Agroforestry in Participatory Integrated Watershed Management

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Objectives

- To understand the role of agroforestry in PIWM and discuss various agroforestry systems, their practices, advantages and disadvantages

- To identify most suitable practices and incorporate them in PIWM

What is agroforestry?

Various definitions of agroforestry have been proposed. FAO (1996) defines agroforestry as 'the deliberate growth and management of trees along with agricultural crops and/or livestock in a system that aims to be ecologically, socially and economically sustainable'. Or simply as the 'integration of trees with farming systems'. But the widely accepted one is developed by ICRAF (1982) as 'agroforestry is a collective name for all land-use systems and practices in which woody perennials are deliberately grown on the same land management units with crops and/or animals. This can be either in some form of spatial arrangement or in a time sequence. To qualify as agroforestry, a given land-use system or practice must permit significant economic and ecological interactions between the woody and non-woody components'.

From the definitions it can seen that agroforestry encompasses all ways that trees and shrubs, intentionally integrated into agricultural land-use systems, provide tree products and protect, conserve, diversify, and sustain vital economic, environmental, human and natural resources. It has the potential to provide stable increases in and diversification of income sources, improved environments, and reduced risk of economic failures. The potential of agroforestry to provide simultaneously economic, environmental, conservation and social benefits to agroecosystems has been widely recognised.

A key principle in agroforestry is 'working trees' — the right trees and shrubs planted in the right place to do a specific job. Therefore the choice of tree or shrub species is an important concern in agroforestry.

What are the main aims of agroforestry?

The main aims of agroforestry are

- increased productivity and income,

- improved equity in benefit sharing,

- sustainable use and management of soil, water, forests and other natural resources, and

- sustainable environmental management.

Why is agroforestry important in participatory, integrated watershed management?

Water and wind erosion, excess nutrient and pesticide movement, declining fertility of farmlands, lowland productivity, lack of biodiversity on farms, and lack of active participation of local people in watershed management have become major problems for sustainable development in mountain regions.

Agroforestry can address these problems in the following three ways.

- Rehabilitation of degraded lands by conversion to alternative production agroforestry practices such as alley cropping, contour hedgerow systems, tree/pasture systems, fuelwood plantations, etc.

- Protection of sensitive lands by integration of windbreaks, riparian forest buffers, and other conservation agroforestry practices.

- Motivation of local people to participate actively in watershed management by increased income, combination of short-term and long-term benefits, and improved environments.

Since agroforestry combines agriculture and forestry technologies to create more integrated, diverse, productive, profitable, healthy, and sustainable land-use systems to meet the economic, environmental and social needs of people, it has the potential to improve agricultural productivity, diversify and increase farm income, conserve land, maintain biodiversity and contribute to poverty reduction.

Earlier afforestation/reforestation activities did not take local people's needs into sufficient consideration and lacked a combination of long- and short-term benefits. This probably explains why most governmental and non-governmental afforestation/reforestation programmes did not fulfill expectations. The introduction of agroforestry in PIWM will contribute to the sustainable use of soil, water, forests and other natural resources and improve the livelihoods of the people.

How many types of agroforestry system are practised?

Agroforestry practices are highly diverse and complex. They are classified on the basis of structure, function, agroecological and environmental adaptability, socio-economic and cultural characteristics, and management practices. Most agroforestry practices can be classified within the following major systems.

- Agrosilvicultural systems
- Agrosilvipastoral systems
- Silvipastoral systems
- Silvipisicultural systems
- Agrosilvipisicultural systems
- Silvi-medicinal plant farming systems
- Agrosilvi-medicinal plant farming systems

Some examples of each major agroforestry system are listed in Table 1.

What are the most suitable agroforestry practices for PIWM?

Agroforestry practices are diverse and vary in different regions. For the purposes of PIWM the following agroforestry systems may be used.

- Contour hedgerow systems
- Windbreaks
- Riparian forest buffers
- Multipurpose plants-crop systems
- Tea-nitrogen-fixing woody plants' systems
- Forest-cash plants' systems
- Mulberry-fishery systems

Contour hedgerow systems

Contour hedgerow systems are an agroforestry concept using single or double hedgerows of nitrogen-fixing trees or shrubs planted very densely along contour lines, with crops grown in the alleys between the hedgerows. The trees or shrubs include various nitrogen-fixing and multipurpose species.

Benefits of hedgerow systems

- Reduce water and wind erosion
- Improve crop production
- Improve soil fertility
- Provide supplemental income
- Provide wildlife habitat and corridors
- Provide aesthetic diversity

Table 1: Major Agroforestry Systems and Examples of Agroforestry Practices	
Major agroforestry systems	Example of agroforestry practices
Agrosilvicultural systems	Shifting cultivation, *taungya* system, tree garden, alley farming, contour hedgerow system, multipurpose plants and crops system, windbreak, soil conservation hedgerows, fuelwoods and crops
Agrosilvipastoral systems	Home gardens, woody hedges for browse, mulch, green manure, soil conservation.
Silvipastoral systems	Fodder and crops, living fence of fodder trees and hedges, trees and shrubs on pasture.
Silvipisicultural systems	Trees and fishing farming.
Agrosilvipisicultural systems	Trees, crops, livestock and fishing farming.
Agropastoropisicultural systems	Sericulture and fishery system.
Silvi-medicinal plant farming systems	Woody plants and medicinal farming.
Agrosilvi-medicinal plant farming systems	Woody plant, crops, and medicinal plants farming.
Others	Apiculture with various woody plants.
Source: Air 1987, with modifications and additions	

Considerations in contour hedgerow systems

Species to plant: In this system, the best plants are nitrogen-fixing woody plants that are fast growing and multipurpose. Planting more than one species in the hedgerows reduces risk from disease and insects.

Width of tree strips: Most contour hedgerow systems use double rows of trees or shrubs to control soil erosion efficiently and provide sufficient fresh biomass to improve soil fertility. Single row hedgerows will also function well if improvement of soil fertility is not a priority.

Space between strips: Widths of the hedgerows are determined by slopes and management options. Sufficient room must be allowed for crop strips. Studies show that a width of 4-6 m is reasonable for agricultural land, while 8-12 m is fine for cash plants' cultivation on sloping lands.

Orientation of strips: As indicated by its name, contour hedgerows of nitrogen-fixing plants should be planted on the contour to control water erosion.

Windbreak systems

Windbreaks are vegetative barriers of sufficient height to create a windless zone to their leeward or protected side. These barriers typically reduce open field wind speeds by 20 to 75 per cent at distances of up to 10 times their height. The effects of windbreaks are many and overwhelmingly positive. Benefits are as follow.

- Increasing income
- Increasing crop yield
- Conserving soil and water
- Protecting livestock
- Improving water quality

Riparian filter strips

Riparian filter strips include water-loving trees and other plants that grow near the banks of streams, rivers and lakes. Riparian vegetation is not only luxurious and beautiful but it plays many important roles in the ecosystem. A riparian filter strip may be natural or planted but it can offer generous benefits in return for minimal expense and care. A healthy riparian strip is evidence of wise land management.

The benefits of riparian trees are as follow.

- Yield wood products
- Reduce floods, erosion and bank cutting
- Trap nutrients and enhance aquatic environment
- Provide home for wildlife and enhance biodiversity conservation
- Store water

Multipurpose plants-crop systems

These are widely distributed and diverse and include numerous practices. Multipurpose plants include mainly fruit/nut trees, medicinal plants, tea, rubber, nitrogen-fixing plants. They are grown on farmlands or farm boundaries or separate woodlots for various purposes.

Benefits of the system are as follow.

- Increased income
- Combination of long-term and short-term benefits
- Stable income sources
- Improved environments
- Help conserve biodiversity

Considerations

- Appropriate space between multipurpose plants and crops
- Avoidance of biologically negative effects between plants and crops, e.g., few plants grow well under walnut trees
- Appropriate management to minimise competition

Some practices of this system include fruit/nut trees - crops; fodder trees- crops; timber trees- crops; mulberry trees- crops; and medicinal plants-crops.
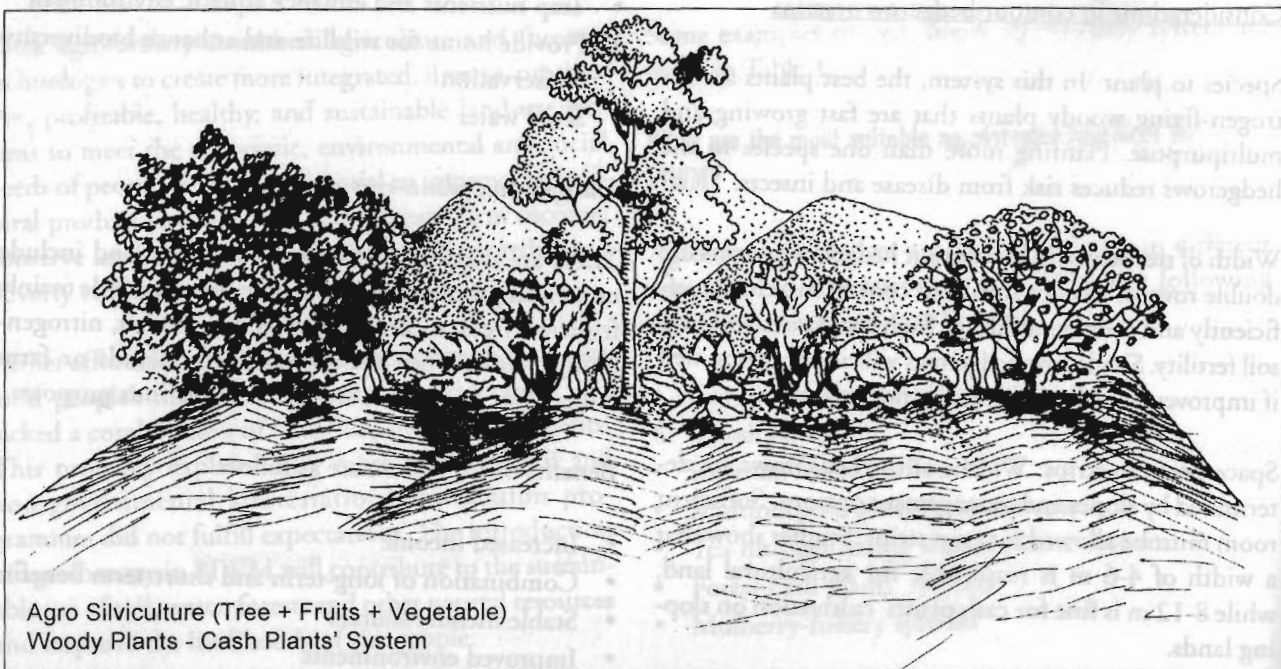
Woody plants -cash plants' system

Woody trees or shrubs are planted for timber, shade, fodder or other purposes, and cash plants are grown beneath them in the forest. This may be a multistrata (tree/shrub/grass) structure.

Benefits of the system are as follow.

- Increased income
- Improved environment/climate
- Water and soil conservation
- Habitats for natural enemies of pests
- Wildlife and biodiversity conservation

Considerations of the system are as follow.

- Selection of marketable plants
- Others similar to the above systems

Agro Silviculture (Tree + Fruits + Vegetable)
Woody Plants - Cash Plants' System

Some practices of the system include medicinal plants in Chinese fir forests; tea and other cash plants in rubber plantations (cash plants may include pepper, coffee, pineapple, cardamom, etc); cardamom in *Alnus nepalensis* forests; vegetables in *Paulownia* forests; medicinal plants in *Paulownia* forests; and ginseng in forests.
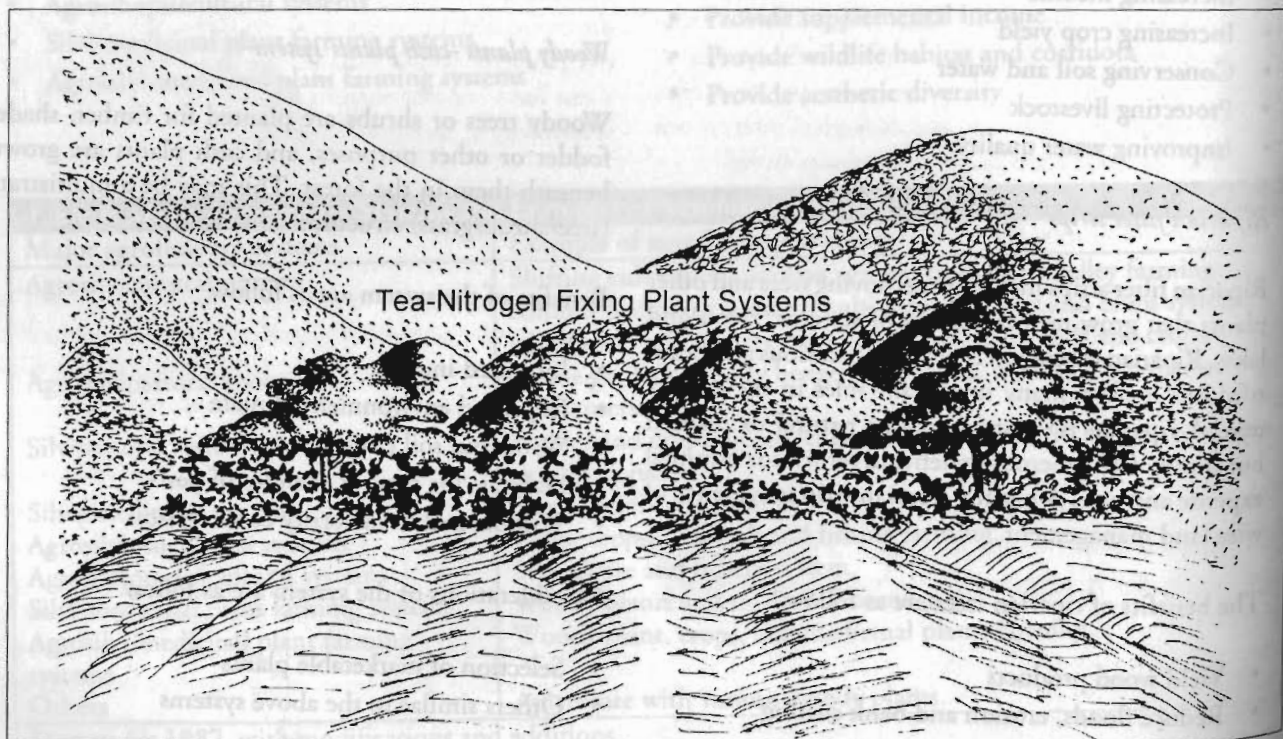
Tea-nitrogen-fixing plants' system

Tea production is a key economic activity for many Asian countries and many types of tea plantation have been developed, of which several are good agroforestry practices. In the system, nitrogen-fixing plants are sparsely planted in the tea plantation, mainly for shade. However, the nitrogen-fixing plants are also soil fertility improvers.

Forest farming

Forests are an important component of watersheds. As well as providing economic and ecological benefit to people, natural or planted woodlands also provide life-giving essentials for wildlife.

Tea-Nitrogen Fixing Plant Systems

Food: Woodlands produce seeds, berries, leaves, grasses, nuts and fruits, all of which can be food for different wildlife species.

Living space: Although some species will cover a large territory in their daily activities, woodlands provide places for nesting, brooding or rearing their young.
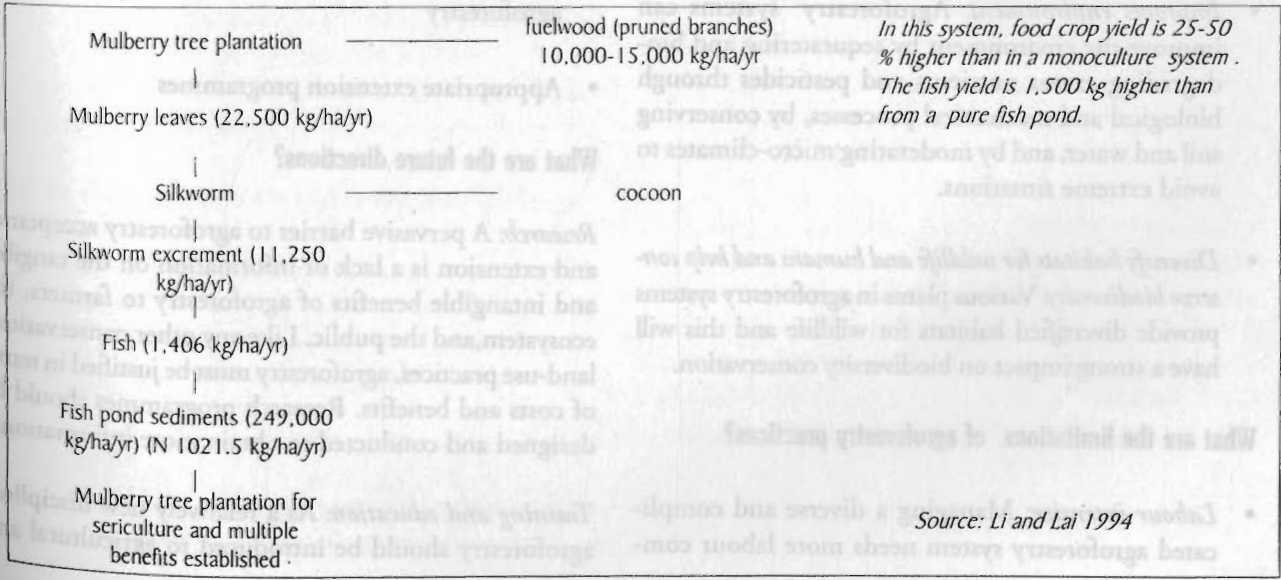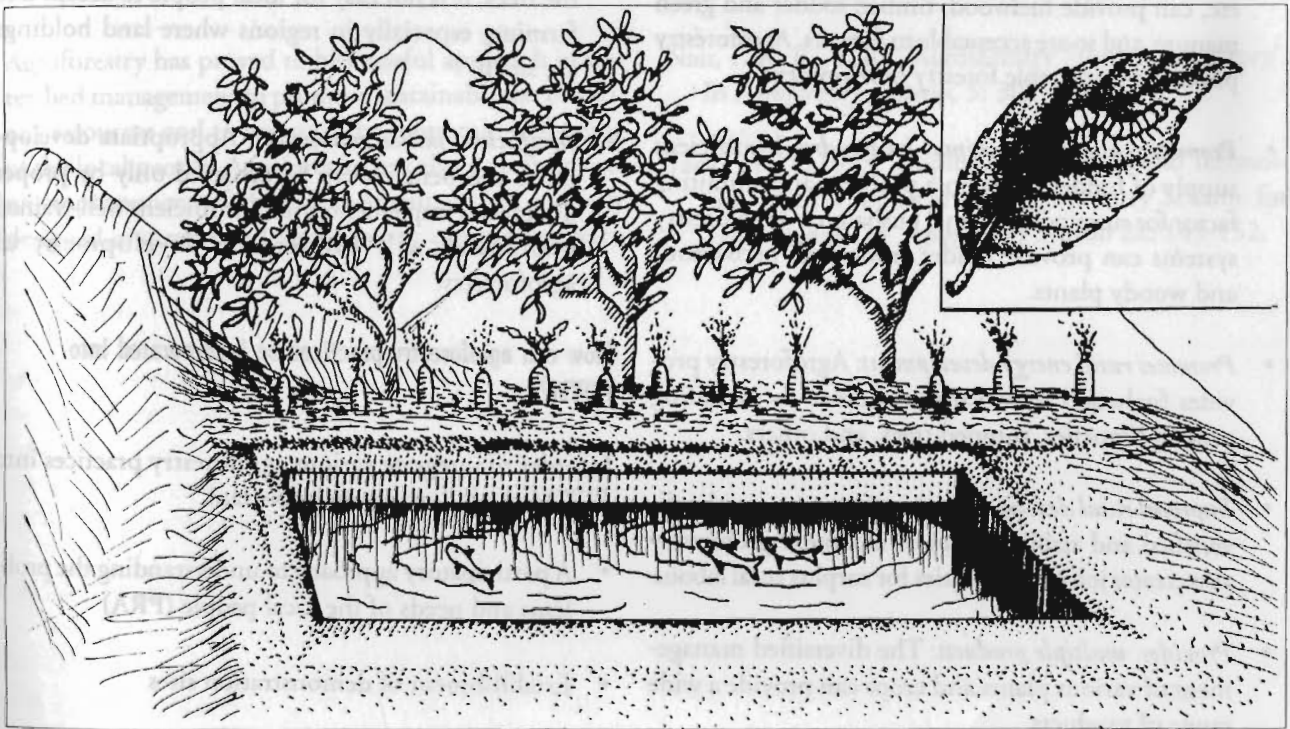
Cover: Trees and shrubs provide shelter and protection from predators, cold winds and snow, and summer heat.

Water: A nearby stream or pond can be an important source of water for birds and animals.

Woodlands in a watershed can also be used to produce food, vegetables, mushrooms, medicinal plants and others items. Because biodiversity has been declining due to habitat loss, the forests and woodlands can be managed for wildlife protection in the following ways.

Mulberry and fishery systems

This is a system in which mulberry trees are planted on farmland and crops or vegetables are intercropped. Mulberry leaves are fed to silkworms. The silkworm excrement and silkworm chrysalis are used to feed fish. After consummation by the fish, sediments in the fish pond are used to fertilize mulberry trees.

Mulberry tree plantation	————	fuelwood (pruned branches) 10.000-15.000 kg/ha/yr
↓		
Mulberry leaves (22,500 kg/ha/yr)		
↓		
Silkworm	————	cocoon
↓		
Silkworm excrement (11,250 kg/ha/yr)		
↓		
Fish (1,406 kg/ha/yr)		
↓		
Fish pond sediments (249,000 kg/ha/yr) (N 1021.5 kg/ha/yr)		
↓		
Mulberry tree plantation for sericulture and multiple benefits established		

In this system, food crop yield is 25-50 % higher than in a monoculture system. The fish yield is 1,500 kg higher than from a pure fish pond.

Source: Li and Lai 1994

What are the benefits of agroforestry in PIWM ?

- *Promotes sustainable agricultural development*: Many agroforestry systems ,such as windbreaks, tree and crop intercropping, and contour hedgerow systems, promote sustainable agricultural development. This can be achieved by improving habitat, conserving soil, improving soil properties, enhancing crop yield and reducing risk.

- *Promotes sustainable forestry development*: Pure afforestation/reforestation programmes have their limitations and usually are not acceptable to farmers. Inclusion of tree planting on farmlands or on farmland boundaries, tree and food/cash crop intercropping, etc, can provide fuelwood, timber, fodder and green manure, and so are acceptable to farmers. Agroforestry promotes sustainable forestry development.

- *Promotes sustainable animal husbandry*: Insufficient supply of fodder has been a problem and a limiting factor for sustainable animal husbandry. Agroforestry systems can provide fodder from both herbaceous and woody plants.

- *Promotes rural energy development*: Agroforestry provides fuelwood from various sources — including pruned branches, thinned trees, and others.

- *Improves rural development*: Agroforestry provides diversified and stable sources of income. Agroforestry also creates job opportunities for surplus rural labour.

- *Provides multiple products:* The diversified management of various plants and crops can provide a wide range of products.

- *Improves environment:* Agroforestry systems can improve the environment by sequestering and bio-degrading excess nutrients and pesticides through biological and mechanical processes, by conserving soil and water, and by moderating micro-climates to avoid extreme situations.

- *Diversify habitats for wildlife and humans and help conserve biodiversity*: Various plants in agroforestry systems provide diversified habitats for wildlife and this will have a strong impact on biodiversity conservation.

What are the limitations of agroforestry practices?

- *Labour intensive*: Managing a diverse and complicated agroforestry system needs more labour compared with simple crop cultivation. This will hinder development in areas where labour supply is a problem.

- *Competition between trees and crops*: As an integrated system, competition for sunshine, water and nutrients is present between tree plants and crop plants. It is important, therefore, to select appropriate tree species with minimum competition with crops.

- *Low benefit in the first few years*: Crop yields may be low in the first few years due to competition, although the total benefits of agroforestry systems in the long run are much higher than in monocultural systems. Since it can take a long time to benefit from the trees, it is not easy for local people to accept tree farming, especially in regions where land holdings are small.

- *Insufficient skilled manpower*: Appropriate development and benefits can be achieved only by proper design and implementation. Insufficient well-trained manpower will hinder the development of agroforestry.

How can agroforestry practices be incorporated into PIWM?

In order to integrate various agroforestry practices into PIWM the following are important.

- A participatory approach to understanding the problems and needs of the local people (PRA)

- Establishment of demonstration sites

- Enhancement of education and training on agroforestry

- Appropriate extension programmes

What are the future directions?

Research: A pervasive barrier to agroforestry acceptance and extension is a lack of information on the tangible and intangible benefits of agroforestry to farmers, the ecosystem,and the public. Like any other conservation/land-use practices, agroforestry must be justified in terms of costs and benefits. Research programmes should be designed and conducted to obtain more information.

Training and education: As a relatively new discipline, agroforestry should be introduced to agricultural and.

forestry education systems as a formal subject, and informal training courses should be organized on specific agroforestry systems for technicians, extension workers, and farmers.

Capacity building: International and national organizations should work together to train enough personnel in the fields of research and extension.

Establishment of watershed-level demonstration sites: 'Seeing is believing' is the best way for extension and acceptance of agroforestry practices. In this regard, demonstration of various agroforestry practices should be a priority in watershed management programmes.

Conclusion

Agroforestry has proved to be a useful approach in watershed management to promote sustainable use of various resources and to improve the economic well-being of the local people. Agroforestry has also a great impact on improvement of the environment. When properly designed and managed, agroforestry can provide various benefits and has the potential to meet environmental and socioeconomic requirements.

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