Tropical Ecology **44**(1): 63-71, 2003 ISSN 0564-3295

The tree behind the forest: ecological and economic importance of traditional agroforestry systems and multiple uses of trees in India

DENIS DEPOMMIER*

French Institute of Pondicherry, 11 Saint Louis Street, Pondicherry - 605 001

Abstract: Traditionally, agroforestry is extensively practiced in India, in the form of the shifting agriculture, a variety of cereal cropping systems, home garden systems, traditional plantation systems, etc. In recent times, many of these agroforestry systems have started breaking down for a variety of reasons. In many situations, high diversity based agroforestry systems have been replaced by low diversity simplified cash crop systems, and this is questionable in terms of sustainability. The paper argues for traditional ecological knowledge based approaches linked with provision for multiple value non-wood products. It is concluded that gaps in the knowledge of multi-purpose trees (MPTs) and systems functioning needs to be better understood for sustainable agroforestry.

Resumen: Tradicionalmente la agroforestería se practica de manera extensa en la India, en la forma de agricultura transhumante, una variedad de sistemas de cultivo de cereales, sistemas de huertos familiares, sistemas tradicionales de plantaciones, etc. En épocas recientes muchos de estos sistemas agroforestales han comenzado a desintegrarse debido a una variedad de razones. En muchas situaciones, los sistemas agroforestales basados en una alta diversidad han sido reemplazados por sistemas de cultivos comerciales, simplificados y de baja diversidad, y esto es cuestionable en términos de la sostenibilidad. En el artículo se argumenta a favor del conocimiento ecológico tradicional con base en enfoques vinculados con la disponibilidad de productos no maderables de valor múltiple. Se concluye que todavía existen lagunas en el conocimiento de los árboles de uso múltiple (AUM) y que el funcionamiento de los sistemas necesita ser comprendido mucho mejor en bien de la agroforestería sostenible.

Resumo: Tradicionalmente, a agro-silvicultura é extensivamente praticada na Índia, sob forma de cultura itinerante, uma variedade de sistema cerealífero, sistemas de hortas caseiras, sistemas tradicionais de plantação, etc. Recentemente, muitos desse sistemas agroflorestais têm vindo a ser desfeitos por um conjunto variado de razões. Em muitas situações, sistemas agroflorestais fortemente diversificados têm vindo a ser substituídos por sistemas de culturas comerciais de baixa diversidade e simplificados, o que é questionável em termos de sustentabilidade. Este artigo argumenta para a necessidade de abordagens com base no conhecimento ecológico tradicional ligado à provisão para múltiplos valores de produtos não lenhosos. Conclui-se que as lacumas no conhecimento das árvores de uso múltiplo (MOTs) e das necessidades de funcionamento dos sistemas necessitam ser mais aprofundadas para a sustentabilidade da agro-silvicultura.

Key words: Agroforestry systems, coffee based system, homegarden, mangroves, multipurpose trees, social forestry, sustainable development, traditional ecological knowledge.

*Phone: 91-413-2334168/2222497, fax: 91-413-2339534, e-mail: denis.depommier@cirad.fr

Introduction

Agroforestry, the combination of woody perennials with crops and/or animals on the same unit of land management, is an age-old practice in India. Being a traditional land use system able to satisfy a large diversity of socio-economic needs in a sustainable way and in many different agro-ecological conditions, agroforestry is found from north to south India through hundreds of systems and an equivalent number of management practices of multipurpose trees, shrubs and palms.

Unfortunately, agroforestry systems and practices are little known in terms of functioning and dynamics. Besides their descriptive knowledge, the economic and environmental importance of associated trees is rarely assessed. Finally, the potential roles these "trees out of the forests" can play in soil fertility maintenance, water conservation, tenural issues, landscaping and multi-production (food, fodder, fuel wood, timber, medicines, etc.) is clearly not fully used. From a research and development point of view, little progress has been made in the study and promotion of agroforestry and other tree-based systems, or in giving this domain of study a comprehensive understanding, at the interface between forestry, agriculture, livestock rearing, and social sciences.[1] Will the trees behind the forests be seen once the latter have disappeared?

From ancient times to the green revolution

Secular uses of trees

From a historical perspective, many current multipurpose trees such as *Prosopis cineraria,* a legume tree species extensively grown in Rajasthan and Gujarat to maintain soil fertility and feed livestock during the dry season, or *Ficus religiosa,* well-known in tree worship, are mentioned in ancient literature (Rig Veda, Atharva Veda) and other Indian scriptures (Pathak *et al.* 2000). Neem *(Azadirachta indica),* the famous medicinal, insecticidal and pesticidal tree, is part of many folklores in the dryland areas of India and is quoted in Ayurvedic literature (Rawat 1995; Sidhu 1995; Sreekantaiah unpublished). In Tamil Nadu, the palm tree Nera *(Borassus flabellifer)* has been praised for its 801 uses in a Tamil poem from the medieval period, the 'Tala Vilasam' (Lubeigt 2001).

These few examples of tree uses, wood and non-wood products and services, are representative of the importance Indian farmers give to their various trees planted or kept on croplands or grazing lands and exploited since immemorial time.

The diversity of products and services corresponds to the different needs, constraints and strategies of rural societies, be they economic, social or religious, or even environmental. It may considerably vary from one site to another, making species and their uses site-specific and the agroforestry systems complex by nature.

Traditional agroforestry system and socio-economic changes

Tree uses may also vary with time and accordingly, traditional agroforestry systems, like any other system, are indeed subject to adaptation or disappearance. Demographic and economic conditions may notably induce drastic changes in the livelihood of rural communities and directly affect agroforestry systems and landscapes.

This is the case for shifting cultivation, a once common cropping system of semi-nomadic population in the tropical forest zone. In the mountains of north-east India, the system locally called "jhum" by tribals is based on slashing and burning of the natural vegetation which, after a short period of cultivation, is allowed to re-grow for thirty to sixty years in its longest cycle. But under demographic pressure, the cycle has been shortened from 2 to 3 years, which provides insufficient slash material and has meant change to sedentary systems of agriculture at the expense of forest and soil sustainability (Ramakrishnan 1998).

At a different scale, but within a similar context of socio-economic changes, a comparable trend can be observed when analyzing the effects of the Green Revolution of the 70s. Whereas the agro-technical progress of this unprecedented agricultural shift has undoubtedly enabled India to feed

1 Although agroforestry research-development has been carried out in various centres in India for 20 years and a strong impetus has been given, notably through ICAR, the National Research Centre for Agroforestry, Jhansi (Pathak *et al.* 2000) and NGOs, foresters, agriculturalists, social scientists and other concerned scientists rarely interact.

its huge population, notably by increasing crop productivity and extending croplands, the massive use of chemicals, the promotion of selected varieties and mechanization and irrigation have led to the mismanagement of natural resources, viz. soil, water and trees. The ecological importance of indigenous trees has been ignored by eliminating them from the landscapes or simplifying the floristic composition and structure of traditional farming systems. In mountain areas, such as the western ghats, deforestation and the uncontrolled development of agriculture have induced an unprecedented risk of water dysfunctionning in the downstream commanded plains (the Cauvery watershed area, for example). This is why a "Doubly Green Revolution" is now proposed by scientists to define new environment-friendly technical and policy models where agroforestry appears to be a major avenue of reconciling agricultural productivity and sustainable management of natural resources (Griffon & Mallet 1999). This involves the many roles trees are able to play in land use systems (farming systems, grazing lands, etc.) and the benefits they may provide in site-specific conditions.

Biodiversity and multi-production of forest-based agroforestry systems

Environmental and agro-ecological functions of trees (soil protection, water control, soil fertility maintenance, conservation of biodiversity, etc.) as well as their various functions of production (wood, food, fodder, medicines, etc.) are remarkably expressed in agroforestry systems derived from forests, such as the coffee based-system of the Coorg District, Karnataka, or imitating them, such as the home gardens of Kerala, in the western ghats.

The homegardens of Kerala

The home gardens of Kerala constitute the predominant farming systems of the state (Guillerme 1999). They are small in size (more or less 0.5 ha) and traditionally coconut-based, *Cocos nucifera* still being widely used for food, energy and building materials. Home gardens are typically multi-strata systems characterized by a high density and diversity of the tree component. Density is commonly found between 400 to 800 trees, shrubs and palms per hectare and the number of species is more than 120 according to various surveys (Mohan Kumar *et al.* 1994; Nair & Krishnamurthy 1984), although floristic composition and density may vary significantly at plot level according to site conditions and farmers' needs and strategies.

Although the diversity of Keralese home gardens is not as high as the diversity of evergreen forests of the western ghats (the Simpson Index varies from 0.44 to 0.86, against 0.90 according to Mohan Kumar *et al.* 1994 and Jose 1992) and partly differs in terms of floristic composition (exotic and domesticated species such as fruit trees are common in homegardens), it is interesting to point out that the highest densities and indices of diversity are found in the smallest home gardens. The medium and large homesteads, which have been massively integrating rubber trees (*Hevea brasiliensis*) for a generation, at the expense of tree diversity, have clearly been making trade-offs between subsistence crops and cash crops (Jose 1992). Conversely, small home gardens correspond to the farmers' strategy to reduce risk and achieve food security, an unvoidable strategy for the dominant category of small and marginal farmers of Kerala in a context of high demographic pressure on natural resources (Kerala is one of the most densely populated states of India with 750 inhabitants km^{-2}).

Home garden systems also record greater total canopy coverage (130 to 150% as a total of lower, medium and upper stratas; Jose 1992). Accordingly, soil erosion levels are remarkably low (1 t ha^{-1} yr^{-1}), given the high rainfall and steep slopes of the medium altitude environment of these home gradens (Moench 1991). Interestingly, when comparing successive developmental stages of land use systems based on forest clearing -which is still a common practice in the forests of India, be they protected or not- organic matter appears to rebuild to high and sustainable levels in well-established agroforestry systems and more efficiently than in other ones, thanks to the capacity of trees to build soil fertility.

The other main characteristic of the home gardens is their high productivity and diversity of production to satisfy the primary needs of the farmers: food (with the exception of rice which is cultivated in adjacent valleys), fuel, timber and cash (Nair & Sreedharan 1986). According to various surveys and apart from the coconut, the domi-

nant woody perrenial crops include: arecanut (*Areca catechu*), the betel-nut used as a masticatory, black pepper (Kerala being the first producer in the world, thanks to its home gardens), the rubber tree (*Hevea brasiliensis*), the cashew nut (*Anacardium occidentale*), the jackfruit (*Artocarpus heterophyllus*) and its wild variety used as a valuable timber (*Artocarpus hirsutus*), fruit trees, mango (*Mangifera indica*) and tamarind (*Tamarindus indica*), many other wood species such as teak (*Tectona grandis*), *Ailanthus triphysa*, a commercial soft wood used in the match industry, and legume trees like *Erythrina indica*, a fast-growing species commonly used to trail and shade pepper vines and maintain soil fertility. According to Krishnankutty (1990), the home gardens of Kerala provide some 80% of the total wood requirements of the state, mostly its firewood, while timber is supplemented by imports. Therefore, home gardens appear to be an appropriate way to reduce pressure on natural forests and contribute to the environmental balance of this fragile mountain area. Nevertheless, since the Ministry of Environment and Forests imposed in the 80s a ban on tree felling in the reserved and protected forests of India, home gardens are in their turn excessively pressured to satisfy the increasing demand in wood, and one may ask whether the system will be able to follow this trend if additional intensification and adapted management is not promoted in the near future.

The coffee-based system of Coorg

Since the introduction of coffee by the British in the mid nineteenth century, a comparable multi-strata system has developed in Coorg, Karnataka, at the expense of the evergreen and wet deciduous forests. The coffee-based system is cash crop oriented, initially developed with *Coffea arabica*, which notably requires shade, low variation of temperature and good soil fertility, all requirements the forest can meet. Through a selective clearing of the forest, an appropriate number of trees is kept and managed to control shade, with additional plantations of trees, if necessary. In this system, tree and coffee canopies appear as an efficient cover to control soil erosion, which naturally develops on steep slopes, and of weed development. Trees provide a quite important amount of organic matter to the benefit of the coffee, as well as wood, fodder, fruits and other by-products to the farmers who are, for the most part smallholders (having less than 2 ha). Since the liberalization of coffee prices, in 1992, and following a considerable increase in prices, coffee plantations have been extended by 30%. They today cover 20% of the total area of the district. Productivity has increased by 100%, thanks notably to performing varieties of *Coffea robusta*, which has emerged as the dominant coffee species and made Coorg the first zone of coffee production in India. One major trait of this change is that *Coffea robusta* does not require the same amount of shade as *Coffea arabica* (25% as opposed to 50%), and some new varieties even require no shade at all.

As a consequence, and in addition to the fact that the forest area of Coorg has dropped to 30% (compared with 50%, 25 years ago), the tree component of the coffee-based system has been directly affected in its structure and floristic composition. Tree densities have progressively reduced and tree canopies are severely lopped. In a survey carried out by Desjeux (1999), tree density varies greatly according to the variety of coffee, but also with the age of the coffee plantation, the size of the trees and the site, from 285 to 1471 trees per hectare. These figures are comparable to the densities observed in the surrounding deciduous and evergreen forests of Coorg. If biodiversity remains globally high (Simpson Index: 0.8 to 0.9), it may be locally low at plot level because of the increasing number of exotic species competing with the local species. *Erythrina sumbubrans* and *Grevillea robusta*, two fast-growing species, are among the most commonly planted species for coffee shading -and also for trail pepper vines, the second cash crop of the system-, before *Clerodendron viscosum*, *Mangifera indica*, *Olea dioica*, *Litsea floribunda* and *Artocarpus heterophyllus* in the evergreen forest zone, and before *Sapindus laurifolia*, *Artocarpus heterophyllus*, *Acrocarpus fraxinifollius*, *Ficus racemos*a, *Dalbergia latifolia* and *Citrus reticulata* (mandarin, a progressively forsaken tree crop) in the wet deciduous forest zone. In this zone, recent coffee plantations of *robusta* are shaded by only one or two exotic species, constituting an extreme in the floristic composition of the system, the structure of which comprises one or two strata of trees, whereas it is two to three in the "traditional" system. Moreover, in the latter, trees which are lopped every year to control shade, are able to satisfy farmers' needs, entirely

for fuel wood (approx. 2 m^3/year/homestead) and partly for timber and service wood. This clearly cannnot be the case with a mono-specific shading cover made of *Erythrina sumbumbrans*. The shift from a long-run management system based on the high diversity and multiple uses of the tree component toward a simplified and short-term profitable system -strictly devoted to cash crops- is, therefore, indeed highly questionable in terms of sustainabilty.

Multipurpose trees to bridge environmental and socio-economic issues in the drylands of India

Drylands cover considerable areas in peninsular India, in its north-western, central and southern parts, where trees may be observed in many different farming systems and spatial arrangements in the agrarian landscapes: associated with irrigated or rainfed cropping systems, in agri-silvicultural or silvipastoral systems, scattered on farmlands, along farm boundaries, around plots (live fences, windbreaks, etc…), or on bunds (paddy fields), in woodlots -which is a more recent way of planting trees as a reply to the recurrent shortage of fuel wood and the demand in poles for building materials and pulpwood. Trees around homesteads are not rare, although comparable with home gardens of the humid zone, and trees for fodder, fuel wood (*Prosopis juliflora*, for example) as well as other uses on rangelands and wastelands, are not negligible due to the area these lands cover in arid and semi-arid zones. Whether trees for multiple and traditional uses with multiplier effects in the activities of households, promoting rural industries and employment, or species with limited scope such as the *Eucalyptus*, they all appear through their various management practices to be extremely important for the fragile environment they help to protect and the economy of the local populations (Pathak *et al.* 2000). Because of the scarcity of water, low productivity of soils, shortage of wood, food and fodder, and the low level of farmers' revenue which characterize the drylands of India, trees have a considerable scope for soil and water conservation, including soil fertility maintenance and resaturation of degraded lands, diversification of revenues, promotion of marketable products, woody and non-wood products and, finally, alleviation of poverty.

Traditional knowledge of trees and use of non-wood products: the cases of the neem tree and palmyra, and the Kejhri model

Neem, nature's drugstore

Neem (*Azadirachta indica*) is one of the most cultivated trees, accounting for 14 million individuals in most parts of India, except in high and cold regions (Sidhu 1995). It is also one of the most valuable multipurpose trees of the arid and semi-arid zones, particularly valued for the basic needs of rural households, like medicines (anti-allergic, anti-fungal, anti-inflammatory, cardiac, diuretic, etc.), pesticides, nematicides, insect repellent, fertilizers, fodder, soaps, lubricants, tooth brushes, etc. As mentioned by Rawat (1995), it is truly nature's drugstore. As the species is a good source of chemicals (alkaloids) for use in pest management, and as modern agriculture is based on the uncontrolled use of synthetic pesticides with toxicity for the environment and residual effects, there is a good scope for promoting biodegradable products of the neem tree as an efficient and cheap alternative.

In addition to this, the species is drought tolerant, easy to propagate and manage in a large variety of edaphic conditions, able to rapidly provide a sufficient quantity of active ingredients from its leaves (fodder, medicinal uses, insect repellent), seeds and oil from them, which is the major non-wood product. From it, the active compound azadirachtin is extracted for medicinal and nematicidal purposes, soap, toothpaste and cosmetics. Seed cake, the main by-product, is an excellent organic manure with insect repellent and nematicide properties. Many other medicinal properties have been registered from its bark, gum and flowers (Rawat 1995; Sas Biswas *et al.* 1995). Finally, the wood, which is a durable one, is largely used for house and boat construction, furniture, agricultural tools and crafts. It is also a good fuel wood and an excellent shade tree for man and livestock during the dry season. For all these reasons, and most particularly for its non-wood products, the neem tree is subject to an increasing attention from research, with priorities concentrated on the genetic selection and improvement of the species (particularly of its medicinal and pesticidal proper-

ties) to get the best value-added products (with export potential) which in return should benefit the small farmers. In this perspective, new models of agroforestry systems which integrate selected neem trees, product exploitation and pest management have to be promoted. In arid and semi-arid lands where drought and soil erosion is affecting crop yields, attention should be given to windbreaks and shelterbelts composed with neem and possibly other species and to its management with the protected crops.

The sugar palm tree (Borassus flabellifer)

Borassus flabellifer or palmyra is one of the most common sugar palm trees of South and South-East Asia. In Tamil Nadu where it is named Nera, this palm tree is extensively planted or transplanted in the croplands and wastelands of the coastal areas. Because of its high and narrow canopy and limited rooting system the species may be associated with crops in rainfed systems, but it is also propagated on irrigated lands, on bunds of paddy fields and dikes of dams and water tanks. In all cases, palm trees are usually managed on lines at narrow spacings and require almost no care once they have been planted. One of the main uses of Nera is for its sap extracted from the inflorescences regularly cut in the season (6 months) to traditionally make alcohol (toddy) and sugar (jaggery) products which are locally commercialized. The management of Nera, the exploitation of its sap and its processing in sugar, belong to different stakeholders. Thus, the owner of a grove of palmyras will rent them to a sap tapper, who is exclusively a Naddar, whereas sugar will be made by another player and toddy will be sold by someone else, who is the owner of a toddy shop (from the Grammany caste) with whom the tapper has made a deal. To complicate the system, the sale of toddy is forbidden in Tamil Nadu, but still authorized in Pondicherry territory. Accordingly, and apart from the fact that alcohol from Nera continues to be illegaly commercialized in Tamil Nadu, the future of the palmyra appears today highly compromised. First, because there are less and less sap tapers who want to do such a low-profit and dangerous job (tree climbing). Consequently, sugar makers are less numerous as they now collect lower quantities of fermented sap and because sugar cane is preferred to jaggery, at equivalent sales prices. Finally, as palmyra owners are less and less concerned by the multiple uses and benefits they may get from it, palm groves are insufficiently regenerated or even cut to get immediate profit from the sale of the trunks. As Nera "wood" is cheap and extremely durable, it is used as building material (roofs, shelters). Other important commercial products of the palmyra are obtained from the leaves to make baskets, mats, etc. providing incomes to the women often employed by "palm-leaf" co-operatives. Women also collect the ligneous rachises of the Nera leaves which are used as firewood, as are the rachises of coconut leaves. To complete this review of the main uses of the Nera, one should mention the consumption or commercialization of the edible immature seeds and germinated seeds, at the local level. But these products, be they of economic or social importance, will certainly not be enough to maintain the palmyra in the landscapes of Tamil Nadu unless a renewed interest is brought to its ecological and economic roles (for example, processing and marketing of new products).

The Khejri (Prosopis cineraria) *model*

Prosopis cineraria in Rajasthan, as *Faidherbia albida* (syn. *Acacia albida*) in Sahelian Africa (Depomier *et al.* 1992; Mallet *et al.* 2000), are the kingpins of a traditional agroforestry system at the interface between rainfed agriculture, silviculture and pastoralism. The species known as Khejri is a versatile multipurpose tree which provides fodder (leaves and pods of high digestibility and nutritive value), fuel wood (high calorific value), thorny twigs as fencing materials, medicinal products from its bark and various other specific secondary products (food, crafts, etc.). The tree, which is drought resistant thanks to its long tap root system, which can draw water in the deepest layers of the soil, is also well-known for its ability to maintain soil fertility. It is, therefore, an appropriate low competitive species of a subsistence system developed in areas where rainfall ranges from 100 to 350 mm per year. In Rajasthan, trees are propagated in a scattered way (sometimes on boundaries) in association with cereals and pulses at a density of 5 to 80 trees per hectare (Tejwani 1994). Khejri is a slow-growing species in its early stage, with low fodder production and limited fertility effects before 10 years. Farmers continue to maintain it in their fields to sustain crop production and feed their livestock, the droppings of

which will, in return, contribute to the maintenance of the fertility of the soil. Being an efficient and still thriving traditional agroforestry system, the Khejri system should be improved, notably at the tree level (selection of the best provenances and genetic improvement are currently done by the CAZRI) and at the level of its management (ideal density, effect of high-intensity lopping for fodder on fertility maintenance, best combinations of tree-crops).

Commercial trees on croplands: teak and other woody perennials

Agroforestry systems are neither exclusively traditional nor strictly multipurpose oriented. This is the case of poplar (*Populus deltoides*), a fast-growing species planted in association with wheat, sugar cane and other crops in the alluvial plains of North India. The tree, which is usually planted at wide spacings on lines within the plots and on boundaries (or in woodlots), provides a soft wood for pulp and plywood industries and high returns to the farmers in a short rotational period of less than 10 years. As the reduction in crop yields (up to 50%) is largely compensated by the profit obtained from the sale of poplars, such technically feasible and financially viable plantations under "modern" agroforestry schemes are currently encouraged through bank loans offered to the farmers.

Similar developments of commercial trees planted on boundaries or woodlots have been observed in the drylands of Tamil Nadu for 20 to 30 years and mainly in coastal areas, with *Casuarina equisetifolia*, and more recently (10 to 20 years) on irrigated lands, with teak (*Tectona grandis*). The latter has brought a renewed interest in the private lands of South India due to the increasing demand for teakwood. This includes small logs and, therefore, can be produced in a rotation of 20 to 25 years which may be 15 to 20 years if performing germplasm and appropriate silvicultural backstopping are provided to the farmers. In a survey carried out by Demenois *et al.* (2002), small farmers are planting teak in small numbers on boundaries (62%) or greater numbers in woodlots (38%) at narrow spacings (usually at 1 to 2m). Irrigation is provided to the trees at least during the first years when in blocks, and every year in the case of alignments. Accordingly, growth of teak trees when properly managed (fertilized at the planting time, regularly weeded and pruned in early stages) may be very fast, up to 20 cm diameter in 10 years. Meanwhile, growth performance and the form of the trunk (straightness, branchless) may vary significantly according to site and management conditions and also according to germplasm, which is poor in many cases. In addition to that, a quick growth of teak is synonymous with lower quality wood and particularly with a large quantity of sapwood which cannot be marketed at the same high prices as the wood of larger teak slowly grown in natural forests or long rotational plantations. Nevertheless, the teakwood from the private lands of Tamil Nadu in the coming years will be comparable to the small logs of teak currently massively imported from West Africa and South America, and will, therefore, compete with it. As the Indian demand for teakwood, and particularly for "cheap teakwood", is expected to increase, there is potentially much room for it, at least on regional and local markets. In this perspective, one of the main constraint remains the rules and regulations applied to teak and doubtless to other local species of commercial interest. The dynamics of private teak plantations and the promotion of its wood in the Indian market will depend largely on *ad hoc* forest policy, notably if the system of authorization from the Forest Department for cutting trees and transporting the wood without restrictions can be simplified. One may be certain that encouraging such profitable tree farming will contribute to reducing the pressure on forests and sustain rural development.

Mangroves as a multipurpose ecosystem

Mangroves may be considered as peculiar agroforestry systems or, more precisely, aquaforestry systems, associating animal components (fish, prawns, crabs, shells, etc.) with a specific flora of trees and shrubs developed in the intertidal zone of coastal areas and sheltering larvae and immature individuals of this fauna. Mangroves are considered to constitute one of the most productive ecosystems and, as such, are multipurpose but also complex and fragile ecosystems. Because of their faunal and floristic richness, mangroves have been over-exploited, notably for their wood by the local population of fishermen. This is the case for the mangrove of Kakinada, Andhra Pradesh, where

trees (*Avicennia* sp., *Excoecaria agallocha* and *Lumnitzera racemosa*, in particular) constitute the main source of fuel wood and are still an important source of materials in the building of traditional houses, shelters and fences, in spite of the interdiction to cut trees imposed by the Forest Department.

As a consequence of the strong pressure exerted on mangroves, big trees are rare, having been exploited long ago, and some species have become endangered due to the lack of regeneration, whereas others with good coppicing ability appear to have a better resilience. As noticed by Collin *et al.* (2002), large gaps inside the groves -beyond the visible front line of trees lying along the waterways- can be observed; and on the other hand, species such as the spiny scrub *Acanthus ilicifolius* are invading large areas and, therefore, making fishing zones in accessible to the fishermen and their nets. Exploitation of the mangrove varies also according to the distance from the villages; the shorter the distance, the greater is the exploitation and disturbance of the tree stands, in terms of sanitary conditions and dynamics. The influence of other human activities, grazing and trampling by livestock (buffaloes), are additional sources of degradation. Though more and more people are using new building materials for their houses and gas or kerosene stoves rather than mangrove wood, the change does not concern the poorest fishermen, whose dependency on the mangrove should not be less in the near future. Regarding the fish and prawn resources extracted from the mangroves, which are of first importance for this population, this dependency could be drastically threatened by the unconsidered development of prawn cultivation which has taken place at the expense of the mangrove itself, and can be compared to the Green Revolution in its blue version, immediately profitable but not sustainable.

Conclusions

The traditional ecological knowledge of farmers concerning agroforesty systems and multiple uses of indigenous trees is eroding with socio-economic changes and the development of rural societies in India, as in other developing countries. But the trend differs according to various factors: notably agro-ecological conditions, demographic pressure and access to the market. In the most fragile zones, mountains and dryland areas, where thriving traditional tree-based systems still exist, the dynamics of social forestry, including the improvement of existing agroforestry systems or the development of new agroforestry models, can be easily promoted. In this context, gaps in basic knowledge of MPTs and the functioning of systems must be surveyed and analysed by researchers[2] and developers to build up a sustainable management.

References

Collin, S., C. Plaza, D. Depommier, F. Dahdouh-Guebas, J. Prosperi & N. Koedam. 2002. Multiple uses, wood supplying and fishery-related importance of the Coringa mangrove, East Godavari, Andhra Pradesh. *Proceedings of the National Seminar on Conservation of Eastern Ghats*. March 24-26, 2002, Tirupati, Andhra Pradesh, EPTRI.

Demenois, J., A. Heurtaux & D. Depommier. 2001. Managerial and legal issues of teak plantations in the farmlands of South India. *Proceedings of the National Workshop on Policy & Legal Issues in Cultivation & Utilization of Bamboo, Rattan and Forest Trees in Private & Community Lands*. August 7-9, 2001, KFRI, Peechi.

Depommier, D., E. Janodet & R. Oliver. 1992. *Faidherbia albida* parks and their influence on soils and crops at Watinoma, Burkina Faso. pp. 111-115. *In*: R.J. Vandenbeldt (ed.) *Proceedings of the International Workshop on Faidherbia albida in the West African Semi Arid Tropics*. April 22-26, 1991, Niamey, Niger, ICRISAT/ICRAF.

Desjeux, Y. 1999. *Contribution des arbres d'ombrages des caféiers à l'approvisionnement en bois de feu des petits planteurs du Coorg, (Karnataka, Inde du Sud)*, Mémoire de fin d'études, ENITA.

Griffon, M. & B. Mallet. 1999. En quoi l'agroforesterie peut-elle contribuer à la révolution doublement verte, *BFT* **260**: 41-52.

Guillerme, S. 1999. Pratiques agroforestières et stratégies paysannes au Kérala (Inde): dynamique rurale en contexte de forte pression démographique, Thèse de doctorat en géographie, University Paris.

Jose, D. 1992. Structure and productivity of the homegardens of Kerala: a case study. pp. 17-19. *In:*

2 The IFP is currently finalizing a data base on the MPTs and Agroforestry systems of South India at agro-ecological level and from surveys carried out at a farm level. It is to be developed in an illustrated CD-ROM and as a primary source of information for the diagnosis and design (modeling) of appropriate technologies in agroforestry and MPTs management.

C.G.R. Ramachandran Nair (ed.) *Proceedings of the Fourth Kerala Science Congress.* Feb. 27-29, 1992, Thrissur, Science, Technology and Environment Department of Kerala, Thiruvananthapuram.

Krishnankutty, C.N. 1990. Demand and supply of wood in Kerala and their future trends. KFRI, Report 67.

Lubeigt, G. 2001. Une civilisation du palmier à sucre en Asie. *Le Courrier du CNRS* **44**: 24-35.

Moench, M. 1991. Soil erosion under a successional agroforestry sequence: a case study from Idukki District, Kerala, India. *Agroforestry Systems* **15**: 31-50.

Mohan Kumar, B., G. Suman Jacob & S. Chinnamani. 1994. Diversity, structure and standing stock of wood in the homegardens of Kerala in penninsular India. *Agroforestry Systems* **25**: 243-262.

Nair, C.T.S. & C.N. Krishnankutty. 1984. Socio-economic factors influencing farm forestry. A case study of tree cropping in the homesteads in Kerala, India. Paper presented at the EWC/FAO Workshop on socio-economic aspects of social forestry in the Asia –Pacific region, Bangkok.

Nair, M.A. & C. Sreedharan. 1986. Agroforestry farming systems in the homesteads of Kerala, Southern India. *Agroforestry Systems* **4**: 339-363.

Pathak, P.S., H.M. Pateria & K.R. Solanki. 2000. *Agroforestry Systems in India. A Diagnosis and Design Approach*. ICAR/NRCAF, Jhansi, Mini Printers.

Ramakrishnan, P.S. 1998. Sustainable development, climate change and tropical rain forest landscape. *Climatic Change* **39**: 583-600.

Rawat, G.S. 1995. Neem *(Azadirachta indica)* -Nature's drugstore. *The Indian Forester* **121**: 977-980.

Sas Biswas, P. Singh & S. Chandra. 1995. Neem (*Azadirachta indica* A. Juss.) - A versatile multipurpose tree. *The Indian Forester* **121**: 1057-1062.

Sidhu, D.S. 1995. Neem in agroforestry as a source of plant derived chemicals for pest management. *The Indian Forester* **121**: 1012-1021.

Tejwani, K.G. 1994. *Agroforestry In India.* Oxford & IBH Publishing Co. Pvt. Ltd.