptive Capacities in Communities, Livelihoods and Ecological Security in the Kanha Pench Corridor. The project is to be executed jointly by Royal Bank of Scotland Foundation, India (RBS FI) and Madhya Pradesh Forest Department.

8.8. Industrial Agroforestry/Farm Forestry – Institutional Engagement Frameworks

8.8.1. Forest-based Industries

The main considerations governing the establishment of forest-based industries and supply of raw material to them is as follows:

As far as possible, a forests-based industry should raise the raw material needed for meeting its own requirements, preferably by establishment of a direct relationship between the factory and the individuals who can grow the raw material by supporting the individuals with inputs including credit, constant technical advice and finally harvesting and transport services. No forest-based enterprise, except that at the village or cottage level, should be permitted in the future unless it has been first cleared after a careful scrutiny with regard to assured availability of raw material. In any case, the fuel, fodder and timber requirements of the local population should not be sacrificed for this purpose. Forest-based industries must not only provide employment to local people on priority but also involve them fully in raising trees and raw-material. Natural forests serve as a gene

pool resource and help to maintain ecological balance. Such forests will not, therefore, be made available to industries for undertaking plantation and for any other activities. Farmers, particularly small and marginal farmers, would be encouraged to grow, on marginal/degraded lands available with them, wood species required for industries. These may also be grown along with fuel and fodder species on community lands not required for pasture purposes, and by forest department/corporations on degraded forests, not earmarked for natural generation. The practice of supply of forests produce to industry at concessional prices should cease. Industry should be encouraged to use alternative raw materials. Import of wood and wood products should be liberalized. The above considerations will, however, be subject to the current policy relating to land ceiling and land-laws.

8.9. Organizational intervention through Contract farming

Organizational intervention through Contract farming is possible through various frameworks which have been tried and tested, needs to be an integral part of Industrial agroforestry/Farm forestry initiatives. The frameworks which have been tried are:

8.9.1. Bi-partite arrangement

This is direct arrangement between farmers and industry, specially referred to/known as a captive plantation / social forestry by industries

8.9.2. Tri-partite arrangement (two types)

(a) This framework has industry, growers and a research institution (wherein Industry players don't have / have limited research facilities. Under this system, the industry supplies quality material at subsidized rate and assures buyback at minimum support price or prevailing market price, whichever is higher. Research institutes provide advice on site specific technology and also organises trainings.

(b) In this framework, industries with research facilities engage the banks / financial institutions in a tripartite arrangement. This Industrial agroforestry value chain model is practiced by some paper industries like ITC-BPL, JK Paper & BILT in the name of 'Farm Forestry' mainly involving 3 stakeholder groups viz. Farmers-Industry, Financial Institution/Bank. In this framework, the focus is more on production and distribution.

8.9.3. Quad-partite arrangement

This framework has involvement of financial institution in addition to the three parties in the tripartite model and seems to be more suited to fulfil requirements for farmers preferring high yielding short rotation varieties/species. The financial institution provides credit to the growers in three/four instalments at a pre-decided/simple interest with a grace period for repayment till felling. The quad-partite framework has worked successfully in the State of Tamil Nadu. In this framework, because of the presence of the Research Institution, the focus is more on research for (a) bringing out new and alternate genetic resource development (b) site specific clones and (c) precision technology development & dissemination.

8.9.4. Quin-partite arrangement

This is possible where insurance companies play a role in covering for natural calamities and other risks/perils (Fire, Lightning, acts of terrorism, riot & strike, Storm, hailstorm, cyclone, typhoon, tempest, hurricane, tornado, flood, inundation, impact of road/rail vehicles and loss due to wild animals) as has been done in TN with United India Insurance Co. For developing the Comprehensive Tree Insurance Plan, the Research Institution works out the sum assured based on the input costs for different trees species.



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Annexures: Backup Support Information for Agroforestry Development



A. Agroforestry systems present in different agroecological zones of India

Agro-ecological zone	Major benefits	Component Examples
I. Himalayan Region		
1. Trees in agricultural fields/bunds (Agrisilviculture)	Production of food, fruits, fodder, etc. and stabilization of bunds.	<i>Grewia optiva</i> and other fodder trees in Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim and other North-Eastern hill region.
2. Intercropping in fruit orchards (Agri horticulture)	Production of fruits, food etc.	Orange and other citrus, and guava intercropped with cereals, tuberous and rhizomatous crops in Sikkim, Meghalaya and other North-Eastern states.
3. Plantation crops under shade of trees (Multi-storeyed/Specialized system)	Food, spices, fuelwood, timber etc.	Large cardamom, coffee etc. under alder in Sikkim and Nagaland; tea under leguminous trees in Assam and West Bengal; betel vine and black pepper on arecanut and other trees in Meghalaya and other north-eastern States.
4. Silvipastoral	Fodder, fuel wood etc.	Tree leaf fodder from <i>Grewia</i> , <i>Celtis</i> and other species in the Himalayas.
II. Indo-Gangetic Plains		
1. Trees for soil Reclamation (sodic/ saline / degraded soil)	Reclamation of degraded lands	<i>Prosopis chilensis</i> , <i>Acacia nilotica</i> , <i>Parkinsonia aculeata</i> and other species for problem soils.
2. Fodder trees in degraded grazing lands (Silvipastoral)	Fuel, fodder, timber	<i>Albizia lebbbeck</i> , <i>Bauhinia purpurea</i> , <i>Dalbergia sissoo</i> and other species on grazing lands.
3. Trees in fields/bunds (Agrisilviculture)	Fuel, fodder, timber, shade, cash, minor products.	Poplar, <i>Tamarindus indica</i> , <i>Bombax ceiba</i> , Eucalyptus, <i>Dalbergia sissoo</i> , <i>Melia</i> spp. etc.
4. Fodder banks and woodlots.	Fodder, soil conservation, fuel etc.	<i>Azadirachta indica</i> , <i>Melia azadirach</i> , <i>Albizia</i> spp., <i>Syzygiumcumini</i> etc. fodder trees. <i>Casuarina equisetifolia</i> , Eucalyptus, Bamboos, <i>Dalbergia sissoo</i> etc. woodlots.
III. Arid and Semi-arid Region		
1. Multipurpose trees in agricultural fields (Agrisilviculture)	Fodder, fuel wood, fruits, cash, shade and minor products.	Khejri (<i>Prosopis cineraria</i>), <i>Ziziphus</i> spp., <i>Acacia senegal</i> , <i>Ailanthus excelsa</i> , <i>Acacia nilotica</i> , <i>Acacia leucophloea</i> etc. tree species.
2. Trees for reclamation of degraded soils.	Reclamation of soil, fuel, fodder, minor products.	<i>Albizia lebbbeck</i> , <i>Casuarina</i> sp., <i>Acacia tortilis</i> , <i>Azadirachta indica</i> and other tree species.
3. Windbreaks and shelterbelts.	Sand dune Stabilization	<i>Acacia nilotica</i> , <i>Acacia senegal</i> , other Acacias, <i>Azadirachta indica</i> , <i>Cassia</i> spp., <i>Prosopis chilensis</i> , <i>Tamarix</i> spp. etc.
4. Fodder banks and woodlots	Soil conservation, fodder, fuel, etc.	<i>Prosopis cineraria</i> , <i>Ziziphus nummularia</i> , <i>Salvadora persica</i> , <i>Salvadora oleoides</i> , <i>Acacia nilotica</i> etc.
5. Trees on rangelands (silvipasture system)	Fodder, fuel shade, timber.	<i>Prosopis chilensis</i> , <i>Acacia senegal</i> , <i>Acacia tortilis</i> , <i>Prosopis cineraria</i> , <i>Ziziphus</i> spp., <i>Azadirachta indica</i> etc. in pasture lands
IV. Humid and Sub- Humid Region		
1. Home gardens / Homesteads	Production of multiple outputs.	Home gardens in Kerala, Assam, West Bengal have a mixture of trees, shrubs, herbs etc. Coconut, Arecanut, Erythrina, Gliricidia, with black pepper, cacao, coffee, cassava and other cash crops.
2. Multi-tier system or plantation crop combination	Cash, and multiple outputs.	Coconut, arecanut, Erythrina and other trees with coffee / banana, pineapple / papaya, cacao /coffee and black pepper / betel vine, large cardamom.
3. Multipurpose trees in agricultural fields	Fodder, minor products	<i>Acacia auriculiformis</i> , <i>Aegle marmelos</i> , <i>Albizia</i> spp., <i>Anogeissus latifolia</i> , <i>Anthocephalus chinensis</i> , <i>Artocarpus</i> , <i>Casuarina equisetifolia</i> , <i>Diospyros melaxylon</i> etc. Coffee under Erythrina lithosperma, Cacao with coconut, black pepper on Gliricidia, <i>Grevillea robusta</i> , Cardamom under <i>Toona ciliata</i> , <i>Artocarpus</i> etc.

V. Coastal and Island Region		
1. Plantation crop combination, multistoried	Production of multiple outputs, cash	Composite fish culture in ponds and multipurpose trees in homesteads.
2. Trees with aquaculture	Fish, fuel, fodder, timber.	<i>Acanthus ilicifolius</i> , <i>Avicennia officinalis</i> , <i>Carberaadollam</i> , <i>Rhizophora conjugata</i> etc.
3. Mangroves plantations as part of homesteads.	Shore protection, fuel, fodder, environmental protection.	<i>Azadirachta indica</i> , <i>Casuarina equisetifolia</i> , <i>Prosopis chilensis</i> , <i>Acacia senegal</i> etc.
4. Shelter belts and wind breaks	Shore / beach stabilization.	<i>Aegle marmelos</i> , <i>Albizia</i> spp., <i>Azadirachta indica</i> , Bamboos, <i>Bombax malabaricum</i> , <i>Calliandra calothyrsus</i> , <i>Cassia</i> spp. etc.
5. Trees on boundaries of agricultural fields (Agrisilviculture)	Fodder, fuel, shade, minor products	<i>Aegle marmelos</i> , <i>Albizia</i> spp., <i>Azadirachta indica</i> , Bamboos, <i>Bombax malabaricum</i> , <i>Calliandra calothyrsus</i> , <i>Cassia</i> spp. etc.

B. Improved agroforestry systems for various agroclimatic zones of India

Agro -climatic zone	Agro-forestry system	Tree component	Crop/Grass
Western Himalayas	Silvipasture (RF)	<i>Grewia optiva</i> <i>Morus alba</i>	Setaria spp. Setaria spp.
	Agri- horticulture	<i>Malus pumila</i>	Milletts , wheat
	Agri- horticulture	<i>Prunus persica</i>	Maize soybean
Eastern Himalayas	Agrisilviculture	<i>Anthocephalus cadamba</i>	Paddy
	Agrisilviculture	<i>Alnus nepalensis</i>	Large cardamom/ coffe
	Silviculture	<i>Bamboo Parkia roxburghii</i> , <i>Morus alba</i>	-
	Silvipasture	<i>Bauhinia variegata</i> and <i>Ficus</i>	Napier
Lower gangetic plains	Agrisilviculture (irri)	<i>Eucalyptus</i> <i>Albizia lebbeck</i>	Paddy
	Agrihorticulture (irri)	<i>Mango/banana/litchi</i>	Wheat, paddy, maize
	Silvipasture	<i>Morus alba</i> , <i>Albizia lebbeck</i>	Dicanthium, Pennisetun
Middle gangetic plains	Agrisilviculture (irri)	<i>Populous deltoides</i>	Sugarcane-wheat
	Agrisilviculture (irri)	<i>Eucalyptus</i>	Rice-wheat
	Agrisilviculture	<i>Dalbergia sissoo</i>	sesamum
	Agrihorticulture (irri)	<i>Mango/citrus</i>	Rice-wheat
	Silvipasture	<i>Albizia lebbeck</i>	<i>Chrysopogandicanthiv</i>
Trans gangetic plains	Agrihorticulture (irri)	<i>Emblica officinalis</i>	Black gram/green gram
	Agrisilviculture	<i>Azadirachta indica</i>	Black gram-wheat
	Silvipasture	<i>Bauhinia variegata</i> , <i>Albizia lebbeck</i>	<i>Cenchrus pennisetum</i>
	Agrisilviculture (irri)	<i>Populous deltoides</i>	Wheat, Bajra fodder
Upper gangetic plains	Agrisilviculture (irri)	<i>Eucalyptus</i>	Rice-wheat
	Silvipasture	<i>Bauhinia variegata</i> <i>Albizia lebbeck</i>	<i>Chrysopogonpoa</i>
Eastern plateau & hills	Agrisilviculture	<i>Gmelina arborea</i>	Paddy, linseed
	Agrisilviculture	<i>Acacia nilotica</i>	paddy
	Silviculture	<i>Acacia mangium</i> , <i>Anilotica bamboos</i>	-
	Silvipasture	<i>Leucaena leucocephala</i>	<i>Chrysopogon pennisetu dicanthium</i>

Central plateau & hills	Agrihorticulture (irri)	<i>Psidium gujava</i>	Bengal gram, groundnut
	Agrihorticulture	<i>Emblica officinalis</i>	Black gram /green gram
	Agrisilviculture	<i>Acacia nilotica/ Leucaena eucocephala/ Azadirachta indica. Albizia lebbeck</i>	Soyabean, Balck gram- mustard. Wheat
	Silvipasture (rf-and degraded lands)	<i>Albizia Amaraleucaena Leucocephala, dichrostycuscinera</i>	<i>Chrysopogon stylosanthes, Hamata scabra</i>
	Tbos (rf)	<i>Jatropha curcas</i>	-
Western plateau & hills	Agrihortisilviculture irri	<i>Tectona grandis, Achrus zapota</i>	Paddy maize
	Agrihorticulture	<i>Areca catechu</i>	Black pepper cardamon
	Silviculture	<i>Prosopis juliflora ailanthus</i>	-
	Silvipasture	<i>Acacia mangium, Albizia amara</i>	Cenchrus sps.
Southern plateau & hills	Agrisilviculture (rf)	<i>Eucalyptus</i>	Cotton
	Agrisilviculture (rf)	<i>Eucalyptus</i>	chilli
	Silviculture (rf)	<i>Leucaena leucocephala eucalyptus</i>	-
	Agrihorticulture	<i>Tamarindus indica</i>	chilli
	Tbos	<i>Pongamia pinnata</i>	-
	Agrisilviculture (rf)	<i>Ailanthus excels</i>	Cow pea
East coast plains & hills	Silviculture	<i>Casuarina equisetifolia Leucaena leucocephala</i>	-
	Tbos	<i>Pongamia pinnata</i>	-
	Silvipasture	<i>Artocarpus</i>	Chrysopogon, Napier, Cenchrus
West coast plains & hills	Agrisilviculture (rf)	<i>Acacia auriculiformis</i>	Black pepper
	Agrihorticulture (rf)	<i>Artocarpus heterophyllus</i>	Black pepper
	Agrisilviculture (rf)	<i>Acaiaayriculiforms</i>	Paddy
	Agrihorticulture	<i>Cocos nucifera/areca catechu</i>	Paddy
	Agrisilviculture	<i>Casurina equisetifolia</i>	Paddy
	Silvipasture	<i>Hardwickia binnata Albizia lebbeck</i>	<i>Cenchrus setaria</i>
Gujarat coast plains & hills	Agrisilviculture	<i>Azadirachta indica</i>	Cow pea
	Silviculture	<i>Prospis juliflora Acacia nilotica</i>	-
	Agrisilviculture	<i>Ailanthus excelsa</i>	Green gram
	Silvipasture	<i>Leucaena leucocephala</i>	<i>Cenchrus setaria</i>
Western dry region	Agrisilviculture	<i>Prosopis cineraria, Azadirachta indica</i>	Prarl millet
	Tbos (rf)	<i>Jatropha curcas</i>	-
	Silvipasture	<i>Albizia lebbeck</i>	Cenchrus sps
All islands	Agrihorticulture	<i>Cocos nucifera</i>	Paddy
	Silvipasture	<i>Bauhinia erythrina leucaena</i>	<i>Cenchrus pennisetum</i>

C. Agroforestry tree species present in various agroforestry systems

S.No.	Scientific Name	Local Name	Family	AF Systems	Common uses
Forest tree species					
1	<i>Alnus nepalensis</i>	Utis	Betulaceae	AS	Fodder, Fuel, Timber
2	<i>Bauhinia purpurea</i>	Guriyal	Caesalpiniaceae	AS, ASH	Fodder, Fuel, Timber, Medicine
3	<i>Bauhinia variegata</i>	Kachnar	Caesalpiniaceae	AS	Fodder, Fuel, Timber, Medicine
4	<i>Betula alnoides</i>	Saur	Betulaceae	AS	Fodder, Fuel
5	<i>Bombax ceiba</i>	Semal	Bombacaceae	AS	Fuel, Fibre, Timber, Medicine
6	<i>Cassia fistula</i>	Amaltash	Caesalpiniaceae	AS	Fodder, Fuel, Timber
7	<i>Cedrus deodara</i>	Deodar	Pinaceae	AS, ASH	Timber, Fuel
8	<i>Celtis australis</i>	Kharik	Ulmaceae	AS, ASH	Fodder, Fuel, Timber
9	<i>Dalbergia sissoo</i>	Shisham	Fabaceae A	S	Timber, Fuel-wood
10	<i>Desmodium elegans</i>	Chamlai	Fabaceae	AS	Timber, Nitrogen fixation
11	<i>Emblica officinalis</i>	Amla	Euphorbiaceae	AH, AHS	Edible, Medicinal
12	<i>Eucalyptus</i> spp.	Eucalyptus	Myritaceae	AS	Fuel, timber
13	<i>Ficus palamata</i>	Bedu	Moraceae	AS, ASH	Fodder
14	<i>Ficus roxburghii</i>	Timla	Moraceae	AS, ASH	Fodder, Fuel, Fruit
15	<i>Grewia optiva</i>	Bhimal	Tiliaceae	AS, ASH	Fodder, Fibre, Timber
16	<i>Jatropha curcas</i>	Ratanjot	Euphorbiaceae	AS	Medicine in skin dis-orders, Fuel oil
17	<i>Juglans regia</i>	Akhrot	Juglandaceae	AH, AS, ASH	Fruit, Timber
18	<i>Lyonia ovalifolia</i>	Ainyar	Ericaceae	AS, ASH	Fuel, Timber
19	<i>Melia azedarach</i>	Dekkain	Meliaceae	AS, ASH	Fuel, Timber, Fodder
20	<i>Morus alba</i>	Sahtoot	Moraceae	ASH	Fodder, Fruit, Fibre, Medicine, Fuel
21	<i>Myrica esculenta</i>	Kaphal	Myricaceae	AS	Fuel, Fruit, Timber
22	<i>Pinus roxburghii</i>	Chir	Pinaceae	AS, ASH	Timber, Fuel
23	<i>Prunus cerasoides</i>	Painya	Rosaceae	AS, ASH	Fuel, Timber
24	<i>Pyrus pashia</i>	Mole R	osaceae	AS	Fuel, Fruit, Timber
25	<i>Quercus floribunda</i>	Moru oak	Fagaceae	AS, ASH	Fodder, Fuel, Timber
26	<i>Quercus leucotrichophora</i>	Banj	Fagaceae	AS, ASH	Fodder, Fuel, Timber
27	<i>Rhododendron arboreum</i>	Burans	Ericaceae	AS, AHS	Fuel, Fruit
28	<i>Salix babylonica</i>	Majnu	Saliaceae	AS	Fodder, Fuel, Timber
29	<i>Shorea robusta</i>	Sal	Dipterocarpaceae	AS	Gum, Timber
30	<i>Toona ciliata</i>	Tun	Meliaceae	AS	Fuel, Timber
31	<i>Woodfordia fruticosa</i>	Dhaura	Lythraceae	AS	Fodder, Fuel
Fruits tree species					
1	<i>Carica papaya</i>	Papeeta	Caricaceae	AH	Edible fruit
2	<i>Citrus aurentium</i>	Narangi	Rutaceae	AH, AHS	Edible fruit
3	<i>Citrus lemon</i>	Nimbu	Rutaceae	AH	Edible fruit
4	<i>Citrus sinensis</i>	Malta	Rutaceae	AH, AHS	Edible fruit
5	<i>Juglans regia</i>	Akhrot	Juglandaceae	ASH	Edible fruit
6.	<i>Malus domestica</i>	Apple	Rosaceae	AH, AHS	Edible fruit
7	<i>Mangifera indica</i>	Aam	Acanthaceae	AH, AHS	Edible fruit, timber, worship
8	<i>Musa paradisiaca</i>	Kela	Musaceae	AH	Edible fruit, worship
9	<i>Prunus amygdalus</i>	Badam	Rosaceae	AH E	Edible fruit
10	<i>Prunus armeniaca</i>	Chullu	Rosaceae	ASH	Edible fruit
11	<i>Prunus persica</i>	Aadu	Rosaceae	ASH, AH	Edible fruit
12	<i>Psidium guajava</i>	Amrood	Myrtaceae	AH, AHS	Edible fruit
13	<i>Punica granatum</i>	Anar	Punicaceae	AH, AHS	Edible fruit
14	<i>Pyrus communis</i>	Pear	Rosaceae	AHS	Edible fruit

Abbreviations used above AS: -Agri silviculture System, AH: Agric Horticulture System; ASH: Agri Sivi Horticulture System; AHS: Agri Horti Silviculture System

D. Herbs and shrubs commonly present in agroforestry systems

S.No.	Scientific Name	Local Name	Family	Category	Common uses
1	<i>Achyranthus aspera</i>	Latjira	Aceraceae	Herb	Medicinal
2	<i>Ageratum conyzoides</i>	Goat weed	Asteraceae	Herb	Medicine in Skin ailments
3	<i>Amaranthus viridis</i>	Junglichaulai	Amaranthaceae	Herb	Vegetables
4	<i>Artemisia vulgaris</i>	Kunja	Asteraceae	Herb	Medicine in Intestinal treatment
5	<i>Avena fatua</i>	Jangali jai	Poaceae	Herb	Fodder
6	<i>Berberis asiatica</i>	Kingore	Berberidaceae	Shrub	Fruit, dye
7	<i>Cannabis sativa</i>	Bhang	Cannabaceae	Herb	Bark fibre for ropes, Fuel, condiment
8	<i>Carissa opaca</i>	Karonda	Apocyanaceae	Shrub	Fodder, fruit, soil, binder
9	<i>Chenopodium album</i>	Bathua	Chenopodiaceae	Herb	In making bread from the grinded grains
10	<i>Cynodondactylon</i>	Doob	Poaceae	Shrub	Used in several religious ceremonies
11	<i>Cyperus rotundus</i>	Morya	Cyperaceae	Herb	-
12	<i>Datura metel</i>	Dhatura	Solanaceae	Herb	Seed are used for medicinal purpose.
13	<i>Desmodium elegans</i>	Chamlai	Fabaceae	Shrub	Medicine in Fever, dysentery
14	<i>Dodonaea viscosa</i>	Vilayati mehndi	Sapindaceae	Shrub	Local beverages
15	<i>Euphorbia hirta</i>	Dudhi	Euphorbiaceae	Herb	Medicine in Bronchial infection and asthma
16	<i>Euphorbia royleana</i>	Sulla	Euphorbiaceae	Shrub	Latex and to check soil erosion
17	<i>Fragaria nubicola</i>	Wild strawberry	Rosaceae	Herb	Fruit, local beverage
18	<i>Lantana camara</i>	Kuri-ghas	Verbenaceae	Shrub	Fuel, skin ailments, soil binder
19	<i>Lathyrus aphaca</i>	Jangalimatar	Fabaceae	Herb	Fodder
20	<i>Malvastrum coromandelianum</i>	Suchi	Malvaceae	Herb	Fibre, medicine in wounds, dysentery
21	<i>Murraya koenigii</i>	Curry-patta	Rutaceae	Shrub	Used in flavouring curries, cutlets.
22	<i>Myrsine africana</i>	Chupra	Myrsinaceae	Shrub	Flowers used in apiculture.
23	<i>Nerium indicum</i>	Kaner	Myrtaceae	Shrub	Medicine in Skin ailments
24	<i>Oenothera rosea</i>	Primrose	Onagraceae	Herb	Ornamental
25	<i>Oxalis corniculata</i>	Bhilmori	Oxalidaceae	Herb	Vegetables, medicines in cataract and conjunctivitis treatment
26	<i>Oxalis latifolia</i>	Khatura	Oxalidaceae	Herb	-
27	<i>Parthenium hysterophours</i>	Gajar-ghas	Papaveraceae	Herb	-
28	<i>Polygonum capitatum</i>	Ghundi	Polygonaceae	Herb	Manure
29	<i>Punica granatum</i>	Anar	Puniaceae	Shrub	Fruit, good soil binder
30	<i>Reinwardtia trigyna</i>	Phiunli	Linaceae	Herb	Indicator of spring season, petals chewed as tongue wash
31	<i>Rhus parviflora</i>	Tungla	Anacardiaceae	Shrub	Fruits, fuel, medicine in cholera
32	<i>Rosa brunonii</i>	Kunja	Rosaceae	Shrub	Soil binder, medicines in diarrhoea
33	<i>Rubus elipticus</i>	Hisalu	Rosaceae	Shrub	Fruit, local beverages, soil-binder
34	<i>Rubus niveus</i>	Kala hinsalu	Rosaceae	Shrub	Fruits edible

35	<i>Rumex nepalensis</i>	Pahadi palak	Polygonaceae	Herb	Vegetables
36	<i>Rumex hastatus</i>	Amilada	Polygonaceae	Shrub	In making sauce
37	<i>Salvia lanata</i>	Ghaniya	Lamiaceae	Herb	Medicine in cold and cough, colic, diarrhoea
38	<i>Senecio nudicaulis</i>	Neelkanthi	Asteraceae	Herb	Medicines in skin ailments and fever
39	<i>Solanum nigrum</i>	Makoi	Solanaceae	Shrub	Fruit, medicine in liver piles, dysentery, diarrhoea, fever, eye ailments
40	<i>Spergula arvensis</i>	Jangali Dhaniya	Caryophyllaceae	Herb	-
41	<i>Urtica dioca</i>	Kandali	Urticaceae	Herb	Fibre, pot herb, medicinal
42	<i>Vicia sativa</i>	Kurphali	Fabaceae	Herb	-
43	<i>Vitex negundo</i>	Nirgundi	Verbenaceae	Shrub	In manufacturing basket, bio-fencing
44	<i>Zanthoxylum alatum</i>	Timru	Rutaceae	Shrub	Walking sticks
45	<i>Ziziphus mauritiana</i>	Ajapriya	Zingiberaceae	Shrub	Fruit, construction, agriculture implements

E. Important grasses and legumes for agroforestry systems

Grass/Legume	Scientific name	Area ('000 ha)	Productivity of green forage (tonnes/ha)
Napier grass (Elephant grass)	<i>Pennisetum purpureum</i>	100	70-100
Guinea grass (Green panic)	<i>Panicum maximum</i>	100	70-140
Setaria grass	<i>Setaria anceps</i>	40	50-95
Deenanath grass	<i>Pennisetum pedicellatum</i>	20	50-90
Para grass (Angola grass)	<i>Bracharia mutica</i>	100	100-190
Ruzi grass (Congo signal grass)	<i>B. ruziziensis</i>	15	70-90
Signal grass (Palisade grass)	<i>B. brizantha</i>	10	50-80
Dharaf grass (Goria)	<i>Chrysopogon fulvus</i>	*	30-50
Anjan grass (Buffel)	<i>Cenchrus ciliaris</i>	200	15-40
Yellow anjan grass (Birdwood)	<i>Cenchrus setigerus</i>	30	10-30
Sewan grass	<i>Lasiurus hirsutus</i>	100	7-25
Rhodes grass	<i>Chloris gayana</i>	*	20-35
Marvel grass (Karad grass)	<i>Dichanthium annulatum</i>	*	20-35
Sabai grass (Little para grass)	<i>Urochloa mosambicensis</i>	*	40-60
Sudan grass	<i>Sorghum sudanense</i>	100	50-80
Lablab bean	<i>Lablab purpureus</i>	10	15-30
Kulthi (Horsegram)	<i>Dolichos biflorus</i>	10	15-25
Moth bean	<i>Vigna aconitifolia</i>	10	15-30
Subabul	<i>Leucaena leucocephala</i>	*	60-120
Shevri (Common sesban)	<i>Sesbania sesban</i>	*	50-110
Agathi	<i>Sesbania grandiflora</i>	*	40-60
Dasrath grass (Hedge lucerne)	<i>Desmanthus virgatus</i>	*	50-90
Aparjita (Butterfly pea)	<i>Clitoria ternatea</i>	*	30-50
Siratiro	<i>Macroptilium atropurpureum</i>	*	15-25
Stylo	<i>Stylo santheshamata</i>	*	30-55
Brazilian lucerne	<i>S. guianensis</i>	*	30-55
<i>S. humilis</i>	<i>S. humilis</i>	*	40-50
Axillaris	<i>Macrotyloma axillare</i>	*	25-40
Desmodium (green leaf)	<i>Desmodium intortum</i>	*	25-45
Silver leaf	<i>D. uncinatum</i>	*	25-35
Centro	<i>Centrosema pubescens</i>	*	15-35
Glycine	<i>Glycine wightii</i>	*	20-35

*Area not known

F. Seed collection, sowing and other parameters of important agroforestry species

S.No.	Common name	Scientific name	No. of seeds per kg	Best seed collection period	Pre-sowing treatment	Viability (months)	Germination (%)
1	Eucalypts, Safeda	<i>Eucalyptus tereticornis</i>	>357000	September-December	Fresh, mixed with ash/ sand	24	90
2	Ipil-ipil, Subabul	<i>Leucaena leucocephala</i>	8000- 10000	April	Hot water treatment for 2-3 minutes	24	90
3	Alder, Utis, Kosh	<i>Alnus nepalensis</i>	18 lakh	November-December	Stratification	3	58
4	Whistling tree, Jhau	<i>Casuarina equisetifolia</i>	760000	June-December	Fresh, mixed with ash	12	70
5	Indian Lilac, Neem	<i>Azadirachta indica</i>	1750- 4000	June-July	Fresh, de-pulping and sowing	2 weeks	50
6	Kadamb	<i>Anthocephalus cadamba</i>	16 lakh	January-February, October-November	Overnight water soaking	6	76
7	Maharukh, Ardu	<i>Ailanthus excelsa</i>	9500	April-May	De-winking, water soaking 12-24 hrs.	6	70
8	Teak, Sagaun	<i>Tectona grandis</i>	2500- 3000	Nov.-January	Alternate wetting and drying for 7-10 days	24	30-60
9	Indian siris white	<i>Albizia lebbeck</i>	9200	November-February	Water soaking for 24 hr	48-60	40-60
10	Anjan	<i>Hardwickia binnata</i>	3900	April-May	Fresh, no treatment	12	60-80
11	Gum Arabic, Babul	<i>Acacia nilotica</i>	700- 11000	April-June	Fresh, 40-50 min H ₂ SO ₄ scarification	> 24	88
12	Mangium, Black wattle	<i>A. mangium</i>		January-June	Soak seed in hot water for 2-5 minutes then in cool water for a day	24	60-80
13	Karanj	<i>Pongamia pinnata</i>	800-1500	March-May	Fresh, no treatment	12	80
14	Tamarind, Imli	<i>Tamarindus indica</i>	1000- 1200	October-December	Fresh, 15 min H ₂ SO ₄ scarification	36	>60
15	Jamun	<i>Syzygium cuminii</i>	1200	June-August	Fresh, no treatment	1	50

G. Propagation techniques and standards of planting stock of agroforestry species

S.No.	Common name	Scientific name	Period in nursery	Age (months)	Height (cm)	Collar diameter (cm)	Stock type*
1	Poplar	<i>Populus deltoides</i>	Jan./Feb. to Jan./Feb.	12	300- 400	3-4	Transplant
2	Eucalypts, Safeda	Eucalyptus (different species and hybrids)	Throughout the year (In controlled conditions)	3	30	0.3-0.5	Clonal
3	Eucalypts, Safeda	<i>Eucalyptus tereticornis</i>	Feb.- August	5	40 0.	3-0.5	Seedling
4	Bakain, Drek	<i>Melia composita</i>	Feb. - August	8	50-60	0.5 -0.6	Seedling
5	Bead tree, Bakain	<i>M. azedarach</i>	Feb. - August	8	50-60	0.5 -0.6	Seedling
6	Malabar Neem	<i>M. dubia</i>	Feb. - August	8	50-60	0.5 -0.6	Seedling
7	Ipil-ipil, Subabul	<i>Leucaena leucocephala</i>	Feb.-July	5-6	40-50	0.4-0.5	Seedling
8	Alder, Utis, Kosh	<i>Alnus nepalensis</i>	January-Feb.	13	40-50	0.4-0.5	Seedling
9	Whistling tree, Jhau	<i>Casuarina equisetifolia</i>	Dec.-May	5-6	40-50	0.3-0.4	Clonal
10	Indian rosewood, Shisham	<i>Dalbergia sissoo</i>	Feb.-July	4-5	40	0.5-0.6	Seedling/ clonal
11	Robinea	<i>Robinia pseudoacacia</i>	March-Dec.	9-10	0.5-0.8	0.5-0.7	Seedling/ grafts
12	White willow	<i>Salix alba</i>	Jan.-Dec.	12	80-120	0.6-0.8	Clonal
13	Elm	<i>Ulmus villosa</i>	March-Feb.	12	50-60	0.4-0.5	Seedling
14	Indian Lilac, Neem	<i>Azadirachta indica</i>	June-Feb.	7-8	30-40	0.3-0.4	Seedling
15	Bhimal, Buel	<i>Grewia optiva</i>	March-June	15	60-80	0.4-0.5	Seedling
16	King of desert, Khejri	<i>Prosopis cineraria</i>	July-June	12	30 -40	0.3-0.4	Seedling/ grafts
17	Kadamb	<i>Anthocephalus cadamba</i>	Feb.-July	4-5	35-50	0.4-0.6	Seedling
18	Toon	<i>Toona ciliata</i>	June-Feb.	7-8	30-40	0.5-0.6	Seedling
19	Mulberry, Toot	<i>Morus alba</i>	Jan.- July	6	0.7-0.8	0.5-0.7	Clonal/ cutting
20	Sandal, Chandan	<i>Santalum album</i>	June - Feb./Feb.-Aug.	7-8	30	0.3-0.5	Seedling
21	Mehndil	<i>Lawsonia inermis</i>	March-July	4	30	0.2-0.3	Seedlings
22	Maharukh, Ardu	<i>Ailanthus excelsa</i>	Dec. - July	6	40	0.4-0.5	Seedling
23	Mahogany	<i>Swietenia mahoganii</i>	Dec.-July	6-8	40	0.4-0.5	Seedling
24	Mahua	<i>Madhuca indica</i>	July - Jan.	6-7	30	0.3-0.4	Seedling
25	Pilu	<i>Salvadora oleoides</i>	July-May	10-12	20-30	0.3-0.4	Seedling
26	Arjun	<i>Terminalia arjuna</i>	June- April	10	30-40	0.3-0.4	Seedling
27	Bedda nut tree, Beheda	<i>Terminalia bellirica</i>	March-July	3-4	20-30	0.5	Seedling
28	Harar	<i>Terminalia chebula</i>	June -May	12	40	0.4	Seedling

29	Semul	<i>Bombax ceiba</i>	June-May	12	50	0.4	Seedling
30	Teak, Sagaun	<i>Tectona grandis</i>	January- August	6-7	30-40	0.5	Stump planting
31	White teak, Gumhar	<i>Gmelina arborea</i>	January- August	6-7	40-60	0.5	Seedling
32	Pink cedar	<i>Acrocarpus fraxinifolius</i>	May-February	8	40	0.3	Seedling
33	Indian siris white	<i>Albizia lebeck</i>	January-June	4-5	35	0.3-0.5	Seedling
34	Albizia	<i>Albizia chinensis</i>	January-June	4-5	35	0.3-0.5	Seedling
35	Indian siris black	<i>Albizia procera</i>	January-June	4-5	35	0.3-0.5	Seedling
36	Anjan	<i>Hardwickia binnata</i>	May/June-June	12	40-50	0.4-0.6	Seedling
37	Gum Arabic, Babul	<i>Acacia nilotica</i>	January-June	4-5	30-40	0.3-0.4	Seedling
38	Khair	<i>A. catechu</i>	January-June	4-5	30-40	0.3-0.4	Seedling
39	Mangium, Black wattle	<i>A. mangium</i>	January-June	4-5	30-40	0.3-0.4	Seedling
40	Earpod wattle, Acacia	<i>A. auriculiformis</i>	January-June	4-5	30-40	0.3-0.4	Seedling
41	Gooseberry, Aonla	<i>Phyllanthus emblica,</i> <i>Emblica officinalis</i>	February-April (seed sowing Feb.)	4-5	30-40	0.5	Grafted
42	Tamarind, Imli	<i>Tamarindus indica</i>	March-July	3-4	30-40	0.8-1.2	Seedling
43	Jamun	<i>Syzygium cumini</i>	Sowing seeds: June-July	12-18	30-40	0.8-1.2	Seedling
44	Coconut	<i>Cocos nucifera</i>	February-August	8-12	50-75	0.5-0.8	Seedling
45	Bael	<i>Aegle marmelos</i>	June-July	12	30-40	0.5-0.8	Seedling
46	Ber	<i>Zyziphus jujube</i>	March-April seed sown June -September budding	8-15	30-40	0.8-1.2	Grafted
47	Bamboo	<i>Bambusa spp.</i>	January-June	6	60-80	0.2-0.4	Seedling/clonal

* Seedling material could be raised in root trainers or polythene bags of variable sizes

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