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Agroforestry research in India: a brief review

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Abstract. India's long tradition of agroforestry has been influenced by numerous religious, social, and economic factors. Several indigenous agroforestry systems, based on peoples' needs and site-specific characteristics, have developed over the years. Agroforestry research was initiated in the country about two decades ago; since then, considerable progress has been achieved. The interactions between and among the tree, crop, grass, and animal components have been studied, and several agroforestry technologies have been developed and tried on farmers' lands. Agroforestry research is now conducted under the auspices of the All India Coordinated Agroforestry Research Project of the Indian Council of Agricultural Research at 31 centers distributed over India's tropical and temperate regions. In addition to research, the program includes agroforestry training of farmers, technicians, and scientists at 28 centers throughout the country. Expectations from agroforestry are high in India in both rural and urban areas; these expectations include production benefits that are in harmony with the ecology, environment, traditions, and heritage of the country.

Introduction

Although agroforestry research is a relatively recent endeavor in India, agroforestry, as a land-use practice, has a long tradition in this country. In many parts of India, the socio-religious fabric of the people is intricately interwoven with raising, nurturing, and respecting trees. For centuries, trees have been essential components of several crop- and livestock-production systems.

During the past few decades, the ancient traditions of harmony and balance between man and nature have been seriously disturbed. More than 800 million people and 400 million livestock have exerted increasing pressure on forests, tree cover, and land use in general. Of the total geographical area of 328.8 million ha, forests constitute 67.4 million ha, of which approximately 50% is in a degraded condition. Similarly, it is estimated that about 60 million ha of agricultural land is eroded or otherwise degraded. Tree planting and agroforestry interventions have been suggested as viable strategies for rehabilitating these lands. As a consequence, agroforestry and social forestry programs have received considerable emphasis in the country and are promoted by governmental, non-governmental, and academic institutions. This paper presents a brief overview of the status of government-sponsored agroforestry research and development efforts in India, including the problems encountered.

Traditional agroforestry systems of India

Agroforestry is widespread in all ecological and geographical regions of India. The systems and practices, in response to local conditions and traditions, vary enormously in structural complexity, species diversity, productive and protective attributes, and socioeconomic benefits. They range from apparently 'simple' forms of shifting cultivation — observed especially in the northeast — to the complex multistoried homegardens of the humid coastal areas in the south. The *khejri* (*Prosopis cineraria*)/crop combination of the hot arid region meets local needs for fodder, small timber and food, while the *Alnus nepalensis* and *Amomum subulatum* (large cardamom) combination in the Himalayan region's humid subtemperate zone is an excellent example of a commercial, but traditional, agroforestry system. Other prevalent agroforestry systems include the deliberate growing of trees on field bunds, their sporadic distribution in agricultural fields, and the systematic retention of shade trees in tea and coffee plantations. It is also common to cultivate crops for 2—3 years in the open interspaces in newly planted orchards and forests and, later, to interplant shade-tolerant crops such as turmeric and ginger.

Several reviews and descriptions of the agroforestry systems of India are available [ICAR, 1981; Singh, 1987; Tejwani, 1987], as are more specific descriptions of several individual systems and practices [Nair, 1979, 1983; Kumar and Abrol, 1984; Nair and Sreedharan, 1986; Shankarnarayan et al., 1987; Mittal and Singh, 1989; Singh et al., 1988, 1989; Singh, 1990; Rao et al., 1990; Sharma et al., 1990]. A good overview of the different systems in various parts of the country was provided by Nair and Dagar [1991].

Agroforestry research in India

The first national seminar on agroforestry in India, organized by the Indian Council of Agricultural Research (ICAR) in Manipur in the Northeast, heralded the beginning of scientific agroforestry in India. Although several aspects of research conducted in many agricultural-, forestry-, and other related institutions in the country would later be recognized as agroforestry research, it was only in the late 1970s that agroforestry became recognized as a distinct activity with that name. Subsequently, several national seminars and workshops (most of them attended by scientific teams from ICRAF) have been held in different parts of the country. The initiation by ICAR (in the 1980s) of a national agroforestry program, the All India Coordinated Research Project on Agroforestry (AICRPAF), was a significant landmark in the development of agroforestry research in this country. AICRPAF has a nationwide research network, involving collaboration with several State Agricultural Universities and ICAR institutions in 31 locations [ICAR, 1990]. The ICAR also administers a National Research Centre for Agroforestry (NRC-AF) at Jhansi in Uttar Pradesh State. The overall emphasis of

the AICRPAF program is on adaptive research to help increase the productivity and profitability of agroforestry at the farm level; basic research forms only a small part of the research effort. However, NRC-AF and other national laboratories and universities undertake some research on basic issues. In this paper, we will focus on the AICRPAF activities.

There are six major research projects under AICRPAF. Each collaborating center conducts research on one or more of these broad projects, with appropriate local modifications. The six projects are:

- diagnostic survey and appraisal of existing farming systems and agroforestry practices;
- collection and evaluation of promising multipurpose tree and shrub species for fuel, fodder, and small timber;
- management aspects of various agroforestry technologies;
- social, anthropological, and economic aspects of agroforestry;
- agroforestry for environmental protection, wasteland reclamation, and community development; and
- post-harvest technology and non-timber forest products in relation to agroforestry.

In addition to research, providing extension workers, community-development personnel, farmers, and scientists with training in various aspects of agroforestry is a major activity in all research centers.

Research accomplishments within India's agroecological zones

Results of trials at different research centers are reported in the project's annual reports, as well as in other publications. At the national level, agroecological zones have been accepted as the basis for coordinating and reporting agroforestry research results. The ecology and climate of India are extremely varied, with almost all of the world's agroecological zones represented at one or another location within the country. This enormous diversity makes it difficult to classify the country into a few distinct agroecological zones. Any classification will have limitations and drawbacks; there cannot be a universally accepted demarcation of agroecological zones, which will suit all purposes, in a country as vast and varied as India. Reviewing agroforestry in India, Singh [1987] identified eight agroecological regions, whereas Nair and Dagar [1991] identified five regions. The government of India has classified the country into 15 regions [GOI, 1989]. For its purposes, AICRPAF has decided to organize research activities on the basis of five agroecological zones [Chinnamani, 1992]. In the following review, agroforestry research efforts will be briefly examined in each of the agroecological zones identified by AICRPAF.

Himalayan region (western and eastern)

In this region, the most common types of on-going studies are those which evaluate fodder trees and various forms of intercropping practices. Important fodder trees which are being evaluated include *Bauhinia purpurea*, *Grewia optiva*, *Celtis australis*, *Ficus hookerii*, *F. elevata*, and *Alnus nepalensis*. Silvopastoral trials using a combination of *F. hookerii* and *Thysanolaena agrostis* (a grass) have produced average fodder yields of 12.3 t ha^{-1} $year^{-1}$ (dry matter), the tree and grass components yielding 2.4 and 9.9 t ha^{-1} $year^{-1}$, respectively. In three-component combinations of alder (*Alnus nepalensis*) + stylo (*Stylosanthes guineensis*) + guinea grass (*Panicum maximum*), forage yields of up 14.5 t ha^{-1} $year^{-1}$ (dry matter) could be obtained.

Intercropping systems being studied include maize and wheat intercropped with eucalyptus, and *Alnus nepalensis* over large cardamom (*Amomum subulatum*). Evaluations of the effect of trees, especially eucalyptus, on the growth and productivity of intercropped food crops are a major type of study. In general, there is a 30—40% yield decline of maize or wheat (compared to sole crop yields) when intercropped with eucalyptus. The effect of various management practices on the growth of crops is a common element of these studies. An example would be evaluations of root trenching at depths up to 2 m, at varying distances from the tree rows.

Gangetic Plains

Growing poplar trees (*Populus* spp.) with crops is a promising agrisilvicultural system in the vast Gangetic Plains. Results of extensive seven-year studies have shown that while the presence of trees on field boundaries or at 5 × 4 m spacing in fields does not adversely affect crop yields, it will provide supplementary income to farmers. At the end of the seven-year growing period, each tree could be sold for Rupees 300 to 700 (1 US $ = RS 30; 1992); with up to 500 trees per hectare, the additional income from the trees is quite substantial under local conditions.

Intercropping trials in this zone include tree species such as eucalyptus, leucaena, and acacia with crops such as common cereals and sesamum (*Sesamum indicum*). In general, crop yields were lower when intercropped with eucalyptus and leucaena, as compared to sole crop stands.

Semiarid and arid regions

Intercropping food crops with various multipurpose trees is the common agroforestry practice in this region as well. The common trees are *Acacia tortilis* and *Prosopis cineraria* (known locally as *khejri*). The common agricultural species include millets such as pearl millet (*Pennisetum glaucum*), legumes such as cluster bean (*Cyamopsis tetragonaloba*) and green gram

(*Vigna aureus*), and oil-yielding crops such as sesamum. Voluminous data are available on crop yields and economic returns from medium-term (up to six years) trials of different crop/tree combinations at various centers (AICRPAF Annual Reports).

Humid and subhumid eastern region

The major agroforestry systems in this region are multistory combinations with plantation crops and fruit trees, and various types of intercropping. A six-year study in Orissa state showed that ginger and soybean could be grown successfully as intercrops in stands of *Acacia auriculiformis*, but rice and pigeon pea could not. The yield reduction of intercropped rice was as high as 60% as compared to the sole stand of rice. The same study showed that, during six years of intercropping, there was no appreciable increase in soil nitrogen or organic matter content, whereas P content increased 20—50% over the initial levels.

Southern tropical region

In the southern states of Kerala, Tamil Nadu, Karnataka, and Andhra Pradesh, numerous forms of agroforestry are popular. Homegardens and multistory combinations involving plantation crops are prevalent in Kerala; tree-spice gardens, and crop combinations involving them, are common in coastal Karnataka; energy plantations, especially of *Casuarina* spp., are popular in coastal districts of Tamil Nadu and Andhra Pradesh; and various forms of intercropping with fruit trees and silk cotton (kapok) tree (*Ceiba petandra*) are widespread in Tamil Nadu. Research on these various site-specific systems is focused mainly on management practices and economic evaluations.

Discussion and conclusions

Since time immemorial, India has maintained a rich cultural and religious tradition of planting, protecting, and respecting trees. Farmers and land owners throughout the country integrate a variety of trees into their crop and livestock production systems, depending upon the local agroclimatic and socioeconomic conditions. Given this positive attitude towards trees and tree-based land-use systems, new initiatives in scientific agroforestry and government-sponsored tree-planting became widely popular among the farmers and general public. Naturally, expectations from these activities are very high. New commercial ventures, several of them with the backing of industrial concerns and the private sector, have also begun to popularize and support the small-scale planting of preferred pulp and timber species in various parts of the country. Thus, while the various developmental arms of

the government promote agroforestry and tree planting for rural poverty alleviation, environmental protection, and wasteland development, the private/commercial sector focuses on economic returns from tree planting activities.

Research is still heavily and predominantly government-sponsored in India. A major share of agroforestry-research funding goes to support the low-input agroforestry technologies that are promoted by government-sponsored development initiatives. Therefore, the thrust of AICRPAF and other publicly funded research is on adaptive research. Nevertheless, some commercial companies and government laboratories support basic research, especially on biotechnology application for rapid multiplication of preferred tree species, such as teak, bamboo, and eucalyptus.

Apart from the lack of financial resources and scientific and institutional capabilities, there are also some policy and social impediments to agroforestry development and supportive research. A large number of indigenous trees and shrubs are used in agroforestry systems in different parts of the country; this is an asset, but also causes problems when selecting a few species for concentrated study. The nationalistic fervor and sentimental feelings aroused by highly influential voluntary organizations have placed an embargo on the so-called 'exotic' tree species even if such species have been in the country for a long time. Difficult-to-implement or conflicting directives and policies of the federal and state governments and various government agencies are also a matter of concern. For example, hill preservation legislation forbids the cutting of trees in the hills and mountains without government-issued permits (which, for various reasons, are seldom granted); the wildlife protection act forbids the killing of animals, even if they cause great damage to tree seedlings and saplings in wasteland reclamation or reforestation programs.

In spite of these constraints and impediments, agroforestry programs have made significant strides in India. As time passes, the emphasis on research will shift from the present state of 'what' type of research (see Nair, this issue) to the 'why' and 'how' types of research. Nevertheless, the history of agriculture and forestry research in independent India suggests that agroforestry research will continue to be primarily government-sponsored, and focused on adaptive, farmer-oriented approaches.

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