PART TWO

Trees outside forests, transmitting a universal lore

Case studies

Photo 47. Woodlot within a barley field (© Jones/FAO)

Responsibility of the authors

The definitions used in these case studies vary from one country to the next, reflecting national legal, institutional and technical diversities, and thus the definitions, terminology and statistics of the forest resource assessment programme vary as well.

Trees Outside Forests: Costa Rica

David Morales Hidalgo and Christopher Kleinn
Tropical Agricultural Research and Training Centre (CATIE)

Photo 48. Growing coffee under shade. Costa Rica (© Harmand/Cirad)

Context

The latest land use survey, done by the National Meteorological Institute in 1992, showed that 54.08 percent of the national territory is covered by primary and secondary forest; 32.32 percent is used for livestock production; and agriculture, infrastructure and water account for the remaining 13.6 percent (NMI *et al*, 1992).

The international market for meat brought about considerable change in forest cover over time as livestock production activities steadily pushed back the forest frontier. When the market for meat fell in the nineties, secondary forest regenerated on rangelands no longer used for grazing.

Tree systems outside forests, in addition to their ecological importance in carbon sequestration, account for over half of wood production in Costa Rica. It is therefore imperative to conserve and enhance them. With this in mind, the regional project TROF: *Tree Resources outside Forests* worked out a methodology to inventory and monitor these resources.

Concept

Forests (and hence Trees outside forests) are defined differently in Costa Rica depending on the sector involved. The definition may be legal, technical, environmental, or other, which makes it harder to compare the various studies of forest and crown cover. There are also no explicit criteria for the definition of terms such as natural forest, secondary forest, and unlogged forest.

Forest law, which comes under the Ministry of Energy and Environment (MINAE: *Ministerio del Ambiente y Energia* responsible for the application of forest laws and regulations, defines the forest as “an original or autochthonous ecosystem, logged or not, regenerated naturally or silviculturally, covering two or more ha, and characterized by the presence of uneven-aged mature trees of various species and sizes, with one or more stories, a crown cover of at least 70 percent, and including at least 70[19] trees/ha with a minimum dbh of 15 cm" (Forest Law 7575, Article 3).

A typology has been devised for tree systems outside the forest (Kleinn, 1999; Morales, 1999). It makes a distinction between tree formations lying outside natural forests and under two ha in area, and tree formations that are the result of human activity. Eight categories have been classified as follows: agroforestry systems, scattered trees in pastures, line planting, trees growing among permanent crops, trees growing among annual crops, windbreaks, living fences, and trees growing in built-up areas. Silvopastoral systems are in the statistical forefront with coverage of 30.22 percent of the territory, followed by seasonal crops at 2.57 percent, coffee plantations at 2.11 percent, and palm groves at 0.56 percent, orange groves at 0.48 percent and mango at 0.12 percent (NMI, 1996; MAG, 2000).

Patterns and extent of change

The pattern of change in tree systems outside forests is closely linked to a land privatization process which fostered deforestation. Under decolonization, title could be granted only to land acknowledged as productive land, which meant that it had to be cleared prior to use. Successive governments upheld this provision, maintaining the rule that land title was to be conferred only on land free of forests. It is also true that with the arrival of the first Europeans, forests were cut back to provide land for livestock production – first to meet local demand and, subsequently, to supply foreign markets. The 1961-1995 data on land use show that forest land shrank from some 3 240 00 ha to 1 569 000 ha during that period, whereas rangeland rose from 915 000 ha to 2 330 000 ha (FAOSTAT). Grasslands, which in l961 represented only 18 percent of the territory in 1961, covered over 45 percent by 1990.

Other causes of deforestation, in addition to the expansion of the agricultural and livestock frontiers, were unauthorized logging, forest fires, credit policies and urbanization. According to González and Lobo, 1999, deforestation rose to an annual 50 000 ha in the years between 1950 and 1990. Studies done in 1967 and in 1977 provided estimates of the area of the various tree formations and the density of tree cover. In 1967, 48 percent of the country was forested with a crown cover of 90 percent, whereas the same parameters were 33 and 81 percent by the year 1977. Regression of the cover of virtually all tree resources was also noted (Table 9).

The literature on the economic, ecological and social scope of Trees outside forests is rather scant. It is known, however, that 43.43 percent of the total volume of wood harvested in 1990 came from this resource. By 1998, this figure had risen to 51.58 percent (Gonzàlez, Lobo, 1999). The trend is bound to accentuate in that mature forest resources are increasingly limited. Wood resources currently supply 18.4 percent of the energy produced (Central Bank of Costa Rica, 2000). In economic terms, trees not growing in forests contribute 0.38 percent of GDP. Coffee production represents 26.93 percent of the aggregate value of the agricultural sector and bananas 18.49 percent, with the forest sector contribution estimated at 8.92 percent (McKenzie, 2000). In the 1980s, the agricultural sector accounted for 20 percent of GDP, of which one-fifth to one-quarter from the meat sub-sector (Pérez, 1995).

1. Freely translated.

Table 9: Comparison of forest cover in 1967 and 1977

Category	1967					1977				
	Tree cover		Density	Crown cover		Tree cover		Density	Crown cover	
	km²	%	%	km²	%	km²	%	%	km²	%
I	3 628	7,1	5,6	2 03,2	0,7	5 220	10,2	1,4	73,1	0,4
II	13 337	26,1	21,1	2 814,1	9,7	18 947	37,1	12,4	2 349,4	12,0
III	7 716	15,1	50,3	3 881,1	13,4	7 857	15,4	45,1	3 543,5	18,1
IV	24 528	48,1	90,3	22 148,8	76,3	16 806	32,9	81,1	13 629,7	69,6
V	1 891	3,7	0,0	0,0	0,0	2 270	4,4	0,0	0,0	0,0
Total	51 100	100,0				51 100	100,0			

Source: Sylvander, 1981, in Kleinn, 1999
Cat. I Zones with few or no trees, used for agriculture and/or livestock;
Cat. II Zones with scattered trees and small forest formations used primarily for agriculture or livestock;
Cat. III Zones with large forest formations and farmland or grasslands;
Cat. IV Zones entirely or mostly covered by forest;
Cat. V Zones covered by mangrove, palm or mountain shrub.
Categories I, II and III include mostly Trees outside forests.

Various tree species have been used in non-forest tree systems to improve soil fertility, *inter alia* in silvopastoral schemes (Russo, 1981; Canet, 1986). Trees outside forests also play a role in biodiversity: 79 different species have been identified in an area of 25 000 ha of pasture (COSEFORMA, 1995). Line planting, windbreaks, living fences and other pasture borders are introduced systems which nature often alters over time. The species composition of these systems depends partly on the environmental circumstances and farmer preferences, but mainly on the availability of nursery seeds and seedlings. Line planting in corridors influences herd movements and seedling distribution (Burel, 1996, cited in Camero *et al,* 2000). Such systems act as biological corridors, which are essential in an agricultural landscape characterized by fragmented ecosystems.

Institutional and management aspects

Natural resources are regulated by legislation covering wildlife, national parks and biodiversity, in addition to forest law. However, these legal instruments are not designed to regulate the management of trees outside forests – though forest law does devote the most attention to the issue, as it specifically regulates the management and use of agroforestry systems. It is important to point out that the Government supports tree resource management through financial incentives to forest and forest plantation owners. Trees not growing in forest areas are neither specifically nor adequately covered by these measures, and so they tend to be sidelined, and, over time, degraded.

A certain amount of data has been produced on trees outside forests in recent years, particularly in agroforestry systems. CATIE, the Tropical Agricultural Research and Training Centre in Turrialba, has been working on the topic for years. In collaboration with universities and with the Ministry of Agriculture and Livestock, CATIE has given priority to the development of agroforestry. The emergence of a national development and management policy for this invaluable but as yet little-documented resource would be greatly favoured by increased and accessible information on the subject.

Farmers and livestock producers, who improve the countryside by planting trees along rivers and streams, living fences around their holdings, windbreaks, trees in vegetable gardens, and the like, are aware that this is an economically profitable and ecologically viable resource. It is worth pointing out that the economic and cultural background of farmers and stockowners has a bearing on the importance they attach to these trees.

Assessment and Planning

Most of the completed inventories of tree systems outside forests have focussed on agroforestry systems at the smallholder level. They cover small areas, use random or systematic sampling systems, and gather data on circular or rectangular sampling plots.

There have been a few inventories covering larger areas, such as a 1981 inventory based on aerial photographs which systematically sampled 1 km^2 plots throughout the country (Sylvander, 1981). In 1995, natural forests in the Huetar Norte region and rangelands with six or more trees/hectare were assessed using clusters of sample plots forming a scheme of sampling points covering this region (COSEFORMA, 1995). Another inventory covered on-farm trees, based on a sampling of holdings (Van Leeuwen and Hofslede, 1995; Harvey and Haver, 1999). In 2000, the TROF project inventoried 10 000 representative hectares in the Pacìfico Norte region, systematically selecting 5 100 ha sub-plots on which all trees were counted.

The results of these studies remained in the technical domain, the data untapped by policy makers, who need to be made aware of the significance of these resources and provided with the country-wide numerical data they would need for planning.

TROF Inventory Project in Central America

The TROF Project covering the Central American region has been in operation since 1998. Implemented by the MAG in collaboration with CATIE and the University of Fribourg in Germany, its dual objective is to formalize an inventory and monitoring methodology and to disseminate the ensuing data.

The inventory is now completed. The two-stage sample was the method deemed most appropriate for trees growing outside forests. The recommended application of this sampling method is to pre-select the sampling sites (primary units of 1 km x 1 km) based on existing data, followed by sample plots on the ground as secondary units, in proportion to the tree cover of the resource, assuming the presence of Trees outside forests as the most relevant variable.

The ideal situation would be pre-stratification based on the segmentation and fusion of a LandSat image with an IRS image, (a process to be developed by the TROF Project), enabling a stratification of densities. Subsequently, in accordance with the rules concerning sample size, the primary units would be selected, and, within each, the secondary units.

The methodology was tested on silvopastoral systems because they are so extensive in Costa Rica. The inventory was done near Cañas in Guanacaste in the dry northern Pacific region on an overall area of 294.33 ha (cf. table 10). All trees with a dbh of 10 cm or more and a mean height of at least 5 m. were counted. The height limit selected for living fences was 1.3 m.

In 2000 the TROF Project worked on the development of the final stage of the sample. The job involved analyzing and simulating different probability sampling methods. Some results are already available and the method is now being tested. The experience acquired by the TROF Project should help identify the necessary methodological and operational components for a successful inventory of trees outside forests.

Plot size must be considered regardless of plot shape, and the plots have to be compact. In Central America, as indeed elsewhere, there tend to be many fairly

Table 10: Data summary from the inventory on pasture in Cañas, Guanacaste

Type of formation	Number of trees/ha	Ground area m^2/ha	Volume m^3/ha	Number of species
a. Undisturbed primary forest	235,00	25,56	191,94	46
b. Older secondary forest	308,00	19,62	101,63	37
c. High 'Tacotal'	202,2	7,03	26,14	24
d. Pasture not bordered by trees	9,25	1,34	5,02	69
e. Pasture bordered by trees	7,21	0,88	3,03	40
f. All pasture (d+e)	*16,46*	*2,22*	*8,05*	74
Ratio of pasture/forest (f/a x 100)	7,00 %	8,68 %	4,19 %	

Source: TROF Project, 2000

small holdings. This implies a time-consuming search for authorization to take ground measurements. One option is to use easily plotted, 50m x 50 m (or 100m x 100 m) square plots. All trees growing on these plots are measured and land use noted using a dot grid, or a point in the plot centre.

Where remote sensing is the chosen method, high resolution is essential due to frequent perceptual problems with satellite images of trees growing outside forests. Where aerial photographs are used, the preferred scale is 1:50 000 – 1:10 000 (though cost may be a constraint, as the TROF Project found). Due to the rapid pattern of change in these systems, the photographs should be recent. And for work on the ground, access to trees growing on privately owned land can be a further constraint. The heterogeneity of this kind of resource, its variable configuration and the diversification of its physiognomy further complicate the sampling process, necessitating different sampling intensities and different types of plots. Lastly, mindful that the definition of forests varies from one country to the next, the objective of the study needs to be constantly borne in mind.

The data from the inventory methodology tested in Costa Rica should make it easier for users and policy makers to include Trees outside forests in their development and management policies. The data are not only useful for regional interpretation, they might also serve to map non-forest tree resources, estimate stored carbon and volumes of wood, and identifiy tree species and biological corridors.

Conclusions

Trees outside forests are increasingly on the agenda. People are learning that, over time, this resource alone can meet wood and non-wood requirements in many countries. In Costa Rica these trees should be included on a more systematic and specific basis in both management and incentive policies for tree conservation conservation and regeneration, and in felling and harvesting regulations. Policies need to be devised to promote them, regulate their use and management, and establish cooperative links among all stakeholders affected by the future of trees outside forested areas.

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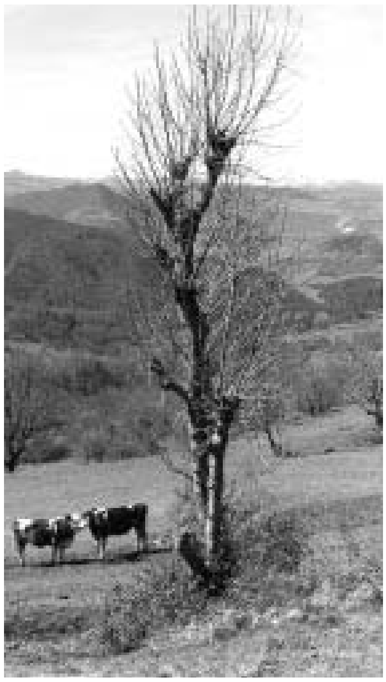

Photo 49. Pruned tree in Auvergne, France (© Bellefontaine/Cirad)

Trees outside forests: France

Thierry Bélouard
National Forest Inventory, Lattes, France

Frédéric Coulon
Solagro Association, Toulouse, France

Context

In the aftermath of World War Two, food self-sufficiency became the prime target of French agriculture. Farm mechanization developed as a means of intensifying production, with land consolidation as an instrumental component of mechanization. The ensuing rise in productivity was such as to produce agricultural surpluses and drive a rural/urban exodus, reinforced by the pull of the city lights. Compared to the year 1936, when half of the people of France lived in the countryside, three-fourths of today's population are now urban.

In this new farm context in which production had become more highly specialized, a great many agroforestry practices fell into disuse. Trees outside forests now cover only 1.7 million ha – which is three percent of the land area, compared to 4.5 million ha at the turn of the twentieth century. Nonetheless, trees remain remain a major component of the rural landscape, and as such are inventoried. They have gained renewed legitimacy from their environmental role and scenic impact, which is reflected in official policy and in the implementation of programmes to promote trees outside forests and support reforestation. The inventory of these tree systems under the NFI (National Forest Inventory - *inventaire forestier national)* is an illustration of efforts to boost awareness among stakeholders on this issue.

Concept

The two main entities monitoring trees outside forests in France are the NFI, which has been inventorying them since 1998, and SCEES, the Central Bureau of Surveys and Studies (*Service central des études et des enquetes)*, which has been running the Teruti land use survey, (*Utilisation du territoire)*, since 1981. A typology[20] of Trees outside forests was established based on these sources:

– Woodlots; wooded areas with > 10 percent forest cover, 500 to 5000 Ha;
– Line-planting; large, even-sized trees planted at regular intervals, in rows, with a special category for poplars;

2. The typology can vary somewhat depending on the data source.

– Hedgerows; compact linear formations of small trees, bushes and/or shrubs;
– Scattered trees – tree formations under 500m^2, including single trees;
– Fruit-tree meadows – fruit trees grown on permanent, productive grasslands;
– Orchards – fruit production on an area of at least 500 m^2.

Patterns and extent of change

The changing pattern of trees growing in non-forested areas of France is reflected in the various inventories done since the 1960s.

Hedgerows and scattered trees*:* The aggregate figure for hedgerow length dropped from 1 244 110 km to 707 605 km between 1975 and 1987 (Pointereau and Bazile, 1995). Hedgerow regression, repeated in 1981-1990, seems to have tapered off since 1992 to an annual figure of less than 0.3 percent (SCEES, 1999). A similar trend is reported for scattered trees. Found on 342 500 ha in 1998: the drop was less than 3.6 percent between 1993 and 1998. Trees planted in the last 20 years have not yet offset the large-scale elimination of scattered trees and hedgerows between 1960 and 1980.

Agroforestry areas*:* from 1982 to 1990, fruit-tree meadows shrank by nearly 20 percent, then by 30 percent from 1991 to 1998, and now cover only 163 000 ha. The Lower Normandy region lost 63 percent of its tree orchards from 1963 to 1990, a total of 8 million trees. At that rate, this type of formation would disappear by 2020. Moreover, tended walnut, olive and chestnut groves now cover only 36 000 ha, compared to a figure of 265 000 in 1929.

Photo 50. Trees lining rural roads are also under threat from agricultural intensification in France. (© Bellefontaine/Cirad)

Roadside trees*:* the aggregate linear length of roadside trees fell by 23 000 km from 1975 to 1987. This 42 percent drop amounted to some 3.5 million trees. While there has been a reported 14 percent increase in trees bordering roads since 1992, the frailty of this aging legacy is heightened by security constraints. It is also inadequately managed.

Agricultural modernization accounts for 52 percent of the drop in Trees outside forests. Land consolidation to facilitate mechanization has affected over 15 million ha since 1945. And 2.7 million ha of grasslands have been brought under the plough since 1970. Farm subsidies under the Common Agricultural Policy (CAP) for cereal crops favoured this transformation. At the same time, the “disappearance” of 40 percent of non-forest trees is attributable to agricultural set-asides and the incorporation of hedgerows into forest lands and wooded moors. Lastly, a small (eight percent) portion of this shrinkage can be traced to urbanization (Pointereau and Bazile, 1995). Because French forestry resources are not fully exploited, the development of off.forest tree systems is not encouraged. And though it contributes to the economy and helps to sustain ecosystems, this largely self-consumed or bartered resource appears to be part of an “underground economy”.

Farmers report a harvest of 4.4 millions m^3 of wood from hedgerows, which approaches the annual 4.5 million m^3 annual output of Trees outside forests

(Solagro, 1997. This amounts to 620 000 TOE/yr[21], or 11 percent of domestic fuelwood consumption. Not counted in this estimate are hedgerows harvested by private individuals and undeclared volumes of output. It would appear that TOF contribute some five percent of the total ouput of wood, although this is marginal lumber due to poor maintenance such as tree wounds or poor pruning, which compromises the quality of the product.

Fruit-tree meadows are a productive agricultural system. The traditional fruit-tree meadows of Lower Normandy supply 40 percent of the output of cider apples. The total figure comes to 300 000 tonnes and involves over 13 000 farmers. The income generated by a fruit tree orchard is four times that from a grassland in terms of milk and meat (Nevoux, Opezzo and Richert, 2000). Mirabella plum production was relaunched in Lorraine in the 1980s, and since then 200 farmers have successfully developed or maintained a product which brings in 30 to 40 percent of their income and diversifies their output as well.

Agricultural consolidation and intensification have also been a factor in erosion, yet another proof of the prominent role of trees in the protection of water and soil resources. In the Yonne watershed, the ploughing-under of grasslands and elimination of hedgerows halved the volume of ground storage water (Baumann, 1983). Flooding is more severe now and low-water discharge has fallen (Mérot *et al*, 1976). Rows of trees growing along water-courses (riparian buffers) improve water quality and take up 70-100 percent of the nitrates contained in surface waters and runoff, which amount to 900kg/ha of nitrogen each year (Hickie *et al*, 2000).

Windbreak hedgerows have a demonstrably beneficial agricultural impact, producing better and earlier yields and protecting crops. Trees outside forests have had a comparable impact on soil fertility (Hickie *et al*). They also help maintain biodiversity among bird populations (Moore, 1976, cited in Pointereau and Bazile, 1995) and insects useful to farmers (Karg, 1989, Karg and Ryszkowski, 1991; Blab, 1988), aiding crop pest control (Scapotjev, 1976, cited in Pointereau and Bazile, 1995).

The parallel and growing demand by society for scenic landscapes provides an incentive to preserve off-forest trees, and trees are essential for farmers wishing to diversify by introducing farm hospitality and agritourism on their land. The occupation rate of rural lodgings is higher by 30 percent in a landscape criss-crossed by trees and hedges than in an open one bare of trees (Armel, 1994). Local authorities are encouraging such activities as part of a broader rural development trend.

Institutional and management aspects

The rules and regulations for trees outside forested areas are laid down in various laws. The Civil Code establishes the principles and rules for establishing, harvesting and eliminating hedgerows. The Forest Code, however, devotes little attention to non-forest wooded areas and takes no note of scattered trees or agroforestry areas. A growing number of laws, decrees and regulations designed to protect hedgerows have been issued as environmental protection components under the Code governing rural areas and the environment. Aid from the European Commission since 1992, a stronger law to protect nature, and the land use planning law are also pertinent here.

Trees growing outside forests are primarily administered and managed by the Departmental Divisions of Agriculture and the Forest (DDAF – *Direction départementale de l'agriculture et de la foret)*. Together with forestry agencies such as

3. Energy equivalent: one stere = 0.147 ton oil equivalent (TOE).

the Institute for Forestry Development and the regional centres for forest ownership, and agricultural bodies such as the Chambers of Agriculture, they provide oversight for tree-planting. The Regional Divisions of the Environment (DIREN – *Direction régionale de l'environnement)* support projects to conserve and restore hedgerows and trees.

The DDAF have been increasingly active in the last five years in promoting non-forest tree systems. They established a rural management fund in 1995 (FGER – *Fonds de gestion de l'espace rural),* and land use contracts (CTE – *Contrat territorial d'exploitation)* in 1998, as a follow-up to agricultural/environmental measures enacted in 1992. Working with the DIREN, they also headed a campaign to promote Trees outside forests.

The administrative role of these bodies is evolving and changing. The management of non-forest tree resources in the last two decades was the responsibility of the forest or farm services, but now local groups such as regional councils and the regions themselves are initiating environmental policies. They have been given responsibility for financing hedgerow operations and managing land development efforts within their sphere of competence. They are encouraged to develop area projects such as land-use contracts and State-Region Plan contracts. Several departments have pooled their resources and drawn up charters to promote and accentuate attention to trees in land development schemes. Incentive policies for replanting or maintaining bocage hedges and rows of trees in the rural landscape are now underway in 80 percent of France's departments. One remaining weakness of these promotion policies, however, is the lack of research on off-forest tree resources. Very few scientific teams are focussing on the significance of on-farm trees, or the interaction between trees and crops, or that between trees, pasture and animals.

There is a growing trend to give greater responsibility for non-forest tree management procedures to local authorities, and priority to broadly designed, collective operations whose objectives are tailored to social or environmental targets, including awareness-building, protection, replanting, maintainance and enhancement efforts. Also favoured are tree maintenance initiatives by associations, towns or districts (sometimes grouped together), and by farmers, who are, in the final analysis, the prime managers of trees and hedgerows in non-forest areas. Group purchases of maintenance equipment are another option.

Orchards are also the target of specific action. The Rénova Federation established a programme in 1995 in Ariège and in Haute-Garonne to restore and enhance old-fashioned fruit varieties. The rural social fabric of these regions was under threat following the widespread abandoment of agricultural lands, and local authorities and farmers were looking for ways to preserve the local fruit-tree legacy. An awareness-building campaign was followed by rejuvenation pruning in over 300 orchards in the region. More than 50 farmers are now responsible for a high-quality cottage industry which has sparked such enthusiasm that farmers belonging to the Rénova network are now building a plant to process fruit into cider and juice. The target is 80 000 bottles by 2004. An experimental orchard programme to enhance never-before-studied local varieties is now in the planning stages.

Assessment and planning

As we saw in section two, the main statistical bodies in charge of assessing off-forest tree resources are the NFI and the land use survey. They are increasingly attuned to environmental concerns, identifying and implementing environmental indicators.

The NFI, headed by the agency of the same name, is designed to assess forest resources. Spurred by the growing importance of off-forest tree formations since the 1960s, the NFI undertook to parallel the general inventory with special inventories of hedgerows, line plantings and scattered trees in the relevant departments (Chevrou, 1988). Methods suited to each type of formation, based on the interpretation of aerial photos and ground plots, were adopted. The intersection method was adopted for inventorying linear formations such as hedgerows. Circular plot sampling was used for line plantings like poplars, which are usually found in the same geographical areas. A sampling method similar to that used for forest formations: point sampling with site-specific plots, was used for scattered trees.

In the late 1990s these three inventories were combined into a single, cost-cutting, inventory of trees outside forest areas, to better meet user needs without blurring the accuracy of the data.

The Teruti survey, begun by the surveys and studies service of the Ministry of Agriculture in 1981, monitors changes in non-forest treed areas and shows what is happening in wooded areas. It is based on a systematic two-stage sampling. The first stage is comprised of a systematic series of aerial photographs covering the entire country, overlain by a second stage made up of a 36 dot regular grid. Physical and functional use of the area is recorded for each point. The Teruti survey includes permanent sampling so that any change in land use patterns can be monitored.

Community-financed companion assessments to the NFI and the Teruti survey, which are both national in scope, now meet the needs of local communities, especially in western France. The DDAF did a 1995 inventory of existing hedgerows in Mayenne (cf. Annexe), where a former bocage landscape had been transformed by the elimination of hedgerows. Another survey done in Brittany sought to relate farming practices to water quality.

NFI inventory of Trees outside forests

The NFI inventory of Trees outside forests covers formations not included in either the general inventory or in the poplar inventory. Excluded are orchards, vineyards, walnut groves and truffle sites. The inventory covers line plantings (distinguishing between poplars and other row plantings), hedgerows (tree and non-tree hedgerows), and scattered trees. Not included in the inventory are formations found on manmade sites (such as settlements or leisure areas), or sites where access is dangerous (such as busy highways and railway lines) or difficult (such as private properties and enclosed grounds).

The associated strips method used to inventory linear formations consists of attributing an area to the formation in question, in which a set of points is located at a distance of less than r from the formation, (r being roughly 25 metres). The length is then estimated by dividing the area by the length of the strip ($2r$,). Practically speaking, circular plots with a radius of r are used: A hedgerow or other line planting is taken into account where the point in this formation closest to the centre of the plot belongs to the plot of the radius r, and is not one end of the formation. The method used for scattered trees remains unchanged: point sampling with a control plot.

A two-stage sampling method with stratification is used. Stage one consists of the photo-interpretation of points on aerial photographs (noting the clear presence, where possible, of the numbers and kinds of formations). Stage two consists of systematic ground monitoring, perhaps accompanied by a description such as configuration, environment, permeability, etc., and eventual tree measurements such as volumes and growth where external financing is available. Lastly, the statistical data are accompanied by confidence intervals (cf Annexe).

The inventory with its now fully operational design is currently being applied country-wide. It should afford a better response to user expectations because it addresses environmental concerns and tailors the detail of the data to local interests.

Conclusions

The lack of specific legal status for Trees outside forests can be a constraint to conservation where CAP subsidies apply to treeless areas, because most such trees are growing on farmland. The establishment of an agroforestry working group within the Ministry of Agriculture is a positive step toward broader discussion of the role and status of Trees outside forests. Bearing in mind the amenities trees offer to society, agriculture could come to be seen as providing services as well as goods. Support for Trees outside forests could also be indirectly expressed through modern economic channels such as labels, guarantees of origin, the ‘agroforestry’ stamp of approval, or subsidies for group acquisitions of maintenance equipment such as saw blades and the like, or the establishment of channels for fruit collecting and processing. Such measures would help to preserve the quality of rural areas and diversify rural activities, plus enhancing rural income and thereby fostering local development.

Despite the diverse range of actions, there are still very few areas where specific, pluriannual targets for replanting, restoration or maintenance have been clearly defined. The establishment of monitoring indicators would likewise facilitate the evaluation of ongoing efforts, enhancing the effectiveness of future programmes and offering guidlines for future policies at the local level. One weak point of the policies thus far implemented is the absence of venues for an exchange of views and discussion of trees growing outside forests, particularly for the benefit of local stakeholders. Research programmes should be developed to evaluate modern forms of agroforestry such as tailoring bocage to the current farm context; tree/crop and tree/meadow interactions, and new developments in maintenance practices.

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Annex: Inventory of Trees outside forests in the Department of Mayenne, 1999

Figure 5. General situation of the Department of Mayenne. The forest regions:
1. Normandy hills
2. Avaloirs-Coëvrons
3. Bas-Maine
4. Bocage area of Angers

Brief description. The Department of Mayenne in the northern administrative division of Pays de la Loire covers 521,352 ha. Mayenne lies in the eastern portion of the Armorican massif. The highest point is Mont Avaloirs (417 m) in the northeastern sector of the department. The department has no coastline, but its oceanic climate has fostered the development of agriculture and cattle production. The oceanic climate and cattle sector have helped to create a bocage landscape. Very little of the area is forested (33 814 ha –Second Mayenne Forest Inventory of 1983, a rate of only 6.5 percent).

Operations of the inventory The inter-regional level of the NFI was responsible for operations.The first stage, in 1998, involved photo-interpretation of 17 786 points based on aerial photos taken in 1996 ; 30,7 percent of the points (5 457 in number) included one or more segments of Trees outside forests. Sampling, ground verification and description were done in late 1999 and early 2000. For lack of external financing, no dendrometric measurements such as diameter, height and growth were taken. The second stage involved visits to 645 plots including 842 segments of trees outside forested areas (global sampling rate 11.8 percent, strata with at least one segment appearing in the photo-interpretation stage). Spot and ground photo-interpretation operations were timed as follows : the photo-interpretation of points with TOF takes about 20 seconds compared to 60 seconds for a point located in a forest area (forest formations inventory). In ground operations a two-agent team was able to take readings on about 15 plots per day.

General situation of the Departmen of Mayenne

Selected findings

Table 11. Extent of linear formations

Type of formation	Length (km.)	Confidance interval: threshold 95%* (%)
Rows of poplars	641	54,9
Other line plantings	289	83,2
Tree hedgerows	22 011	7,0
Non-tree hedgerows	4 463	21,1
Total linear formations	**27 404**	**6,5**

*Corresponds to twice the ratio of the standard deviation and the estimated length

Table 12. Length of hedgerows by presence of embankments or low walls, and ditches or streams

Embankment low wall	Ditch or stream	Length (km.)	Confidence interval at 95% (%) threshod
Embankment or low wall	Stream	339	82,0
Embankment or low wall	Ditch	3 807	27,0
Embankment or low wall	Neither	10 552	14,8
Sub-total		**14 698**	**11,2**
No embankment or low wall	Stream	1 661	44,0
No embankment or low wall	Ditch	1 626	37,8
No embankment or low wall	Neither	4 026	25,4
Sub-total		**7 313**	**18,2**
Total Mayenne		**22 011**	**7,0**

Corresponds to twice the ratio of the standard deviation to the estimated length

Trees outside forests: India

Dr. Devendra Pandey,
Former Director of the Forest Survey of India
Consultant to the International Centre for Forest Research,
Bogor, Indonesia

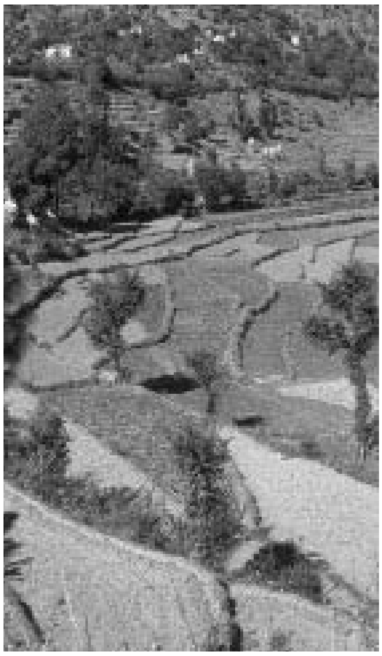

Photo 51. Agroforestry utilization of land in the Middle Hills section of the Indian Himalayas. Irrigable terraces. (© Hofer/FAO).

Context

India is the world's seventh largest country and one of the most heavily populated. The country covers a total of 328 720 000 ha. India's population, which is 74 percent rural, was estimated in 1997 at 995 million: a population density of 290/ha2. Of the total area, 43 percent is farmland, 19.4 is forested and 1.6 is savannah. Cultivated trees and woodlots cover one percent, pasture 3.7 percent, and human settlements 6.7 percent (FSI, 2000a). Between 1951 and 1999, development plans were responsible for implementing tree-planting on 9.8 percent of the total land area, mostly Trees outside forests.

With an annual population growth rate of 1.58 percent (World Fact Book, 2000), there is a constant and growing demand for food. Farmland cuts into forestland and the expansion of livestock herds encroaches upon the forest, where the herds often graze. Since the introduction of social forestry in 1980, a great many trees have been planted, of which 35-40 percent on private, communal or village lands outside the forest domain. The Government has sponsored tree-planting along roads, railways, canals and around ponds. Over 70 percent of these trees are growing outside forest areas (FSI, 2000b).

Official bodies responsible for land-use planning and tree-planting long neglected Trees outside forests. Then, as awareness mounted of the critical role of this resource for rural populations. their focus on the issue sharpened. In 1991, the FSI – Forest Survey of India - which is responsible for forest inventories, launched a process to assess trees growing outside forests , starting in the States of Kerala and Haryana.

Concept

The expression 'Trees outside forests', which has a strong connotation of social forestry in India, is not the term commonly used. The KFRI - Kerala Forest Research Institute – selected two designations for its survey: trees on homesteads and trees on estates. The first category includes trees on inhabited lands and areas, and the second rubbertree, cardamom, coffee and tea plantations (Krishnakutty, 1990).

The FSI, which works under the Ministry of the Environment and Forest, coined the term 'non-forest areas (rural)' to designate trees in non-forest areas. This term includes all areas other than the traditional or gazetted protected forests or forest reserves, excluding inhabited areas. The non-forest areas are sub-divided into eight categories:

i) trees bordering homesteads and woodlots under 0.1 ha (social forestry)
ii) trees growing naturally or planted on communal or private lands (village woodlots.
iii) block plantations over 0.1 ha
iv) trees planted in and around ponds
v) trees bordering roads
vi) trees bordering railways
vii) trees bordering canals
viii) other categories not included in the above, including homesteads.

States which have assessed their tree resources (surveys of wood production and consumption: forests plus trees outside forests) have used terms such as trees on non-forest lands, or trees on private land.

Patterns and extent of change

There is growing interest in the conservation and protection of natural forest. During the 1970s, 12-14 million m^3 of wood were extracted from the forest each year (Anon, 1976), whereas the figure today has dropped to 4 million m^3/yr (ICFRE, 1999). Private, non-forest areas supply 80 percent of the aggregate output of wood, and forest areas supply 49 percent of the fuelwood – the latter figure is estimated by some to be even higher (Natarajan, 1996; Saxena, 1997; Agarwal, 1998).

Government agencies have planted a great many trees for the purpose of stabilizing dunes, checking erosion along coastlines and rivers, reclaiming gully-eroded areas, and establishing windbreaks. They have also planted trees along roads to provide shade and shelter to travelers, and in parks and gardens for shade and aesthetic purposes.

Despite the goods and services these trees offer to society, their contribution to the local and national economy remains mostly 'invisible'. And yet, in rural areas the resource meets domestic wood needs for fuelwood and construction, provides fruit, fodder and shade, and is a source of income. There are also sacred groves, places of worship which may be man-made but are more often remnants of natural forests. The biodiversity in these is often quite remarkable.

Most fruit trees grow in small, privately owned orchards. When they no longer bear fruit, their wood is used for construction and fuelwood. *Mangifera indica*, the famous Indian mango, covers some 1 million ha (MAG, 2000), and is the most important indigenous species. Other multi-use indigenous fruit trees cover smaller areas, such as *Artocarpus heterophylla* (jackfruit), *Tamarindus indica* (tamarind), and *Madhuca indica.* The 0.53 million ha of cashew plantations are found mostly along coastal areas. Domesticated fruit tree species mainly include apples, which grow at high altitude and cover 187 200 ha, a further 102

500 ha of guava plantations, and 349 000 ha of citruses (MAG, 1994). There are also 0.55 million ha of rubber plantations, 1.8 million ha of coconut plantations, and a number of oil palm plantations. Most plantations are privately owned.

Institutional and management aspects

The legislation on forest resources varies from one State to the next, as most of the natural forests belong to the State in which they are found. Generally speaking, the rules and regulations on the felling and transport of trees away from private lands have had a negative impact on tree-planting in this sector. Land ownership regulations stipulated that a designated land use could not be altered, which had the indirect result of limiting tree-planting (Hedge, 1991) There is now a trend in several States to simplify the rules governing private plantations. Unfortunately, however, the issue of marketing wood products from non-forest zones is rarely addressed (Saxena, 1991).

There is no specific policy to promote tree-planting in areas outside forests. The Ministry of Environment and Forest's own National Forest Policy (1998) does specify, however, that the wood industries must procure their own raw materials for forest-based industries, and that these industries are allowed to purchase supplies from persons practicing agroforestry in the private sector, provided food production is not adversely affected. Farmers have tapped into their traditional skills to breed, plant and manage fruit trees and the other useful species which used to be planted rather sparingly on their farms and around their fields. With the rise of social forestry in the early 1980s, farmers' decisions on which trees to plant came to depend on the availability of seedlings in the government tree nurseries, and quite a few farmers learned to grow economically beneficial trees.

Photo 52. Hedgerows criss-cross a mountain farming district in India (© Hofer/FAO).

There is a modest though growing interest in genetically superior planting materials. The Forestry Science Centres (Van Vigyan Kendra), operated by the Government and NGOs, have been instrumental in promoting this interest. The Forest Research Institutes have helped to develop the relevant technologies. In 1994 and 1995, private agencies spearheaded the production of clonal seedlings to enhance the productivity of plantations. New clonal seedlings of eucalyptus, poplar and teak for which farmers are willing to pay five to six times more are now being produced in the tree nurseries of the Department of Forests and in farmers' nurseries (Kisan). Hopefully, the production of high-quality seedlings will be improved and expanded in future to include more species.

Assessment and planning

The Revenue Departments, which are the government agencies responsible for land use records, try to maintain updated lists of tree species in non-forest areas, but the data is often incomplete or out-of-date. The Horticulture Department collects data on fruit tree species and the Rubber Board draws on the records of private growers for its data. These, however, are purely numerical data which have little bearing on the management of trees growing outside forests..

The lack of information on the commercial scope of the resource has been a constraint to studies on its productive aspects. Not until 1990 were the development and production of two specific species, eucalyptus and poplar, investigated. The study showed that the growth rate of trees in agroforestry systems outpaced that of trees planted in forest areas (Dwivedi *et al,* 1990).

In the 1980s, with the advent of social forestry programmes in a number of States, the need for an inventory of Trees outside forests became increasingly apparent. Tree resources were thus made an integral component of the FSI. But the production of wood from this source was tentatively estimated based on local knowledge or aerial photos, and ignored if the contribution was not deemed significant. The data were also gathered over a very short timeframe and the selected methodology lacked precision.

Systematic assessment of trees in non-forested areas, including a proper sampling procedure (given the time and budget constraints), dates back only to 1988-89. This inventory was conducted by the KFRI in the State of Kerala. Aware that the resource was a major contributor of timber and fuelwood, the FSI followed this up with a nationwide assessment in 1991. The pace of inventory has accelerated since 1999, and the four FSI zonal offices are now working exclusively on this inventory. The methodology has been modified to reduce the extent of fieldwork, and the FSI is the sole agency in charge.

The KFRI designed a three-stage sampling procedure for the survey of homesteads. The State of Kerala was stratified in terms of farmland area and population density. The first-stage sampling units in each stratum were the villages. A group of households made up the second-stage units, and from this group a number were randomly selected as third-stage units based on the ownership criterion of dryland holdings. All trees in the selected homesteads were then counted and measured. Growing stock in the estates was estimated from collateral data.

The FSI adopted a stratified random sampling procedure where the district or group of districts in a given State were treated as the strata and the villages as sampling units. All standing trees over 10 cm in diameter in the villages selected were physically counted and measured. In some States trees 5 cm or over were also measured. In Haryana State, 219 villages were selected out of the total 7 000, and the inventory took four years. The design was modified in 1999 to speed up the process. The percentage of trees enumerated and measured in a village is now established in accordance with the total number of standing trees: i.e, 50 percent for 2 000 or more trees, 25 percent for 5 000 or more trees, and 10 percent for 10 000 or more trees.

Inventory of trees outside forests in the States of Kerala and Haryana

The FSI methodology described above was put into practice in several States, including Kerala and Haryana, which are economically more developed than most Indian States. Kerala and Haryana are quite different in terms of climate and social conditions. Kerala, India's most densely populated State, lies in the south and has a humid climate and long coastline. Haryana is located in a dry region of northern India.

The total number of trees on homesteads in the State of Kerala, excepting rubbertree plantations and palms other than coconut palms, is estimated at 442 million, with an average 113 trees/ha. The figure for coconut palms is 21 percent higher. The volume of growing stock is assessed at 104 million m^3, averaging 26.6 m^3/ha. Of this volume, coconut trees account for 33 percent, jack-trees for 15 percent, mango for 11 percent and cashew for 12 percent -- these are the most numerous species. About 50 percent of the growing stock is in the 20-30 cm diameter class. The volume has been measured down to 10 cm over bark and includes branch wood. The percentage of commercial volume (stem wood down to 20 cm diameter) in the total growing stock was only 27.4 percent (Krishnakutty, 1990).

Of the estimated total annual production of 14.4 million m^3, a full 83 percent came from homesteads, 10 percent from estates and only about 7 percent from forest areas, though 26 percent of the State of Kerala is covered by forest. In terms of species, 10 species alone accounted for 85 percent of the volume of production (FSI, 2000). Trees outside forests met 90 percent of the fuelwood needs, and of this figure, 70 percent was made up of the woody and non-wood parts of the coconut palm. The coconut is a multi-purpose tree, offering the benefits of both agricultural crop and tree crop, furnishing a constant supply of nuts for food, and a biomass of leaves, fibre, husks etc., from six to sixty years of age. Coconut, like many other versatile trees, is valued as much for the income it produces as for its products.

In the State of Haryana, 80 percent of the land is under crops, and only 2.2 percent is forested (FSI, 2000). The total number of trees in the rural, non-forest, areas is estimated at 55 million, with an average 13 trees/ha. *Acacia nilotica,* the main species, accounts for 25 percent of the total. The total growing stock (measured down to 10 cm in diameter) in the entire rural area of Haryana was estimated at 10.34 m^3, an average of 2.43 m^3/ha. Though the number of trees in the lowest diameter classes is quite high at 62.7 percent, volume is evenly distributed in the various diameter classes (23.6 percent from 10- to under 20 cm, 25 percent from 20 to under 30 cm, 28.4 percent up to 40 cm, and 23 percent 40 cm and over). The volume of growing stock consists primarily of *Eucalyptus spp,* (2l.6 percent), *Acacia nilotica* (21.2 percent)*, Prosopis spp* (17.4 percent), *and Dalbergia sissoo* (12.5 percent).

Social forestry, an increasingly popular practice, supplies 41.2 percent of the volume of growing stock, with village woodlots contributing 24 percent. Most of the roads and canals in Haryana are lined with trees. Roadside trees account for 13 percent and trees along canals 9.6 percent of the total volume (FSI, 2000). The State of Haryana has fuelwood and pulpwood surpluses, mostly produced by Trees outside forests (Anon, 1996).

The data from these two States give a fair indication of the importance of non-forest tree resources for India. The composition of species, the area they cover and the types of planting are governed by a vast range of factors, predominately climate, land distribution and socioeconomic conditions.

Conclusions

India's growing population will inevitably exert mounting pressure on its natural resources. People were very quick to adopt social forestry, and trees outside forests are a constantly expanding resource. Their promotion is crucial, therefore. It must be solidly based on a sound agroforestry policy consolidating the agricultural, forestry and rural sectors, covering market mechanisms, and simplifying land ownership regulations.

Such a policy can only bloom if the increased productivity of these tree resources is tied to crop productivity, and this means identifying the optimum tree/crop associations. A standard methodology must be developed to assess off-forest tree resources using a combination of remote sensing technology and field inventories (Panday, 2000). Exchanges of regional assessment experiences, such as those of Pakistan, Bangladesh or Sri Lanka, should be promoted.

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Photo 53. Microreforestation with *Eucalyptus*. (© Faidutti/FAO)

Trees outside forests: Kenya

James Legilisho-Kiyiapi
Department of Forestry, Moï University, Eldoret, Kenya

Context

Kenya covers an area of 582 600 km^2, including some 10 700 km^2 of lakes. One quarter of its population of 28 million are urban dwellers. Forested areas, comprising forest reserves, national parks and sanctuaries are all state-owned and represent less than three percent of the territory. Other woodlands, including woody savannah (bushlands) and forest plantations, cover some 27 percent of the national territory, with agricultural holdings, ranchlands, human settlements and urban areas accounting for a further 16 percent.

Kenya's growing population is exerting considerable pressure on natural resources. As forest resources dwindle with the expansion of agriculture onto forest land, forests will no longer be able to meet the rising demand for wood and non-wood products. This will drive the demand for Trees outside forests and social forestry will become the keystone of tree resources, as an assessment of the woody biomass of the Nakuru and Nyadarua districts clearly indicated.

Concept

Forest land is by Kenyan law a designated and legally gazetted forest estate governed by the provisions of the Forest Act. All other land comes under the regulations and usages of either customary law (e.g. communally owned forests), or private tenure regimes (e.g. privately owned forests).

The Kenyan concept of Trees outside forests thus exists within a broad context of land tenure systems comprising all tree resources and land lying outside gazetted or protected forests. Included are woodlands, pastoral systems, agroforestry (the recognized Kenyan designation is social forestry), scattered trees, hedges, and the like. Trees may occur naturally or they may have been planted, and there are no conceptual limits on density or area.

Patterns and extent of change

There is a growing trend in Kenya towards expansion of tree cover and species diversification in intensive farming systems which include trees. As natural formations shrink, are destroyed, or become less accessible, social forestry becomes increasingly important.

Forest plantations, in decline because the rate of replanting has failed to offset the rate of felling, are giving way to grassland. At the same time, farms and settlements are encroaching upon remnants of indigenous forests at an annual rate of 5 000 ha and upon woodlands at a rate of 55 000 ha/yr, with bushland dwindling as well. As timber resources from forest estates decline, wood supply will increasingly come from farmlands and remnant natural woodlands.

There are three distinct agro-ecological, zonal classifications in Kenya. The first two, termed high-potential and medium-potential, correspond to the humid and semi-humid zones. Trees are scattered throughout these two zones on small wooded plots, or dedicated plantations such as eucalyptus grown for fuelwood. The third, low-potential, category consists of the arid and semi-arid zones in which silvopastoral systems predominate.

Early in the 1930-1940s, the high-potential zones still had a fair amount of plant cover and natural forest, but much of the area was then cleared in the process of agricultural expansion. To offset this loss, farmers were offered incentives during the 1970-1980s for extensive tree-planting on farms, with secure land tenure as a pre-condition. The social and economic benefits of this are felt today in the form of income and product diversification which acts as a safety-net to buffer the risk of hardship and destitution. In the low-potential zones where land tenure is less secure, there are two major trends. Tree resources are being depleted in areas of rapid agricultural expansion, but degradation is less severe where traditional land-use systems are still firmly entrenched.

The Kenya Forestry Master Plan (KFMP) stressed the on-farm contribution of trees, which provide wood and poles for construction, fence posts, fuelwood and charcoal, not to mention fruit, fodder, medicines, gums and resin, all for home consumption and/or sale. A study demonstrated that on-farm income from tree crops amounted to 51 percent in the high-potential zones, 40 percent in the medium-potential zones and 18 percent in the low-potential zones (Njenga, *et al*, 1999). Honey from the Transmara forest region can bring in some US$ 715/yr, in a place where the mean per capita annual income is estimated at US$ 370 (World Bank, 1992).

In any case, the value of all these products would be greatly enhanced if marketing and distribution circuits were designed for profit-sharing. A long chain of middlemen in the wood and charcoal sector, for example, works to the detriment of the grower.

By the time a bag of charcoal or wood reaches the final consumer the mark-up can be as high as 150 percent. The same is true for apiculture, where it is often hard for the farmer to market his product for lack of access to outlets. These disfunctional aspects burden the market for off-forest tree resources, hampering official recognition of their contribution to the national economy and allocation of budgetary allocations.

These resources are found mainly in medium-potential woodlands, low-potential bushlands or savanna, and on farms. The mean annual productivity of woody biomass in woodlands is $16m^3$. In 1995, farms produced 7.4 million m^3 of woody biomass, representing 65 percent of the wood production in the high- and medium-potential zones. Assuming a steady growth rate for tree-planting, the figures would rise to 17.8 million m^2 and 80 percent by the year 2020 (see Annex 3). The percentage distribution of woody biomass from Trees outside forests is as follows: 20 percent for wood, 7 percent for poles and 73 percent for fuelwood (Holmgren, *et al*, 1994). In low-potential zones the resource provides forage for livestock.

The most significant role of on-farm trees is environmental. Trees stabilize soil and check erosion in highland areas. A rainforest microclimate has been created by agroforestry areas on Mount Kenya and in western Kenya. Tree/agriculture mixed cropping on farmland offers a habitat for the conservation of increasingly endangered indigenous tree species such as *Prunus africanus.* Another increasingly popular practice is the domestication of natural forest species and their introduction on farms and in urban areas. In the Masai and Turkana communities, the bond between people and their environment has produced a conservation ethic for this resource, underpinned by a social and cultural value system.

Institutional and management aspects

The Forest Act applies only to the legally gazetted forest estate, with no mention of other tree formations such as those growing outside forests. New legislation was formulated to bridge this gap and broaden the framework of tree resource management. The Chief Authority Act, the Agriculture Act and the Water Act serve as points of reference for trees outside forests but their thrust is more punitive than motivational. The legislation is currently undergoing reform in light of the renewed interest in natural resources and the innovation of people’s participation. Recent legislation such as the 1996 Physical Planning Act and the 1999 Environmental Management and Coordination Act provide a legal framework for participatory land management at local and regional levels, and are bound to influence future institutional provisions concerning off-forest tree resources.

The Department of Forestry, backed by cooperation agencies and working in liaison with NGOs, has implementated action to promote Trees outside forests. Illustrative of this process are the Transmara Forest and Resource Management Project, the Regional Land Management Unit (RELMA) which focusses on how trees are used on farms and in private and communal natural woodlands, and the Forest Action Network (FAN) which is actively involved in the conservation of community forests and tree resources. These actions are often fragmentary, and coordination among them and with research, extension and the farmers can be problematic.

Phot 54. Single trees scattered throughout fields. (© FAO)

Concerning research, on-farm species trials are being run by the International Council for Research on Agroforestry (ICRAF) in collaboration with the Kenya Forestry Research Institute (KEFRI). Ethnobotanical work by the National Museums of Kenya is also underway on these resources.

Farmers draw upon traditional tree improvement, planting and maintenance skills for Trees outside forests. They apply traditional resource management practices to communal areas. Tree resources and land are all collectively owned in the silvopastoral systems, where the accent is on the management of natural tree formations.

Assessment and planning

National forest inventories have not been conducted on a regular basis. The most recent and detailed assessment, dating from 1993, covered forest resources and selected community forests. Although virtually no specific inventories preceded the implementation of action to promote Trees outside forests, surveys and assessments had been done in target intervention areas.

Prior to the implementation of the Nakuru-Nyandarua social forestry project in 1991, the Ministry of Natural Resources and Environment conducted a baseline woody biomass survey funded by FINNIDA on gazetted forest and farms, which was replicated in 1993 and in 1998 (Pukkhala, 1991, Höyhtyä *et al,* 1998). A large-scale woody biomass survey was conducted in 1991-92 on approximately 10 million ha as part of the KFMP development process. A systematic grid of low-altitude aerial photos was combined with field measurements to produce a sub-sample. The national wood supply was estimated from variables such as species identification, volume, density and potential wood uses (Holmgren, *et al.*, 1994). Other local assessments included a 1996 GTZ-funded forest/woodland survey in the district of Transmara which combined satellite imagery, aerial photographs and line transect-fixed radius plot methods, and an on-farm tree inventory by KEFRI in Tharada-Nithi (Kigomo, 1997, Kiyiapi, 1999). An ongoing assessment of trees in semi-arid zones based on the same methodology as the Transmara survey is expected to report its findings in 2001. ICRAF has also begun on-farm and tree nursery surveys in western and central Kenya.

The KFMP plans to make the forest sector an integral part of both the National Environmental Action Plan (NEAP) and the National Development Plan. With the new policies and legal provisions on decentralization, land-use planning will increasingly become a local responsibility, a likely boost for off-forest trees. Their role in relieving pressure on indigenous forests is significant in the light of global agreements to which Kenya is a signatory, primarily those relating to forests, biodiversity and climate change.

Assessment of woody biomass in Nakuru and Nyadarua

The Nakuru-Nyandarua Farm Forestry Project (1990-95) was started with the goal of raising trees for the farmers' benefit and easing pressure on existing natural forests.

The first stage of this project consisted of a 1991 baseline woody biomass survey. While satellite imagery was useful in broad-level vegetation classification of indigenous forests and plantations because of their size, it was not very helpful for detailed assessments of trees at the farm level. A second stage of the survey launched in 1993 combined aerial photos and ground surveys to establish a more realistic tree cover baseline against which to judge the success of the project. Aerial photographs were taken at one-kilometre intervals at the 1:10 000 scale. Each photo covered a ground area of 2.3 km x 2.3 km. Subsequent enlargement at a scale of 1:2500 produced a 23 cm x 23 cm print representing 575 m x 575 m on the ground.

The photo-interpretation method used delineated the boundaries of the farms closest to the centre of each 1:2500 enlargement, i.e., the farms selected for photo-interpretation. Tree species and sizes could not be distinguished due to the distorting effects of shade, differences in tree form and size and the difficulty of recognizing boundaries, but homesteads, border trees, grazing areas, farm size, kitchen gardens and woodlots could be classified. About 20 percent of these farms were then selected for detailed field measurements (38 in Nakuru and 24 in Nyandarua). Each tree on the farm was assessed and, where necessary, sub-sampling was applied to woodlots and boundary trees. The parameters assessed were tree location, species and origin, and tree volume determined from established allometric relationships. A 1998 assessment based on the same methodology revealed a significant increase in woody biomass.

The surveys showed an increase in per hectare productivity. The productivity of trees on farms rose from 25 m^3 in 1993 to 56.9 m^3 in 1998, an increase of 128 percent, with an overall boost in productivity of 9.6 m^3 in 1993 to 19.9 m^3 in 1998 for the entire zone, i.e., up 107 percent for that period. In 1993 as in 1998, 70 percent of the tree diameters were under 5 cm, making the trees too small to harvest. The volume of usable wood on each farm was 17.l m^3 in 1998 compared to a figure of 7.5 m^3 in 1993. The results revealed both the positive impact of the project and the usefulness and effectiveness of the inventory methodology, which is now being applied in other districts.

From the standpoint of methodology, satellite imagery is primarily relevant for broad classification of large-scale plant formations. The results from the interpretation of aerial photos compared with those obtained from field surveys suggest that aerial photos are useful at the stage of defining the sample, but are not very reliable for estimating tree biomass on farms. There was no relationship between the values obtained from photo-interpretation and actual field measurements, making extrapolation of the data to other aerial photographs impossible. And the high cost of aerial photography may well penalize ground measurements, bearing in mind that their comparative advantages depend on assessment parameters that must be very strictly defined prior to the establishment of the sampling-plan.

Trees outside forests comprise a number of highly complex systems, so further study is needed. Assessment methodologies which combine remote sensing techniques with ground verification offer promise, but much remains to be done before generalized assessment designs can be developed. And assessment should draw much more heavily on participatory methodologies.

Conclusions

Population growth is exerting considerable pressure on Kenya's natural resources. The constant decline of forest resources coupled with new developments in land tenure systems further the exploitation of remnant natural woodlands, hence the renewed interest in trees growing on farmland. The future of forests and tree resources basically depends on the growth and management of woody biomass which lies outside Kenya's forest estates.

The national development strategy for Trees outside forests stipulates sustainable management of natural forests and woodlands in the semi-arid and arid zones, as well as tree-planting on farms and in settlements. Recent legislation and the promulgation of the new forest law will facilitate a multisectorial and participatory approach to environmental protection and natural resource management, including the management of trees growing outside the forest Sustainable land-use planning, effective organization of this tree resource and co-ordinated land distribution can become a reality. But users, including farmers and herders, must partake in the decision-making and negotiation stages of the process to sageguard Trees outside forests.

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Annex: Woody biomass trends and potentials

Table 13 indicates a downward trend for indigenous forest, woodlands, savanna and forest plantations, whereas Table 14 shows an upward trend for farms and settlements.

Table 13: Wood resources: current trends and prospects ('000 ha)

Type of formation	Year					
	1995	2000	2005	2010	2015	2020
Indigenous forest	1 295	1 270	1 245	1 220	1 195	1 170
Woodlands and savanna	37 425	37 150	36 875	36 600	36 325	36 050
Farmlands and setlements	9 720	10 020	10 320	10 620	10 920	11 220
Forest plantation	148	134	118	107	93	78
Total	48 588	48 574	48 558	48 547	48 533	48 518

Source: Kenya Forestry Master Plan (1994).

Table 14: National woody biomass inventory, current trends and prospects (productivity in m^3/ha.

Type of formation	Year					
	1995	2000	2005	2010	2015	2020
Indigenous forest	176	176	175	174	170	165
Woodlands and savanna	16	16	16	16	16	16
Farmlands and setlements	9	12	14	16	18	21
Forest plantations	347	332	317	302	287	272

Source: Kenya Forestry Master Plan, 1994.
Note: In line with the concepts outlined in this paper, Trees outside forests are those found on woodlands, savannah, farmlands and settlements.

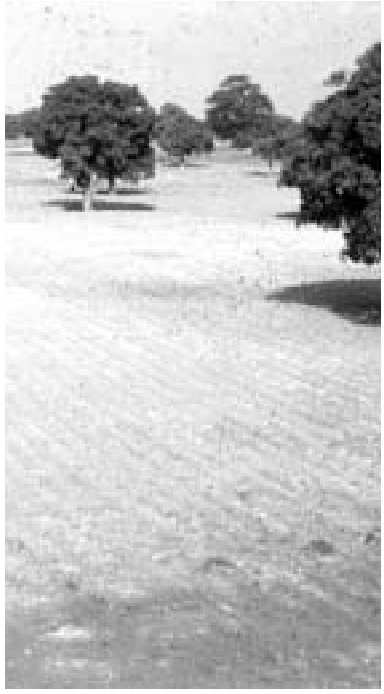

Photo 55. Growing millet on a sheanut (*Vitellaria paradoxa*) agroforestry parkland in Mali. (© Cossalter/Cirad)

Trees outside Forests: Mali

Harouna Yossi and Amadou Malé Kouyaté
Forest Resources Programme, Institute of Rural Economy, Bamako

Context

Mali covers a total area of 1 240 000 km^2, with a population of some 10 million people, 80 percent of whom live in rural areas. Mali's agricultural lands cover an estimated 33 517 031 ha (CPS, 1998), and forest domain another 100 million hectares, including 32.3 million ha of tree formations (Sidibé, *et al.*, 1998). There are several million ha of village plantations (FTPP/SSA Mali, 1999), and 15 000 ha of fruit and market garden crops (ESSOR, 1999).

Natural resource management has been hampered by the virtual mining of the natural resource base that occurred in the past, coupled with people's mistrust of some of the earlier legislation. The opening of dialogue between the Government of Mali and its people in March 1991 was a positive step toward devolution, the transfer of power to local levels, and legislative review, particularly of the Forest Code. Among the constraints to enhanced development of woody resource production systems and maintenance are: demographic pressure, agricultural intensification, herd increase and the advance of the desert. In this context, agroforestry parklands are attracting great interest.

Concept

In Mali, the concept of Trees outside forests covers all multi-purpose trees growing on village lands that can improve soil fertility, check erosion on croplands, fix soils, provide fodder, wood, fruit, shade and products for medicinal use, and offer recreational and scenic benefits.

Agricultural parklands make up some 39 percent of Mali's land area. These systems are the major agricultural landscape in the Sahel, Sudanian and northern Guinean climatic zones. Other non-forest tree systems include fruit orchards (primarily mango and citrus), linear plantings and living fences, which provide protection, fodder and fruit, help to check erosion, and mark boundaries[22]. There are also village plantations of fast-growing species[23] and village forests consisting of plantations and remnants of natural forest.

Patterns and extent of change

Factors exerting increasing pressure on natural resources and driving resource exploitation in the last half-century include population expansion, the introduction of draft animal traction, herd increase and drought. Agriculture expanded and intensified, while fallow periods grew shorter, and nomadic herd movements altered. In the year 1952 in Lagassagou in the Bankass district (*cercle*), croplands represented 31 percent of the total land area, whereas by 1996 the figure had risen to 70 percent. A similar pattern of change was seen in the Koutiala cotton basin (Karembé *et al*., 1998). This was paralleled by a steadily southward search for pasture to feed the herds of nomadic pastoralists. These land-use changes in the agricultural and livestock production sectors entailed a reduction of natural forests and an expansion of the agroforestry parklands where useful species[24] grow.

The Institute of Rural Economy (IER) and the International Centre for Research in Agroforestry (ICRAF) have looked at the structures of these agroforestry parklands in two agro-ecological zones, the Mid-Bani Niger and the Gondo Plain. In the Mid-Bani Niger, 20 types of parkland covering 415 700 ha were identified, with shea trees predominating. In the Gondo Plain 17 parkland types were identified with *faidherbia albida* (kad) as the predominant species over an area of 387 700 ha (Yossi, 1999). These studies identified tree types and species coverage, but assessed neither resource production and dynamics nor local rural management techniques.

In semi-arid zones, agroforestry parklands now concern some 2.5 million people (Cissé, 1995). These resources fail to fully meet the demand for wood and non-wood products for lack of proper management. And yet their socioeconomic and environmental role is critically important. Parkland trees provide income, food, wood, fruit, traditional medicines, tannins and gums. They also supply forage, browse and veterinary products for the livestock sector, and help to maintain the balance of nature by enhancing soil protection, soil fertility and the conservation of plant genetic resources.

Particularly worthy of note is the contribution of fruit trees to food security and nutritional balance: 200 000 tons of mangoes from engrafted and 50 000 tons of fruit from grafted trees are produced each year (Reynes and Odoux, 1999). The vitamin C content of *Tamarindus indica* (tamarind) fruit and of *Adansonia digitata* (baobab) is very high. Baobab leaves (fresh or dried) and baobab seeds are both good sources of protein, vitamin A, calcium and iron. *Vitelleria paradoxa* (shea-nut) is protected by the Forest Code because of its high social, economic and ecological value. This species supplies an annual 60 000 t of kernels (Terpend, 1982), and has an estimated production potential of some 661 500 t (CECI, 1994). Other useful parkland trees are the locally very popular *Borassus aethiopium* (ronier) and *Parkia biglobosa* (néré), in addition to *Acacia senegal, Acacia seyal, Sterculia setigera* and *Combretum spp* from which gum arabic is extracted. The potential growing-area for gum trees is thought to be as much as 200 km^2, or one-sixth the land area of Mali, with a hypothetical output of 100 000 t/yr.

The products of these non-forest trees are consumed locally, factory-processed, or exported. One study of the mango trade in the Sikasso region showed that 72

4. The main species grown are *Jatropha curcas, Ziziphus mauritiana, Ziziphus mucronata, Acacia nilotica*, and *Lawsonia inermis*.

5. *Eucalyptus camaldulensis, Gmelina arborea, Azadirachta indica. Parkia biglobosa, Anacardium occidentale* and *Vitellaria paradoxa* are also current favourites.

6. *Vitellaria paradoxa, Parkia biglobosa, Cordyla pinnata, Tamarindus indica, Pterocarpus orinaceus, Ficus gnaphalocarpa, Bombax constantum, Borassus aethiopium* and *Adansonia digitata.*

percent of the output was sold locally, 17 percent was transported to non-mango regions and 11 percent was exported (Coulibaly, 1999). The figures for shea-nut were 30 400 t of kernels, 2 500 t of unrefined oil and 2 300 t of refined oil exported from 1988-1992 (CECI, 1998). Gum Arabic exports amounted to 800 - 8 000 t/yr from 1971-1987. Exploitation of all these species is hindered by the poor performance of the fruit and vegetable processing sector, and generic marketing problems of the small-scale sector (Reynes and Odoux, 1999).

Trees outside forests also help to meet energy needs and other wood uses. From 1984-1986, total official wood output was estimated at 680 869 steres of fuelwood, 649 297 quintals of charcoal, and 59 345 m^3 of construction and industrial wood. A total of 4 000 725 trees provided timber, including *Borassus aethiopium*, (ronier) *Hyphaena thebaica* (doum), *Raphia sudanica* and *Bambusa spp*. (CPS, 1998). Charcoal production is endangering tree resources and should be controlled. Charcoal produces the same amount of heat for the same cooking-time as fuelwood, but demands twice the number of trees. Additionally, specific rates have been established for assessing the leafy biomass of off-forest trees, a key factor in feeding livestock and maintaining soil fertility.

Institutional and Management Aspects

Forest legislation governing forest trees in forested areas and on farmlands comes under the *Direction nationale de la conservation de la nature,* DNCN, (formerly the forest service or *Direction des eaux et forêts),* which comes under the Ministry of Facilities, National Development, the Environment and Town Planning.

The devolution of authority and legislative revision launched in 1991 altered the patterns of decision-making. Territorial collectives and decentralized services acquired broader authority. The new Land and Forest Code made local territorial collectives responsible for forest management, natural resource management, and the maintenance of ecological equilibrium. By decree, a territorial collective could protect, wholly or partially, and on a temporary or permanent basis, any species acknowledged to be useful. Customary rights exercised collectively or individually over non-registered lands were to be inalienable, save in the case of public utility, and providing indemnification were made (MDRI, 2000). A communal council, working in cooperation with the competent services and farmers' associations, would be responsible for regulatory activities, in accordance with the law and local conventions.

Public and private agencies, such as the DNCN, IER, Rural Polytechnic Institute, and NGOs like Care Mali and the SOS Sahel UK have designed research and survey strategies for off-forest tree management and operations. They have worked to establish living fences for protection purposes, identify and extend citrus varieties, establish village plantations, and test and extend new techniques and practices. IER worked out a pruning method for shea trees to control parasitical mistletoe and enhance fallow land through the introduction of trees, thus fostering biological recovery (Yossi, *et* al., 1999). In regions where the Mali Textile Development Firm (CMDT) operates, techniques have been developed for the domestication of local fruit species[25]. Under FAO's "Trees, Forests and People" Programme for Sub-Saharan Africa (TFPP/SSA), soil protection and reclamation, water conservation and fruit tree planting was carried out in Mopti by the *Alamodiou,* (traditional sociocultural village associations).

Farmers and pastoralists maintain and manage ecosystems in accordance with local rules and customs governing resource access and trade. This is true of shea-

***7. Adansonia digitata, Vitellaria paradoxa, Parkia biglobosa, Ziziphus mauritiana, Sclerocarya birrea, Tamarindus indica, Prosopis africana, Pterocarpus erinaceus,*etc.**

nut, néré, and kad (*Acacia albida*). In the area around Ségou, for example, pastoralists contract to supply milk to farmers one day out of three in return for the kad pods consumed by their stock. Other than these restricted species, the fruit of trees growing wild in parklands is free to all. Rural people undeniably possess a considerable body of skills and local knowledge. During clearing operations in southern Mali, peasants were able to identify fertile land by the type of trees growing there (Bagnoud, 1992). People living in the Upper Niger Valley use rock salt to foster baobab growth (Cissé, 1995).

Assessment and Planning

All plant formations including the agroforestry parklands have been inventoried (PIRL, 1990), and all wood resources assessed for planning and management purposes. Specific inventories of all vegetation in parkland areas, including fields and fallow, have also been done by IER, DNCN and Care Mali. A great deal of data have been collected, but unfortunately, most is too sectoral to permit interface with either soil and agricultural or socioeconomic issues (Cissé).

An experimental method of estimating wood volume was tested. The three trees closest to the centre of the inventory plot were identified and their horizontal distance from the centre of the plot measured (Kouyaté, 1995). Field staff in the Sikasso region found ground applications of this method to be rapid and practical. There were no empty plots, the spatial configuration of trees could be read, the equipment, consisting of a compass, rope and double decametre plus two or three tapes was minimal, and a very small team could do the job. The major constraints were the low readings on biodiversity and overestimation of the surface area. Still, the procedure might well prove useful for technical people and forest managers.

The Swiss Cooperation programme for sustainable management of natural resources developed a participatory approach to forest research for land-use planning purposes. Peasant skills, knowledge and reasoning are appraised for a comparison of their technical solutions with research proposals. This provides a framework for discussion and negociation, local associations meeting with technical partners for discussions followed by negotiations with various experts and representatives of the plant, community forestry, local conventions, classified forests and gender sectors. The results of the work and discussions are then presented to a regional council for further discussion.

Assessment of shea and néré parklands

In Mali, as in all countries with scant tree cover where desertification is a constant threat, all off-forest wood resources, including trees and other woody biomass, are vital. The future of tree cover is heavily dependant on widespread recognition and enhancement of the myriad functions of agroforestry parklands. These major challenges presume an understanding of parkland dynamics. This prompted an assessment to advance the state of knowledge of shea and néré parklands (Sénou and Bagnoud, 1998), determine any changes in terms of production systems, and, working closely with the local population, suggest ways of boosting productivity. The research team opted for a participatory approach to assessment. Working with the villagers, they first explained the scope and purpose of the assessment and then, with active village participation, gathered and processed the relevant data.

Two plots shapes, circular and square, were tested before starting the inventory. Circular plots offer greater species representivity where there are few trees, so these were used for fallow areas, whereas the time-saving square shape was used for fields.

In the fallow areas, all trees in a 1 500 m^2 area were systematically included in the sample. The inventory threshold for shea and néré was one centimeter in circumference at 1.30 from the ground, and for other species 16 cm in circumference at 1.30 m from the ground. All trees of the same height but under 16 cm were also counted within a 300 m^2 circle. For fields of up to 5 ha, all trees were systematically recorded on a one-hectare square plot with the centre taken as the middle of the field. Fields of 5-10 ha were divided into two lots, with a sample plot for each lot. Three plots were established for all fields over 10 ha.

The extent of parasitical growth was rated by the number of clumps of *loranthacea* (a hemi-parasite that stifles fruit productivity) growing on each tree. The sampling rate was 30.5% for fields and 13.5 percent for fallow.

The assessment data covered species density, diversity, extent of parasitism, and resource dynamics. Tree density in fields varied by agro-ecological zone. Density was greater in the southern guinean zone at 20-28 stems/ha, and lesser in the northern sudanian zone at 9-15 stems/ha in an area which had been intensively and constantly under cultivation during the last 20-40 years. Density was also greater in bushlands at 15-28 stems/ha than in village fields which had been cultivated over a longer period of time, and where density was 8-20 stems/ha. In fields, shea and néré are the commonest species, but néré is not found in fallow areas. Species diversity is greater at 11 - 40 species among trees growing in fields, as compared to the 15 - 19 species found on fallow land. The study did not, however, lead to the identification of species in other non-forest systems. Parasitism rates in shea trees ranged from 89-100 percent to 57-74 percent, depending on the survey area.

Concerning parkland dynamics, there was a clear regression of shea and néré due to the physical elimination of standing trees caused by bark removal. This trend was more accentuated where harvesting had gone on for a long time, and in the Koutiala cotton basin where there is little arable land and substantial agricultural investment. Baobab is the only species which is planted or maintained, and the sole agroforestry practice remains the living fences which protect and demarcate farmlands. In the northern guinean zone, farmers plant néré in their fields and carefully maintain universally valued species such as tamarind, *Khaya senegalensis* (cailcédrat), *Sterculia setigera*, *Daniellia oliveri* (santan), and *Afzelia africana* (lingué). In fallow fields far from villages, a high rate of regeneration of various species, with circumferences of 8-15 cm at 1.3 m from the ground, was recorded. However, spontaneous regrowth in fallow fields near habitations is systematically cut back. Generally speaking, shea regeneration is more intense in fallow fields, but the species is better developed and more productive in fields.

This assessment was followed by an on-farm trial of parasite control to establish resistant shea trees. This initiative was also extended to neighbouring villages in the target area. But unless concrete steps are taken to ‘educate’ people to plant trees in their fields, the future of shea and néré parklands may well be jeopardized. The decentralization of natural resource management is a golden opportunity to skirt this reef, offering the best opportunity for motivating farmers to maximize the productivity of agroforestry parklands due to the enhanced value of their products.

Conclusions

In a country such as Mali where forest land is very scarce and trees are associated in the popular mind with parkland systems, there is bound to he heightened pressure on these areas to meet the growing demand for wood and non-wood products. In the face of advancing desertification, Trees outside forests not only combine an ecological role with a cultural role in the rural community, they are also an economic and social asset in the struggle to alleviate poverty and foster food security.

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Trees outside forests: Morocco

Omar Mhirit and Mohamed Et-Tobi
Ecole nationale forestière d'Ingénieurs, Salé
Ministry of Agriculture, Rural Development and Forestry

Photo 56. Olive and almond groves in the 1970s in Morocco as part of soil protection and restoration efforts (© Bellefontaine/Cirad)

Context

Morocco conducted a national forest inventory (NFI) in 1999 on 44 650 000 ha. The results show that 12.5 percent of the national territory is forest domain, of which 5.5 percent is classified as forest and 7 percent as other wooded areas. Some 20 percent of Morocco's land area is covered by non-forest tree systems. Subtracting the 11 percent of bare and desert land, we are left with a figure of 56.5 percent of agricultural, pastoral and urban lands. This leaves considerable potential for the expansion of non-forest tree systems.

The population totalled 28 238 000 in 1999, of whom 49 percent are rural dwellers. Of this number, 80 percent live in farm households, accounting for 80 percent of rural employment.

Population growth, soil erosion, desertification, disease and crop pests all take their toll of natural resources, and the burgeoning agro-food industries and expanding export markets also have an impact. Within this changing context, there is a need for a closer look at non-forest tree systems and how to enhance them. The carob tree discussed in this paper is a case in point.

Concept

Data from the 1999 NFI and the agricultural surveys were tapped for a classification of non-forest tree systems. These included the 1998-99 general farm survey (RGA - *Recensement général agricole*) by the DPAE (*Direction de la planification agricole et de l'environnement*) and specific surveys such as the 1991 citrus survey (Mhirit and Sbay, 1991) and the 1995 survey on *rosaceae* (Basler *et al.*, 1995).

Treed permanent pasturelands alone carry 84 percent of these tree systems. Orchards plus scattered fruit trees account for a further 12 percent. The DRS (*défense et restauration des sols*) plantations, which serve to protect and restore the soil and may include fruit, forest fruit or silvopastoral species, amount to about 3 percent. The remaining 0.5 percent consists of urban and peri-urban parks, green shelterbelts, line plantings and rows of poplars.

Patterns and extent of change

Not all non-forest tree systems exhibit the same patterns and extent of change. Pasturelands, for instance, tend to be under great pressure, whereas fruit-tree orchards have expanded. Natural rangelands are not all managed and used in the same way, partly because of certain ambiguities in the legislation concerning usufruct, and largely because of the size of the herds, estimated at 17 million sheep, 2.6 million head of cattle and 5 million goats. The fruit tree sector, on the other hand, has benefited from the development of large and medium-scale water harnessing schemes, and from the 1969 Code on Agricultural Investment, which breathed new life into the agro-industries and opened new markets.

There is no actual inventory of off-forest tree systems as such, but available agricultural and forestry statistics indicate a steady expansion of orchards: first, olive orchards from 1968 to 1988, and then a steep upward swing from 1989 with the introduction of the big *rosaceae* plantations. Conditions in Morocco have always favoured the introduction and adaptation of a wide range of fruit species, including citrus fruits. Fruit-tree cultivation has accordingly been encouraged, fostering the establishment of both rainfed and irrigated fruit corps.

Trees growing outside forests play a prominent role in food security. The 1998-99 estimates for fruit production were 2 934 370 tonnes, distributed as follows: citrus fruits 50 percent, *rosaceae* and olives 20 percent each, scattered fruit trees, mainly figs and walnuts, 5 percent, date palms 3 percent and almonds 2 percent (Ministry of Agriculture, Rural Development and Marine Fisheries -- MADRPM) (2000a, 2000b). Their contribution becomes crucial in times of scarcity. The herds supply 98 percent of red meat production, meeting 35 percent of the demand for food. For the livestock production sector, dairy production meets 87 percent of the national requirement, with rangelands and crop by-products supplying 65 percent of this output (MADRPM, 2000b).

Trees outside forests also benefit the national economy: the resource and its products is the prime source of supply for the agro-industries. The agro-industrial sector has seven sub-sectors: oil processing, cold storage, fruit and vegetable processing, vegetable canning, dairy products and byproducts, compound foods, and red meat. Of the 17 846 units involved, 94 percent are traditional industries, 91 percent of which have to do with oil-processing. In terms of providing employment, the fruit production sector offers the equivalent of 56.5 million workdays, on a seasonal and year-round basis. Wood supplies 30 percent of the national demand for energy, second only to oil at 51 percent. Forest species supply 53 percent of the woody biomass consumed in Morocco, fruit tree species 28 percent, and crop residues 28 percent (CDER), 1998).

Soil protection is a major environmental function of trees growing outside forests, particularly rangelands in watersheds. In urban areas, greenbelts and shelterbelts not only add to the beauty of the landscape, they provide an essential bulwark against wind, sand and erosion, produce oxygen and mark boundaries.

Rural populations also benefit from the resource, which supplies fuelwood and wood for home-building, artisanal activities and tool-making, not to mention food and the preparation of home remedies and cosmetic products. The trees are also a source of income – honey is just one example. Several species, such as the olives, figs and pomegranates frequently cited in the Koran, reflect specific values of Arabic and Islamic culture and religion. In rural areas, trees are perceived as refuges, symbolizing prosperity and the sense of belonging to a particular place or group. Multi-purpose trees have considerable social and economic significance.

Photo 57. Date-palm grove in The Todra Valley, Morocco. (© Bellefontaine/Cirad)

Institutional and management aspects

The Code on Agricultural Investment is the main legal instrument for trees outside forests. It stipulates incentive measures for afforestation, reforestation and restocking, and for fruit–tree cultivation. Forest law, town planning and natural resource legislation also cover these resources. In terms of land ownership, some 86.5 percent of these trees come under collective ownership systems, 12 percent are on private land, one percent are on public land, and 0.5 percent on state land.

Management responsibility lies primarily with specific services of the Ministry of Agriculture, Rural Development and Forestry, and with the Ministry of Land-Use Planning. DRS, a forest service activity, involves soil protection from wind and water erosion, water conservation, boosting productivity on slopelands, buffering the socioeconomic infrastructure from the impact of erosion, and enhancing farmer income. Where erosion constitutes a menace to the community, the affected areas are declared zones of national interest (*périmètres d'interêt national* – PIN). The State then bears the cost of erosion control infrastructures and protective reforestation. Subsidies are granted to farmers for the construction of bunds around fruit-tree, forest or cereal crops.

The most notable planning and management systems for non-forest tree systems evolved as part of the Rif Integrated Development Project and the Eastern Pasture and Livestock Development Project (PDPEO). The Rif project involves forest and peri-forest areas. The goal is global and integrated land use and natural resource planning and development for homogenous zones, based on a flexible, participatory planning approach assuming stakeholders as partners and these lands as their legacy. The Eastern project concerns rangelands and combines several types of action: improved production (browsing and grazing resources, mostly trees and bushes); environmental protection (water and soil); resource enhancement (product diversification, fuelwood, planting and management of rosemary bushlands, tree crops and apiculture).

Natural resource management has long been in the capable hands of rural people, with their undeniable traditional skills and knowledge. The most striking illustration is the wise and complex exploitation of natural rangeland under a regime of nomadic herd movements and practices judiciously planned to make the most of plant resources. In these nomadic systems the herds follow the rains, but they also move from the plains to upland areas with the change of seasons. The social abilities of farmers and pastoralists have also favoured the emergence of peasant associations. There are 56 national and 124 regional associations and a number of cooperatives, 58 percent of which are agricultural cooperatives.

Assessment and planning

Resource planning for these systems represents a wide range of stakeholders and viewpoints, including state management sectors, ministerial services such as the departments of the interior, urban planning, environment, public works and so forth, plus the National Councils for Agriculture and Forests. Farmers associations such as the chambers of agriculture, local communities and NGOs are all involved, as are the big fruit farms and the paper and pulp industries.

Various plans and strategies designed to check resource degradation and promote woodland areas also concern these tree systems. The national watershed management plans, the desertification control plan, reforestation, farmland conservation management and the Master Plan for protected areas, the law on development of the *bour* areas (rainfed agriculture zones), the rangeland development strategy, the national forestry programme, and the 2020 rural development strategy all have sections on these systems. The 1994 reforestation Master Plan specifically stresses the sustainable development of forest and peri-forest lands and watershed protection. It also targets a new reforestation process based on a participatory approach favourable to non-forest systems. Various state and semi-state funds such as the Hassan II Foundation, the National Forest Fund, and funds for rural and agricultural development and community infrastructure all support these guidelines.

Agricultural surveys and censuses provide data for agricultural policy monitoring and follow-up. The data processing and statistics division does annual random sample surveys on plant and animal production, (permanent national surveys or occasional regional surveys). Tree statistics were provided by the 1991 citrus survey and the 1995 *rosaceae* survey, whereas the 1998-99 RGA survey furnished statistical data on tree cover, varieties, maintenance, age, health, etc. The purpose of the RGA was to collect structural data on agriculture, pinpoint changes with respect to the 1974 census, and establish a data file on all farms to provide a sampling basis for topical agricultural surveys. The sample stratification contained eight classes based on land use, rainfed croplands, irrigated croplands, fruit plantations, forests, rangelands and uncultivated lands, small towns, large towns, and big *douars* (villages). Sample size was determined in accordance with the importance of agriculture within the region and crop diversity. Morocco now has a fairly well-developed circular sampling system designed to cover supply side, extension, agricultural policy extension, monitoring and planning sectorial needs.

Carob-tree assessment

The carob-tree (*Ceratonica Siliqua L.)* is of considerable social and economic significance. This Mediterranean legume ranges from the plains to the hills. In thermocline terms, it grows in arid to semi-arid Mediterranean areas and adapts well to poor soils. Homogenous stands of trees are found on privately owned land and in state forests.

Forest species growing on private and state land face a number of severe constraints, but farmers are careful to protect the carob-tree, a privilege justified by its unique virtues and advantages. Its great popularity is mostly due to its vast potential for rural development and soil conservation, and for mountain-area economies. Both the fruit and the seeds have numerous domestic and industrial uses, as well as undeniable qualities. Every part of the tree is useful and valuable. There are six production units for gum arabic[26], and ten crushing plants with an annual processing capacity exceeding 80 000 t.

No unauthorized removal of forest products is legal on state land, so carobs growing there are used more for browse than for fruit. The forest administration guarantees the right of sale for carobs of authorized provenance. On private land, the owners are simply obliged to pay a pre-harvest tax on the estimated volume of the harvest. In state forests, carob output is auctioned on an annual basis with no guarantee of quantity or quality. In fact, this is more properly seen as a right to pick the harvest, which is done by people living nearby, who then award the harvest to the highest bidder.

The juxtaposition of private and state-owned lands where carob thrives makes it hard to identify the provenance and quantify the product. In 1995 in the province of Ben-Mellal in the western high Atlas region, a thriving carob zone, a survey was carried out to learn more about the carob sector (Zouhir, 1996). An estimated 12 000 ha are under carob in this region, with an average density of 16 stems/ha. This works out to 7 000 ha of state forest with a density of 20 trees/ha, 4 000 ha of private land with a density of 10 trees/ha, and 1 000 ha of collectively owned land with a density of 15 stems/ha. The data on the public or private provenance of the product, quantities, and income were gathered by forestry staff at the pick-up centres in the weekly *souk* (market) where bidders and sellers meet during the season. The data were then compared to the forest service and exchange office data for the 1991-95 periods on sales and prices, as well as import and export figures.

The survey findings for the province estimated actual harvest quantities at 8 395 quintals from six forests, and user income from the product at US$ 470 120. At the national level, government records indicate an average annual 8 206 quintals of carob offered for sale for an intake of US$ 261 760. In exchange terms, the year 1994 showed a major flow of carob and carob by-products: 110 280 quintals exported for a value of US$ 8 322 404, and imports of 26 680 quintals for a sum of US$ 5 244 045.

The survey highlights the social and economic importance of carob. It also shows that a part of the carob crop is not officially recorded. The actual quantities harvested in just one province exceeded the amount offered for sale at the national level. The volume sold represented some 33 percent of the volume actually harvested. The 67 percent difference is thought to have come from carob harvested on private lands. The findings seem to make sense in terms of the production potential of the two categories. Income to the population would therefore represent 64 percent of the total amount and over twice the income put in the hands of the rural communes, showing the importance of carob for local economies.

Because the survey concentrated more on carob as product than as resource, it had its limitations. Neither the carob fruits nor foliage consumed *in situ* by livestock nor the value of carobwood was considered. Still, the survey can be used by rural communities to determine local harvests, by foresters to assess unmonitored amounts, by farmers' associations for market data and/or to stimulate investments, and by development agencies to appraise the impact on rural income. It could also

8. Gum arabic is extracted from carob seeds. It is used in the food industry, but also has other applications in the paper, textile and pharmaceutical industries.

be upgraded by bringing in other assessment criteria such as whether state or private property is involved, carob varieties, productive and unproductive trees. The foregoing is all strong justification for a tree-by-tree survey.

The size of the carob crop is an argument in favour of carob promotion and of such tree systems. Some industrialists, looking at the international demand for and importation of specific carob by-products, put money into carob plantations in forest areas. For lack of a clear legal framework, the results fell short of expectations. They then turned to the intensive carob plantations in the Khémisset and Agadir regions. Rural populations have also expressed real interest in growing carob, especially since the harvest and transfer process presents economic advantages for farmers. Carob could be safely introduced on a large scale as it is a hardy tree that can adapt well to marginal and sloping lands, whilst offering real economic and environmental benefits.

Conclusions

Generally speaking, each off-forest tree system faces its own specific constraints, but some obstacles to development are common to all. These include: the complex legal status of land, the fact that plantations are scattered, poor plant matter and farm practice performance, the lack of water, and so forth. The woody biomass yield of local and introduced species is low. Meeting the demand for biomass fuel raises the problem of mounting need coupled with ecosystem degradation. Carob trees, multi-purpose trees in pastoral and mountainous zones, and date palm culture in oasis and pre-Saharan zones are all sectors suitable and advisable for development. The best species and land use interactions also need to be identified.

The focus of the 2020 Rural Development Strategy is on natural and agricultural resource issues, of which Trees outside forests are an integral part. The objective is to foster the emergence of a climate of economic growth and well-being for the people of Morocco, while at the same time correcting disequilibria in rural areas and enhancing rural potential. The establishment of agro-ecological criteria and the identification of social and territorial areas are positive ways of respecting local specifics. The new rural and agricultural development code puts forth a number of principles. These feature multi-purpose agriculture, the contractualization of relations between public and/or private actors, and the regionalization and territorialization of policy-making. These measures also hold promise for improved management, planning and assessment of Trees outside forests.

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Trees outside forests: Namibia

H.O. Kojwang and M. Chakanga
Ministry of Environment and Tourism, Forest Service, Windhoek

Context

Namibia covers an area of some 825 000 km^2. The population, estimated at 1.7 million people, of whom 68 percent live in rural areas, is growing at an annual rate of three percent. Urban populations, fed by rural-to-urban migration, are growing faster than rural populations at an annual five percent compared to two percent in rural areas. In northern Namibia, where both human and tree populations are highest, the Ministry of Environment and Tourism carried out a major forest cover mapping exercise in 1996 on some 28 430 000 ha. The study found[27] that 6.4 percent of the area was under extensive, subsistence cropping on woodlands and savannah; 0.3 percent was intensively cropped; 54.3 percent was open grassland and 26 percent was woodland. The remaining, treeless, 13 percent was comprised of open water, grasslands and valley bottoms (MET, 1996).

Namibia is a semi-arid country. The presence of Trees outside forests is due to a series of interactions, including the conversion of woodland into farmland, the food value of indigenous fruits, the need of a predominantly pastoralist society for forage and shade, and the introduction of processing plants for wild and domesticated fruit species. In this context an assessment of on-farm, non-forest trees is clearly needed to track tree production, evolution, and the potential contribution for natural resource conservation and enhanced food security.

Concept

For forest inventory and management purposes, Namibia defines as forest any woody formation with at least 15 percent tree cover and mean tree height of at least 4 m. The latter figure is justified by the considerable woody biomass potential of Namibia's substantial acacia and mopane woodlands for a potentially lucrative charcoal-making industry.

9. The criteria chosen for forest classification were: tree height over 5 m, and crown cover over 15 percent.

Trees outside forests are growing in heavily cultivated agricultural fields, villages and settlements, and in scattered formations in savannah and arid zones. These systems include trees left standing on woodland converted to farmland, on-farm woodlots, living fences, ornamental hedges, natural regeneration on farmland, scattered trees in the savannah, and isolated formations in the desert. The most intensive of these systems are found on heavily cultivated farmland, where trees play a major economic role.

Patterns and extent of change

The backdrop to the predominant agro pastoral systems of northern Namibia is a semi-arid environment characterized by low productivity, scarce credit and little infrastructure. One study (Erkkilä and Löfman, 1999) showed forest cover shrinking at an annual 0.5 percent as croplands expanded. Presumably, agricultural expansion and the concomitant deforestation will favour trees growing in non-forest areas. In the absence of an inventory of this resource, however, we can only assert with certitude that there are now fewer trees on farms than in woodland and bush savannah.

Some woody species do survive the expansion of the agricultural frontier. These include forage-producing *Lonchocarpus nelsii,* nut-producing *Guibourtia coleosperma,* plus *Faidherbia albida* and *Acacia eriolob,* which bear the highly nutritious indehiscent pods livestock find so irresistible. *Scelerocarya birrea* (marula), *Berchemia discolor* (bird plum), *Strychnos spp*, *Diospyros mespiliformis* and *Hyphaene petersiana* (makalani) are rarely cut down as people are very much aware of the value of their fruits and nuts.

Marula fruit is an excellent source of vitamins. The kernel is crushed to extract a stable cooking-oil rich in unsaturated fatty acids. Marula oil is currently being promoted in the UK for pharmaceutical and cosmetic purposes. Marula juice is exported to South Africa to produce an alcoholic beverage. Other fruits also gain in value when processed, such as bird plum, which is dried and marketed, and manketti nut (*Schinzophyton rautenei*) , which is crushed to obtain an edible oil or ground for porridge, particularly during periods of drought. Manketti oil is now being tested to assess its potential for industrial use. Makalani leaves are used to weave baskets for export (Ministry of Environment and Tourism, 1996).

The consumption of processed or unprocessed indigenous fruits and nuts, the pharmacopoeia, and the living fences to protect crops all illustrate the value of off-forest trees, as do fence posts, fuelwood and construction wood for housing and livestock shelters. The resource also has an important role to play in environmental protection. Trees such as *Acacia erioloba, G. coleosperma* and *F. albida* improve soil fertility by fixing nitrogen and recycling minerals.

Institutional and management aspects

The main national backing for Trees outside forests is found in the 1968 Forest Act and the 1998 New Draft Forest Bill, as well as the 1997 Nature Conservation Ordinance Amendment Act. These texts protect trees, wild flora and fauna, and their habitat. The forest rules forbid the destruction of trees and other woody vegetation, except as authorized or in the case of specific land use plans. The proposed draft forest law stipulates that no one can plant more than 5 ha of woodlots on farmland unless the new trees are fruit trees. Customary law also includes sanctions against the cutting of fruit trees.

The new forest legislation and policies acknowledge the collective ownership of forests and woodlands. This encourages good management by local communities, who are perfectly aware that usufruct is contingent upon how well they manage their tree resources. A further incentive is that rural people are heavily dependant for their livelihood on a natural resource base increasingly degraded by deforestation, overgrazing, and the lack of rain.

The potential of trees to protect ecosystems, alleviate poverty, enhance food security, and generate and diversify income has mobilized a number of institutions around a common vision of the economic benefits of specific tree species. These include: the Ministry of Environment and Tourism, whose mandate comprises forests, nature conservation and the environment; the Ministry of Agriculture, Water and Rural Development; and the ministries responsible for the advancement of women and decentralization. Even agricultural policy with its traditional focus on crops and livestock now has chapters on indigenous fruits and other wood and non-wood products.

The promotion of off-forest resources is gaining ground with concrete efforts such as living fences to protect harvests, extension campaigns to encourage farm forestry, and research on indigenous fruit tree breeding, improvement and domestication. Community forestry projects to prepare action plans for tree resource management are increasingly on the agenda. The Forest Service and the Ministry of Agriculture are jointly implementing a community forest management project in the Outapi district. They have also set up a working group for marketing value-added indigenous fruits and nuts throughout the country.

Research at the regional level is increasingly targeted at the domestication of indigenous fruit species. Genetic trials are being run on marula by SADC member countries (Southern African Development Community). A project is now in preparation to ensure follow-up for the ICRAF (International Centre for Agroforestry Research) trials in Malawi.

At the local level, farmers follow customary rules and standards for the use of trees on communal land, and have direct control over the trees on their own farms. Rural people are very conscious of the myriad uses of the various tree species. When new fields are prepared, trees that supply fruit, nuts and medicinal products, and trees that enhance soil fertility and provide shade, are not felled. Farmers leave most young or mature fruit trees such as *Diospyros, Grewia, Ziziphus* and *Schinzophyton* standing in the fields, tend the trees and protect their seeds, watering, thinning or singling and cutting as needed at the different stages of growth. Crops and trees compete for good arable land, however, so there are not too many trees.

Traditional management systems for trees growing outside forests are gaining broader recognition. A 1999 report presented 19 case studies on peasant farmer tree management skills, practices and techniques in north central Namibia. Projects look at ways to capitalize on local skills and traditional practices, and to ensure their continuity, now and in the future. The Community Level Forest Management project, the Community Forestry Extension Project, and the Centre for Research Information and Action for Development in Africa have all worked on traditional management systems.

Assessment and planning

The objective of the Forest Service's inventory was to ensure the availability of adequate forest resource information for strategic planning and operational management. The inventory was based on stratified sampling according to plant cover density at a sampling rate of 0.10 - 1 percent of land area. Data were gathered on trees, shrubs, grasses and herbs. The target was not only to gather data, but also to establish a mechanism for monitoring wood resources in northern Namibia, using these same sample plots in combination with remote sensing. The Forest Service has the institutional and staffing capability to do this, drawing on its own staff and that of the National Remote Sensing Centre. Fire-scars have already been mapped.

In addition to the NFI, which covered areas of low tree density, two inventories were done on trees growing outside forests, one on makalani and the other on manketti. These assessments had the financial backing of cooperation agencies with programmes to improve living conditions in rural households. One pilot community forestry project designed an assessment system that deserves to be tested in a variety of contexts for cost appraisal and practicality. We need to remember, also, that inventories are expensive. Large-scale inventories of off-forest resources are prohibitive unless there is a very good economic reason to conduct one. With this in mind, the forest service devised an assessment system for marula, given the export and marketing potential of marula oil. Other than these special cases, however, no assessment methodology *per se* has been developed for off-forest resources, and there is no systematic, detailed, national documentation on the subject. Some pilot forestry projects and community natural resource management projects do offer data on nut yields and foliage volumes, however.

The forest service should develop simple but analytical methods to gather data on on-farm trees. These would serve to support local priorities and make the most of local knowledge. During the manketti survey, for example, people from the !Kung group proved to have excellent visual assessment skills. Such capacities, which illustrate the potential for using local skills in tree identification and assessment efforts, could be harnessed for reconnaissance surveys.

Inventory of on-farm single trees and woodlots

The pilot community forestry project in northern Namibia assessed off-forest trees in the community of Ontanda. The objective was to gather data to allow community design of an integrated forest management plan. The assessment had two components: single trees and woodlots. The field work was led by a group of farmers. Their participation was essential to create a climate of confidence, stimulate interest, facilitate communication (especially once the results were in), and gather data on local lore concerning tree species and their products. Training the work-team, which involved teaching them how to take measurements, took one week.

On-farm single tree inventory. All single trees on farms and/or in fields were enumerated by species. The systematic sampling covered mature and immature, and male and female trees. The owner of the holding or his or her representative reported on local names and how trees were used and managed. The co-ordinates of the holder and holding, including farm size, were recorded along with the number of specimens of each tree species, specifying maturity and sex, utilizations and management practices. The biomass volume was calculated using standard height and diameter measurements. The sampling rate was 3.2 percent.

An average of 20 mature single trees was found on farms, mostly multi-use species with predominance of marula. All trees grown or left standing for fodder also provide shade, and 26 percent are grown solely for this purpose.

Trees giving fruit, feed or medicinal products are held in high esteem by farm households. Some products from these scattered trees also provide a modest income. They could, if better managed, make a significant contribution to household income, especially for women.

On-farm woodland inventory. Two circular sample plots were subjectively marked out to enable a reasonable representation of wooded land. An average holding was found to have some 9 trees/ha with diameters greater than 5 cm. These trees averaged out as follows: diameter = 11.4 cm; height = 4.8 m; volume = 0.434 m^3/ha with a mean annual increment of 0.0143 m^3/ha.

Annual consumption of wood for construction on an Ontanda farm is estimated at 3.5 m3/yr. This is eight times the total tree resources on the average farm for trees over 5 cm in diameter. The annual increment of forest resources on an average farm of 0.014 m3 covers only four percent of the annual wood consumption for that farm.

These figures show that standard methods could be adapted for application to Trees outside forests, particularly single or scattered trees. The margin of sampling error should be reduced, however. Conventional inventory variables are of less significance for off-forest trees than other variables such as the amount and quality of the fruit harvest, the kinds of medicinal products obtained and the sex of the tree.

Conclusions

Namibia, faced with problems of food insecurity and poverty, proposes two major development orientations: new markets for wood and non-wood forest products, and natural resource protection. Community management programmes for Trees outside forests are gaining in importance, particularly for the ecologically and economically promising indigenous fruit-tree species.

The assessment of this tree resource is constrained by a number of factors such as the scattered distribution of trees and settlements, the high cost of sampling, and limited access to privately owned lands. The economic, ecological, social and cultural benefits of these tree resources deserve and demand greater attention on the part of policy makers. Meticulous assessments of available natural resources and a careful look at their potential for sustainable use would do much to bolster policies to promote food security and diversify rural income.

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Photo 58. Agroforestry stand of *Acacia senegal* (gum-tree). (© Cossalter/Cirad)

Trees outside Forests: Sudan

William M. Glen, Consultant
Bonshaw, Prince Edward Island, Canada

Context

Sudan covers an area of 2.5 million km^2 and is characterized by three vegetation zones: desert in the north, savannah and dry grassland in the central region, and the large swamp called the Sudd with some rain forest in the south. According to the 1995 Forest Resources Assessment, forests cover 17 percent of the territory and wooded land 10 percent. Sudan, though not a heavily forested country, is heavily dependant on tree resources for its basic supplies of fuelwood and building materials (FAO, 1995b).

Maintaining the productivity of the land is crucial in such a context, and this implies the existence of land use and land cover data. The 1995 National Forest Inventory (NFI) had as its prime objective the assessment of plant cover, and was designed to inventory both land cover and land use.

Concept

Sudan's forest service, the Forests National Corporation (FNC), established no legal or other type of definition for 'forest', and, accordingly, none for Trees outside forests. The data on land distribution indicate the following division: 27 percent forest and wooded land, 29 percent desert, and the remaining 44 percent upon which off-forest trees can be found.

Patterns and extent of change

The 1995 Forest Resources Assessment showed a 0.8 percent deforestation rate for 1990-95. A review of old maps of Sudan at the 1:250 000 scale revealed a significant decrease in treed area since 1900.

There is no real acknowledgement of the importance of trees growing in non-forested areas, with the exception of *Acacia Senegal* (L.) Willd in the savannah area. There is a growing and worldwide demand from the food and pharmaceutical industries for the gum Arabic extracted from it. Sudan is the world's top producer of gum Arabic. Exports in 1995 amounted to US$ 56 million, i.e., almost 11 percent of all Sudanese exports for that year.

The people of Sudan are partly dependant on Trees outside forests for the wood to build their homes, for charcoal, and especially for livestock forage. To some extent they also depend on these trees for their livelihood. Fodder and wood for charcoal have not been quantified, but their utilization is clearly exerting growing pressure on trees (FNC, 1995). These trees are also clearly beneficial for soil maintenance. Erosion, especially wind erosion, is twice as severe in treeless areas. Tree-planting to stabilize dunes and check the encroachment of the desert onto farmland is a common practice in northern Sudan.

Management

Forest law and the guidelines for action of the Forests National Corporation (under the Ministry of Environment and Tourism) clearly recognize the importance of forests. The FNC established that a 20 percent expansion of wooded areas was essential to meet national needs. It is carefully tilting management strategies toward a more balanced ratio of forestland to farmland and rangeland. Dry grasslands are now the focus of increasing attention. This contrasts with an earlier lack of interest in these areas because of their low woody biomass, despite their importance as a source of supply for local populations (FAO, 1988; von Maydell, 1990; FNC, 1994 and 1995).

Assessment and planning

FNC's mandate includes forest resource assessment. Most inventories have focussed on areas of known tree density. Moreover, the 1983-84 Blue Nile Province inventory, which used aerial photography combined with randomly laid out ground plots, was not repeated due to the excessive cost.

Some inventory projects had focussed on areas with low tree densities. The work done by a team from Lund University of Sweden from 1987 to 1990 covered 5 800 000 ha in the Eastern Region using Landsat Thematic Mapper imagery, and the Sudan Reforestation and Anti-desertification /Sudan Resource Assessment and Development projects (SRAAD) between 1987 and 1993 covered 3 60000 000 ha, using a combination of satellite imagery and systematically laid out ground plots.

The main lessons learned from these two projects were that satellite imagery without good ground verification can produce misleading results, and that there is a need for ground plots to supply details on volume, stems/ha, species, site conditions and land use. Global Positioning System (GPS) units used in the SRAAD projects demonstrated the feasibility of sampling grid networks. The review of the procedures used for these inventories plus the expertise acquired by the staff facilitated the 1995 implementation of the NFI.

National forest inventory

The primary purpose of the NFI project was to provide area and volume statistics for regional and national planning, thus defining this as a reconnaissance survey. The data on plots and species distribution could facilitate assessment of nonwood products such as gums, fruits and nuts.

Methodology. The inventory design was flexible enough to combine with more detailed inventories, such as the national parks survey, or be used as a working model for regional inventories. The field work was done in 1995 and 1996, following a 1994 methodology preparation stage and staff training sessions in early 1995. Only ground plots were selected as saving on both costs and time (there were only three crop seasons for inventorying 77 000 000 ha). The lack of current inventories and current base maps (the available maps dated back more than 40 years), were further constraints.

The inventory covered 2 608 sampling plots representing some 26 000 000 ha in Central Sudan. These are typical dry grassland and savannah zones, which would not be considered forest land under the FAO definition that sets the tree cover threshold at 10 percent. The inventory project was based on the measurement of fixed area plots on a systematic grid throughout the inventory area. The use of the GPS units meant that the sampling locations could be mapped using their co-ordinates without reference to any base mapping.

The sampling grid used was 10 km by 10 km with a field plot being established at each grid intersection. Because the sampling was systematic, the measured plot was assumed to be representative of the sampling cell (i.e., 10 km or 10 000 ha). The chances of the plot falling into any particular land use or forest type were proportional to the occurrence of that type in a given area (FAO, 1981; SRAAD project, 1990b).

The plot size used was 20 by 100 m, with an east/west orientation, the same as the SRAAD projects. This type of plot had been used in most inventories in the Sudan since 1983, and the FNC field staff was familiar and comfortable with this plot design (Groupe Poulin, 1984; Vink, 1987; SRAAD projects 1990 a, 1990b; Ali, 1993; Vogt, 1994). Rectangular plots are more difficult to accurately establish than circular plots, however, and so the latter would have been preferable.

A number of data categories were devised as follows, each corresponding to multiple choice questions, excepting the items ‘slope percent and aspect’ and ‘year of felling’:

• Land use: forestry, grazing, cultivation, population centres, other;
• Land cover: trees, shrubs, grass, barren or water;
• Land condition: eroded, flooded, wind erosion (drifting or scouring), water erosion (rill, sheet or gully erosion, pedestalled plants), or no damage.

Photo 59. Camel browsing on one of the few trees in the region (© Braatz/FAO).

• Soil type: sandy, rocky, clay, loamy, dune, alluvium or sandy-clay;
• Landform: dune, wadi (water-course), jebel (uneven-height mountains), knorr or no features;
• Slope percent and aspect;
• Origin of any trees: natural, plantation;
• History of harvest: clear-cut, partial cut, cleared or no cutting;
• Year of felling.

All trees or shrubs in the plot with a root collar diameter greater than five cm were tallied. Each plant was recorded as to species, live or dead, root collar diameter, total height, crown diameter measured at right angles to the plot's long axis, diameter at breast height, bole height and percent of cull. Shrub measurements were only taken in accordance with form and accessibility.

A regeneration subplot of 1 x 10 m was located in the south-western corner of the plot. The species and number of stems in it were tallied for all woody plants with a height greater than 15 cm and less than 130 cm.

The field data was entered into three databases, one for the plot observations, and one for the tree measurements and the third for the regeneration plot. Plot location information which included the 1/250 000 map sheet references, the Universal Trans-Mercator (UTM) co-ordinates and the administrative region were added to the plot file. The information in these databases combined with volume equations were used to produce a summary database which included statistics for each plot. This plot summary file was used to produce aggregations of area or other criteria.

Results. The above results (Glen, 1996) concern 16 730 000 ha and 1 673 plots in the country south of Khartoum straddling the two Niles. The land cover results were as follows: bare ground 30.2 percent, grass 34.7 percent, shrubs 14.1 percent, and trees 19.3 percent and water (the two Niles) 1.6 percent. The land use for the same area was: cultivation 41.4 percent, grazing 21.0 percent, forestry 18.7 percent, population centres 2.8 percent and 16.1 had no evident use. On these 16 730 000 ha, wind erosion had damaged 500 000 ha (three percent), and water erosion 2 080 000 ha (12 percent), confirming that the impact of erosion is in direct proportion to land cover – the more exposed the soil the more severe the erosion.

Out of a total wooded area[28] of 4 680 000 ha, only 1 160 000 ha, or some 7 percent of the area, met the FAO definition of forest. TOF represented 21 percent of the wooded areas measured, and thus a little over 75 percent of the total wooded areas, in addition to the potential represented by areas currently without trees, such as pasture, estimated at 35 percent of the entire inventory area.

Table 15 shows the estimated volume of woody biomass for the inventory areas for all diameters and species lumped together. The per hectare volume of wood is low in most places, but it must be remembered that this vegetation is certainly not negligible in terms of local wood supplies for Smallwood and other miscellaneous products, not to mention soil protection.

The inventory identified 33 species and their distribution can be mapped. *Acacia, Balanites, Combretum* and *Terminalia* were the main genera in treed areas outside the forest. The overall statistics from the 177 field plots established in the TOF area were as follows: average crown cover, 4.43 percent (including shrubs); average number of stems with a root collar diameter greater than 5 cm, 13; average live volume 4.6 m^3/ha; average dead volume 0 m^3/ha; average basal area 0.24m^2/ha; and number of regenerating seedlings 4.61/ha.

10. The 4 680 000 ha were measured on 468 wooded plots containing woody vegetation.

Conclusions

The methodology of this primarily reconnaissance survey, with its sampling rate of 0.002 percent, enabled us to obtain the desired information at low cost and in a short timeframe. It could be adapted for various situations by modifying the sampling rate of the grid, and the size and type of parcels as well as the data-gathering criteria. Bearing in mind that the plots were located with the use of GPS co-ordinates, they can be revisited to produce data on size and any changes. Only ground plots were used for this national forest inventory. Aerial photographs could be helpful in areas where access is a problem and aerial photography is available. The combination of both ground plots and aerial photographs is another possible option (CFIC, 1998).

Table 15: Average per hectare volume and area by diameter class

Average volume (cm.)	0-5	Area by diameter class ('000 ha.) 5-10	10-15	15-20	20 et plus	Diameter classes (m^3/ha)
Khartoum	470	0	0	0	0	0,59
Kamlin	70	0	0	0	0	0,55
Geteina	300	40	0	0	0	1,95
Wad Medani	50	10	0	0	0	2,37
Aba Island	220	30	10	0	0	1,70
Sennar	360	10	10	0	30	4,16
Jebelein	680	30	0	0	0	1,44
Karkoj	550	100	20	0	140	9,87
Er Roseires	630	270	60	50	40	5,84
Fazugali	80	90	60	30	210	23,23
Total	3 410	580	160	80	420	6,31

Source: Glen (1996).
Note: These measurement were taken only on 'wooded' plots, i.e., with woody vegetation, out of a total area of 4 680 000 ha, excluding plots with no woody vegetation.
The total volume is the volume and the aboveground portion as of a diameter of 5 cm
The woody biomass can be calculated when the conversion equation is available.

Sudan now has data to take up issues of sustainable land use. The data on land use and erosion damage could underpin a land use planning effort to address the scope and location of soil conservation problems.

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