CDM Specifics

Deliverable D 2/1, CDM specifics (Task 2.1)

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1 Major differences between Annex I Countries and Non Annex I countries

There are noteworthy differences between Annex I Countries and Non Annex I countries what regards the cultivation of trees, the competitive situation between trees and annual crops, the usage of wood and fuels in general, labor and material cost etc. These differences are highlighted in the current section. To some readers the described contrasts might appear exaggerated what regards provided numeric figures and not valid in all cases, however the objective is to widen the horizon with regard to a better mutual understanding of readers having different cultural backgrounds. It has to be added that there are considerable differences within each country, e.g., in particular, in such huge countries such as India or China, between the concrete local situations of farmers which are not taken fully into account here.

1.1 Socio-economic differences

Subsistence farming and risk of food scarcity in Non Annex I countries In many Non Annex I countries food scarcity is a major issue because there is a strong overlap between the countries covered by the notion of Non Annex I countries and those denoted as 'least developed countries'. This is why, when describing crops subsistence farmers grow in Non Annex I countries a distinction is made between 'food crops' (→ used for feeding the family) and 'cash crops' → sold at the market in exchange for cash.
Actually, in the Indian state of Uttar Pradesh during a pioneer phase of poplar agroforestry sytems (1984-1987) the state's government would not allow bank loans for such systems for more than two hectares per farmer and plantations were restricted to be implemented on boundaries or peripheries of the farms or on barren/fallow land ('boundary plantations'). Cultivated land was not eligible to be diverted for the purpose (*Study on agroforestry in Uttar Pradesh*). However, later on during the same year these restrictions were given up.

There is a separate public deliverable of the Benwood project which deals with the area conflict between woody biomass energy and food crops. This paper is on standards for land use management and part of the deliverable D 4.1, SRF guidelines.

Different concepts of land tenure and land tenure regulations For instance in India, no private juridic person can hold more than a certain amount of hectares of land which obliges Indian wood processing industry to deal with co-operatives of farmers. In China, no private person can own land as such but only rent it from the state.
The limitations of concepts of Non Annex I countries on land tenure are well explained in Unruh 2008. The article bears on regions in Africa where customary and informal land tenure systems govern. It is highly interesting that planting trees on land is tendencially considered as taking actively ownership of that land and therefore can be perceived as an aggressive act. A similar statement is made for the Brazilian Amazon region in Smith et al. 1998, p. 32. This has a relevance for theoretical concepts such as Afforestation/Reforestation (A/R) projects within the CDM methodology where tree planting is the key project element. In the Tabora Region in western Tanzania land is a public commodity but farmers have secure user rights to the land they use (Franzel 2010).
In particular, Unruh 2008 states that the fact that official legal regulations on property do not always apply in practice is 'especially true in a good number of African countries where the state will be perceived of as weak, having separate interests than those of most of the population, and of questionable legitimacy.'

Different shares of farmers in the total working population of a country In 2005 (Eurostat 2007) on the average of 25 EU countries only 4,9% of the total income of natural persons was due to incomes from agriculture, hunting, forestry and fisheries. For instance, what regards Austria (Lebensministerium 2009), in 2007 313.870 people worked

in the sector of agriculture and forestry, which corresponds to about 8% of the working population (about 4 mil. persons).
For some of the Annex I Countries though, the share of people working in agriculture is considerably higher than the average; what regards Europe these are mostly countries from the EU10.
On the other hand, in most Non Annex I countries the share of the population obtaining their income from agriculture is much higher. For instance, in 2002, 75 to 80 percent of the labor force in most African countries was still employed in agriculture (Gladwin 2002). In India, nearly 75% of its population lives in rural areas and a majority of the villagers are engaged in agriculture, making it the backbone of the Indian Economy (*private comment, 2011-05-27*).

The importance of return on labor and land Franzel 2010 states that financial analyses of agricultural practices are frequently too narrow minded calculating returns to one resource only, to land (expressed in €/ha/a). Return to labor (expressed in €/working hours) matters as well, especially in those regions and situations where labor is scarce.
With regard to return on labor and land it is useful to distinguish two categories of farmers:

1. Farmers who are rather *short in land*. These are smallholders who will often also depend on income from off-farm activities

2. Farmers who have more land than they and their family can cultivate and who consequently are *short in labor* and pay cash to labor force from thirds. For instance, farmers in the Tabora Region in western Tanzania make extensive use of hired laborers, who migrate to Tabora during the cropping season (Franzel 2010)

Both categories of farmers have their according interest in new agricultural practices.
To the first group, farmers rather short in land, those practices will matter which increase the area specific productivity even if farmers would have to invest further labor. Increasing return on their labor is not that important to those. However, their interest in the new approach will decline as their return on labor drops below a threshold value where they could obtain a similar amount with off-farm activities. To the second group, the owners of land more than they can cultivate with their own hands, it will matter to reduce labor input, in other words to increase return on labor, because they have to pay in cash for it.
The shares of these two categories of farmers in the total population of farmers may vary regionally. For instance, about 70% of the farmers in the Indian state of Uttar Pradesh declared in two districts (Saharanpur, Muzaffarnagar) in 2004 that they can manage their agroforestry farms without hired labor (*Study on agroforestry in Uttar Pradesh*). However in three other states, Aligarh, Moradabad and Rampur, farmers declared to depend on hired labor.

The important role and fate of women, for instance in fuel collection *Contribution by Ass. Prof. Dr. Sanjeev Chauhan from project partner Punjab Agricultural University, Dept. of Forestry and Natural Resources:*
It is generally women who dominate in carrying out the time consuming tasks of fetching water, fuel, fodder and leaf litter, in addition to performing household chores and raising children. However, gathering is an important economic activity for poor women. Much of the hardship suffered by women and forest dwellers in India is due to deforestation, which has removed the resource on which their livelihoods were previously based. In a study of the Indian States of Orissa and Chattisgarh, which were heavily forested a few decades

back, the average journey required to collect fuelwood has increased four-fold in 20 years. The receding tree line means that only adult community members can now go to forests for wood collection. Diminished supplies force them to shift to inferior fuels such as leaves (which cause more smoke), as they must market a greater proportion of their collection of fuelwood.

Fig. 1.1: Women carrying headloads of wood in Haryana (Northern India). Photograph:

At the national level, about two hours per day per household are spent on gathering biomass for fuel. Such human effort for gathering may increase with declining supply and may have important social and economic consequences for women and children, the principal gatherers. Self-employment of this magnitude is, however, distress employment, as it is at the cost of the gatherers' health and the children's education, and when it brings cash, it leads to environmental damage. In some areas, collecting fuelwood from public lands by the poor, and then carrying it on their heads to the nearest market had emerged as an important activity for livelihood. It is a low paid and a high risk occupation, as pilfering wood from reserved forests for sale is an offence (collecting wood for own consumption from protected forests is permitted on paper, but frowned upon by the forest staff in practice). Women firewood pickers may disappear into the forests. They cut timber and greenwood, which is illegal. Many women may get hurt either by the axe or by wild animals while collecting wood.
The vagaries of weather also worsen the hardship of collection and use of the fuels. The monsoon months are particularly troublesome in gathering of forest-based fuel. With the lashing of incessant rain and water everywhere, not only collection but also drying of wood and animal dung, usually done in the sun, becomes very difficult.

1.2 Economic differences

Wood price A ton of wood chips costs about 70-80 €/ton dry matter (DM) free of gate in European Annex I Countries. In India, fuel wood rates vary from 39.51 € (2500 INR)-47.41 € (3000 INR) per ton (*private comment, 2011-05-27*). In Africa this cost is specified to have been 5,28 US-$ in 1996 (Franzel 2010, p. 31, appendix B) which is today's equivalent of 3.61€/ton - without taking account of inflation since 1996.

Labor cost It is broadly known that labor cost is extremely lower in Non Annex I countries than in Annex I Countries. Here are two examples: In *Africa* labor cost is specified to have been 0.08 € (0.11 US-$) per hour in 2001 (Franzel 2010, p. 31, appendix A) which corresponds to about 0.62 € (0.9 US-$) per working day. In Annex I Countries a cost of about 8 €/h in countries such as Austria or Germany is usual. This results in a factor of 72!. A more recent figure is given for *India* in *Employment Generation Through Poplar Farming* where the wage for a day is specified to be about 1.58 € (100 INR).[1]

Fig. 1.2: Manual weeding of poplars in northern India. Photograph: Chauhan, pers. comm.

1.3 Differences in agricultural practices

The high importance of agroforestry in Non Annex I countries In Annex I Countries economic assessments and proposals to farmers usually focus on short rotation forestry (SRF) in its pure form, that is trees – and nothing else. Agroforestry, although practiced (see Rigueiro-Rodriguez, McAdam, and Losada 2009) what regards the combination of trees with annual food crops does not yet receive broad attention from science or from farmers whereas in Non Annex I countries mixing trees with annual crops or other forms of agroforestry is an important economic issue (see also p. 30).
In the first half of the 20th century the gap between agricultural practices of Annex I Countries and Non Annex I countries was narrower because several traditional techniques for cultivating trees and plants have been gradually lost or marginalized in Annex I Countries since the inception of industrialization whereas such techniques are still practiced in Non Annex I countries. This regards in particular the joint cultivation of trees and annual food crops or fodder on the same area.

[1]From *private comment, 2011-05-27*: 100 Indian Rupees per day include food and accommodation otherwise the government rates are 2.37 € (150 INR) per day (8 hours).

Agroforestry does exist though in Annex I Countries. In Europe this in particular the case in the Mediterranean (Southern) area, however still much less than in Non Annex I countries. An overview on agroforestry practices in Europe can be found in Rigueiro-Rodriguez, McAdam, and Losada 2009.

In 2005 a highly interesting project has been completed which dealt with agroforestry in Europe. The according final report (Dupraz et al. 2005) is available online .

Moreover, the vegetation period in many of the Non Annex I countries extends throughout the entire year (see also the concepts of kharif crop and rabi crop in India) whereas in Annex I Countries during winter nothing can be grown. Accordingly, it seems more attractive to use the space between the trees as well for annual crops in Non Annex I countries than in Annex I Countries. On the other hand, also the potential reduction in annual yield from annual crops is higher by introducing trees on the fields (opportunity cost).

Usage of different species Whereas some species such as poplar are commonly used in Europe as well as in India, others are specific to a climatic region. E. g. bamboo is used for pulp & paper in India (H.D. Kulkarni 2008, p. 149) whereas it is not used in Europe. See also the tables **Tab. 3.2**, **Tab. 3.3** and **Tab. 4.1** and the registry of trees at the end of this document.

Usage of mineral fertilizers for annual crops Farmers in many places in Non Annex I countries do not use mineral fertilizers even if fertilizing would boost profits for annual crops. The reason is simple: Farmers often do not have the cash to buy fertilizers (e. g. see the according statement on farmers in Zambia/Africa in Franzel 2010). Franzel 2010 states, based on Peterson 1999, that women declared they would not buy fertilizers even if credits were made available to them for the fertilizers because of the risk of losing their assets in case of drought which might result in an inability to pay back their loan.

See also the following questions: 11.3, 11.4, 11.5, 19.2, 19.10

Rather than using fertilizers, to restore soil fertility, farmers use the concept of fallow and improved fallows/rotational woodlots.

Obviously using fertilizers or not makes a huge difference in yield. An example for this difference is specified in Franzel 2010 for eastern Zambia/Africa as a yield of 1.159 kg of maize per ha and year without fertilization compared with a yield of 4.077 kg of maize per ha and year with fertilizers (figures relate to pure conventional annual crop land cover not to agroforestry). This is equivalent to a factor of 3,5! of yield with fertilizers / yield without fertilizers.

On the one hand the lack of fertilizers in large regions of Non Annex I countries can be perceived as a drawback because of untapped potentials on the other hand the opportunity cost is much less when growing trees instead of annual crops; the lost yield of annual crops is not that high as it were if fertilizers were available for annual crops.

In Annex I Countries agricultural cultivation without using mineral fertilizers seem unconceivable. In financial analyses of SRF systems, if opportunity cost for annual crops are taken into account, nearly exclusively the application of mineral fertilizers and the according elevated yields are assumed.

Planting trees to improve soil fertility As stated above, in many areas of Non Annex I countries mineral fertilizers are not used because of the lack of the according cash.

Nevertheless soil fertility decreases when cultivating annual crops, sometimes leguminous trees are used to support the restoration of soil fertility via nitrogen fixing trees (legumes) or simply the enrichment of the soil with organic matter by litter (litter fall or forest floor) is the desired effect.

Fig. 1.3: Leaf addition into soil (litter fall), northern India. Photograph: Chauhan, pers. comm.

Such a practice with legumes is mentioned in Pattanayak and Depro 2010, p. 170, for the Manggarai region in Indonesia. Using *Acacia spp.* and *Eucalyptus spp.* for this purpose is common in Australia (*private comment, 2011-05-27*). This practice is rarely applied in Annex I Countries where mineral fertilizers dominate agriculture. However, Benwood project partner Dubas has trials under operation mixing *Robinia pseudoacacia* with *Salix spp.*.

See also the remarks on India and Kenya in question 11.3 and in 19.2 on Brazil.

Preference of rooted plants over directly struck cuttings In many Non Annex I countries semi-arid or arid conditions prevail. This poses a risk for freshly planted trees to dry out. The risk is particularly high in the case of planting material in the form of cuttings which have not yet grown roots. Bare cuttings lack the root system to uptake soil moisture. Accordingly, rooted plants are preferred in Non Annex I countries as a planting material despite their higher price compared with mere cuttings.

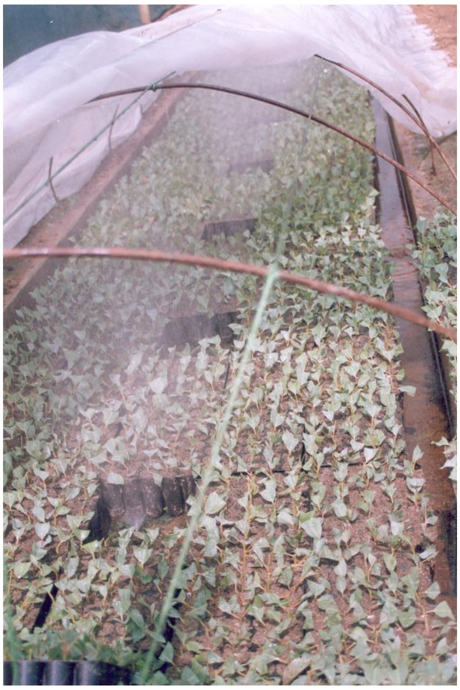
Fig. 1.4: Low-cost arrangement for the rooting of cuttings in a nursery, northern India. Photograph: Chauhan, pers. comm.

The following text is contributed by *comments (internal papers)*: Vegetative propagation is one of the most important tools and is widely used in tree breeding to manage breeding population more effectively. It has major advantage over sexual reproduction as a means of mass production. All the genetic components of the 'donor' plant can be captured and duplicated. The best trees can be vegetatively propagated and tested as clones and multiplied for commercial plantations. The gains will be substantial and fast, but unless it is backed by continued breeding and testing it becomes a dead end situation. The main advantages and importance of vegetatively propagated *Eucalyptus spp.*, *Acacia spp.*, *Casuarina spp.* and *Leucaena spp.* ('Subabool' in Hindi), etc. are namely uniformity, adaptation, cost and wood productivity. Whereas, the seedling stock is not uniform and less productive also. Seedling sources though suit best on the water scarce areas.

Fig. 1.5: Low-cost nursery structure for propagation, northern India. Photograph: Chauhan, pers. comm.

The planting of directly struck cuttings of trees is limited to poplar and willows in the Himalayas where these species are planted using tree branches during winters when they are dormant and enough moisture is available in the planting sites for their rooting and growth immediately after planting. In most other locations and tree species rooted plants in case of clonal forestry and seed origin planting stock are used for growing plantations. Poplar is routinely grown from stem cuttings and its seed route is followed only in research. *Eucalyptus spp.*, another major tree species planted in India (3.9 million ha planted area) by clonal and seedling routes. By 2002, approximately 25000 ha of clonal *Eucalyptus spp.* was established and its acreage is now over 100.000 hectares. For other planted trees, the major planting is through seed origin, though the clonal route is also followed in some other species like *Casuarina spp.*, *Leucaena spp.*, , etc.

Pressure on natural forests The pressure on natural forests is higher in Non Annex I countries. Such a pressure by deforestation is for example mentioned in Franzel 2010, p. 11, for Tanzania where farmers have an elevated need (beyond the demand for household needs) for tobacco curing (drying), in Pattanayak and Depro 2010, p. 171, for local public forests in the Manggarai region in Indonesia or for India in H.D. Kulkarni 2008, p. 149, where the government has restricted access for industry to natural forests ('ban on green felling').

Pruning trees for fuel wood In Non Annex I countries the trees are also pruned in order to obtain fuel wood.

Fig. 1.6: Material from pruning, crushed under a tractor, northern India. Photograph: Chauhan, pers. comm.

Fig. 1.7: Pruning material for fuel purposes, northern India. Photograph: Chauhan, pers. comm.

1.4 Differences in harvesting, transport and conditioning of the wood

Methods of transport

Fig. 1.8: Transport of whole stems to the field's edge with a bullock cart in Andhra Pradesh, Southern India. Photograph: HD Kulkarni 2010

Transport methods are often based on animal or human power in Non Annex I countries (using animal power is still found occasionally as well in Annex I Countries in Central and Eastern Europe). Meanwhile, in India transport cost according to H.D. Kulkarni 2008, p 149, accounts for 30-50% of the landed cost of poplar wood. Accordingly, the paper mills who buy the wood try to establish plantations near the mills.
RA! 'The present landed cost (in my view) is not more than 5% of landed cost in poplar wood (with approximately 50 km average transport distance). This also includes around 1% transport cost from harvesting fields to road heads where vehicles are loaded' (*comments (internal papers)*).

Methods of harvesting Manual harvesting is frequent in Non Annex I countries, however, for large scale harvesting, the chain-saw is also used. In any case, it is important to emphasize manual harvesting is cost effective and generates employment. (*private comment, 2011-05-27*)

Fig. 1.9: Manually digging out a poplar tree at harvest time with the roots (uprooting) in northern India. Photograph: Chauhan, pers. comm.

Trees grown on farms need total extraction (including roots) to facilitate fresh replanting immediately after harvest and for agricultural operations including plough the fields. In case of poplar, the main anchoring roots are cut near the base of trees by exposing them (see **Fig. 1.9**) and then pulling the trees to a desired direction along with its root system.

Fig. 1.10: Manual sawing of a felled tree in northern India. Photograph: Chauhan, pers. comm.

Fig. 1.11: Manual sawing of a felled poplar tree in northern India. Photograph: Chauhan, pers. comm.

Fig. 1.12: Mobile chipper, here used for willow in Poland. At the left the driver of the tractor helps with chipping. One person also working on the field is not visible. The total team is three persons (1 driver and two workers). Photograph: Jan Dubas, Poland

In India low cost locally fabricated chippers are available (see **Fig. 1.13**) and can be hired on rent (*private comment, 2011-05-27*). As an example for Annex I Countries, in Austria the transport of a big 'mow-and-chip' harvester to the site is alone about 600 € regardless if 20 hectares or just half a hectare are to be harvested. This is a huge fixed cost which poses a barrier and can only be compensated by farmers establishing larger plantations or changing the harvesting method.

Fig. 1.13: Chipping residues from pruning on the field (northern India). Photograph: Chauhan, pers. comm.

1.5 Differences in the usage of the wood

1.5.1 Usage as a feed-stock (non-thermal usage)

Portfolio of products made from wood There are slight differences between Non Annex I countries and Annex I Countries what regards the usage of the produced wood on the one hand and the choice of material for various products on the other hand. E.g. whereas poplar is used for pulp production in the United States and in China it is not so much used for this purpose in Europe.

Fig. 1.14: Peeling of poplar logs for plywood production, northern India. Photograph: Chauhan, pers. comm.

Rather as an example for a difference in culture than of quantitative importance is the production of ice-cream spoons in India from poplar wood (*Employment Generation Through Poplar Farming*) which in most Annex I Countries are made from plastics.[2] Similarly south-east Asian countries use poplar wood for chop sticks (*private comment, 2011-05-27*).

1.5.2 Thermal usage

Usage in stoves for on-farm heating and cooking Please see also the according paper of the Benwood project on cooking stoves.

Fig. 1.15: Cooking stove based on logwood in Germany. Photograph: www.nexusboard.net 2010.

[2]It has to be added that the ice-cream sector accounts for only 0,3% (500 people) of total Indian employment within the poplar processing sector with the bulk of employment generated by poplar in the plywood / veneer / sawmills sector (100.000 persons) according to (*Employment Generation Through Poplar Farming*).

Fig. 1.16: Simple, unefficient stove at a farm in Haryana, Northern India. Photograph: .

There is a separate public deliverable of the Benwood project dealing with the issue of simple cooking stoves and the improvement of their efficiency which is part of the deliverable D 5.1, R&D agenda.

Usage as a fuel for drying farm products In western Tanzania, in the Tabora region tobacco is a cash crop for farmers, about 60% of the farmers grow tobacco, averaging 1.0 ha per farm (Franzel 2010). The tobacco has to be cured (dried) which requires large quantities of wood. Most farmers hire trucks and cut and transport firewood themselves from the forest. Until 'recently' (Franzel 2010, published in 2010), wood was plentiful but the situation has changed. As a solution rotational woodlots, an agroforestry practice, have been implemented there.

1.5.3 Usage of trees as fodder

Leaves of shrubs and trees are an important source of fodder in Non Annex I countries. This practice of using leaves for fodder was in use in Europe for a long time (Lukschanderl 1989), up to the 20th century, and has declined only during the last century.

1.6 Fuel alternatives to wood fuel

Oil boiler in Austria. Photograph:

From *comments (internal papers)*: Non-traditional tree components, viz. thin branches, foliage and roots now constitute an important source of firewood at least for boilers in industry. With poplar almost all the wood components are collected from the fields and also those left from later industrial utilization which are used as firewood. Chips made from the foliage including thin branches are now increasingly used in boilers in industry and are fast replacing the traditional fossil fuels like coke etc.

Fig. 1.18: Dung for drying in northern India. Photograph: Chauhan, pers. comm.

Manual work versus mechanised processes Using combustion engines machines on the one hand or human and animal labour on the other hand makes a difference what regards the area specific energy consumption in agricultural field work. What regards the consumption of energy of human labour on the average about 12 MJ per person and per day may be assumed for male persons.

Fig. 1.19: Mechanised weeding in Austria 1. Photograph: .

Fig. 1.20: Mechanised weeding in Austria 2. Photograph: .

Fig. 1.21: Mechanised weeding in Austria 3. Photograph: .

Fig. 1.22: Harvesting manually in Andhra Pradesh, Southern India. Source: HD Kulkarni 2010

Usage of mineral fertilizers From Nair 1993:

1. In a study comparing the two species, Beer (1987, 1989, and Beer et al., 1990) showed that E. poeppigiana, when pruned two or three times a year, with the prunings added

to the soil, can return the same amount of nutrients to the litter layer of coffee plantations as the crop fertilized with inorganic fertilizers at the highest rates recommended for Costa Rica (i.e., 270 kg N kg/ha year, 60 kg P kg/ha year and 150 kg/ha year). The annual nutrient return in this litter fall represents 90-100% of the nutrient store in the aboveground biomass of E. poeppigiana.

2. An eight-year alley cropping trial conducted by Kang et al. (1989, 1990) in southern Nigeria on a sandy soil showed that, using L. leucocephala prunings only, maize yield could be maintained at a "reasonable" level of 2 t ha1 , as against 0.66 t/ha without leucaena prunings and fertilizer (see Table 9.7). Supplementing the prunings with 80 kg/ha year N increased the maize yield to over 3.01 t/ha/year. Unfortunately, the effect of using fertilizer without the addition of leucaena prunings was not tested. Yamoah et ah (1986b) reported that, to increase the yield of maize alley cropped with C. siamea, G. sepium, and F. macrophylla to an acceptable level, it was necessary to add nitrogen. However, an earlier report by Kang et o/.(1981) indicated that an application of 10 t/ha/a of fresh leucaena prunings had the same effect on maize yield as the addition of 100 kg/ha year N, although to obtain this amount of leucaena leaf material it was necessary to supplement production from the hedgerows with externally-grown materials. However, in this study it appears that, instead of returning the L. leucocephala prunings to the soil as green manure, they were taken away as fodder.

Chemical versus mechanical weeding In Europe chemical weeding is the dominating practice whereas also mechanical weeding may be used. The choice of weeding technique can make a difference on CO_2 emissions and on the energy requirement. and moreover, although not so much relevant in this context, on the environmental impact.

2 Introduction

2.1 Describe the feasibility of development of afforestation/reforestation projects regarding the economic, social impact, policies and regulations.

China Relevant international organizations have developed policies and resolutions in order to provide a method to solve the problems around afforestation and reforestation (A/R) projects. Although still many problems remain, it really provides a guideline for the implementation of these projects. Take the effect on the income of local people after the implementation of afforestation projects into consideration, the benefit farmers get from forest is not high under the current model of agroforestry, they obtain the cost from crops mainly. The state raises the initiative of afforestation by subsidy. The economy is in rapid growth in China in the present and for a long period of time, with the development of society and economy and modernization, changes of land-use are linked to uncertainty. However, in the large urban areas and where convenient transport develops land use changes significantly. There land available for planting is small. And where barren hills and wasteland exist in the most remote and underdeveloped areas. There is little possibility for the state and for the local governments to develop or to use these kinds of land. Moreover, due to the limitation on the accumulated amount of carbon resulting from Clean Development Mechanism (CDM) afforestation projects which may be implemented in China, the area of forest for CDM afforestation project accounts for only a small part of the annual afforestation area. Moreover, there is a much area eligible for site selecting. If choosing a suitable site, a project will not pose a threat to land use in China. In recent

This is different to India

years, China has developed a series of policies for the sustainable development of Short Rotation Forestry (like eucalyptus, poplar, willow, etc) , such as improving the forest cover percentage, and vigorously advocating returning farmland to forest land and so on, also there is subsidy for forestry.

India It is important to mention here that India is at number two after China as the plantations are concerned, however, the concept of SRF in the country is just two decades old with very little scientific history. There are number of potential fast growing tree genera (mostly exotics) like *Populus*, *Eucalyptus*, *Leucaena*, *Salix*, *Robinia*, *Cryptomeria*, *Sesbania*, *Prosopis*, *Bamboo*, Paulownia, *Ailanthus*, *Melia*, *Anthocephalus*, *Acrocarpus*, *Casuarina*, *Acacia*, *Trewia*, *Gmelina*, etc. which are raised under SRF including farm forestry. Tree farming is also gaining popularity among the farmers because of depleting natural resources, poor economic returns from agricultural crops, and frequent failure of rainfed crops. The trees act as natural green tube wells, which help greatly in maintaining the underground water table in degraded areas and this fact has been universally acknowledged. National Forest Policy of 1988 and state policies emphasized that forest based industrial units should meet their raw material requirements themselves by involving the individuals to raise trees under suitable agroforestry models without adversely affecting the food production. Even Government investment in the plantations have increased over the years and recently launched Greening Indian Mission will prove to be a mile stone in extending area under tree cover to address the issues of climate change and GHG emission reduction. In India, areas under man-made forests have increased considerably than under natural forests. Since the rates of forestation did not balance the deforestation/degradation/over exploitation of forests, thus, resulted in depleting of valuable biological/soil resources and environmental deterioration thus necessitating the plantations. Plantations have much higher productivity than the natural forests due to introduction of fast growing high yielding species, intensive management and their potential to fully exploit the site conditions. Plantations today constitute a very important part of forest resources to meet the domestic as well as industrial requirements because the Honourable Supreme Court of India has imposed clean ban on the green felling from forests so we have to meet our requirements either from plantations outside forests or through import. Major portion of wood (about 80%) now produced in the countrycomes from tree plantations established outside forest reserves under the private ownership and these plantations constitute a very important part of the forest resources in India. Plantation though cannot take over all the functions of natural forests but it is important to reduce deforestation and other forms of depletion from natural forests.

Kenya Land tenure is a major issue and varies considerably from one African country to the next (Unruh 2008). In some countries, tree planting can be controversial due to the associated implications for land title. Trees often hold different ownership than the land they stand on and depending on the laws of the country, they might be owned by the state government or the official land title holder rather than the person renting the land. It is highly important to be aware of such issues when designing an A/R project and being clear about who will ultimately benefit from the trees and their products. For projects to be successful, they need to generate community support and be aware of local and national legalities concerning land rights and rights to benefits accruing from project land. In Kenya, planted trees outweigh natural forested areas to a great extent with less than 2% of natural forests remaining. Agricultural land is continuously expanding or becoming more intensive due to population increase and the fact that the majority of the population still rely on agriculture as their main means of income. Trees are mainly incorporated into farms as hedgerows, boundary markers, woodlots, and in cropland. Plantations are not so widespread but where they do exist, it is mainly exotic species such as *cypress* (48.4%), *pine* (35.2%) and *eucalyptus* (8.2%) because of their fast growing nature and suitable wood for timber. There has been a high demand recently for electricity poles, bought by the Kenya Power and Lighting Company, because of the increasing demand for access to electricity by the populace. This has spurned more landowners to plant up land with eucalyptus. There are efforts being made by the Government, because of heightened pressure from various organisations (in particular the Green Belt Movement), to plant more native tree species and replace the eucalyptus that now has a bad reputation for drying up water sources. To try and develop a project without taking this into account would face great opposition. There is great potential for A/R projects to be developed because of the dwindling natural forested areas but they would have to be sensitive to current politics and country interests. A major restricting factor has been the complexity of applying for CDM projects and the high investment cost.

Brazil According to ABRAF (Brazilian Association of Planted Forests Producers), the SRF crops planted in the country are the *Eucalyptus spp.* e *Pinus spp.*. In 2009, Brazil had 4.5 million hectares of *Eucalyptus spp.* plantations and 1.8 million hectares of *Pinus spp.* plantations. These tree plantations mainly supply the pulp and paper industries, iron and steel mills and furniture companies. The feasibility of development of A/R projects in Brazil by Short Rotation Forestry finds its way on the iron and steel industries, where the option of using coal coke in the blast furnace makes the renewable charcoal a possible alternative of energy and it could give incentives for SRF for to meet the demand of renewable charcoal from the industry. The possibility of the development of forestry incentive programs, aiming at the production of renewable charcoal for the iron and steel industry and other wood products, has a large social impact in new A/R project activities. However in Brazil, the A/R CDM projects still lack of economical feasibility due to many costs related to their development such as consultancy, validation and verification audits, project monitoring, etc. The Brazilian Government launched in June, 2010 the ABC Program (Low Carbon Agriculture) considering the available resources for project financing in agriculture, at low interest rates, in order to mitigate GHG emissions. The projects include SRF, Agroforestry, among others. However, until May 2011 no project has been approved for financing.

2.2 Which main technical factors should be considered when implementing afforestation/reforestation projects?

China Technical factors include: Choosing a suitable site (climate, soil irrigation condition etc), development of the sapling and so on. China encompasses vast areas and a different location implies different climates, soil conditions, water resources, etc, so the suitable species are quite different from place to place. Take Northeast of China for example (the classical region for SRF production in China): The average temperature there is 8.4 °C, the annual precipitation is about 450mm (mostly concentrated to the period of June to August), the frost free period is 120-155 days. It is windy and unwatered in spring and autumn, wind is usually 2-3 grades, and in winter, northwest wind prevails and is strong. There are a variety of kinds of soil and trees in China, the main soil type being the lush black earth, main trees are *Chinese pine*, *pinus sylvestris* and *seabuckthorn*. In China, the state has the complete ownership of the land, but it is up to the farmer what he plants. He sells the products by his own, so decisions are just determined by supply and demand. Water resources in the northeast of China are sufficient for irrigating, for the average rainfall is 437mm (mainly concentrated to June to August), accounting for 73% of the annual precipitation.

India Technical factors: Identification of land where plantation is to be raised, locality factors (climatic, edaphic, topographical and biotic factors), pre- planting activities (earth work), quality of planting stock, tending operation, protection and maintenance, harvesting and marketing potential. Tree species are selected according to their adaptability and actually growing species in the area are the best indicator for afforestation, otherwise, the new tree species are selectedafter proper testing of their suitability for ecology including long term affects and economy.

Kenya Selection of tree species needs to be considered in relation to climatic conditions, soil type and local water regime. In most cases, stronger support will exist for native and/or naturalised tree species to be planted as part of A/R schemes because of their evolved resilience and adaptive capacity to local conditions and perceived benefits of regenerating degraded areas with original vegetation. Without first trialling a tree species in the local area, there is more risk of failure. Native tree planting was a large component of the Ethiopian case study (UNFCCC/CCNUCC 2008) because of its broader objective of increasing biodiversity in a degraded area, while the Ugandan CDM project (UNFCC/CCNUCC 2006) incorporated a lower level of native tree planting into its reforestation efforts because of its plantation focus and from having a lack of knowledge about native tree species growth performance and susceptibility to pests in a plantation system (it was hoped to further understanding in this area). In terms of SRF, there have been failed plantations in Kenya because the location was not matched well with the species, thus the growth was not optimum and the farmer paid heavily for it. Advice should be taken with regards to species and where they can be successfully grown before implementing any A/R project. It very much depends on what land use is being replaced by SRF production as to the costs/benefits associated with it. There may be economic benefits occurring at the same time as heavy environmental costs, and these aspects would need to be weighed up. However, by incorporating SRF practices into current agricultural land use, this could potentially take pressure off surrounding natural forests. In relation to the two A/R CDM projects in Africa, trees were being planted on degraded land and this was going to be benefiting the local area more than anything else. There are strict guidelines as to what land use can be replaced by trees as part of an eligible CDM project. This leads to an avoidance of
A/R projects taking place on agriculturally productive land. An environmental impact assessment would need to be carried out before implementing any project.

Brazil Brazil has all favorable climate conditions to the implementation of SRF all over its territory. The selection of the species to be planted in the different areas of the country depends on the adaptation from these species to the local climate conditions. Considering the largest plantation species, the Eucalyptus spp. can be found in the states of Minas Gerais and São Paulo, southeastern Brazil, and the Southern are of the state of Bahia, in the northeast of the country. The Pinus spp. plantations are mostly located in the states of Paraná, Santa Catarina and Rio Grande do Sul, southern Brazil. The technical factors that influence the commercial plantations are: disease control, especially ants during the establishment of the plantations; fertilizations, which improve productivity by the application of NPK; appropriate genetic material considering the location of the plantations and end use of the wood; and issues related to the logistics for harvesting and transport, which represent the highest costs of the forestry activity in Brazil.

2.3 If agroforestry systems exist in your country - what are the benefits? Please give an example.

China Dominant agroforestry modes in China are intercropping of poplar and grain or corn, intercropping of *fir* and grain, etc. SRF/agroforestry systems can not only let the productive potential of the existing cultivated land be fully tapped because of light and heat resources and utilizing the ecological space efficiently, but also changes large areas of degraded land into high-yield farmland. Some tree species can efficiently absorb nitrogen from the air and transfer it to the soil, so fertilizer input may be reduced up to 75% and lead to a substantial increase in crop production.

India Agroforestry systems are good source of timber fuel wood and energy, provide fodder and feed to animals, enrich soil with organic matter and nutrients, check soil erosion, provide wind breaks and shelter belts, employment generation, raw material to small cottage industries, ecotourism, moderates temperature extremes, etc. Lesser availability of land, low returns from traditional crops and the ever-increasing demand for fuel, fodder and timber are the main reasons that compel farmers to integrate multipurpose tree species into the farmland. Agroforestry is a resource-conserving, not depleting system compared with the existing land management systems involving few crops like rice, wheat, sugarcane, cotton, which are extremely resource-exhaustive, be it in terms of natural, financial or human resources. The most common crop rotation (rice-wheat) is over exploiting the water resources. Experiments across the country have shown soil improvements under agroforestry to a significant level. Carbon sequestration and back transfer of nutrients through twig/litter fall, etc. help the system positively. In the coming years, the tree-based direct needs will exclusively be met from farm forestry or agroforestry. At present, poplar (*Populus deltoides*), eucalyptus (*Eucalyptus tereticornis*), dek (*Melia azedarach* and *M. composita*), leucaena (*Leucaena leucocephala*), kadam (*Anthocephalaus cadamba*), teak (*Tectona grandis*), Ghamari (*Gmelina arborea*) among other trees, are grown by farmers on a commercial scale.

Kenya Agroforestry practices are widely carried out by smallholder farmers in Kenya and other African countries, but less so by plantation owners. By carrying out such practices, farmers are able to benefit from multiple goods from their land rather than depending on just one crop. This is important for a smallholder because all the products play a role in his/her livelihood, whether it is a means of food, building material, fuel, cash income. Plantations are more business oriented towards investing and making as much profit from one crop. Multiple benefits can be gained from agroforestry systems: timber, fuel wood, fodder, mulching material, increased soil fertility by adding nutrients and preventing soil erosion, and protection of crops from strong sunlight, winds and heavy rain. By incorporating trees into cropping systems, extreme temperatures can be buffered by the creation of microclimates. This is useful in coffee farming because it means the coffee plants grow under lower levels of stress than those coffee plants grown in full-sun plantations. In Kenya, smallholdings are predominantly a mix of agricultural crops, fruit trees and trees for wood products; trees appear along boundaries, around the homestead, integrated with crops, or in separate woodlots depending on the species and farmer needs and capacity.

Brazil Due to its continental dimensions and to the diversity of edaphoclimatic conditions found in Brazil, there are several agroforestry systems (AFS) in the country. The models of agroforestry systems involve SRF, such as *Pinus* or *Eucalyptus*, agricultural crops and cattle. In this model, the annual crops are planted between the line plantations. After the third year, there's the insertion of cattle in the system. The harvesting occurs from 10 to 13 years, and the wood is mostly for sawed wood, which adds more value to the product. The AFS models in smaller properties are more diversified. The models involve fructiferous trees and trees for timber and several crops between the tree lines. This way, the small producers have a higher diversity of food and also have some income from timber species.

2.4 Please give details of CDM projects relevant to afforestation/reforestation in your country according to available experience/information.

China Project Name: The application of CDM in afforestation Project Site Zhangjiayao, Kangping Prefecture, Shenyang, Liaoning Province Co-operation: Keio University, Japan Brief introduction of the project: Since 2002, according to the requirements under small-scale A/R CDM projects in the "Kyoto Protocol", the Forestry Bureau in Shenyang and Keio University developed a CDM Carbon Sink Afforestation pilot project in Zhangjiayao, Kangping Prefecture. In March 2009, the National Development and Reform Commission agreed to carry out this project, and this is the first small-scale A/R project under CDM in China. There are 370.98 ha of poplar protect forest in Zhangjiangyao, Kangping Prefecture. In this project, there are 23 reproducing land, and 15 of used for afforestation from 2003 to 2009, the other 8 will be implemented between until 2012. The expected emission reduction of total CO_2 equivalents within the 20 years is 23 thousand tons, and 1.1 thousand tons CO_2 equivalents annually. Keio University will but the carbon sink (20.769 thousand) produced by this project from 2003 to 2023. If there is more carbon sequestered before the contract expires in 2023, the Keio University has the prior purchasing right, and China also has the right to sell the additional carbon emission reduction to other buyers.

India

	1	2		3	4
	Project	**Reduction equiv.**	**mtCO2**	**Area (ha)**	
1		3594		106	1200
2	Small scale cooperative afforestation CDM project (Haryana)	11596		370	227
3	Reforestation of severely-degraded landmass (ITC project, Andhra Pradesh)	57792		3070	3398
4	Saber Papr Ltd., Una (Himachal Pradesh)	74692		–	–

BWCDMSpecificsTables)*punjabGrowthOfPoplarChauhanNandaBrar*

Tab. 2.1: Registered projects under A/R in India

In total, 506 projects have been registered worth CERs 78.8mtCO 2 . Renewable energy is important and major sector in CDM in India. India's carbon market is growing faster than even information technology, bio-technology and BPO sectors as 850 projects with a huge investment of Rs. 650,000 million are in pipeline. As per the Prime Minister's Council on Climate Change, the revenue from 200 projects is estimated at Rs. 97 billion till 2012. Carbon, like any other commodity, is traded on India's Multi Commodity Exchange, Mumbai (first exchange in Asia to trade carbon credits).

Kenya There are currently no registered CDM A/R projects in Kenya, with the only two registered projects in the whole of Africa located in Uganda (Uganda Nile Basin Reforestation Project No. 3) and Ethiopia (Humbo Ethiopia Assisted Natural Regeneration Project), but there are others in the pipeline. For projects to be successful, they need both institutional and political support, as well as strong community support. The latter is particularly the case if the project is operating through a cooperative structure and has a long term objective, i.e. providing for and benefiting from the carbon market.

Humbo Ethiopia Assisted Natural Regeneration Project (UNFCCC/CCNUCC 2008) The Humbo project was focusing on facilitating establishment of mature trees in the long term, with associated benefits for local communities through potential sustainable harvesting of forest products. The project developers ensured they understood the legalities of land title and followed the necessary procedures to ensure the communities would benefit from both the future forest products and payments for carbon sequestration. The main objective was to increase tree and animal abundance and diversity in a degraded former forest area. Project activities were proposed to cover an area of 2728ha of community land by establishing seven community cooperatives with legal ownership of this land. The communitygroups would then manage the areas for carbon removal by undertaking farmer managed natural regeneration that would result in environmental and socio-economic benefits for the local area. It was recognised that bylaws would have to be agreed upon at project inception in order for the community cooperative societies to have rules to manage the project by.

Uganda Nile Basin Reforestation Project (UNFCC/CCNUCC 2006) Project activities were to cover an area of 341.9ha within the Rwoho Central Forest Reserve with the National Forestry Authority being responsible for 319.2ha (93%) and the remaining planting area being held under the responsibility of local community groups 22.7ha (7%). The focus was on establishing a timber plantation system of predominantly pine trees to be mixed with a small percentage of native tree species, i.e. *Maesopsis eminii* and *Prunus Africana*. Establishment was proposed to take the form of a block design in degraded grassland areas. *Pine* and *Maesopsis* were going to be managed on a 22 years rotation cycle or until the target diameter was reached, i.e. 45 cm. *Prunus* would be used for both bark and the timber and managed for medicinal bark production in a 10 year rotation period. The plantation was going to be established in 14 blocks of 25 ha each.

Brazil There are 02 registered AR CDM Projects in Brazil. The first one is the "Reforestation as Renewable Source of Wood Supplies for Industrial Use in Brazil" by Plantar S/A which was registered in July, 2010. This project foresees the planting of eucalyptus as a renewable source of raw material for the pig iron mill for 28 years. The second registered project registered in the country was the "AES Tietê Afforestation/ Reforestation Project in the State of São Paulo, Brazil" from the AES Tietê Power Company, which registration was accepted in January, 2011. This project is willing to restore 13,939 hectares of riparian forests alongside the water dams of 10 hydroelectric power plants in the State of

São Paulo, throughout the planting of native forest species. The removals of this project could reach157, 635 tCO_2eq per year for 30 years.

2.5 From available case studies, please summarise experiences, problems and improvement measures of CDM projects which are relevant to afforestation/reforestation.

China

Environmental Benefits Through establishing forests, the proposed activities will provide the following additional local environmental effects, namely enhancing biodiversity by:

1. Increasing the effective size of protected forests (forest park habitats with important wildlife and flora), enhancing the long-term survival of many species, and helping to improve the status of currently unprotected species.
2. Generating increased income for local communities from the project activities. This will reduce their tendency to degrade biodiversity through practices such as poaching, forest fires and illegal logging and NTFP collection in the forest park.

- Controlling soil erosion
- Improving air conditions
- Reducing air pollution through providing sustainable firewood for local communities to replace coal.
- Improving watershed management and contributing to the ecosystem
- Improvement through demonstration and extension of the project experience to other areas.

Environmental Risks All the species selected for the project planting are native to local. However, because of the afforestation activities planned under the project, there are risks from disease, pests and fire among other things. The project design will identify these risks and work to manage them appropriately through the use of best practice and the latest innovative technologies.

Socio-economic benefits Local people will directly participate in the afforestation activities such as site preparation, planting, weeding, thinning, harvesting, etc. and will benefit from the project. The main socio-economic benefits of the project include:

1. The project activities will create a great amount of employment opportunities for the local farmers
2. It is expected that the income of local farmers will be increased
3. Forests established would provide sustainable fuelwood to the local communities
4. Improving scenery of cultural relics and promoting tourism.

A vital component of CDM is capacity building; without training and other technical assistance there would certainly be a risk of poor performance in some project activities. The project includes strengthening of local capacity by:

1. Developing, testing and disseminating local best practice; introducing improved silvicultural and forest management technologies; disseminating extension materials; and providing training and technical assistance to the project beneficiaries.

2. Establishing legal structures to aid in the sale of CERs; and testing carbon purchase transactions to accumulate practical experience and technical knowledge on reforestation-related CER programs.

Social-economic risks

1. The emission reduction is only estimated and the calculation may be inaccurate.

2. There might be some noise influencing citizens' life due to the preparation work such as the digging, the transportation of the raw material, construction of power stations and so on.

3. There might be lack of funding and of technological knowledge.

India

Barriers Lack of awareness and clear objectives, cumbersome procedures, lack of data base, financial institutional and market barriers, lack of capacity and skills, etc.

Risks technology risk, financial risk, performance risk, disaster risk, CERs price risk, political risk, etc.

The advantage of the SRF programme : it will help in employment generation.

Plantation activities Nursery, plantation, tending/management, inter-cultivation, harvesting, transportation, processing, etc. generate enough employment. On an average, one hectare of plantation generates approx. 450 mandays.

Technical reasons for plantation failure Locality factors (abnormal weather/site conditions, etc.), use of unsuitable species and provenances or in appropriate techniques, failure to apply unknown techniques, poor quality planting stock, injury to plants/improper storage, etc.

Fundamental reasons for plantation failure Lack of adequate preliminary research, lack of planning, inadequate supervision, financial problems, over-enthusiastic targets, etc.

Kenya The case study in Ethiopia was set up with political and community support, as well as making sure that land rights had been considered and that the income from carbon trading would come back to the community (UNFCCC/CCNUCC 2008). In the case of the Ugandan project, it was to take place on government owned land but local community groups were given responsibility for a proportion of the project land (UNFCC/CCNUCC 2006). Both projects were able to meet the strict requirements for A/R projects under

CDM, while at the same time being sensitive to local communities and legal aspects within the countries themselves. At the moment in the African continent, there are many projects that fail or don't even attempt to meet the CDM requirements as it is a complex and costly process to get registered. The other option is the voluntary market and this has proven to be a more successful route for carbon trading in an African context. A major issue has been cited as land tenure and rights to the income generated from carbon trading (Minang, pers. comm., 2010; Unruh 2008). After trees have been planted as part of a project, sometimes other people will lay claim to the financial benefits that come from those trees – this may be the land title holder or more likely the government. This means that any project developer has to work hard to make sure that all these aspects are well considered in order for it to be successful in returning money back to the community.

2.6 Summarise the factors currently hindering a smooth implementation of short rotation tree plantations.

China

1. Due to the short rotation, it is difficult to form a forest ecosystem that should exist in the mountain forest. It would do harm to the living environment such as wild animals, birds and insects;

2. Some SRF species, especially the eucalyptus has great water and fertilizer adsorbing ability, and often makes the forest surrounding them can not survive

India Fast growth of trees can be achieved through intensive management (integrating genetic and management principles). Low awareness, unfavourable attitude and constraints (land, technical, financial/marketing, legal, social, etc.) hinder the smooth adoption of SRF in India.

Kenya There are a few factors that currently hinder further establishment of SRF plantations. One of these is the ban on further cutting of natural forests for the sake of establishing SRFs. These natural forests are considered primarily for conservation of biodiversity, and establishment of SRFs could act contrary to this objective as it involves clearing of all natural vegetation which is considered as weeds. A second factor is the lack of improved germplasm of most of the tree species used for SRFs. Majority of seed is obtained from existing stands and thus may suffer reduced growth. Another factor is the fact that where harvesting debris is collected by the local community members, the soils are depleted of nutrients and in the long run become less productive. Furthermore, with an ever-increasing human population, more land becomes necessary to meet the food requirement, thus reducing the area available for tree planting. Additionally, increased soil erosion and interference with livelihoods through reduction of medicinal and herbal trees, bee foliage for honey production, activities that are relied upon by people, cause resentment of these forests. Constraints are many in a developing country context, i.e. land availability and tenure, mechanisation, technical knowledge, financial/marketing constraints, politics and legal issues, etc. These all can hinder the smooth adoption of SRF in Africa.

Brazil The initial costs of SRF implementation can be very high for smallholders who depend on the income from their own production, making it very difficult to allocate any amount of resources on a long term investments. Therefore, the foster forestry programs developed by forestry companies contribute with small and medium SRF producers. In these programs, the companies support the costs of implementation of the forests, which will be paid back at the time of harvesting. Another issue related to the implementation of SRF is the myths related to some SRF cultures, especially Eucalyptus spp. Several producers decide not to plant SRF fearing that the plantations would harm the soils, by drying it or even depleting the nutrients of their properties, making future crop plantations something unfeasible.

2.7 Enlist indigenous and exotic SRF species

China

Hardwood *black poplar*, followed by *white poplar*, *eucalyptus*, *willow*, *birch*, *popinac*, *alnus*, *sycamore*, *paulownia*, *chinaberry* etc.

Softwood *pinus radiata*, *loblolly*, *masson pine* etc.

India

Exotic species *Populus deltoides*, *Eucalyptus spp.*, *Casuarina equisetifolia*, *Crytomeria japonica*, *Leucaena leucocephala*, *Prosopis juliflora*, *Salix alba*, *Robinia pseudoacacia*, *Acacia auriculiformis*, *Acacia mangium*, *Grevillea robusta*, *Melia composita*, *Hevea braziliensis*, etc. Indigenous/naturalised species: *Bombax ceiba*, *Ailanthus excelsa*, *Morus alba*, *Gmelina arborea*, *Trewia nudiflora*, *Terminalia arjuna*, *Anthocephalus cadamba*, *bamboo*, *Melia azedarach*, etc.

Kenya Exotic species: *Acacia mearnsii*, *Cupressus lusitanica*, *Pinus patula*, *Casuarina equisetifolia*, *Leucaena leucocephala*, *Calliandra calothyrus*, *Eucalyptus grandis*, *Eucalyptus camaldulensis*, *Eucalyptus saligna*, *Eucalyptus urophylla*, *Grevillea robusta*, *Prosopis juliflora*, *Gmelina arborea*
Indigenous/naturalised species: *Melia volkensii*, *Bambusa spp.*

Brazil In Brazil, the commercial forest plantation with native species for timber purposes is the *Araucaria angustifolia (Bert.) O. Ktze.* Some native species are also planted for non-wood products, such as *Hevea brasiliensis Muell. Arg.* (rubber production with the harvesting of the wood at the end of the productive cycle); *Ilex paraguariensis St. Hill.* (production of tea leaves – Erva-Mate); *Theobroma grandiflorum (Willd, ex Spreng.) Schum.* (fruit production); *Theobroma cacao L.* (fruit production); *Elaeis guineensis Jacq* (fruit production); *Euterpe oleracea Mart.* (fruit production and palmetto); among others. The most used foreign species of SRF as commercial forests in Brazil are: *Eucalyptus spp.* and *Pinus spp.* Besides these species, it's also found in Brazil some foreign species in smaller scales are *Tectona grandis Linn. F.*; *Acacia mearnsii De Willd.*; *Toona ciliata M. Roem var. australis.*

3 Total cycle

3.1 How many steps are included in the total cycle of SRF?

China The cycle includes:

1. Planting (season is around March)
2. Tree species selection: selecting is according to the local climate, soil type and other factors such as economics and political preferences
3. Site condition analysis: different tree species should be planted in the suitable site to make sure they can grow up healthy and efficiently
4. Soil preparation: providing appropriate conditions for the tree planting

The total cycle of SRF as well includes breeding, cutting, transportation, etc.:

Fig. 3.1: Planting.

Fig. 3.2: Cultivation.

Fig. 3.3: Transportation.

Fig. 3.4: Cutting.

Fig. 3.5: Pruning.

India

1. Assessment of site characteristics
2. Selection of tree species
3. Quality nursery stock (clonal/ seedling source) procurement
4. Land preparation and planting
5. Cultural operations, irrigation, fertilization, weeding, pruning, etc.
6. Harvesting, transportation and Marketing

Kenya Sixteen (16) steps are normally taken from identification of tree species to planting in a given site to utilisation. From the beginning to the end user (e.g. site selection, planting selection, planting, cultivation, maintenance, harvesting, transportation, and utilisation), the steps in chronological order include:

1. Tree species selection based on the site and end product desired.
2. Acquisition of quality seed either through collecting on-farm or purchasing from seed merchants or seed collection centres.
3. Raising and maintenance of the required number of seedlings including a 10% allowance to cater for seedlings that may die during the first season after establishment.
4. Preparation of the planting site through removal of vegetation, putting the debris in rows or burning them, and carrying out cultivation of the site to loosen the soil.
5. Staking the planting spots on the ground at the desired spacing dependent on the species, rotation period and desired end product.
6. Digging of planting pits for seedlings.
7. Hardening of the seedlings two weeks before the envisaged planting date to improve their survival in the field.
8. Delivery of hardened seedlings from the nursery to the planting site.
9. Actual planting of the seedlings, which should be after accumulation of adequate soil moisture from the first rains in April (at the Coast, Central, Rift Valley and Western regions of Kenya) and October/November (in the Eastern drylands of the country)
10. Maintenance of seedlings through regular weeding which is normally achieved through intercropping the seedlings with agricultural crops.
11. Depending on the species such as Cupressus lusitanica, Pinus spp. and Grevillea robusta, trees are pruned three or four times to encourage the development of high quality timber product. Other species such as Eucalyptus species and Casuarina equisetifolia are pruned generally to allow accessibility into the plantation.
12. Selection for thinning: On farms, the large trees are normally selected and sold early to allow the smaller ones to develop to the desired size. However in public forests, the small trees are normally thinned out to allow the bigger ones to develop.
13. Harvesting is usually carried out by the buyer of the wood under the supervision of the tree owner. This is critical especially among eucalyptus plantations that require the maintenance of healthy stumps to regenerate the next rotation through coppicing.
14. Transportation of harvested material from the plantation: carried out by the buyer to their destination.
15. Processing of wood to various end products.
16. Utilisation of wood in its various forms: poles, posts, timber, firewood, props.

	1	2	3
	Step	**Timing**	**Activity**
1	1		This is normally based on previous experience or observations made in neighbouring farms. It comes once the site has been identified where the trees are to be planted.
2	2	September/ April	Most tree species' seeds take around six months to produce seedlings of planting size. For sites where planting is done in April, seeds are acquired in September and put in the nursery by October; for November planting, seeds should be acquired by April.
3	3	Oct – March May – October	For April planting at the Coast, Central, Rift Valley and Western Kenya (humid areas). For November planting in Eastern Kenya and drylands of Kenya in general.
4	4	March October	Humid areas – Preparation of planting sites through bush & cultivation. Drylands – same preparation as in humid areas.
5	5	March October	Humid areas – a month or so before the intended planting date. Drylands –same preparation as in humid areas.
6	6	March October	Humid areas – just before the rains. Drylands – same preparation as in humid areas.
7	7	March October	Humid areas – approximately two weeks before the intended planting date. Drylands – same preparation as in humid areas.
8	8	April November	Humid areas – after soil moisture build up can support seedlings planting in the field. Drylands – same preparation as in humid areas.
9	9	April November	Humid areas – actual planting of seedlings. Drylands – same preparation as in humid areas.
10	10	From April From November	Humid areas – weeding of young plantations as weeds develop. Drylands – same preparation as in humid areas.
11	11	May	Humid/dry areas – carried out during the rains when plants are growing vigorously.
12	12	March	Humid/dry areas – done before the rains so that actual thinning can be carried out after pruning operation.
13	13		Carried out any time except during the rains as this causes heavy destruction of land.
14	14		As in 13 above, especially as concerns the forest roads.
15	15		Throughout the year; the sawmills stock adequate material to take them through the rainy season.
16	16		Any time of the year.

BWCDMSpecificsTables.*SRFStepsInTotalCycle*

Tab. 3.1: Further breakdown – timings of each step and further details in African Area.

Brazil Considering *Eucalyptus spp.* and *Pinus spp.* as the most used species in Brazil for commercial purposes, the following steps can be found at the forest cycle:

1. The choice of genetic material, according to the edaphoclimatic features of the site and

end use of wood;

2. Seedlings production: it involves the selection of the best clones for the formation of the clonal gardens. The large companies already work with clonal gardens, where the seedlings are originated from mini-cuttings. Some companies are also developing in vitro stumps which will be the future forest clones.

3. Soil preparation: usually it is used minimal tillage when the soil preparation involves only the plantation lines, in order to avoid soil disturbance

4. Fertilization: there is one application of limestone before the soil preparation. The application of NPK is done in every pit in order to favor the growth of the plants. The maintenance fertilization aims at the increase of productivity and to supply the necessary nutrients to the soil which will be important for the development of the plantations;

5. Ants and termites: these insects are very common within the plantation sites, especially during the first years of the culture. The extermination of cutting ants is essential for the success of the plantations. This is considered one of the worst forestry plagues in Brazil.

6. Maintenance: some companies use chemical weeding during the first years of plantation in order to reduce weed competition. Depending on the end use of the forest, thinning and artificial branching are applied, in order to improve the quality of wood.

7. Harvesting: it consists on the cutting of trees, removal of branches and bark, slashing and transportation to the side of the stands.

8. Transport: it is the removal of wood from the stands and the transportation to the industrial mill's patios. This step and the harvesting are considered the most expensive ones in the forestry activities.

9. Wood processing: the processing of wood for different uses such as pulp and paper, iron and steel mills, timber, panels, saw wood and furniture.

3.2 If you want to shorten the amount of time taken to plant, manage, harvest the trees and transport without affecting the quality of the end product, how would you do this? (e.g. how to increase efficiency)

China Factors include: Climatic conditions (light, temperature, moisture), site conditions, species, cultivation level and cultivation technique, management level, etc.

1. ensure that species selection and site selection are consistent and achieve an optimal configuration

2. improve the management level of SPF and ensure the smooth progress of each step.

3. develop new technologies including new varieties, new cultivation methods, etc.

India

1. Good quality planting stock including site specific species/genotype
2. Proper management (nutrition, irrigation, tending operations, insect-pest/disease management, etc.)
3. Marketing intelligence including personal involvement (no intermediary for harvesting marketing), etc. are essential parameters for enhanced efficiency

Kenya Keep the trees free from competition by weeding them as regularly as possible, establish them on a site that has been cleared of bushes and other vegetation, space them closely so as to encourage height growth at the early stages of establishment and thin appropriately before competition among the trees sets in. Use high quality planting material that gives high yields.

Brazil The site conditions directly influence the productivity of the Brazilian forestry industry, considering the edaphoclimatic conditions and the improvement of genetic material for adapted clone (plague and disease resistance). With the productivity increase, there is more efficiency within the industry. In a partnership with genetic improvement, activities such as fertilization, irrigation and forestry management will maximize the clone's genetic potential. According to ABRAF, the Annual Mean Increment for *Eucalyptus spp.* and *Pinus spp.* increased from 36.7 and 30.7 $m^3/ha\ year$ in 2005, to 40.5 and 37.6 $m^3/ha\ year$ in 2009, respectively.

3.3 Specify the years of rotation of felling trees by tree species in your country.

China The main tree species of SRF are *poplar*, *eucalyptus*, *paulownia*, *willow* and *Pinus morrisonicola*, and the main shrub for SRF are *seabuckthorn* and so forth.

	1	2	3
	species	**Region**	**cycleyear**
1	Poplar Chinese white poplar	Reaches of Yellow River	4-8
1	Occidental Poplar	North China	6-8 12-13
1	Eucalyptus Urophylla U6 Hybridized Eucalyptus LHI Hybridized Eucalyptus East China sea No 1	South China	05/07/12
1	Urophylla shilling No 1	0	0
1	Paulownia Based on forest Lay equal stress on forest and grain Based on grain	National wide	03/05/12
1	morrisonicola	National wide	04/05/12
2	Seabuckthorn	Middle reaches of Yellow River	04/07/12

BWCDMSpecificsTables.*SRFStepsInTotalCycle2*

Tab. 3.2: The main species and rotation period of SRF in China

India

Poplar Eucalyptus Leucaena
5x4m (block plantation) 3 m (boundary plantation) 2x2m,3x3m,4x4m 4x2m under agroforestry 2x2 m for energy
5-8 years 2-15 years lopped for fodder and fuel wood 3 rd year onwards 3 r d year onwards 10-12 years 8-12years 10-15years 4 t h year onwards
Gmelina Melia Salix
6x6m(Agroforestry) 6x6m 4m on bunds and 5x5m (block) 5x5m

Kenya

	1	2
	Tree species	Rotation period (years)
1	Acacia mearnsii	6 – 10
2	Cupressus lusitanica	20 – 30
3	Pinus patula	16 – 30
4	Casuarina equisetifolia	3 - 8
5	Leucaena leucocephala	3 - 5
6	Calliandra calothyrus	3 - 5
7	Melia volkensii	8 - 12
8	Eucalyptus grandis	5 - 25
9	Eucalyptus camaldulensis	6 - 8
10	Eucalyptus saligna	5 – 25
11	Eucalyptus urophylla	5 - 12
12	Grevillea robusta	15 - 25
13	Bamboo	3 – 5
14	Prosopis juliflora	8 – 15
15	Gmelina arborea	– 25

BWCDMSpecificsTables.*Tabelle8*

Tab. 3.3: Tree species and their rotation periods in Kenya.

Brazil

Eucalyptus spp.

1. Pulp and paper: 7-8 years

2. Renewable Charcoal: 5-7 years

3. Timber: 12-18 years

Pinus spp.

1. Pulp and paper: 18-20 years

2. Timber: 20-25 years

3.4 Which main production chains (methodologies, techniques) of producing wood from SRF/agroforestry can be depicted?

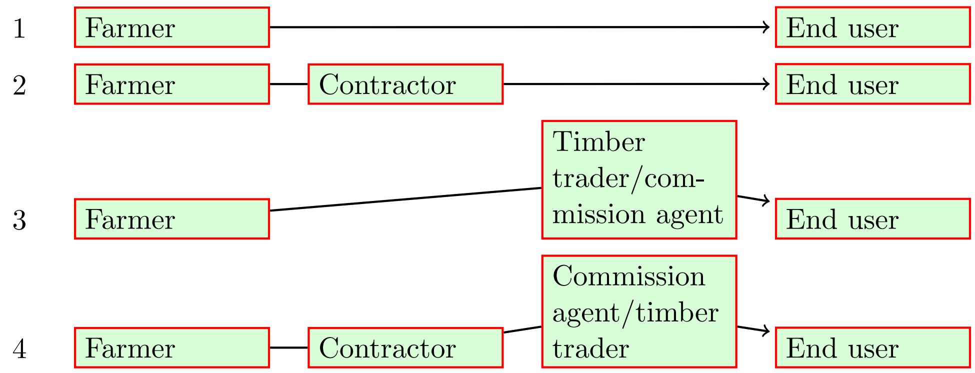

Fig. 3.6: Intermediaries along the wood trading chain.

China In China, most of the forestry belongs to the government, farmers do not have right to cut it down. Only the forest especially for economic purpose can be harvested. The classical channel for this part is number 3 in **Fig. 3.6**.

India Specific production chain is not available, however, the market channels are specific and defined. The movement of wood follows different pathways involving various market intermediaries, which give rise to different market channels and costs. Market channels for farm grown wood are 1 to 4 in **Fig. 3.6**.

Kenya Main production chains are 1, 2 and 3 in **Fig. 3.6**.

Brazil The largest SRF areas in Brazil are from the private properties of the industries of pulp and paper, iron and steel, and other wood products. A small part of these companies also have foster forestry programs, where the company finances the implementation of SRF within small and medium properties.

4 Choosing the site

4.1 Which site classification methods are used?

China Domestic and foreign site classification methods can be divided into three types:

1. Classification of the sites according to suitability. The American classification map of potential capability of eight land grades is the representative method. This method is based on the evaluation of the suitability of regional site conditions; it is suitable for a site classification which aims at a specific task or a purpose the wood is dedicated to.

2. Classification of the sites according to aspects of forestry and tree cultivation (silviculture), for instance, using site index and site class differences to classify sites. This type of method may be visualized, but it is only suitable for site classification of forest land and cannot be used in non-forest land.

3. Classification of the sites according to appearances. This type of method is commonly used. It can be divided into four methods;

(a) method of vegetation factors
(b) hierarchical composition of leading life factors method
(c) hierarchical composition of leading environmental factors method and
(d) multiple-factor comprehensive method.

With the development of numerical classification, site classification methods used in our country have changed from factors based on the terrain and soil and according qualitative classification methods to various quantitative site classification methods (Zhan 1990; Wang et al. 1987). See also p. 47.

India The lands are mainly used for agriculture, pastures and forestry. The capabilities of land to grow crops depend on the nature and properties of soils. On the basis of capability or limitations, broadly lands are grouped into two major groups viz., lands suitable for cultivation and lands not suitable for cultivation. The U.S. Soil Conservation Service has grouped lands into eight capability classes and the same is followed in India. The first four classes viz., I, II, III and IV are used for cultivation and the classes from V to VIII are not used for cultivation and used for grazing, wood land or wildlife.

Site types

1. *Vegetation of the forest:* indicator species, total volume of trees, rate of growth of trees, total vegetative growth.

2. *Physical environment:* climate, soil and topography.

Kenya Sites are classified as:

1. grassland (a site with bushes but dominated by grasses);

2. waterlogged sites;

3. bush land (dominated by shrubs and bushes), and

4. forest land (site under natural forest or previously under a plantation).

The main criteria of site selection are soil depths, depth of water table, total annual rainfall, with techniques ranging in degree of detail from farmers' experience and expert judgment. A widely used qualitative physical land evaluation method based on expert knowledge is the land suitability method developed by FAO (1976) for assessing suitability of land for a specific use. Suitability is expressed in descriptive terms: highly suitable (S 1); moderately suitable (S2); marginally suitable (S3); unsuitable with (Nl) or without (N2) possibilities for land improvement (Wandahwa and Ranst 1996).

Brazil The site classification methods involve statistical growth and production models. Throughout these models, a specific genetic material receives its classification for the maximum productive potential for each site, which has its intrinsic features such as soil type, annual rain and sunshine. Therefore, the sites are able to receive the genetic materials that will offer higher productivity.

4.2 What are the dominant factors affecting the site types?

China The main leading factors influencing site types include altitude, terrain, average annual precipitation, nutrient content and pH value of soil, vegetation type, groundwater level and lighting condition (H. Xu 1993).

India Dominant factors that affect the site types are: Climatic, edaphic, physiographic and biotic factors. However, SRF species on-farm is decided on the basis of site specification and marketability.

	1	2
	Species	**Soil sites**
1	Populus deltoides	sandy to fine loam, pH ranging from 6.5-8.0
2	Leucaena leucocephala	variable soils
3	Melia composita	sandy loam and deep fertile soils
4	Eucalyptus hybrid	sandy loam, tarai and alluvial soil are suitable for higher products. However, eucalyptus is grown almost in all the four corners of the country with variable site conditions.
5	Robinia pseudoacacia	normally acidic soils and sloping lands
6	Morus alba	sandy loam to clay loam
7	Prosopis juliflora	saline flats, shifting sand dunes and waste-degraded lands
8	Gmelina arborea	deep and sandy loam soil
9	Ailanthus excelsa	porous sandy loam
10	Casuarina equisetifolia	red gravelly loam, coastal areas, saline soils
11	Terminalia arjuna	moist places with sandy loam soils
12	Tectona grandis BWCDMSpecificsTables.*treeSpeciesInd*	deep black soil, black clay and black loamy soils

Tab. 4.1: Tree species and their soil and site preferences in India.

Kenya The dominant factors affecting site types are the following:

1. Temperature
2. Rainfall
3. Soil depth
4. Depth of water table
5. Prevailing soil types – soil rooting conditions, fertility, salinity and alkalinity hazard, erosion hazards, wetness
6. Altitude

	1	2	3	4
	Tree species	**Rainfall regime**	**Soil type**	**Altitude**
1	Cupressus lusitanica	High rainfall	Deep loamy soils	High altitudes
2	Pinus patula	High rainfall	Deep soils	High altitudes
3	Casuarina equisetifolia	Moderate rainfall	Sandy soil	High temperatures Lowland
4	Leucaena leucocephala	High rainfall	Loamy sandy deep soils	Low to high altitudes
5	Calliandra calothyrus	High rainfall	Loamy deep soils	High altitudes
6	Melia volkensii	Low to moderate rainfall	Sandy soils	High temperatures Low to medium altitudes
7	Gmelina arborea	Moderate rainfall.	Sandy soils	High temperatures Lowland

BWCDMSpecificsTables.*KenyaTreeSpeciesRainfallAltitudeSoil*

Tab. 4.2: Tree species in Kenya and their characteristics regarding rainfall, soil and altitude.

Brazil The soil type, considering physical and chemical features, terrain inclination, altitude, annual average temperature, annual rainfall, sunshine and wind can affect the productivity.

4.3 When classifying site types, which modern methods or facilities are used for advanced testing and analysis in your country?

China In our country, site classification has changed from early qualitative description classification to the present classification system which is based on comprehensiveness principles and leading factors and combines quantitative and qualitative classification by using modern mathematical methods (see also p. 45). Computer technology, remote sensing technology and spatial analysis technology are widely used for forest site classification. The automatic forest site classification and its mapping experiment can be done effectively by using computer and computer-assisted cartographic technique. For instance, using fuzzy clustering analysis method on the computer, choosing leading factors influencing the site such as temperature and humidity from sample units, then using the computer to input raw data and standardizing it, establishing a fuzzy similar matrix and a synthetic operation of similar matrix to compose the fuzzy equivalent relation and proceed to dynamic classification and region partition. Moreover, computer and spatial analysis technology can be used for productivity evaluation. Now various expert information systems have been developed for different applications. Software such as MATLAB is used for site type analysis too (Gao 1994; Shen 2008).

India

1. Available species at a particular site
2. Soil analysis
3. Research backup specifically on exotic fast growing trees
4. Market demand, etc.

Kenya The country is divided into ecological zones that are mainly influenced by the annual precipitation and temperatures, thus resulting into six agro-ecological zones. These zones are dominated by specific tree species. Soils are normally dug out in a potential planting site to determine the average soil depth.

Brazil The Geographic Information Systems (GIS) are widely used in the site classification for SRF implementation. Softwares such as ArcGIS and remote sensing techniques are some of the tools used for the productivity classification of the sites. The use of satellite images also support planning activities such as finding the best areas for forest plantations. The Space Research Institute of Brazil (INPE), a government agency, offers freely an image database of Brazilian satellites online. The soil classification, fertility analysis, environmental indicators such as rainfall, average temperature and sunshine among others, are used in the construction of forest growth and production methods. Larger forestry companies keep forecast stations in situ, soil analysis labs and advanced field equipment in order to evaluate the influence of environmental factors in the plantation's productivity.

4.4 How do site conditions influence the stand growth and management practices of short rotation industrial raw material?

China Take *Eucalyptus urophylla* x *Eucalyptus grandis* man-made forest for example. According to research results, the main factors influencing tree growth and the operating efficiency of *Eucalyptus urophylla* x *Eucalyptus grandis* forest are altitude, soil thickness, and humus layer thickness and so on. Great growing diversities of *Eucalyptus urophylla* x *Eucalyptus grandis* have appeared under different site type conditions. The altitude influences growth and economic benefit of *Eucalyptus urophylla* x *Eucalyptus grandis* greatly, the amount of growth decreases significantly with altitude. The *Eucalyptus urophylla* x *Eucalyptus grandis* forest has good growth, yield and benefit within a planted field altitude range of 220-450m. The growth and benefit of *Eucalyptus urophylla* x *Eucalyptus grandis* forest decreases a lot with the altitude of planted field beyond 500m. Besides, planted in a field with a deep and moist soil layer and with a fertile and loose soil is good for the root and stem growth of *Eucalyptus urophylla* x *Eucalyptus grandis* man-made forest, so that the forest has a high yield and profit. And the yield and profit decreases considerably with a thin soil layer and a bad fertility of the site even if the site is fertilized. The profit may even become negative (W. Li 2009).

India

Locality factors Climatic conditions, soil, physiography and biotic factors influencing the stand growth and management benefit of these tree species. These factors control species composition, density structure, rate of growth, etc. Each and every species has its niche area and performs best under favourable locality factors. For example species like *eucalyptus* have a wider adaptability, whereas, *poplar* is suitable only in a limited area (north-western states with sandy loam soils).

Kenya Once tree species are planted in an appropriate site where they are adapted, establishment is faster and the survival rate remains high. Consequently the growth rate remains high and at rotation age, yields are high.

4.5 How do site conditions impact on the vegetation growing underneath the trees (i.e. abundance and diversity)?

China The main influencing site factors are altitude, gradient, direction of slope and slope position. At an altitude between 1400 and 1800m the amount of shrub and herb species decreases with altitude. At 400m the moisture and temperature conditions are sufficient and they are well coordinated. So the amount of shrub and herb species is numerous. With an increasing altitude, the moisture condition is still sufficient, but the temperature condition worsens. As the altitude increases to 1800m, both moisture and temperature conditions become bad because of the high wind speed and high evaporation, and shrub and herb species are few. A gradient under 10°C has no obvious effect on the amount of shrub and herb species. The amount of shrub and herb species has no obvious variation trend correlated to the gradient because the span of gradient under 10°C is small. In the slope directions of sunny slope, semisunny slope, semi-shady slope and shady slope, the amount of shrub species first decrease and then increase, that may be because of the moisture condition. Besides, the amount of herb species increases all the time, two maxima appearing in the semi-sunny slope and semi-shady slope, and the maximum in semi-shady slope is higher than semi-sunny slope. That is because moisture and temperature conditions go well together in these slopes, especially in semi-shady slope, the solar radiation, air temperature, soil temperature and soil moisture conditions are all in an optimum status. So the amount of herb species is largest in semi-shady slope. The amount of shrub and herb species first decreases and then increases with a rising slope direction, that is because with slope direction rising, there is no obvious change of temperature conditions, but the moisture condition deteriorates, so the amount of shrub and herb species decreases accordingly. The soil layer of the high slope direction is deep, so moisture and temperature conditions match well and the amount of shrub and herb species increases gradually (Wu 1991).

Fig. 4.1: Forest-Medicine

Fig. 4.2: Forest-Livestock

India Soil, climate, biotic factors of that particular area influence the diversity of undergrowth vegetation. Due to better availability of light, temperature, soil moisture, water table, soil surface cover, organic matter, etc. ensure the better survival of undergrowth vegetation. Canopy of upper storey moderates temperature in tropical areas for better growth of understorey vegetation, whereas, in temperate areas it plays negative role. Allelo-chemicals also have the detrimental effect on the under-storey vegetation.

Kenya Normally trees grown under short rotation are intensively managed such that limited vegetation grows below the trees mainly to remove competition; especially through close spacing of the stands and frequent weeding. The trees themselves shade off any potential vegetation that may develop below the planted trees. Therefore both abundance and diversity are generally reduced under such plantations.

4.6 What makes an area suitable for growing trees on a short rotation cycle (i.e. 20 a or less) and what factors would you consider before planting?

China Take *populus* short rotation forest for producing industrial raw material for example. The site of this type of forest should be flat, deep and possessing favourable conditions for irrigation. Suitable soil types include sandy loam, light loam and Aeolian sandy soil and so on, the groundwater level is below 1.5m, and the pH value of groundwater is 7-8.5. Regions with gravel content above 30%, thin soil layer, serious salinization and high groundwater level is not suitable to choose. Take *pinus sylvestris* short rotation industrial raw material forest for another example. Pinus sylvestris requires adequate sunlight, so a site with long sunlight time, long frost free period and high annual average temperature should be chosen. Suitable soil types are dark brown soil and brown soil with low pH value. Briefly, site conditions for short rotation trees such as altitude, terrain, nutrient content, pH value and type of soil, groundwater level and light conditions should be considered before planting.

India Topography, soil conditions, water, skilled labour, aspect/altitude, compatibility with inter-cultivated crops, demand, market, etc. are kept in mind for SRF adoption.

Species selected should be adapted to climate, soil and biotic factors. Soil should be well drained, sandy loam to loam in texture, rich in nutrient and humus, slightly acidic to neutral in reaction, free from injurious salts/chemicals, etc. In hills, altitude as well as aspect is important for selection of site due to intensity/duration of solar radiations. Northern aspect should be preferred but towards the upper limits of the altitudinal zone of the species, southern aspect is better at lower elevations

Kenya

1. Deep, fertile, well drained soils
2. Appropriate rainfall and temperatures for different tree species
3. Appropriate altitude for the different tree species
4. Relatively not too steep to allow logging during harvesting without causing soil erosion
5. At least be accessible by a tractor with a trailer for extraction of logs or semi processed timber

Suitable sites will depend on the species being planted – see above (answer to question No. 2) for suitable site types for the main SRF species in Kenya.

4.7 If a site is problematic (e.g. steeply sloped, waterlogged, too dry, soil unproductive), what measures can be taken to improve it?

China Take site selection of *populus* afforestation under flooding stress in beach land for example. The suitable groundwater level for planting *populus* artificial forest is 0.9-2.4m, and drainage is needed to plant forest when groundwater level is higher than 0.6m. The site with groundwater level deeper than 2.8m is not suitable for afforestation if there is no irrigation. Site with continuous flood inundation period which is less than 20 days has no effect on the growth of *populus*. But the longer the continuous flood inundation period last, the greater the effect on the growth of *populus*. A site with a continuous flood inundation period of more than 60 days should take measures such as ditching to increase the elevation above ground or else it will not be suitable for planting *populus*. Take salinized soil for another example. The common effective method of improving salinized soil is as below.

1. Water conservancy project. Use fresh water to wash the salinized soil and let the salt flow away with the water or sink into the ground.
2. Add exotic soil and separate coarse material.
3. Cover the ground and reduce evaporation, restrain the upmoval and accumulation of salt.
4. Use a modifier or organic manure.
5. Use biological means to improve the salinized soil, change site conditions by using haloduric biont to absorb accumulated salt and improve soil fertility.
6. Separate salt by sunlight from extracted salt groundwater to prevent salt return, lower the groundwater level and help soil desalting.

Generally speaking, biological measures are considered as the most effective measures of improving salinized soil.

Fig. 4.3: Irrigation.

Fig. 4.4: Irrigation.

Fig. 4.5: Fertilization.

Fig. 4.6: Insect prevention.

India In salt affected soils, application of amendment like gypsum is essential prerequisite for the reclamation of these soils. Physical condition should be satisfactory with good permeability and easy leaching. Leaching of salts and lowering of ground water table is enough to reclaim these soils. The hard layer of calcium/magnesium carbonate is broken physically and planting technology has been standardized (pit and augor hole for planting). *Terminalia arjuna*, *Prosopis juliflora*, *Acacia auriculiformis*, *Savadora*, *Tamarix*, *Casuarina*, *Eucalyptus spp.*, etc. are raised to reclaim these soils. The acidic soils can be reclaimed through lime application but for plantations such treatments are rarely followed and only suitable species are planted.

Water logged sites Drainage of area consists in providing an outlet for the excess water either from the surface or sub surface. *Eucalyptus*, *Terminalia*, *Grevillea* species, etc. adapt well in water-logging areas.

Sand dunes Protection against biotic interference, treating the affected dunes by fixing microwind break, tree plantation on treated dunes in such area growing tree like *Casuarina*, *Eucalyptus*, *Acacia auriculiformis*, *Prosopis juliflora*, etc. are suitable.

Kenya There are a variety of measures that can be taken to improve problematic sites, including the following:

1. In steep sites, the ground is not opened during land preparation for planting to avoid causing soil erosion, planting pits are normally dug along the contour and tree seedlings managed through spot weeding;
2. In waterlogged sites, trenches are dug to drain the water and appropriate tree species seedlings that can withstand waterlogged conditions are planted on ridges;
3. In too dry areas species selection is the most critical factor and, additionally, water harvesting micro structures are constructed based on the amount of rainfall received, soil type and the slope. For a limited size of planting site tree in dry areas, seedlings are individually watered using bottles (bottles are covered against direct sunshine to avoid raising the water temperatures thus scorching the fine roots), and
4. The unproductive sites are normally not planted and are left to regenerate naturally.

5 Preparing the soil

5.1 Do you have to clear the site of weeds before planting and what are the methods of weed control?

China From now on and in near future, many short rotation manual forest will be planted on bare and clean soil. Soil preparation of this type of soil is simple; it is the same as modern agricultural soil preparation. But when using soil with weeds and shrubs in it, it is necessary to clear the forest land and control the weeds. This is the key measure of building the short rotation manual forest. Soil preparation often starts in autumn and afforestation will start next year. In the northern part of China, weeds and shrubs are removed to let them renew in August or early September and herbicide is used to control weeds. After a week, use a disk harrow to pulverize the turf, and then do a 10cm shallow tillage. In the spring of next year, use the disk harrow to plough again and use herbicides before planting to prevent annual weed germination. When the planting spacing is 3.3 × 3.3m or narrower, there is no need to continue removing weeds because of the early canopy closure. When the planting density is low, weed control and tending is necessary after planting until canopy closure especially for the forest without fertilizing and irrigation (Guo 1989; J. Xu et al. 2001).

Fig. 5.1: Preparing the soil manually.

Fig. 5.2: Preparing the soil with machinery.

India It is necessary to control weed in the process of preparing the soil. Weeds have the invasive nature and new raised plants need some time to establish. Weeds if not controlled, may overtake the raised plants, thus, affecting its survival as well as growth through competition for light, nutrition, moisture, etc. Weeds in the plantations are controlled through manual, mechanical, chemical and biological methods. In general, weed control in plantations mainly involves two operations i.e., suppression of weeds and elimination of weeds. Weeds are suppressed by means of trampling, beating or cutting them down and most common is to cut them back using cutting tools like sickle, axe, etc. Close spacing is another strategy, which tends to close the canopy early and reduce the weed growth, however, for mechanization wider spacing is essential. Weed elimination requires removal of weeds along with roots, which requires soil working (digging/chopping, etc.). Foliar sprays of brush killer (2,4,5-T and 2,4-D) has been observed to be effective in controlling Lantana from the plantations.

Fig. 5.3: Tractor mounted auger for digging pits.

Hand auger for digging pits
Planting rod

Kenya All planting sites are cleared of weeds before planting which may involve complete cultivation of site (most recommended for fast establishment and high survival of seedlings), slashing the bushes and either broadcasting or heaping them and then burning them or leaving them in rows as mulch between planting rows. On steep sites, planting rows are cleared of vegetation along the contours and bushes heaped on the lower side of the strip. Complete cultivation is not allowed on such sites while maintenance of young seedlings involves spot weeding at 0.5m radius around the seedling.

Brazil Weed control is usually done with manual or chemical procedures. The application of herbicide for clearing purposes is done prior to the planting with the use of sprayers. Whenever the terrain is unable to allow the
machines to operate, the spraying of herbicide is done by employers with specific tools.

5.2 How is sloped land prepared for planting?

China Take the afforestation of eucalyptus in high yield plantation in sloping land for example. The mechanical full reclamation has a good effect and low cost in tablelands and gentle sloping lands, but it cannot be used in sloping lands. Only manual soil preparation is suitable in sloping lands. The manual soil preparation includes full reclamation, strip reclamation, broad base terracing and hole digging. According to investigation results and studies, the manual strip reclamation soil preparation is the best type of soil preparation for eucalyptus high yield forest in sloping lands. This type of soil preparation reduced the competition between weeds, shrubs and eucalyptus trees effectively and it is good for the natural distribution of eucalyptus tree roots. So the growth of eucalyptus trees using this type of soil preparation is good. Moreover, this type of soil preparation is good for preventing soil and water erosion and reducing nutrient loss, it has low cost and good management benefit, so it is used by many afforestation and production departments. The hole digging soil preparation has the worst effect compared with other three types of manual soil preparation, especially in site with flourish weeds and shrubs, trees using this type of soil preparation are hardly to survive (Pan 2009).

India The slopes may be terraced to prevent damage by heavy rains and planting is preferred on terraces (with inward slope on contour). This may be done in horizontal lines commencing at the top of the slope. Protective trenches may be developed, these trenches vary in width and tend to retain the excess water run-off and soil erosion after the rains. Hedge row planting (leucaena, gliricidia, etc.) is preferred under hilly terrain. Nitrogen fixing tree species and shrubs are planted in close spacing across the slope. Sloping Agricultural Land Technology (SALT) is much developed on the hilly areas in South-East Asian Countries.

Kenya Steep land is rarely fully exposed during land preparation as this may cause soil erosion. Because of this consideration, just the planting strips are slashed of vegetation and planting pits are dug in the middle of the cleared strips. The vegetation between the cleared strips is left intact on site. This poses a major challenge in terms of competition for both nutrients and moisture. With the well established root systems of the existing vegetation, competition for nutrients sets in within a short period after planting. A site planted using this approach requires frequent maintenance to reduce shading and competition for nutrients.

Brazil The soil preparation in sloped lands is done by cleaning the planting lines according to the contour lines of the terrain. The line is about 1 meter wide, giving the plants a 50 cm radius of weed free area. This line can be done manually or thru the use of herbicides. Thus, there is the avoidance of soil degradation, the improvement of erosion control, the rain water is slowed down on the surface and consequently the reduction of erosion formations and the loss of fertilizers and herbicides. The soil preparation in lines also improves water infiltration and the maintenance of soil carbon.

5.3 What effect do common soil preparation methods have on root growth, wind resistance and on the ratio of flowering and seed setting of the trees?

China Soil preparation has an effect on root depth distribution. According to investigation results, different soil preparation depths correspond to different root distribution ranges. When the soil preparation depth is 60cm, roots are distributed within 5cm to 60cm. When the soil preparation depth is 100cm, roots are distributed up to 80cm. This shows that root distribution range deepens with the soil preparation depth. But the main root zone only exists in a soil layer with a depth of less than 80cm. There are hardly any roots in the soil layer deeper than 80cm. This may relate to the soil temperature and air. Soil preparation also has an effect on root quantity and root length. The root growth relates to soil fertility, and it is influenced by soil mechanical resistance too. Soil preparation has great effect on root growth. For hole digging and sulciform soil preparation, the root quantity out hole or ditch is only from 10/13 to 20/43 of root quantity in hole or ditch.

The root growth needs loose soil condition and soil without preparation is not suitable for root growth. Take the fine-leaf eucalyptus manual forest for example.
The wind resistance and flowering and seed setting rates of trees are different under different types of soil preparation. In the year of 1993, two strong typhoons landed at Yangxi and the experimental forest is seriously influenced and damaged. In all types of soil preparation, trees with two-times mechanical reclamation were influenced most seriously. The wind-breaking rate of these trees is 28.5%. Trees with manual hole digging soil preparation were not seriously damaged with a wind-breaking rate of 8%. So, wind resistance of trees with mechanical reclamation is worse than trees with manual hole digging soil preparation. The investigation on flowering and seed setting rate of trees shows that trees with different types of soil preparation have significant differences. Only 8% of trees with two-times mechanical reclamation flower, this percentage is the worst. The best percentage, 31%, appears in trees with a one-time mechanical reclamation. This may be because the two times mechanical reclamation has a greater disturbing effect on soil layer, the roots of the young trees were not deep and they stayed in shallow and loose soil layer when the typhoons come, so their wind resistance was bad. Meanwhile, trees were in vegetative growth stage under good soil condition, so their flowering and seed setting rate is low. In conclusion, using two-times mechanical reclamation soil preparation is good for trees growth and biomass accumulation increases per unit area in the regions which are not influenced seriously by typhoons and have no serious water and soil erosion in flat and slope land (Lv 2000).

India Seedling/cutting develops the roots easily, rain water penetrates deeper so that moisture is retained in soil for a long time, improvement in the aeration of soil is additional advantage. After soil preparation roots of weeds are easily dugout and their growth is reduced.

Kenya Where soil preparation has involved manual digging to shallow depth, root development can be impaired and the roots do not penetrate the deep soil horizon. Consequently, the result is that a tree will spread its roots close to the surface and will have poor wind resistance, usually falling over easily. It would not withstand drought conditions even when mature as roots would not be utilising the deeper soil horizon that retains moisture for longer periods. Such trees are also easily attacked by pests such as termites that effectively kill them, especially during the dry season as the trees are easily stressed by lack of moisture. Flowering: no information is available Seed setting: no information is available on this aspect

Brazil Soil preparation is aimed at making water and nutrients available for the fast root development and the growth of the plant. The technique favour water and nutrients absorption by the improvement of physical properties of the soil such as porosity and the reduction of resistance imposed by the root growth. Minimum tillage, which has been increasingly adopted in Brazil since the 80's, is done through the soil preparation and contributes with the reduction of nutrients loss, higher microbiologic activity in the soil, reduction of weeds and the reduction of soil disturbance.

5.4 Do you use manual soil preparation and, if so, what are the benefits of it compared to mechanical means of soil preparation (costs and results) and how is it carried out?

China Yes. Take the high-yield *eucalyptus* forest for example. For this type of forest, although mechanical soil preparation has disadvantages such as being likely to cause soil erosion and a high amount of soil fertility lost by leaching, it can improve soil permeability, helping to release soil fertility and to restrain the competition between *eucalyptus* and weeds. Besides, the cost of mechanical soil preparation is less than manual soil preparation. In brief, it is the best type of soil preparation for planting *eucalyptus* forest in tableland and gentle slope. The manual soil preparation cannot reach the level of improving soil structure to promote *eucalyptus* growth of full mechanical reclamation. Using manual soil preparation could only be considered from the aspect of improving the competition situation between *eucalyptus* and weeds and shrubs at the site. *Eucalyptus* is sensitive to competition, so its competition with weeds and shrubs for sunlight and soil fertility must be reduced as much as possible by soil preparation in its young stage. How to make *eucalyptus* become dominant in forest populations is the key of building high yield *eucalyptus* forest successfully. For the types of manual soil preparation under the condition of preventing soil erosion as much as possible while keeping a reasonable input-output, manual strip reclamation is the best type of soil preparation for high yield *eucalyptus* forest in slope.

India Manual soil preparation is still followed because it helps in employment generation and is cost effective also. Land holdings are small enough to afford mechanization. However, big farmers and private organizations do follow mechanization.

Kenya Manual soil preparation is usually used except in research cases. This is mainly due to lack of machinery and the high cost of hiring tractors. The manual method that is used in public land by the Kenya Forest Service involves allocating parcels of land to the local communities to grow crops for one year but in the second year, tree seedlings are planted while the cultivators continue to cultivate their crops. The cultivators therefore weed for both their crops as well as the tree seedlings. This symbiotic relationship continues for two or three years, or until the tree canopy closes and cultivators realise reduced yields from their crops. This method is also used by farmers on their private land while establishing woodlots. The farmers normally use hand held tools (hoes, forks and machetes) to prepare the site and, thus, the soil is dug to a maximum of 15cm. Deeper pits are dug specifically for planting of seedlings when preparing the soil manually. Where an individual farmer has used a tractor to plough the site, which is quite rare, the soil is dug deeper throughout. This has two sides: on good sites this causes better growth as the soil holds more moisture and more nutrients are made available to the seedlings; on the other hand, if the site is poor with shallow soils underlain by a pan of murram (petroplinthite), digging deeply causes distribution of the limited nutrients into a larger volume of soil and therefore less available to the seedlings. However, such sites hold more soil moisture than those shallowly dug.

Brazil Soil preparation is usually done manually by small producers on their properties due to the high costs of mechanization. In forestry companies in Brazil, soil preparation is done mechanically and it's the most viable system. Due to the large scale of the companies, the operational cost is much lower when mechanized. Besides that, mechanization establishes a quality pattern for the task and requires skilled labour for the activity. Sub-soiling is widely used as mechanized preparation of the soil, and it's used for minimum tillage and total area preparation. The destruction of rigid soil structure in deeper areas offers a better development for the tree's roots. Moreover, the better distribution of fertilizers such as phosphorous, throughout the depth of the soil improves the nutrient availability. Generally, sub-soiling reaches between 40 and 60 cm underground.

5.5 How do the different soil preparation methods affect the wood production?

China Take the *eucalyptus* plantation for example. The purpose of soil preparation is to promote *eucalyptus* plantation to be fast-growing and high-yield. According to relevant research, stands using different types of soil preparation present significant differences on tree height, diameter at breast height and volume growth. Full mechanical soil preparation has a much better promoting effect to the *eucalyptus* yield than manual hole digging. The ranking what regards yield of using different types of soil preparation is as follows:

1. Twice mechanical reclamation.
2. One time mechanical reclamation.
3. Manual hole digging.

Under same site condition, same improved seed, same fertilizing proportion and fertilizer amount and same management condition, mechanical soil preparation can promote fine-leaf *eucalyptus* yield effectively. However, yield of manual hole digging lags behind the stands using mechanical soil preparation. From the comparison between three types of soil preparation, it can be seen that mechanical soil preparation measure has the best promoting effect to *eucalyptus* yield and it can shorten the rotation. The mechanical soil preparation can get good economic benefit from fine-leaf *eucalyptus*. The yield and economic benefit of stands using this type of soil preparation is much better than stands using manual hole digging. The ranking what regards the economic benefit is as below.

1. One time mechanical reclamation.
2. Twice mechanical reclamation.
3. Manual hole digging (Sun et al. 2007).

India Since mechanization is followed at a limited scale, therefore, manual soil preparation for cleaning and earth work (pits, trench, etc.) is followed. Soil preparation facilitates root aeration/respiration, percolation of rain water and killing weeds, which ultimately helps in higher productivity.

Kenya Complete cultivation hastens seedling establishment and high survival and growth rate from the beginning, thus at rotation more wood is realised.
Slashing of weeds leaves the stumps intact and, thus, unless the resprouting vegetation is suppressed regularly, this competes with the seedlings and causes initial slow growth which may lead to mortality and stunted growth – resulting in reduced wood production. Where slashing and burning are carried out, high survival and growth are recorded especially where these are followed up with frequent weeding of the seedlings. The burning causes quick release of plant nutrients and therefore makes them available to the planted seedlings. However, this also causes a reduction of organic matter necessary for continued improvement of the soil structure.

Brazil The soil disturbance caused by subsoiling reduces soil compactness and allows productivity improvements. The soil preparation can be very useful for reform areas, by eliminating stumps and weeds, which can reduce competition over soil nutrients. Therefore, minimum tillage helps the soil to maintain its physical and chemical properties (erosion control and nutrients maintenance) due to the reduced exposure of the soil to several weather conditions. This is important for the improvement of productivity.

6 Genetic material

6.1 Summarize the technical knowledge and national research activity on clone breeding – absolutely and comparing it to activities in other countries.

China The study of clone breeding in China started almost at the same time when other countries started. In the 1980s, the economic objectives of forestry have expanded from the traditional objectives which emphasized the mere production of wood to a sustainable management which is to combine timber production with ecological, environmental and social benefits of the forest. In the 1990s, as people became increasingly aware of clones as an effective and universal manner of breeding and the idea spread that the clones are the best management system for industrial plantations. By then the study of clones where main research focusses on cuttings started again and resulted in achievements. At present, after years of efforts, the clones of *fir*, *white elm*, *casuarina*, *poplar*, *eucalyptus* and other species breeding of clones reached the stage of production and utilization. A selection of clones what regards criteria such as usability for pulp wood, ecological stability and adaptability and genetic variation, moreover a study on the usability for pulp wood have been carried out. This initially solved a series of technical problems of *eucalyptus*, *acacia*, *fir*, *pine* and *larch* etc. and has laid the foundation for clones in general. But compared with the developed countries, some gaps still exist in the high-end technology development in China. Somatic cell embryo testing techniques to *picea abies*, *colorado spruce* and other tree species has been carried out to the stage of pilot tests, but these studies in China are lagging relatively behind (`http://chinaforestry.com.cn/`) .

India Species like *Poplar*, *Eucalyptus*, *Casuarina*, etc. are extensively propagated clonally and success rate is comparable with other countries. But activities on commercial scale have not extended to other species though standardized. Planting stock is mainly produced from seeds collected from seed production areas or plus/elite trees.

Kenya Clone breeding in forest trees is very young in Kenya and is largely at the research stage except for some introductions of *Eucalyptus* hybrid clones from South Africa. These clones are currently being raised locally in two places in Kenya, at the coast (Malindi) and Nairobi for distribution to the farmers. While some research activities on appropriate sites for establishing the majority of these clones have been carried out, some of the earlier plantings were rather poorly sited and therefore experiencing poor growth. The driving motive of planting the clones has been displaced as most farmers have been expecting to sell their *eucalyptus* trees for electricity transmission poles at a premium price but the trees' strength properties do not allow for this. The same material is grown for pulp production in S. Africa. The current varying growth of clones in the field shows that proper research on clone-site matching should be carried out prior to expansive planting. In South Africa the planting of clones has been taken up by private companies that target specific products, unlike in Kenya where small scale farmers are the main consumers of the clones and these farmers often have diverse expectations that may not be realised. The common method of propagation is through rooting of cuttings. This involves the establishment of hedge rows of the different clones where they are maintained under vigorous growth and encouraged to develop into a hedge without growing in height. The young shoot tips are harvested regularly and rooted under non mist propagators from where once they are established, they are hardened before being taken out into the field for planting. So far this has been achieved for the *Eucalyptus* hybrid clones. The current stage on clone breeding research is at the selection of plus trees of various species which include *Cupressus lusitanica*, *Pinus patula*, *Melia volkensii*, *Osyris lanceolata*, *Vitex keniensis*, *Eucalyptus grandis*, *Gmelina arborea*, *Eucalyptus nitensand*, *Eucalyptus saligna*, *Pinus caribaea*, *Pinus tecumininii*, *Pinus maximinoi*, *Eucalyptus urophylla*, *Eucalyptus camaldulensis*, *Eucalyptus tereticornis*, *Grevillea robusta* and *Ocotea usambarensis*; though some species have been subjected to more research than others. Besides selection of superior individual trees in the natural and planted populations, the other main research area has been on determining the appropriate conditions for rooting cuttings and the necessary treatments, if any, that could be used for commercial production of planting material. A critical development is that some of these species have been heavily exploited in their natural populations and, thus, the selection is being carried out from an already poor degraded population. Once farmers establish some of these clones, there has been some tendency for people to collect seed from such populations and hope that the propagules shall perform as the parents. Unfortunately there are no regulations to guard against this practice.

6.2 Are there plants and clones in particular suitable for dry areas? If so in how far are they used commercially and in how far are they just growing naturally?

China Suitable tree species for arid areas are mainly *buckthorn*, *eucalyptus*, *atyiplex canescen*, *masson pine*, *arborvitae*, *staghorn sumac*, *robinia*, *Amorpha fruticosa*, *Salix* and *Caragana* and so on. For the restoration of land in the arid land, sand-fixing plants are mostly cultivated (http://www.shangri-lanews.com/dqrb/html/2009-08/19/content_18195.htm ; Lan 2002).

Fig. 6.1: Eucalyptus.

Fig. 6.2: Masson pine.

Fig. 6.3: Caragana microphylla

India Numbers of species are available for dry sites, however their productivity is quite low and fast growing species like *wattles*, *Prosopis*, *Casuarina*, *Eucalyptus*, etc. have been found suitable. The clones of eucalyptus have been identified for dry/degraded sites commercially and adopted on large scale.

Kenya There are tree species that are particularly suitable for dry areas. These include *Melia volkensii*, *Osyris lanceolata*, *Eucalyptus camaldulensis* and *Eucalyptus tereticornis*. These species are not being used commercially for establishment of plantations. Currently, tree planting in the dry areas is still not a major activity and is mostly carried out at a very small scale. *Melia volkensii* has, however, been planted by some farmers especially around research stations where trials have been established. The *Melia volkensii* and *Osyris lanceolata* seedlings are usually collected by farmers as wildings and the exotic eucalyptus species bought from local nurseries.

6.3 What are the most important performance parameters aimed at when developing new clones (e.g. drought resistance, dendromass yield etc)?

China In most part of China, growth rate and high yields are the most important performance parameters.

India Biomass is priority criteria followed by adaptability to difficult site conditions and disease/insect tolerance. However, their genetic testing through biotechnological approaches is costly affair and not followed.

Kenya For the humid areas with high rainfall, the most important performance parameters are growth rate and overall high yields. In dry areas, several factors are considered and these include drought tolerance, growth rate, pest tolerance and high yields.

6.4 What regulations are in place regarding clone imports and exports? In how far are these regulations respected in reality?

China In China, the Forest Law of The People's Republic of China, the Seed Law of The People's Republic of China and Regulations for the Management of Seed of the People's Republic of China regulate issues of clone imports and exports. All the clone imports and exports respect these regulations. (http://suqian.mofcom.gov.cn/column/print.shtml?/gaikuang/200610/20061003583490) .

India Import permit is provided by National Bureau of Plant Genetic Resources (ICAR) and after quarantine check the material is used. Individual cannot import/receive the material directly. Biodiversity Bill has made the import and export of material little stringent and Biodiversity authority regulates the biodiversity issues.

Kenya There is need to cleared by Kenya Plant Health Inspectorate Services (KEPHIS), the regulatory institution. This involves getting an import permit and sending the same to the relevant exporting country; the exporting country has to treat the material as per the stated standards of the importing country - Kenya; they then prepare a phyto-sanitary certificate that will accompany the consignment imported; KEPHIS inspects the imported material at the entry point and, once satisfied, they allow the material into the country. The regulations are very strict with respect to pests and diseases; before any vegetative or seed is allowed into the country, the KEPHIS stamp as proof of clearance MUST be appended on the documents. However, it is limited in the sense that it is not possible to fully monitor people who come back with some material in the suitcases as entry points are not very tight in checking plant material. The regulations are there to limit the damage that can be caused by letting in certain species without control measures being undertaken. Due to invasiveness nature of some species such as Prosopis juliflora, leaders of communities where the specie invaded tried to take the government to court. However with realisations of its multiple uses and economic potential especially as a dry season fodder and bee foliage, for charcoal making and its easy regeneration, the negative attitude has subsided with time. Ministerial pronouncements against certain tree species, such as *Eucalyptus* species have caused at times the cutting and uprooting of trees on farms. However, reforestation and afforestation achieved through clonal imports will have a major positive environmental impact, especially to the rural communities that depend on firewood energy to cook their foods. A lot of deforestation and resultant loss of top soil due to soil erosion has occurred because of a lack of seedlings to plant to replace the trees cut for firewood.

6.5 Are mono-clonal or multi-clonal plantations more common and what are the according reasons?

China This problem is not obvious in China.

India Mono-clonal plantations are preferred than mixture of clones for better productivity and ease of management of known clones. However, multi-clonal plantations are risk free and broaden the genetic base. Farmers are advised to raise multi-clonal plantations.

Kenya Clonal plantations are generally not common in Kenya. Specifically they have not yet been planted in the public forests and have only been used in private forest – this has been eucalyptus clones, after their introduction from S. Africa. However, monoculture plantations of several exotic and few indigenous trees species do exist. The transfer of proprietary improved *Eucalyptus* germplasm from South Africa to Kenya has been done under a research agreement. Utilization of this superior germplasm for commercial forestry will require negotiations and consideration of Intellectual Property Rights (IPR). Traditionally, tree seedlings have been raised from seeds that are collected from available trees or bought at a relatively small cost. These factors can be seen as a limitation for widespread uptake of clonal plantations. Other factors limiting interest in clonal or mono-cultural plantations are: uncertainty of risks of pest and disease outbreaks as experienced among single species plantations in the country, e.g., cypress aphid on *Cupressus lusitanica*, dothistroma blight on *Pinus radiata*, BlueGum Chalcid (BGC) on *Eucalyptus* species among others; high intensity of management, e.g., clones are raised from cuttings and therefore do not develop strong taproot, thus the trees require proper maintenance to avoid wind throw and resist drought; cost of raising clones, e.g., unlike seedlings raised from seed, clones from cutting require propagators to realise sufficient numbers - this is a deterrent for resource poor farmers who also lack the skills to carry out the propagation.

7 Plant selection

7.1 Which quality criteria are in place by law or by practice regarding planting material?

China

National law Seed law of the People Republic of China

National standards

1. Quality grade classification of major afforestation tree species-GB 6000-1999
2. Tree seedlings of major species-GB 6000-1985
3. Technical code of afforestation-GB/T 15776—2006
4. Grade of forest tree seed-GB 7908-1999
5. Testing protocol of forest tree seed-GB 2772-1999
6. Standard of verity for improved material of forest tree-GB/T 14071-1993
7. Preserving principle and method for CFG-GB/T 14072-1993
8. Forest tree seed storage-GB/T 10016-1988

Provincial standards and rules

1. Provincial standard in Beijing DB11/T 222—2004 Grade of Tree seedlings of major species
2. Provincial standard in Fujiang DB35 - Technical code of afforestation
3. Provincial standard in Yunnan DB53/062-1988 Tree seedlings of major species
4. Provincial standard in Zhejiang DB33/177-2005 Grade of Tree seedlings of major species
5. Provincial standard in Heilongjiang Testing protocol of forest tree seed

India What regards the planting stock shoot the shoot:root ratio should be 2:1 but varies from species to species. Deciduous species can be raised as naked root, whereas, evergreen species are planted with an earthball around the roots or stumps are prepared (the shoot is cut at 5-10 cm to reduce transpiration losses). There are no regulations for the certification of plant material and seeds in forestry in place, however, such standards are available in crops including fruit trees. Recently, the Indian Council of Forestry Research and Education has constituted a committee for necessary suggestions on certification of planting material (a copy of the report is available on the ICFRE website www.icfre.org). ICFRE has also framed the guidelines for the release of varieties/clones, etc.

Kenya Guided by the objectives for importation, as long as the phyto-sanitary conditions are met and the species has been proven not to be invasive or have the potential to develop into a weed, the plants are allowed into the country. However, they are initially put under quarantine to determine their growth habits and establish their relationship with potential pests. The seedling quality of imported material depends on the consumer and the space in the container used for carriage: the logistics of handling the material determines to a large extent the size of material; for example, rooted cuttings of eucalyptus were obtained from South Africa when they were 15cm height, 5mm diameter, with leaves and buds; and therefore these were seedlings ready for planting in the field.

7.2 What are the factors to be considered when choosing SRF species?

China The major SRF species in Northern China is *poplar*. This results from the following aspects of *poplar*: Its rapid growth, high yield, easy to update. Its cultivation is the largest and the yield is the highest in Northern China. SRF poplar is mainly used to manufacture plywood and MDF. The major SRF tree species in the Guangxi region is *eucalyptus*. This results from the following aspects of *eucalyptus*: rapid growth, aridity resistance, strong anti-adversity, high economic value (Z. Li 2001).

Fig. 7.1: Poplar saplings ready for planting.

India Fast rate of growth, ease of establishment, high biomass productivity, compatibility with associated crops, deciduous nature, less prone to insect-pest/diseases, marketing, etc.

Fig. 7.2: Sprouted plants are unsuitable for planting

Kenya Major factors to consider are: Prevailing weather conditions and the adaptability of the tree species - the tree species selected are those that are adapted, this is determined through observations made in the neighbourhood; End products - for fuel wood, Eucalyptus species and Acacia spp. provide the best products within a short rotation while for timber, Cupressus lusitanica and Pinus spp. areselected. In sites where the crop component is also given high priority, species such as *Grevillea robusta*, *Leucaena leucocephala*, *Calliandra*, *Casuarina* and *Markhamia lutea* are preferred. While these tree species are valued for their financial benefit, *Leucaena* and *Calliandra* are also valued for providing alternative source of livestock fodder especially during the dry season. Growth rate - farmers prefer fast growing species that provide the end product within the shortest time possible.

7.3 How are patent rights handled?

China The State Intellectual Property Office of the People's Republic of China and the Office for the Protection of New Varieties of Plants of State Forestry Administration of China have specific guidelines on the issue of patent rights, with the single legislation pattern. There are two ways of China's current legal protection for plant varieties. One is protecting plants directly by applying variety rights. The other is through applying invention patents rights of methods of the product plant varieties. We only protect the plant varieties listed in the list of protected plants variety which is established via application.

India Indian Council of Agricultural Research has specific guidelines on IPR issues in agricultural crops but no specific rules/regulations are followed in tree species at this stage including certification of planting stock. However, Indian Council of Forestry Research and Education is formulating guidelines on these issues and will be applicable.

Kenya Plant Breeders' Rights (PBRs) became operational in 1975 under the Seeds and Plant Varieties Act (Cap 326) of 1972. The rights are granted by the State to protect the proprietaryrights of plant breeders with regard to breeding and discovery of new plant varieties. A grant of Plant Breeders' Rights for a new plant variety gives the holder the exclusive right to produce for sale and to sell propagating material of the variety. In the case of vegetatively propagated fruit and ornamental varieties, Plant Breeders' Rights give the holder the additional exclusive right to propagate the protected variety for commercial production of fruit, flowers or other products of the variety. Currently, the patented *eucalyptus* trees are only produced for research as per agreement with the supplier and no multiplication for sale can be carried out. Mutual respect of the agreement between the supplier and the recipient of the material currently seems to be the case.

7.4 According to end use, what are the main factors (indicators) taken into consideration when selecting seeds?

China When used as a *fuel wood* the following is important:

1. a fast growth rate
2. a combustion with reduced sparking
3. a high calorific value
4. a high biomass yield
5. wood splits easily
6. the plant regenerates easily from seed naturally or through sprouting
7. the harvested wood dries quickly or burns even with a more elevated moisture content

Used as *timber/poles/posts* the following is important:

1. a high growth rate
2. straight main stem of good shape with little taper

3. good timber strength properties

4. little branching

When used as *fodder* the following is paid attention to:

1. high share of branch biomass

2. tree withstands frequent harvesting

3. tree is suitable for intercropping with agricultural crops for better maintenance especially nitrogen fixing and not overly competitive with agricultural crops

India In nature, ideo-types for different end-uses are available and that is the best indicator for their selection. As per objectives of plantations, the parameters of tree species are decided. For timber purpose, the stem is given more weight age, for fuel coppicing potential and ease of establishment; for fodder, broader canopy, low tree height are preferred parameters; for agroforestry straight stem, narrow crown, deciduous nature, etc. are important parameters for consideration for selection of tree species.

Kenya Fuel wood - fast growth rate, burns with less sparking, high calorific value, high biomass yield, splits easily, regenerate easily from seed naturally or through sprouting, dries quickly or burns even with moisture content. Timber/poles/posts - high growth rate, straight main stem of good form with less taper, high timber strength properties, light branching. Fodder - high branch biomass, withstands frequent harvesting, good for intercropping with agricultural crops for better maintenance especially being nitrogen fixing and not overtly competitive with agricultural crops.

7.5 Which tree species are suitable for SRF afforestation in the different areas in your country?

China

1. The *Yangtze River region* is suitable for the *poplar*, *pine*, *loblolly pine* and *bamboo* because of the favourable natural condition and fertile land.

2. The *southern coastal areas* are suitable for *eucalyptus*, *acacia*, *pine*, *Caribbean pine*, *slash pine* because of the unique natural conditions.

3. The *Huanghai and the Huaihai plain region* are important areas for plain afforestation and are suitable for *Chinese white poplar*, *Populus euramericana* etc.

4. *Inner Mongolia and Northeast* are the most forest-rich areas in China and are suitable for *poplar* and *larch*.

India

1. North western states:

   Poplar, *Eucalyptus*, *Melia*, *Bamboo*, *Ailanthus*, *Salix*, *Bombax*, *Leucaena*, etc. Southern states: *Acacia*, *Casuarinas*, *Leucaena*, *Eucalyptus*, *bamboo*, *Prosopis*, etc.

2. North-Eastern states:

   Gmelina, *Bamboo*, *Anthocephalus*, *Terminalia*, *Eucalyptus*, *Alnus*, etc.

3. Western states:

   Prosopis, *Ailanthus*, *Eucalyptus*, etc. Central India: *Leucaena*, *Eucalyptus*, *Gmelina*, *Casuarina*, *Prosopis*, *Melia*, *Bamboo*, etc.

Kenya

	1	2	3	4	5
	Regional type	**Altitude (m)**	**Mean annual Temp (°C)**	**Annual rainfall (mm)**	**Tree species**
1	Humid, lower highlands	2400	12-18	1000 - 1700	Acacia mearnsii, Cupressus lusitanica, Eucalyptus saligna, Pinus patula, Grevillea robusta
2		1800-2400	12-18	1000-1700	Acacia mearnsii, Cupressus lusitanica, Eucalyptus saligna, Pinus patula, Grevillea robusta, Eucalyptus grandis
3		900-1800	12-18	1000-1700	Acacia mearnsii, Calliandra calothyrus, Casuarina equisetifolia, Senna siamea, Cupressus lusitanica Eucalyptus grandis, Eucalyptus saligna, Grevillea robusta, Leucaena leucocephala
4		< 900	12-18	1000-1700	Casuarina equisetifolia, Senna siamea, Leucaena leucocephala
5	Semi-humid, lower highlands	1800-2400	12-18	1000-1300	Acacia mearnsii, Casuarina equisetifolia, Cupressus lusitanica, Eucalyptus saligna, Eucalyptus grandis, Grevillea robusta
6	Semi-humid midlands	900-1800	14-24	700-1300	Acacia mearnsii, Casuarina equisetifolia, Senna siamea, Cupressus lusitanica, Eucalyptus saligna, Grevillea robusta, Leucaena leucocephala
7	Semi-humid lowlands	< 900	12-18	700-1300	Casuarina equisetifolia, Senna siamea, Leucaena leucocephala, Prosopis juliflora
8	Semi arid lower highlands	1800-2400	12-18	450-900	Grevillea robusta, Senna siamea, Melia volkensii
9	Semi arid midlands	900-1800	18-24	450-900	Acacia mearnsii, Casuarina equisetifolia, Senna siamea, Grevillea robusta, Melia volkensii
10	Semi aris lowlands	<900	>24	450-900	Casuarina equisetifolia, Senna siamea, Leucaena leucocephala, Prosopis juliflora
11	Arid midlands & lowlands	<1800	>24	<500	Casuarina equisetifolia, Senna siamea, Leucaena leucocephala, Prosopis juliflora

BWCDMSpecificsTables.*KenyaTreeSpeciesForAfforestation*

Tab. 7.1: Tree species in Kenya suitable for afforestation. Source: Omondi, Maua, and F.N. Gachathi 2004.

7.6 Is it necessary to try out selected tree species? If necessary how to do it? How long do trial periods last?

China It is necessary to try to grow selected tree species locally. But there are neither relevant test methods nor according information on processes.

India Tree species which is best suited to the agro-climatic conditions and meet the needs of the local communities should be selected. These species have been developed/selected over a long period of experience, thus their end using is also established. However, the exotics need thorough testing of at least one generation for their ecological adverse implications.

Kenya It is necessary to try out selected tree species because the overall growth performance depends on a complexity of factors including rainfall, temperatures, soils and their interaction. Trials are carried out usually on small plots of public land and on several farmers' land under diverse soils and land uses in potential growing sites. Trial periods will vary according to species: for *Pinus spp.*, *Grevillea*, *Markhamia* and *Cupressus*, decisive conclusions could be drawn after a ten year period, however these trials are maintained up to rotation periods of between 15 and 20 years. For *Eucalyptus spp.*, *Casuarina* and *Acacia spp.* trials tend to yield adequate data within periods of five to eight years. The trials provide important information regarding the growth performance of the species under various management regimes, for example: spacing and maintenance; necessity for pruning in as far as how persistent the branches are, and the growth rate. It is also essential to evaluate the effect of the species on yield of agricultural crops when intercropped. This is because the majority of farmers cannot spare a site with young seedlings spaced out widely with a large area left empty during the early years of establishment and yet be expected to weed the seedlings. Furthermore the land holdings are generally small and thus intercropping is the usual method of planting trees on farms. Trials are set out under various possible methods that farmers could employ, ranging from close spacing to reasonably wide spacing together with common locally grown agricultural crops. Information is collected at the time of harvesting the various crops and growth information on trees is also collected. This is then compared with pure plots with pure agricultural crops and also pure tree stands. For the crop component, the trials last for three crop seasons (3 years) which is usually marked by drastic reduction of crop yields. The tree component continues to the rotation age as explained above for the various species.

7.7 Which are seedling quality requirements regarding SRF in general and which quality level of seedlings should be chosen?

China Normally the shape of seedlings is the quality criteria in sales. The various types of poplar seedlings should be straight, uniform upper and lower, the terminal bud should be developed normally, the root system well developed and intact. The lateral root of annual seedlings should be not less than 20cm long and the biennial one should be not less than 30cm long. Abnormal seedlings (such as distorted ones, etc.) and seedlings with mechanical injury should not be outplanted.

	1	2	3
	Level	**Girth**	**Diameter**
1	1	14-16cm	4.5-5.1cm
2	2	12-14cm	3.8-4.5cm
3	3	10-12cm	3.2-3.8cm
4	4	8-10cm	2.6-3.2cm

BWCDMSpecificsTables.*Tabelle11*

Tab. 7.2: Quality levels of seedlings of 1m height as provided by the International Poplar Commission based on the diameter/girth.

Seedlings with a girth less than 8cm (diameter 2.6cm) and heights less than 2.5m should not be outplanted. China set the national standards for the major afforestation species seedlings, including 12 *poplar* species.

	1	2	3	4					
	Poplar species	**Type of planting material**	**Age of planting material** [a]	**Quality Grade**					
				I Grade		II Grade		III Grade	
				stem base diameter	height of seedling	stem base diameter	height of seedling	stem base diameter	height of seedling
				cm>		cm		cm<	
5	*Populus tomentosa*	graft	2-0	3	400	2.00-3.00	300-400	2	300
		transplant	1(2)-1	3.5	400	2.50-3.50	300-400	2.5	300
		cover plant	2-0	2.5	300	1.50-2.50	200-300	1.5	200
6	*Populus cathayana*	cuttings	1(2)-1	2.5	300	1.50-2.50	200-300	1.5	200
7	*Populus x euramericana cv. “Sacrau79”*	cuttings	1-0	2.5	300	1.50-2.50	200-300	1.5	200
8	*Poplar6 “poplar72”*	cuttings	1(2)-1	4.5	450	3.50-4.50	350-450	3.5	350

BWCDMSpecificsTables.*ChineseQualityGradesPlantingMaterial*

Tab. 7.3: National standards for grades of poplar seedlings (National Standard of the People's Republic of China GB 6000-85)

India It varies from species to species, normally cuttings 20-25cm long and 1-3cm in diameter are used. For planting stock, normally the shoot: root ratio should be 2:1. However, in species like *poplar* the plant height ranges from 3-5m, whereas, their roots are pruned completely. During rainy season, stumps (only 5 to 10 cm shoot is retained with complete root system) are preferred to reduce the transpiration losses from nursery uprooting to planting. During winter planting months (deciduous species) plants can be transported with naked roots but during rainy season earth ball surrounded roots are essential to avoid moisture stress.

Kenya Selection of seedlings is usually based on the following criteria:

1. Size of the seedling;
2. Health – no pest or disease;
3. High growth vigour;
4. Seedlings available in quantities required;
5. Seed used to raise seedlings should be from a large number of mother trees.

7.8 Which tree species are used for paper making and what is the advantage of using these trees from the economic/end-use point of view?

China As a fast-growing species, the planting areas and stocking volume of *pine* are largest in south China, which distribute in vast areas of south of the Yangtze river. *Pine* is the most important tree species for papermaking. The reservoir of *larch* is largest in North China. *Larch* is a good fast-growing species for fiber materials in North China. Another important species for papermaking is *poplar*. The distribution of *poplar* ranges from Heilongjiang, Inner Mongolia to the North and the Yangtze River region.

India *Acacia* species, *Leucaena leucocephala*, *Prosopis juliflora*, *Eucalyptus hybrid*, *Casuarina equisetifolia*, *Terminalia arjuna*, etc. The quality of paper produced from *bamboo* is superior than other soft/hardwood species but due to higher cost involved, chemical recovery, less *bamboo* resources availability, alternative resource feasibility, etc. *bamboo* is presently not purely used rather mixed with other raw materials (Hindustan Paper Corporation Ltd. Situated in North-eastern states is using sole *bamboo* for paper making and rest of the units are using other raw materials). *Eucalyptus* is the major species due to its higher productivity and adaptability on diverse climatic and edaphic situations followed by *Leucaena*, *Casuarina*, *Wattle*, *Poplar*, etc. The choice depends upon species suitability for pulping (physical, chemical and strength properties), productivity of species, availability of raw material, ease of digestion (less use of chemicals), etc. However, debarking is constraint in *Eucalyptus*, whereas, *Leucaena* is gaining importance due to its use without debarking. But the *leucaena* resources are available at a limited scale than *eucalyptus*.

Kenya *Pinus patula* is the chosen tree species used for paper making. The country has only one paper manufacturing factory which was set up in the 1970s. The main tree species for paper production was originally *Pinus radiata* but its planting was interfered with by dothistroma blight that caused its mortality at the age of between 3 and 8 years. It has long fibres which are good for paper. The alternative species was *Pinus patula* whose disadvantage is that it is also a major timber species, thus posing competition for enduse. The factory could have benefitted from use of Eucalyptus species which grow faster and regenerates easily through coppicing.

7.9 Are there tree species specifically chosen for providing fuel via short rotation?

China China's main fuel energy species are: *Jatropha*, *Pistacia chinensis*, *Bunge*, *light skin tree*, *tallow tree*, *tung tree* and so on.
China's main biomass directly combusted for power generation are: *willow*, *black locust*, *oak* and other shrubs and so on.

India *Acacia species*, *Leucaena leucocephala*, *Prosopis juliflora*, *Eucalyptus hybrid*, *Terminalia arjuna*, etc. These species have high productive capacity that includes poles, wood with good coppicing potential.

Kenya *Eucalyptus species* is a major source of fuel, especially in areas where natural woodlands have been cleared and, therefore, there is not freely available firewood. This is especially so in the high potential areas where available land is either used for crop production or livestock pasture. In such areas, firewood is considered a commodity with monetary value and *Eucalyptus species* are established in woodlots or as lines along boundaries. In public land, SRFs of *Eucalyptus species* are often established to provide fuelwood. The main species providing sources of energy are:

1. *Eucalyptus* - popular for charcoal, and firewood. Important because once trees are established, they have high growth rate and are usually adapted to most soil types and conditions. After harvesting, the species sprouts prolifically and does not require replanting for up to 4 generations, thus saving the attendant costs. The tree can also be used for several other uses such as poles, construction timber by just maintaining them for longer rotations.

2. *Prosopis juliflora* – mainly used for charcoal production. The species is unfortunately invasive and regenerates naturally and is thorny. However, in areas where the species has invaded, other species have been degraded and the ground would be bare without *Prosopis juliflora*. The tree sprouts and grows fast after cutting; it also provides fodder for livestock and does not require artificial regeneration.

3. *Acacia mearnsii* – popular for firewood and charcoal, easy to regenerate through burning of logging debris in the field. Easy to manage and requires no tending as it aggressively covers the ground, thereby, suppressing other vegetation.

4. *Grevillea robusta* – can be intercropped with agricultural crops and, thus, does not require allocation of space on the farm; produces timber and burns well even before complete loss of moisture. Splits easily when wet.

5. *Calliandra* – besides firewood, the species is also popular for its provision of fodder for livestock; it is also adapted to frequent cutting at low level, regenerates easily, and improves soil fertility.

6. *Leucaena leucocephala* – in addition to firewood from the frequently cut stems, the species is nitrogen fixing, good fodder for animals, adapted to frequent cutting at low level, easy to establish, and good for intercropping.

7. *Casuarina equisetifolia* – grows well on poor soils, coppices once after first cutting, provides poles resistant to termite attack and its wood has high calorific value.

7.10 Which trees species are selected for afforesting sites with problematic soils via SRF?

China

1. *Salix matsudana* is a fast-growing species in saline areas.

2. *Chinese white poplar* can grow normally in saline areas and can resist short-term floodings. Some Chinese hybrid *poplar* grows normally in the case of 0.5% salt content in the soil, water table below 1m on an annual average and with surface water during the rainy season.

3. *Salix purpurea* is a kind of deciduous shrub of rapid growth and good adaptability. It can resist slightly saline-alkalic land.

4. *Seabuckthorn* has a strong adaptability and high economic value. It can slow down the desertification of land.

5. *Jatropha* has a strong tolerance to drought and rapid growth and is a high value energy species (oil seeds).

India

1. In water logged areas:

   Eucalyptus, *Salix*, *Terminalia arjuna*, *Grevillea robusta*, *Syzygium*, etc.

2. In mined areas:

   Acacia auriculiformis, *Prosopis*, *Eucalyptus spp.*, etc. In saline/alkaline soil - *Prosopis juliflora*, *Casuarina*, *Leucaena*, *Acacia species*, etc.

3. In areas of water scarcity:

   Acrocarpus, *Ailanthus*, *Prosopis*, *Eucalyptus*, *Tamarix*, etc.

Kenya

1. For *steep sites*, planting of trees for later harvesting has been discouraged to protect soil. However *Prosopis* trees have been found appropriate because of their deep root systems and their prolific regeneration that ensures such sites do not remain bare even after selective cutting of tree for charcoal.

2. In *unproductive sites* such as rocky sites, *Eucalyptus species* have been planted.

3. In the case of soils that are *poor in nutrients*, nitrogen fixing species such as *Acacia mearnsii* and *Casuarina spp.* are planted.

4. In *waterlogged sites*, *Eucalyptus species* are planted as they survive better in such conditions and eventually reduce the water logging conditions and enable the site to accommodate other tree species.

7.11 Are N_2 & non-nitrogen fixing trees preferred for mixed plantations?

China Nitrogen fixing trees are valued when integrated with agricultural crops as part of an agroforest system; this attribute is not such a major consideration for pure plantations.

India Yes, High density short rotation mixed plantations comprising fast growing nitrogen fixing and non nitrogen fixing tree species, e.g. *Leucaena*, where grown in mixture with *Eucalyptus* worked as a nurse crop to give beneficial effect to the growth and production of *Eucalyptus*. *Acacia* with *eucalyptus* is another combination to benefit the productivity of the area.

Kenya Nitrogen fixing trees are valued when integrated with agricultural crops as part of an agroforest system; this attribute is not such a major consideration for plantation planting.

7.12 Are there asexual propagation methods of SRF in your country?

China In the 1990s, as people have become more aware of cloning as an effective and universal manner of breeding and the idea spread that clones are the best management system for industrial plantations, the study on clones via cuttings as a major research area then started again and has had its achievements. At present, after years of efforts, the clones of *fir*, *white elm*, *casuarina*, *poplar*, *eucalyptus* and other species breeding of clones reached the stage of production and utilization.

India Propagation by cutting, grafting and layering, are important vegetative means to propagate stock. Vegetative propagation produces genetically improved genetic materials. However, the propagation through cutting under controlled conditions is followed in majority of the species. Biotechnological approaches (micro-propagation through tissue culture) for mass propagation and their field adoption have not been found successful in SRF species.

Kenya The asexual propagation method used in Kenya is rooted cuttings but this is only appropriate for a few tree species and this method is more often used during trials rather than common practice. This method is limited by the availability of sources of cuttings. It could potentially be expanded by establishing hedgerows whereby growth may be hastened to increase frequency and availability of cuttings. The advantage of the method is that superior material can be replicated which is not possible through sexual propagation.

7.13 Is there a tendency for selecting species what regards indigenous and exotic provenance?

China In SRF/agroforestry plantation, marketing of the species is an important concern including personal requirements. Policies on marketing and pricing of agroforestry produce and land tenure can greatly influence the decision. In fact, the indigenous species are neglected. Reasons are mentioned as below:

1. With the rapid development of society, the indigenous species are not very practicable.
2. Economic efficiency is pursued excessively.
3. Indifference of nursery stock breeding of indigenous species

India Species are selected according to their climatic/edaphic requirement. However, in SRF/agroforestry plantation marketing of the species is an important concern including personal requirements. Farmers' decision to plant trees is primarily decided on economicterms. Policies on marketing and pricing of agroforestry produce, and land tenure can greatly influence the decision. For example, removing restrictions on harvesting and inter-state transport of on-farm grown trees in Punjab (India) has positive influence, while in other states legal hurdles associated with harvesting and transporting of timber have proved to be disincentive in tree growing adoption. Similarly, unrestricted import of cheap wood has upset the wood production by smallholders.

Kenya Species are selected primarily according to market demand, domestic utility, and their suitability for the site. Trees that serve multiple purposes are preferred so that a variety of household needs can be satisfied. The majority of trees used for SRF are exotics that are fast growing.

8 Planting

8.1 What are the main SRF species in your country? Which spacings for trees in short rotation systems are used? Illustrate according to the different species and different purposes.

China Main species of SRF are *poplar*, *eucalyptus*, *paulownia*, *willow* and *Pinus morrisonicola*, and the main shrub for SRF are *seabuckthorn* and so forth.

	1	2	3
	Species	**Region**	**Rotation period in years**
1	***Poplar***	Reaches of Yellow River	
2	*Chinese white poplar*		4-8
3	*Occidental Poplar*	North China	6-8, 12-13
4	***Eucalyptus***	South China	
5	*Urophylla U6*		5-7
6	*Hybridized Eucalyptus LHI*		
7	*Hybridized Eucalyptus East China sea No 1*		
8	*Urophylla shilling No 1*		
9	*Paulownia* Based on forest Lay equal stress on forest and grain Based on grain	nation wide	3-5
10	*morrisonicola*	nation wide	4-5
11	*Seabuckthorn* BWCDMSpecificsTables.*spreadingOfSpeciesChina*	Middle reaches of Yellow River	4-7

Tab. 8.1: The distribution of tree species in China.

	1		2
	species		**plant spacing (mxm)**
1	Poplar	Chinese white poplar	small girth: 2 x 3 or 3x3 large girth: 4x4 or 4x6
		Occidental Poplar	small girth: 3x3 or 3x4 large girth: 2.5x7
2	Eucalyptus Paulownia	Urophylla U6 Hybridized Eucalyptus LHI Hybridized Eucalyptus East China sea No 1	2.5x (1.6-2)m
		Urophylla shilling No 1	1.2x3, 1x3, 1.2x2.8, 1x2.8
3	morrisonicola	Based on forestlay equal stress on forest and grain Based on grain	5x5, 5x10, 4x30
4	Seabuckthorn		1x2
5	Poplar	forest for water and soil conservationeconomic forest	2x3, 1.5x4, 3x2, 4x1.5

BWCDMSpecificsTables.*plantingSpacingsChina*

Tab. 8.2: Planting spacings in China.

India Though various tree species are planted every year, majority of the plantation programmes consist of *Eucalyptus*, *Populus deltoides*, *Albizia*, *Prosopis juliflora*, *Leucaena leucocephala*, *Melia spp.*, *Robinia pseudoacacia*, *Gmelina arborea*, *Anthocephalus cadamba*, *Acrocarpus fraxinifolius*, *Salix alba*, *Ailanthus excelsa*, *Casuarina equisetifolia*, *Terminalia arjuna*, *Acacia spp.*, *Bombax ceiba*, *Bamboos*, etc.

	1	2
	Species	**Distribution**
1	*Acacia auriculiformis*, *A. mangium*, *A. mollissima*	Humid tropical regions of northeastern and the humid tropics in southern states
2	*Populus deltoides*	Irrigated agro-ecosystem in North-Western states
3	*Leucaena leucocephala*, *Eucalyptus hybrid*	In majority of states
4	*Robinia pseudoacia*, *Morus spp.*	In the sub temperate mid hills of northwestern Himalayas
5	*Prosopis juliflora*	In arid and semi-arid areas.
6	*Gmelina arborea*	In north-eastern humid tropics
7	*Bamboo*	Distributed throughout the country, major diversity in north eastern states
8	*Anthocephalus cadamba*	In North- East states
9	*Ailanthus excelsa*	In Central India in the northern part of the Peninsula and in some drier part of India
10	*Casuarina equisetifolia*	Costal areas
11	*Terminalia arjuna*	Lower Himalayan tracts and Eastern India
12	*Cryptomeria japonica*	Eastern Himalaya and in moist climate

BWCDMSpecificsTables.*distributionDifferentSRFSpeciesIndia*

Tab. 8.3: The distribution of tree species in India.

	1	2	3	4
	Species	**Rotation (years)**	**Spacing**	**Purpose**
1	*Acacia auriculiformis, A. mollissima*	10-12	2mx2m, 3mx2m, 2.5x2.5m	Biomass for pulping
2	*Populus deltoides*	5-8	5x5m, 4x4m, 5x4m	Raw material used in plywood and paper industry
3	*Leucaena leucocephala*	2-3	2x2m	Pulp wood and Energy plantation
4	*Melia composite*	8-12	6x6m	Timber
5	*Robinia pseudoacia, Morus alba*	15-20	3x3m 3x1.5m	Energy, fodder and sports industries.
6	*Prosopis juliflora*	3-15	2mx2m, 2mx3m, 3mx3m	Energy and site amelioration
7	*Gmelina arborea*	10-12	3x3m, 6x6m	Pulp and paper
8	*Eucalyptus hybrid*	3-10	1x1m, 5x5m Various spacing depends on end use	Firewood Pulpwood and poles Saw logs Windbreak and shelterbelts
9	*Anthocephalus cadamba*	10-15	5x5m	Plywood
10	*Ailanthus excelsa*	11-16	3x3m, 5x5m	Production of biomass Timber production
11	*Casuarina equisetifolia*	4, 7-10	1x1m, 5x5m Various spacing depends on end use	Poles Fuel wood Pulp Agrisilviculture
12	*Terminalia arjuna*	10	5x5m	For industrial purpose and making agricultural inputs
13	*Bamboo*	4th year onwards	5x5m	Raw material in industries
14	*Salix alba*	10-15	4x4m, 5x5 m	Small timber/ sports industries
15	*Cryptomeria japonica*	5-10	2.5x2.5m	The fuel wood and timber

BWCDMSpecificsTables.*rotationSpacingPurposeOfGrowingSrfSpeciesIndia*

Tab. 8.4: Rotations, Spacings and purposes of Growing short rotation forestry species in India.

Fig. 8.1: A wheat-poplar plantation in India. Source: Chauhan, pers. comm.

Kenya Trees in short rotation systems are established by farmers on farms either as individual trees scattered on the farm, in lines along farm boundaries, in rows along contours on the farm and in woodlots. Various spacings are used by individual farmers so it is difficult to point to specific spacing that is systematically carried out. For example, for production of poles at the coast, farmers plant *Casuarina* at between 1m by 1m to 2m by 2m. Those planting at 1m by 1m harvest the dominant trees earlier for sale and retain the suppressed ones to grow for a longer period. Farmers using wider spacing aim to sell slightly bigger diameter poles and within a slightly longer rotation. Trials carried out by various researchers have ranged from very close spacings of 1m by 1m during the implementation of the Promotion of Sustainable Forest Management (JM Kimondo 1996) project in KEFRI to as wide as 5m by 5m (Maghembe, Kaoneka, and Lulandala 1986).

Brazil The most used species for pulp and paper production and for the iron and steel industry is the *Eucalyptus spp.* in several spacing patterns: 3x2, 3x3, 3x2.5 meters, which represents an area of 6-9 m^2 per tree. In the dedicated plantations for timber, spacing can go from 3x2 and 3x3 to 3x4 and 5x5 after the growth stabilization (about 07 years) by applying thinning techniques to the remaining trees. Also, for timber production, spacing can start at 5x5 from implementation, with a 15-20 years rotation. The SRF with *Pinus spp.* vary from 3x2 to 4x4 meters of spacing and the harvesting occurs at the ages of 18-25 years and thinning practices on years 8, 12 and 16. This species is mostly used for pulp and paper, timber, saw wood and energy.

8.2 What are the main parameters to be influenced by different spacings?

China The main parameters to be influenced by different spacing are as follows:

1. *Canopy closure* of the juvenile forest: A too large plant spacing leads to too much bare area which will soon be covered with weeds. If the plant spacing is too small, the

young forest would have a premature canopy closure acerbating the competition on the limited nutrients space. As a result, forests would have an early differentiation.

2. The *growth* of wood mainly include height-growth, radial (DBH)-growth, volume the stocking volume of forestry and root system growth.

3. The *quality* of wood: Proper spacing can improve the trunk's straight- and roundness. And also, proper spacing can encourage natural pruning and also help cultivating trees fulfilling quality criteria such as little or no knobs.

4. The *stability* of forest: If the plant spacings are too large, the trunks would taper and easily fall down or break by the wind or snow. If the plant spacing is too small, too much weed in the forest would lead to the damage by insects which are not good for forest stability.

India Spacing is governed by the nature of the species, objective of planting, its end use, etc. Growing of trees at narrow spacing produces higher volume and subsequently thinning helps in producing good quality wood. Adverse effects of trees on the associated crops reduce with increasing tree spacing and even the competition among trees is reduced. In nut shell, nature of species, end use of the species/market demand and land use pattern determines the geometry ofplanting.

Kenya Tree growth rate is heavily influenced by different spacing, as reflected in other studies, found that the closer the spacing, the higher the biomass and volume of wood produced because of the high number of trees in a given unit area. However, diameters of individual trees were favoured by wide spacing. Heights of individual trees were least influenced by the spacing. In terms of wood products, wide spacing yield trees of huge size that permits the farmer to utilise the wood for various end products. In close spacing, the size of individual trees remains small, thus providing bulk biomass that can only be used as chips, pulp, and fuel wood. For coppicing trees where fodder is the main product, close spacing s favourable. Besides the tree products, wide spacing allows the growing of agricultural crops between trees, an aspect favourable with smallholding farmers who often have limited land available to sustain their livelihoods.

Brazil The most important parameter to be influenced by the spacings is the end use of the wood production. If the wood is used for energy and pulp, the trees tend to have a higher density, as for the timber production, there's less density of trees, which could increase the diameter of them. The nutrients availability and, consequently, the availability of fertilizers also influence the plantation spacings. The plantations with an adequate nutrition allow denser spacings. In areas where the fertilization is poorly done, plants can compete among each other for nutrients and the productivity can be severely affected. Besides, the SRF spacing influences with tree growth rates, wood quality, forestry rotation, implementation practices, stewardship and harvesting.

8.3 When using cuttings as a planting material – how are cuttings laid (vertically, horizontally?)? Provide reasons for each method.

China Normally we plant the cutting vertically into the soil; also we can choose the method to plant with an angle in the case with heavy soil and long cuttings.

India Cuttings of *bamboo*, sugarcane etc are laid horizontally, cutting of all other species are raised vertically for propagation.

Kenya Cuttings are rarely used as planting material among trees on farms and in public forests mainly because the field conditions are normally such that it is difficult to provide maximum care to all the cuttings to ensure high survival. Secondly the rainy seasons are short and normally too unreliable to provide conditions conducive for planting cuttings and full development of their roots. However, in the drylands, farmers use huge poles of *Commiphora baluensis* in an upright position to make livestock sheds; a majority of these cuttings, which take long to dry, end up sprouting and growing into trees. The trees are, however, not harvested and are planted closely to eventually form a live fence. The usual practice is to obtain small cuttings from selected trees and root them in the nursery. Once they have developed into healthy seedlings they are transferred to the field like other seedlings. Among agriculture crops such as Napier grass and cassava, the stems are planted in a slanting position with at least two or three nodes in the ground to provide rooting points.

Brazil Cuttings are not a common practice in SRF in Brazil. The cuttings are only used for the production of seedlings for plantations. The nurseries use clonal gardens for the production cuttings that will become new seedlings in the future.

8.4 Is data on the rate of success of planting available and how is success of planting influenced by the planting process, soil type/condition and tree species?

China

1. For now, we have no data on the rate of success of planting on inclined areas, but based on on-the-spot investigation, the rate should be more than 70 percent.
2. The main factors which affect the rate of success are as follows:
   (a) Time of lifting:
   Normally, we would choose the time for seedling dormancy and before sprout in spring.
   (b) Technology of lifting seedlings:
   Watering: Water the seedbed two or three days in advance. Depth of dredging when lifting seedlings: Depth of dredging is depended on the depth of different tree root. Usually, over the line of root about 5 to 9 cm is better. Removing of insect and pest tress, cutting the top plants, weak plants, bend plants and tress without phlorrhizin
   (c) Technology of planting:
      i. *Choice of planting site:* Acid soil is usually chosen for spruce, cinnamon, pine, etc, while alkaline soil is used for Zenia insignis, Toona sinesis, etc.
      ii. *Soil preparation and trench excavation:* All cultivated soil preparation is fit for hills or lowland, and blocks-shaped soil preparation or ribbon-like soil preparation is adapat to mountains with a degee above 25.
      iii. *Time of planting:* In the south of China, around Great Cold is the best for planting, and in the north of China, time between Insects Waken and Vernal Equinox is properiate due to the colder temperature.

iv. *Technology of planting:* Seedlings should be put straight, and roots must be unfold, after that, compacting the hillings and spreading a layer of topsoil is necessary.

India Under agroforestry plantations, the survival rate is quite high (more than 80%), however; in forest plantations, the survival rate is low. Certainly quality of planting material, soil, water management, after planting care, etc. influence the survival & growth. The SRF plantations on farm are intensively managed with appreciable results of higher productivity.

Kenya No data is available as it is not a usual practice to record rate of success, but from personal observations made in the field, it is apparent that soils that retain moisture for extended periods and are well drained provide the right environment for rooting of cuttings.The cuttings should also retain high moisture content for a long period and be succulent to ensure root development is supported by nutrients held in the stem – a condition that is dependent on species.

Brazil The SRF of *Eucalyptus spp.* and *Pinus spp.* in Brazil have a survival rate of 98 to 100% in the large forestry companies. The main factors that influence such high rates are actions against plagues, such as cutting ants and termites before planting, soil correction, fertilization of the plantings for an better development of the roots, weed control, to avoid competition for food with other species, and plantation maintenance. At last, the forestry practices adopted in the forest implementation allows Brazil to have one of the highest survival rates in the field.

8.5 Are there any measures taken to ensure the survival of the seedlings or cuttings (e.g. selection of seedlings, cuttings/species/planting process/storage/ management practices)?

China Some measures would be taken in cases with a low survival rate, a small planting density, poor tending quality or slow growth. Such measures would be tending and complementary planting of seedlings. The department in charge would allocate an according sum of money. If the farmers are unwilling to finish the task or can not finish in time, the township government would employ workers using the advanced funding.

Kenya Measures are taken to ensure a high survival rate of seedlings. Only healthy vigorously growing seedlings that have been hardened through reduced watering and root pruning are taken to the field for planting. The pits are dug before the start of the rainy season so that pits collect water which is then covered and retained near the roots during planting. The actual planting is carried out after adequate soil moisture build up but early enough in the rainy season to maximise the period the seedlings can benefit from the rains. All seedlings are potted and the containers are removed next to the planting pit to reduce the time the roots are exposed to the atmosphere. The planted seedlings are weeded to remove competition for water and nutrients with weeds. Mulching is also done using vegetation residual or small rocks while water harvesting structures are constructed to capture and retain any runoff that may occur in the field.

India Choose species which are adaptable to site conditions, choose proper planting season, size and age of planting stock, healthy stock, Proper after care, using appropriate techniques of planting, etc.

Fig. 8.2: Storage of plants and cuttings.
Photograph: Chauhan, pers. comm.

Fig. 8.3: Plants dipped in water for 48 hours before planting. Photograph: Chauhan, pers. comm.

Fig. 8.4: Poplar pruning

Brazil The quality of the seedlings starts at the nurseries. The seedlings production follow s a very strict control of quality that will help to guarantee the seedlings survival.

8.6 Is planting trees in short rotation systems on bunds (mounds of earth) widespread and, if so, why?

China Yes, China also has this kind of situation.

Kenya No, this is not a widespread practice. It is time consuming and thus not appealing to the farmers. However, in waterlogged areas, tree seedlings are planted on mounds of earth to ensure they are not flooded at any time during their establishment.

India Under waterlogged sites, the earth is piled up to keep the plants away directly from stagnating water or the planting is done on raised bunds/mounds so that the plants are not affected. Even in the industrial plantations (phytor-emediation of industrial wastewater), planting on bunds is recommended and followed. Soil is also piled up to protect the plants against wind (more specifically on light soils).

Brazil Not used in Brazil.

8.7 Are mycorrhiza or other similar enhancers in use?

China Mycorrhiza is applied in the following conditions: With ectomycorrhizae the majority of hyphae grows on the surface of roots, while a few of them seep into gaps between the cortical cells, and hyphae replace the function of root hairs. This is the case for species such as *pine*, *Cycas revolute Thunb*, *Fagaceae*, and *Betulaceae*.

1. Ectomycorrhizae

a. Species introduction. When introducing a new plant, we are supposed to introduce the relevant mycorrhiza as well, this especially regards plants with obligatory mycorrhiza, such as *pine*. Mycorrhiza as a forestry method not only may increase the survival rate, but also can increase the production and improve the ability to absorb nutrients.

b. Adverse site conditions for afforestation. In the areas which are very hard for conventional planting, such as barren soil or wasteland, the survival rate can be greatly increased by choosing ectomycorrhizae well-adapted to the plants. This may accelerate the vegetation recovery and prevent soil exhaustion and further environmental deterioration.

c. Prevention and control of root diseases. Ectomycorrhizae play an antagonistic effect for soil-borne plant pathogens. Applying ectomycorrhizae as biological plant disease control has already achieved good results.

2. Arbuscular mycorrhizae

   Part of the fungus does not produce vesicles inside the root but arbuscules, therefore it is called arbuscular mycorrhiza. Arbuscular mycorrhizae are mainly applied in forestry, on field crops, vegetables, on flowers etc. It may encourage plant growth, advance crops resistance, increase production and improve quality.

3. Orchid mycorrhizae

   Orchid mycorrhizae are a kind of endotropic mycorrhizae mainly living on the seeds of roots of orchidaceae. Orchid mycorrhizae play a role in encouraging seed germination and fostering plant growth. It has a very promising future in the field of cultivation and breeding for orchidaceae.

India Commercially they are not used in SRF plantations but they are useful in enhancing the productivity.

1. *Acacia nilotica*: Vesicular arbuscular mycorrhizal (VAM), rhizobium and phosphor-bacterium helps in establishment and growth.
2. *Leucaena leucocephala*: VAM in establishment, not only show better growth performance but also increase the vigor of the plant to overcome the adverse conditions.
3. *Tectona grandis*: Application of azospirillum and phosphor-bacterium increase the height.
4. *Dalbergia sissoo*: Inoculation with rhizobium and VAM helps in better growth.
5. Glomus fasciculatum & Gigaspora margarita in *Acacia mangium*
6. Pisolithus tinctorius in *Eucalyptus*
7. Frankia in *Casuarina* and *Alnus*;
8. Glomus mossiae in *Leucaena* can also be used for better growth.

Kenya Not directly. For tree species that are influenced in their development by mycorrhiza, soils used in the nursery to raise them are collected from near mature trees of the species to introduce the mycorrhiza into the potting soil. For example pine seedlings are raised in the nursery using a soil combination incorporating *pine* soil collected from under mature *pine* plantations. The cost may not be friendly to resource poor farmers and the use of mycorrhiza rich soil in the nursery negates the necessity to utilise artificially prepared mycorrhiza.

Brazil This practice occurs usually in the production of seedlings to be planted in areas of nutritional deficit.

8.8 What are the barriers during plantation?

China This question is not relevant for China.

India Inadequate research, institutional weakness in extension, unavailability of good quality material, financial/human resource constraints, low land holdings, skilled manpower, etc.

Kenya Not applicable so left it out of the report.

Brazil The most of the barriers to the plantation of forests are related to financial and institutional issues that will be further discussed ahead. Considering the technical aspects, there are barriers to the mechanization of the areas. In many plantation areas, as the State of Minas Gerais, the declivity of the terrain prevents some forestry activities such as subsoiling, application of herbicides and fertilizers mechanically and irrigation. For areas with higher declivity, these activities must be performed manually.

8.9 Does the planting material require pre-planting treatment?

China Yes. When a new planting material is introduced, it needs pre-planting treatment. It is common to pretreat before transport planting materials to the plantation site, while there are fewer situations of applying cooling such as using ice bags for seedlings or refrigeration trucks.
What regards the pretreatment of planting material: Seedlings of deciduous broad-leaved wood are used as bare-rooted seedlings. First, moist materials are put on wrappers and then seedlings are layed beyond them roots against roots. Then moist materials should be added between the roots such as lichen, wet wheat straw etc. Finally, seedlings are folded, rolled, and packed into bundles grouped by seedling weight. Seedlings of coniferous wood and majority of evergreen broad leaved wood are sensitive to water lossage from their body because of intensive transpiration and root damage during lifting, so this kind of seedlings are better left with earth balls when lifting them. Moreover, seedlings should be wrapped with plastic films, mats, straw bags, or maybe wooden containers specially made for precious species with special requirements, immediately after seedlings are digged up. After the pretreatment, a label should be attached outside the package with information about name of tree nursery, seedling age, quantity and class.

India Yes against insect-pest and diseases. Termites are the biggest problem therefore, plants as well as soil is treated before planting.

Kenya Seedlings are conditioned for field conditions while still in the nursery. This involves "hardening" them through root pruning a month before the expected planting date and reduction of intensity of application of water for two weeks before planting date. Before packing the seedlings for transport to the planting site, they are heavily watered to withstand the shock.

Brazil Yes, the preparation of the soil for planting activities required the elimination of cutting ants before the planting and after the seedlings at the field. During the planting activity, there is also the application of phosphate in every pit to promote fast growth of the seedlings.

8.10 Which plant material (clonal or seedling) is preferred for high productivity?

China The main species of SRF are *poplar*, *eucalyptus*, *paulownia*, *willow* and *Pinus morrisonicola*, and the main shrub for SRF are *seabuckthorn* and so forth.

India By cloning large number of superior trees can be obtained at considerably lower cost andshort space and time. Clonal tree species provide many opportunities in terms of genetic gain, growth rate, timber quality, resistance to insect-pest and diseases, etc. The clonal material has the uniform growth and is developed from the selected trees, therefore perform better than the seedlings. However, clonal propagation has been commercially standardized in limited number of species (*poplar*, *eucalyptus*, *casuarinas*, *salix*, *robinia*, etc.)

Kenya Clonal planting material is not widely available in Kenya yet but is regarded highly by researchers as a means of producing consistently good material where there is a lack of available seedlings. Because of the lack of options with regards to planting material, seedlings are currently preferred as there is little knowledge about the potential for clones in the country.

Brazil The clones represent higher productivity than the plantings with seeds. The improvement of genetic research has helped to select the best clones considering the plantation sites and weather conditions. Some clones can reach productivity rates of up to 50 m^3.ha - 1 .year - 1 of Mean Annual Increment.

8.11 Does planting generate employment?

China No. farmers generally plant trees without hiring additional labor forces.

India Yes, in any plantation programme, the labour components accounts for about 60-70 % of the total expenditure. Moreover, bulk of the labour components is of unskilled, semi-skilled type such as: nursery work, sowing, planting, weeding, watering, hoeing, after care, etc.

Kenya It depends on the size of the land being planted. If it is on a smallholding then employment generation would be minimal if at all – the farmer and/or family members woulddo the tree planting. If it was a big plantation then labour would have to be hired to carry out the work as it is manually carried out.

8.12 Does planting take place manually or mechanically?

China In China, planting is carried out manually.

Fig. 8.5: Planting.

India Planting exercise is executed manually, which is cost effective and generates rural employment also. However, tractor mounted augor is used in salt affected/waste lands. Industries are using some machinery for soil working.

Kenya Planting is carried out manually on farms and in public forests. The staking, digging of planting pits and the actual planting are all carried out manually. This is because planting sites are normally cultivated with other agricultural crops that could be destroyed by heavy machinery, and another reason for manual labour is the high costs of such equipment. The forest service has not even invested in any tree planting equipments for mechanical planting of seedlings.

Brazil In the regions where mechanization is possible, the semi-mechanization takes places when a machine opens the planting pits, applies the fertilizers and places the seedling. However, it is still necessary that an employee takes the seedling out of the plastic cover and place it on the machine. In the regions where machines are not able to reach, the planting activities are still manual. For these activities, the opening of pits and the placement of seedlings on the ground are all manual.

9 Cultivation, maintenance

9.1 Is the cultivation and maintenance of SRF an issue in your country at all? Are there any relevant data on the requirement of it?

China Yes. Implementing SRF cultures is an area of interest of forest management in China which can not only improve the local environment, but also can increase the income of farmers. So there are many documents to support the development of it both by the statal and local bodies.

1. Technical specifications on afforestation of short rotation Eucalyptus -Documents of Fujian Provincial Forestry Department;
2. The plan on establishing fast growing timber in the key areas - Documents of the State Forestry Administration;
3. Notification on adjusting the management of artificial timber harvesting - Documents of the State Forestry Administration. All of these documents are about how to cultivate the SRF and the preferential politics if farmers plant SRF.

India SRF constitutes a very important part of the wood resource in India. Major portion of wood now produced comes from tree plantations outside the traditional forest area and more specifically on the private land. Plantation forestry has been boosted up since the launch of social forestry programme followed by joint Forest Management and the big/medium farmers started block planting of *Eucalyptus*/*Poplar*/*Melia*/*Bamboo*/*Leucaena*/*Casuarina*, etc. inassociation with agricultural crops, whereas, the small farmers retained/planted scattered trees on their farms and farm boundaries. Still there is large gap between demand and supply of industrial timber as well as fuel wood. A huge quantity of cowdung is burnt as fuel, which otherwise would have been diverted for sustainable agricultural production. There is need for immediate attention to increase the productivity on one hand and save the deteriorating environment on the other. Bio-energy option through SRF has also opened up the avenues for rural employment and improvement in their socio-economic condition of the rural masses. The vegetation besides sequestering CO_2 have a positive effect on the rainfall pattern, water recharging potential, soil conservation, avoidance of nutrient losses, etc. It will also help in fighting climate change – increasing temperature, melting glaciers, rising sea levels, threatened ecosystem, etc. The High Density SRF (HD-SRF) have been targeted to help in meeting wood shortage and a reforestation rate of 3 million hectare per year is requited for next twenty years to meet the National Forest Policy targets.

Fig. 9.1: Layout of nursery.

Fig. 9.2: Organic carbon added to nursery soil.

Kenya SRF are important in Kenya for the supply of wood products to the ever increasing population, as they reduce the pressure on the natural forests and woodlands whose growth rate is minimal and therefore difficult to restore once destroyed. SRF is present in public forests as plantations and on farms in various forms that include scattered trees, rows, along boundaries, woodlots and intercropped with agricultural crops. In public and on farms, the important aspect about these trees is that they are maintained under minimal competition to encourage fast growth. For different end products, the planting density, maintenance and the rotation age are clearly spelt out for plantations established on public land. There are two forest department national documents that guide the management of plantations, while in every forest station a local document (the compartment register) is maintained with respect to every single plantation:

1. Forest Department Technical Orders. These are specific for each tree species and clearly state what the forester has to do from the time of establishment of the plantation, the maintenance such as weeding, the silvicultural operations to be carried out and eventually how the trees are to be assessed and harvested for specific end uses.

2. Forest Department Technical Notes. General information in relation to a given species to guide its management.

3. Compartment register – a local document that spells out all the activities undertaken in a plantation from the history of the site, the source of the seed used to raise the seedlings, all silvicultural activities undertaken and when and if any variations have been applied and reason for the same. These allowed the smooth continuity of the implementation of forest activities even with transfers of staff members from one station to another.

9.2 Is mulching used in the process of SRF cultivation? What is the purpose?

China Not in forestry, but in agriculture such as when cultivating vegetables and fruits. The material protects the soil from wind erosion by increasing the surface roughness lowering the surface wind speed, adjusting the soil temperature by cutting off the solar radiation and reducing the dissipation of soil moisture; it enhances the adhesion of soil particles and thereby reduces soil erosion. Different cover measures can improve the situation of moisture, temperature and nutrients, preventing soil erosion and degradation and promoting growth, so it is one of the measures which are important in agriculture. Currently in China, mulching films and straw are widely used as cover material.

India Not in agroforestry, however, in fruit and vegetable crops mulching is followed to conserve moisture and minimize weed competition. In forest plantations, it is followed on stress sites at a limited scale to conserve water and on sloping lands to conserve soil & water. Additionally mulch, however, adds nutrition to the soil, reduces soil temperature fluctuations, etc. The mulch attracts termites and this would be advantageous if termites prefer mulch over the crop.

Kenya Mulching is not used in SRF deliberately. However, in most situations where trees are intercropped with agricultural crops, plant residues are placed along the tree rows where they act as mulch. Plant residues may be mixed with manure and/or livestock urine for quicker decomposition and extra benefits for the soil. In the dry areas, however, mulch from plant residues attracts termites that may become a menace during the dry season as they attack the succulent stem.

9.3 How to realize weed control in the growth process of SRF? Which are suitable ways according to specific site conditions?

China Weeds may reduce forest and crop productivity and quality. For weed control a thorough species selection is essential taking into account factors such as geographical conditions, plant height and lush level. During planting, fertilizing at the right time and to the amount matching the absorption extent can be important. Moreover, reasonable, adapted planting distances is another way for weed control, with a higher planting density reducing weed growth. The choice between mechanical treatment and chemical treatment must be based on the local agricultural conditions, available technical systems and on the crop species. Mechanical treatment and manual work are used in traditional farming but chemical treatment may save labor force and alleviate the intensity of labor in cases of shortage in manpower. Mechanical treatment translates to various kinds of weeding machines and topsoil work inhibiting weed growth by cutting off the roots. It is appropriate for small areas of arable land because it will consume large amounts of manpower. Chemical treatment may save labor force or at least reduce the labor intensity, boost productivity, and is usually applied in cases of huge areas. However, long-term usage results in phytotoxicity for crops. So in practice, when relying on chemical treatment, we will take all effective measures to reduce weed control to the real necessities and apply substances economically and safely.

India In early stages of establishment of plantation, weeding is done otherwise it is not cost effective and also at later stage the weed competition in the plantations is minimised. In established fields, integrated measures of weed control manual weeding chemical sprays, cultural practices, pre-monsoon/post-monsoon weedicide spray, are followed for satisfactory weed control. In the case of chemical weeding, either contact weedicide like Gramoxone or systemic weedicides like Glycel (Round Up) are used. Some invasive weeds like lantana, parthenium, etc. certainly have become problem in natural forests as well as in plantations andtheir control is big problem and necessary cost effective steps are yet to be explored.

Kenya Weed control is undertaken through complete cultivation of the planting site. In public forests, "taungya" method was used in the past, where farmers were allowed to grow agricultural crops on forest land where seedlings were also planted. Intercropping normally took three years after which the tree canopy closed and adversely affected crop yields. Currently, the same system has been modified to make it more people friendly under the acronym PELIS – Plantation Establish for Livelihood Improvement System, where cultivators are compensated for their labour input. On smallholding farms trees are commonly established together with agricultural crops and are, because of this, weeded. In the case of woodlots on farms, the plots are slashed and individual trees weeded at the base. Weed control will be carried out differently according to specific site conditions:

1. *Waterlogged sites:* vegetation is slashed regularly to avoid shading the planted seedlings and the seedling base is spot weeded.
2. *Dry conditions:* sites are weeded before the rains to encourage percolation of water and weeded again after the rains to remove the weeds and also to create a porous layer of soil on the surface which cuts off capillarity action and therefore conserves the accumulated soil moisture for a longer period.
3. *Weedy conditions:* normally these are sites that are fertile and, therefore, also suitable for agricultural crops. At such sites, trees are intercropped with agricultural crops and thus weeded at all times during their establishment years by the cultivators.

9.4 What is the role of soil compaction within the whole cycle of cultivation?

China Compacting the soil can raise the compactedness of the soil, adjust the soil aeration and the temperature and create a good environment for planting. However, compacting with heavy machinery may worsen soil conditions and thus reduce the crop yield, so over-compaction should be avoided.

India Plants raised the soil is immediately compacted so that no air space remains in the planting hole otherwise the success rate will be reduced. Plants raised are immediately irrigated, which also helps in draining out the air from the holes/pits. However, in mechanized agriculture compaction is not an important issue because mechanization in plantations is still at limited scale in India. The compact soil surface permits less infiltration, even the root proliferation/penetration is restricted in compact soil thus affecting the tree growth and yield.

Kenya Soil is actually loosened to allow entry of water where a hard crust has developed after rain incidences. A porous well aerated layer is thus formed which breaks capillarity action that transmits soil moisture to the atmosphere. Soil is loosened to conserve moisture and allow deep penetration of roots.

10 Water management

10.1 Are there conflicts between domestic water use and SRF?

China From the aspect of water resources there is no obvious conflict caused by SRF in China for now. Water resources in different areas have different influences on the SRF. The water problem is a main issue during SRF planting. For instance, the suitable ground water level is 1 to 25 m when planting SRF with poplar in semiarid areas of China. With the exception of special situations such as severe droughts trees will grow and develop normally once they survived planting. But in areas where the ground water level is not sufficient trees will not grow and develop well. So in those deep groundwater level areas, improving methods are needed to ensure successful planting: First issue is to choose tree species with strong drought resistance such as Populus. Second is to irrigate trees during drought times. Third is to plant trees deeply.

India Yes, the trees are grown according to their adaptability and climatic conditions. The SRF species are required to be intensively managed and irrigated for better productivity. Species like poplar can not be grown in water scarce area. On the other hand, ecologist blames *eucalyptus* for draining and lowering of water table. These are the issues of research and likely to be an important issue.

Kenya According to Agriculture Act (Cap 318), the Agriculture (Farm Forestry) Rules of 2009 Part I, Section 5 subsection 1, every person who owns or occupies agricultural land should establish and maintain a minimum of 10% of the land under farm forestry which may include trees on soil conservation structures or rangeland and cropland in any suitable configurations (Kenyan Ministry of Agriculture 2009). These trees could be of any species or varieties that do not display adverse effects on water sources, crops, livestock, soil fertility and the neighbourhood and should not be of invasive nature. In the same rules, it is clearly stated that no agricultural landowner or occupier should grow or maintain any *Eucalyptus species* in wetlands and riparian areas. There is a certain distance that the trees have to be from water courses.

10.2 If irrigation is used, what irrigation methods are applied and what conditions are they used under?

China SRF/agroforestry irrigation is applied according to water availability. The drip irrigation technique has an excellent water-saving effect in some protection forests in windy and dusty areas of China, especially when the protection forest consists of *pinus mongolica* or *populus bolleana lauche*. At the first time applying drip irrigation let the soil to a depth of 20cm below the lowest root extension reach its maximum moisture-holding capacity and then keep the soil moisture at 70% of the moisture-holding capacity. Drip irrigation for one, two or three days are all suitable, each drip irrigation phase should last for 3h, 4h or 6h. This increases the plant survival rate and also saves 50% water compared to classical irrigation techniques. Chinese white poplar forests in some area in Northern China only needs irrigation during their growing season which means irrigating them twice during May and June. In some dry areas and deserts, use root irrigation and subsurface drip irrigation for poplar and in particular for young poplar trees during the dry season (from April to June). This may achieve remarkable water-saving results. But for now our country still lacks science-based and reasonable irrigation scheduling. For instance, the land allocation between agriculture, forestry and livestock farming is not reasonable and in dry areas bushes rather than timber forest should be planted.

India In SRF/agroforestry irrigation is applied as per the availability of water. However, some species like poplar require regular irrigation (after 7-10 days during summer and 15-20 days during winter months), whereas, other SRF species are not sensitive to irrigation. Life saving irrigation is essential or planting is preferred during rainy season. However, with the additional irrigation, SRF productivity is substantially enhanced. Even the unit water consumed produces more biomass in SRF species than other timber species or agricultural crops.

Kenya Runoff irrigation method is used and involves the construction of water harvesting micro catchments for individual trees in sites with a slight slope in the dry lands. The structure could be circular, square or V-shaped with the seedling planted at the lower part of the catchment. Other methods in use include bottle watering where bottles are dug in close to the tree seedlings and covered with mulch. Through an opening, water is poured in and covered again to reduce evaporation. The covering of the bottle ensures the water does not get hot and thus scorch the roots of the seedlings. The water introduced this way to the seedling is only lost to the atmosphere through evapo-transpiration from the seedling as the ground surface around the seedling remains dry and therefore no evaporation activity takes place. This method is applicable in sites with a permanent water source close to the planting site. Another method of irrigation is use of stone or sand mulch around the seedlings; this is especially the case in dry areas where termites are a prevalent menace to trees. Sand or rocks are accumulated around the seedlings before the rains. These two do not allow capillarity action even during hot days and therefore retain accumulated water next to the seedlings for a long period. The method is used in relatively flat areas experiencing very limited rainfall.

10.3 Are there restrictions on water use in agricultural management, including short rotation tree cultivation?

China There are no obvious conflicts between agricultural water management and SRF in China for now. Now the main challenge in Chinese water management systems is water saving. For now a new water management system, Selffinancing Irrigation and Drainage District, is worth discussing and paying attention to. This is the reformation of the water management system as recommended by the World Bank and has already been tried out in the Jiangsu, Shandong, Anhui, Henan and Hebei provinces with good results.

India Water is a hot topic in the country and keeping in view the dwindling ground water table status, state of Punjab has imposed restrictions on rice transplanting before June 10. Rice is high water requiring crop and transplanting before June results into excessive pumping of ground water due to more transpiration/evaporation losses if transplanted before June 10 (due to high temperature) due to high temperature. However, after June month, monsoon rains meet the rice water requirement and help in ground water recharging, thus exploiting the ground water to the minimum.

Kenya Yes and especially during the dry season when farmers on the upper areas of the main water catchments in the country are prohibited from irrigating their farms; this is in order to allow water to flow downstream. More restriction is being placed on use of surface irrigation as most water is lost through seepage and evaporation between the source and point of use. Where irrigation is in use, piping of the water is a necessity with restriction on the amount of water that one can draw from source. Planting of trees for the purpose of harvesting is discouraged along water ways with strips of at least 30m maintained – the stipulated distance increases in the cases of areas that are steeply sloped. *Eucalyptus species* are not to be planted near water ways or areas where wet conditions are deliberately maintained such as rice paddies.

10.4 Are there systems in place for draining very wet soil? If not, how else are conditions improved?

China In China, waterlogged lowlands are found mainly in Yangtze River valley and in the Pearl River valley. Because the Yangtze River is a wide valley with many great rivers in it and the flooding seasons of rivers in this valley are concentrated, floodings and waterlogging occur often. With the usage of water conservation projects such as the Gezhouba dam and the Three Gorges dam, water storage and dredging effects begin to have an effect on the concentration of flood seasons obviously. Moreover, the Pearl River valley is located mostly in the subtropics, so the rainy season is long, the precipitation is high and floods occur often as well. Many waterlogged lowlands are in the Yellow river-Huaihe river-Haihe river plains, flat terrains mainly belonging to Huaihe River valley and Haihe River valley. In the south of China, such as in Zhejiang province it frequently rains in winter intermittently, thus resulting in a "'rot winter"' (during the growth of winter-crops, the rainfall may reach 700-1000mm), the wet field and bad soil having serious effects on the winter crops. The farmers on the plain areas in Hangzhou and Jiaxing establish dark caves on field (40cm deep with a spacing of 2 meters), deeper drainage (60 cm deep, spacing 4-8 meters) and "concealed conduits" (80-100 cm deep, spacing 10 -15 m) to improve the drainage condition. Drainage in the Sanjiang plain mainly includes surface drainage and soil drainage: Surface drainage concentrates on the low-lying areas, where the micro-topography changes, with heavy sticky soil and other characteristics. There actions are needed which suit local circumstances: digging temporary drainages can both exclude excess water and formation and one can create a dry environment with machines. Drainage works in areas with low humidity include deep drainage and "mouse hole drainage". Mouse hole drainage is low-cost, simple and highly efficient and is suitable for heavy, sticky soil with a poor water permeability. Surface and concealed conduits are difficult to implement and cost much. Concealed conduits do not occupy space; they are easy with regard to mechanical manipulation and weed control, result in a good drainage and are suitable for light, permeable soil. A series of results and progresses of monomial techniques was applied in some water logging areas and some areas can resist common flood and drought disasters, but we have not established a method which can solve problems of all aspects and would embody a synthesis of systematical techniques for water logged areas yet. There are many problems regarding research aspects of different degrees of water logging in areas, such as the research method, and they are to be discussed in depth.

India Sub-surface drainage and bio-drainage (high transpiring plant species like eucalyptus) are normally followed.

Kenya There are no systems of draining very wet soils in forest areas that are prescribed in the country. Most of these places are normally planted with species tolerant of water-logged conditions – *Eucalyptus* will be planted at the edges and this continues draining the soil over a long period. In other areas waterlogged sites may be drained through digging of trenches, and the water is directed to other areas that require the same commodity.

10.5 How does short rotation tree cultivation affect soil and groundwater and are there any environmental benefits resulting from the trees?

China SRF/agroforestry affects soil protection and the quality of ground water. Litter (litter fall or forest floor) of deciduous trees in SRF/agroforestry will form a thick humus layer, highly absorbent which slows down runoff and weakens the peaks floodings. Crop roots may prevent the soil from scouring by rain, soil erosion, land desertification and fix the soil; tree crowns may cut off the rain and lessen its impact to the ground and conserve water and soil. If the vegetation cover deteriorates, when it rains, rainwater flows to low areas and into rivers and lakes and seldom permeates to deeper levels, so the groundwater is reduced. The research on benefit of agroforestry ecosystem in purple soil areas has led to a series of conclusions as follows.

1. The agroforestry ecosystem definitely exerts some control action on soil erosion, on river runoff. Soil erosion in agroforestry ecosystems is much less than in simple agricultural and simple forest ecosystems. Besides, agroforestry ecosystems with different structures show different according effects.

2. Agroforestry ecosystems with different composite ages and different composite varieties have different performances regarding soil improvement. Compared with pure forest, agroforestry ecosystem may improve the vertical spatial distribution of soil nutrients effectively and improve all physical and chemical properties at different soil depths. Ecosystems with different composite varieties have different effects with this regard as well.

3. Compared with simple forest ecosystems, agroforestry ecosystems may change the soil grain size distribution of all soil diameter classes. The overall trend is to increase the silt content and to decrease the sand content which fosters the nutrient enrichment.

4. Agroforestry ecosystem may regulate the microclimate; lower the temperature and increase relative air humidity during long heat periods. But in arid and semiarid regions of northwestern China, unreasonable afforestation may cause soil drying. Protection forest should be planted as the main element of vegetation cover in Chinese areas with an annual precipitation ranging between 400mm and 500mm.

India SRF/Agroforestry practices enrich soil by nitrogen fixation and addition of organic matter. Agroforestry helps in meeting nutrient requirement of plants growing in association with trees and at the same time, the soil structure and infiltration rates are also improved. The environment in the neighbourhood of trees is moderated by adopting an agroforestry programme. The field crop in vicinity of trees received multi-directional effects and benefits. However, with respect to the water management the water productivity is very high in SRF, when evaluated in terms of water used, it is low cost improvement in productivity. It has been found that SRF has very little impact on water table but can add significantly to the land productivity. Still making use of domestic and industrial waste water is useful option for SRF species.

Kenya Some tree species such as *pines*, *eucalyptus* and *cypress* normally make the site poor in terms of plant nutrients because the ground vegetation declines with the aging of the trees. These tree species are more efficient users of water than agricultural crops (**waterUseInAGrevilleaRobusta“IeC –“textendash ˝MaizeOverstoreyAgroforestrySystemKen** and therefore reduce available groundwater. Repeated short rotation forest can cause the groundwater to become more and more inaccessible to crops in a given site. The nitrogen fixing tree species improve soil fertility, making the site more adapted to agricultural crops that are sensitive to absence of nutrients. They also provide nesting sites for birds and small wild animals in addition to bee foliage. Other trees such as *Calliandra* and *Leucaena* provide fodder for livestock which can reduce environmental degradation that results from overgrazing. Trees also provide shade to animals and people on farms, they protect cultivated lands and homesteads by acting as windbreaks while providing domestic fuel supply. After rain incidence, the soil around the tree retains high moisture for longer periods than exposed soil; this is an advantage for intercropped agricultural crops.

10.6 How is waste water managed?

China In China, the usage of recycled water (part of high grade domestic gray water after purification) has just begun in recent years and the usage of recycled water in most cities is still at its experimental stage. Currently the range of usage in cities is as below: First, recycled water is used for urban landscaping, garden landscape, road spraying, municipal engineering, industrial cooling, household flushing and car washing, all applications where water does come into contact with human skin. Secondly, waste water treatment systems built by water using units and residential quarters collect waste water from buildings in certain areas and reuse the recycled water after purification. Facing a series of severe problems such as deficient surface water, over exploitation of groundwater and water pollution, using recycled water to irrigate SRF cultures seems to be a good choice. Our country still needs to consider the existing problems in order to use recycled water effectively, such as establishing wastewater recycling management systems and according reasonable mechanisms, developing theoretical and technical research on wastewater utilization and construction of ecological environments, improving the promotion of the systems and establishinh a new era where water is considered a valuable resource.

India In India, waste water is not properly managed for irrigation purpose in SRF species, which otherwise help in increased productivity.

Kenya Water waste from industries is either disposed through town council sewage systems or treated by the industry and thereafter drained into sedimentations pods and eventually, theresulting clean water released into rivers. Domestic raw waste water is drained through surface farrows into gardens where it is normally used for watering food crops. It is the main source of water for kitchen gardens that supply vegetables to homesteads, especially in urban centers.

11 Nutrients, soil

11.1 Provide an overview about soil conditions where the CDM afforestation/reforestation projects are developed.

China Until now, there are only a few registered projects on A/R and most of them are located in the north of China. Take this area for example: mainly brown earth, warm temperate semi-humid zone, semi-arid monsoon climate. The annual average temperature is 11-14 °C, annual precipitation is 500-700 mm with more than half of it concentrated in summer and in winter there is drought. Forest is focused on mesoxerophyte shrubs. General Characteristics: small amount of calcium carbonate deposition, the soil is neutral or slightly alkaline and minerals and organic matter have accumulated a lot forming a thick humus layer with higher fertility.

India At present, four CDM A/R projects in India have been registered. All the four have been developed outside forest area. The project have been developed by targeting the available wasted lands because due to the population pressure fertile-irrigated land cannot be diverted for trees since crop production is priority for the farmers. However, the project with the involvement of farmers in Sirsa, Haryana State involves fertile land.

Kenya Soils with high organic carbon and pH are high in available soil macronutrients such as Ca, Mg, K, Na and these are good for forestry operations where fertilisers are not used. Organic C, pH and nutrients are normally high in wet recent volcanic soils; these sites are most appropriate for natural and SRF. Wet soils developed on acid rocks are likely to have lower macronutrients status and therefore slower growth of trees will be the result (Allen 1986). Sites under high rainfall whose fertility is derived solely from nutrient recycling through litter fall and organic matter decomposition are less productive and more vulnerable to loss of soil fertility as a result of plantation establishment than sites under high rainfall whose fertility is dependent on replenishment by weathering of basic rock material. In dry areas on acid rocks, both soil moisture and nutrients are constrained as there is reduced litter fall, organic matter; soils have low pH and nutrients and tend to be highly unsuitable for tree planting. It is therefore very important that the most adapted tree species are planted, especially in difficult sites with specific limitations. For example, Melia volkensii is adapted to dry areas with minimal rainfall and requires minimal soil moisture to establish however, it requires to be protected against browsers, domestic as well as wild ones.

11.2 What are the negative impacts of compacting soil excessively? How to avoid or alleviate them?

China If compacted with heavy machinery the structure of soil may be damaged leading to a decline in soil porosity, a change of the physical composition, a reduction of nutrient availability, which are detrimental to crop growth. Such areas become ever more frequent with a rising degree of agricultural mechanization. So we have to apply effective control to the compacting process to avoid over-compaction. The way to avoid or mitigate the impact of compaction is as follows:

1. *Soil tillage:* do not do tractor-plough on high-humidity soil, fertilize more organic manure, rotate, and change the depth, control the wheel tracks, plow deeply;
2. *Technical improvements:* axis load and earth pressure are the main parameters influencing soil compaction, and we should minimize the tractor axis load and the pressure already when designing the tractors.

India A compact soil surface permits less infiltration, whereas, more infiltration occurs in loose soil surface. Even the root penetration and aeration are restricted in compact soil thus affecting the growth and yield.

Kenya Excessive soil compaction is persistent in some dry areas where subsistence farming is practiced. It is caused by continuous tilling of land with manual tools that only penetrate the top 10cm or so. This top soil becomes exhausted and deficient of plant nutrients necessary to support vigorous growth of both agricultural crops and trees. Further, the compacted layer of soil that lies just 10cm below the surface inhibits proper penetration of roots of trees thus leaving them to depend mainly on the top soil and with poor anchorage. The trees therefore become prone to drought and wind throw if they manage to grow. In case of rain incidence, the top soil becomes saturated quickly eventually forming runoff that can cause soil erosion. A method for alleviating soil compaction is deep tillage; this manages to break the hard compacted soil and, thus, allows water to penetrate into the ground and avoids the formation of surface runoff. Roots of trees established on such sites also reduce the overall soil compaction. Through litter fall from tree foliage, nutrients are recycled from the deep soil horizon and made available for agricultural crops.

11.3 How is the soil reclaimed after a culture's end to restore fertility? What is done manually or mechanically?

China Measures to solve the problem of declining soil fertility are as follows:

1. Rotate the crop reasonably according to the local situation to adjust the nutrients and moisture;
2. Use organic fertilizers such as green manure to improve the organic content;
3. Plow deeply with the appropriate combination with no-tillage practices; use straw application, to promote the formation of a beneficial physical structure of the soil increasing the aeration creating pervious soil and increasing the fertilizer capacity;
4. Adjust the proportions of the land dedicated to agriculture, forestry and animal husbandry to provide a large number of organic matter and improve fertility and yields. Among these, rotate the crop and fertilize on small areas always manually.

India Trees are known to contribute towards nutrient inputs in two ways, by capturing the atmospheric input available in rain & dust with their widespread canopy and second by drawing nutrients derived from weathering rock minerals in B or C horizon of soil, and also those leached from top soil called "'Nutrient Pumping"'. Though the SRF species need more nutrients for their optimum growth and these nutrients are exported on harvesting thus depleting the inherited nutrient pool. These losses though are managed by external inputs in addition to inputs from litter shedding, down profile pumping and also by including leguminous trees. Salt affected soils are reclaimed through the addition of gypsum, whereas, acidic soils are reclaimed through lime addition. Breaking of hard-pan of calcium/magnesium carbonate is done mechanically to facilitate penetration of roots down deep to extract nutrition and moisture.

Kenya To reclaim the land at the end of a SRF or after harvesting, the debris realised during harvesting are left on the site and incorporated with the soil during the subsequent land preparation for agriculture crops. Fires are discouraged at such sites although farmers find it very easy and convenient to use fire to clear the land. The site is cultivated with both grains and legumes to restore the soil fertility. The plant residues are also left on site with animals being allowed to feed on them on site, again allowing the residues to be incorporated into the soil. The cultivation of such sites with leguminous plants for two or three season restores the soil fertility. After harvesting of trees, the debris is put into rows and crops planted in-between. These then decompose on site and with time become humus. The crop residues after harvesting are left lying on site where animals are introduced to feed on them. Through their movement, the animals soften the ground and scatter the vegetation residues while also dropping their dung on site. During land preparation, the scattered residues are incorporated into the soil and provide organic matter that improves the soil properties by making it more porous and thus hold more water. These activities are done manually rather than mechanically.

11.4 During the process of cultivation of short rotation forestry - is it necessary to supply nutrients? If so, how to arrange the time and times of fertilization? If not, how to provide nutrients for the crops?

China In China, people don't need to use additional fertilizers, they can just use the ash of straw as fertilizer. However, it is mainly used in agriculture, the burn-off (volatile) rate of it may reach 96%, the other 4% are ashes rich in calcium, magnesium, phosphorus and potassium which can be made into good inorganic fertilizers, and achieve the goal that "'straw-Fuel-fertilizer"' effective recycling.

India Appropriate time of application of fertilizers is very important to decide. In general, mobile nutrient salts e.g., nitrate, chloride and sulphate should be applied at the time of peak requirement because these are easily available to the plants. Immobile nutrients may be applied at the time of planting or before planting e.g., as basal dressing. It is not advisable toapply whole of the fertilizers requirements in one dose. It should be distributed over 2-3 times in a year to avoid losses. In general, the trees are not fertilized exclusively but the fertilizer dose of crops is increased by 25-50% tan the recommended in sole crop so that the nutrients beyond the crop root zone are used by the trees.

Kenya It is necessary to add nutrients to optimise growth, but farmers never add nutrients for the sake of improving growth rate of trees. However, where short rotation is practiced together with agricultural crops, fertilizers and/or manure is added for the sake of the crops, thereby, benefiting also the trees. In public forests no fertilisers are added except from the potting soil mixture that is brought together with the seedlings from the nurseries to improve the soil nutrient status. Manures are normally added at the planting time of the crops which is just before either the short or long rains. Fertilisers, if used, are introduced at the planting time, but are also used by some farmers during the agricultural crop season as top dressing or foliar feed. These are less beneficial to the trees as they are directly placed close to the base of the agricultural crop and away from the tree seedlings. Fertiliser is not used for boosting tree growth on public and private land in Kenya. Manure, where it is used, is applied during planting where it is mixed with top soil before returning into the planting pit. Other means of nutrient addition include mulching where the mulch decompose with time and release some plant nutrients. Where crops are intercropped with agricultural crops, fertiliser added to crops may benefit trees indirectly. On crops, fertilisers are added during the planting time and top dressing during crop growth.

11.5 Which main elements are provided to the soil via chemical fertilizers?

China Ammonium sulfate, ammonium bicarbonate, blood urea nitrogen mainly provide nitrogen;superphosphate, double superphosphate mainly provide phosphorus; potassium chloride, lemery mainly provide potassium; compound fertilizer, such as ammonium phosphate can provide nitrogen and phosphorus, ammonium phosphate can provide phosphorus and potassium at the same time.

India Nutrition to the trees is applied as per the soil requirements. However, Nitrogen and phosphorus are commonly applied. Other nutrients are applied as and when required.

Kenya In plantation forestry, fertilisers are never used in the field at any time including planting. However, at the nursery level, fertilisers are occasionally added to soils that are considered deficient in plant nutrients. The elements targeted are Nitrogen, Phosphorus and Potassium (NPK). Additionally animal manure is added to the soil to improve the carbon content to the soil. Where manure is not readily available, top soil collected from a natural forest is used to provide the organic matter.

11.6 Is limestone added as subsidiary fertilizer?

China Yes. This phenomenon exists in the South of China. Land in southern part of China is mostly acidic soil, so limestone usually is used for neutralizing, and promote the soil aluminum, iron, manganese ion precipitation, eliminate the poisons. Meanwhile it can increase the nutrient, especially the phosphorus, promote the beneficial microorganism, that all good to decomposition of organic substances and nutrient release. But limestone should be appropriate, otherwise may destruct the structure of soil, and obstruct the growth.

India Very low, Acidic soils are very less under cultivation, however, fruit crops in temperateareas are supplemented with lime at the time of planting. SRF species are very limited (*poplar*, *Ulmus*, *Robinia*, *Salix*, etc.) in temperate areas with acidic soils and lime is not added in the trees but in crops including fruit trees only.

Kenya Limestone is not used. Where acidic soils are dominant, adapted tree species are planted rather than trying to manipulate the soil. Some acidic soil tolerant short rotation tree species are *Markhamia lutea*, *Calliandra calothyrus*, *Cassia siamea* and *Sesbania sesban*.

11.7 Is measurement data on nutrient balances for different SRF/agroforestry systems available?

China No. Firstly, in different area, the organic matter content, acidity and alkaline, microelement content are different; secondly, the kind and the dosage of nutrients and different during the growth of different plants. So it is difficult to find a data about nutrient balance of SRF/agroforestry.

India At limited scale.

Kenya This data is not available. Soil analysis for nutrient content is not done mainly because of the costs of laboratory requirements. So far it is also not considered as important to determine such accurate nutrient status of the soil prior to selection of species to plant. However, farmers' observations of crop growth and the plentifulness and dominance of a particular weed or grass may indicate which nutrients are deficient. Generally, dark-coloured soils are assumed to be fertile and high in soil organic matter. Also soils with a loamy texture are assumed to be more fertile than sandy soils. However, theoretically, plantations whose trees are harvested together with their branches, the bark and foliage used for animal feeds cause heavy loss of nutrients from such forests. Where the accompanying site preparation involves slashing and burning of logging debris, large quantities of nutrients are lost (Mackensen et al. 2003).

11.8 When preparing the fields for planting and mechanical weed control, soil is exposed which inevitably releases valuable soil-bound carbon. Do practices in your country take account of this issue trying to minimise soil opening? If yes, what measures are taken?

China In China, measures are taken in order to minimize soil opening which due to land plough, which were called Protected Cultivation. Key techniques are as follows:

1. Farmyard manure is used to change soil structure. Soil is covered with farmyard manure so that it can go soft. Farmyard manure can increase organic matter and humic compound in soil.

2. Land plough is changed with scarification. We are trying to change scarification into land plough to protect the earth's surface and change soil structure. This method can form a cover for the earth gradually and prevent land desertification and soil erosion in the end.

3. Changing from scarification to minimum plough and then no-tillage. This method is taken done based on the soil condition. For example, first, we choose scarification annually, after a while, we choose scarification every two years, and then, no tillage. Eventually protected cultivation of totally no-tillage can be come true.

India In order to minimize soil opening techniques, minimum tillage or zero tillage is followed which helps in carbon sequestration. Additionally, green manuring also helps in cultivating carbon to the soil.

Kenya This is not deliberately done to protect the soil from exposure but rather to protect soil from surface runoff on sloping ground and, therefore, the soil also gets shielded from direct sun baking. However, on relatively flat grounds, soils are exposed from the time of land preparation to the planting time. The debris that accumulates during land preparation is placed in rows along the contour leaving strips of clean exposed soil where planting pits are dug. Consequently, most of the surface remains covered and carbon protected from the sun. Weeding is usually done manually and the weeds are customarily accumulated around the base of the seedling, especially where spot weeding is done. Where trees are intercropped with agricultural crops, the ground is covered by the crops and the uprooted weeds as well as the seedlings, leaving little ground surface exposed.

11.9 Does the loss of nutrients through harvesting based on short rotations rather than on long rotations cause any issues in your country?

China Due to the short rotation, it really has effect on the fields for crops, normally the nutrient can be removed from the soil easier and faster. However, returning leaves and small twigs to the soil during its growth period and harvesting may be a worthwhile to retain nutrient removal from the site, but in energy deficient countries, twigs are rarely added to the soil and almost complete biomass is removed from the system.

India Nutrient export is critical concern in the SRF plantations on farmers fields. Normally nutrient removal through frequent harvesting exceeds the input. However, returning leaves and small twigs to the soil during its growth period and harvesting may be a worthwhile to retain nutrient removal from the site, but in energy deficient countries, twigs are rarely added to the soil and almost complete biomass is removed from the system.

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12 Risks

12.1 What calamities may SRF encounter? What are the main reasons for causing these calamities?

China The calamity that SRF may meet were Pest, disease, harmful plant, meteorological calamity (Mainly have disaster caused by a windstorm, snow calamity, floods), respects such as the damages of livestock and animal, and so on. Take *poplar* as an example, the main reason for causing plant diseases and insect pests are as follows:

1. The area of SRF is increasing constantly, it is apt to catch a disease on the structure of age of stand the worm encroaches on; It is unreasonable to divide the structure in the forest, the varieties of trees are single, and the ability of ecological automatic control is bad.

2. Because of the ecological environment deterioration, the appearance of phenomenon of "Warm winter"', survive the winter disease worm base figure becoming heavy, the spring cold wave being caused the situation of the trees weakly constantly, The plant diseases and insect pests can cause disaster .In addition, because of using chemical medicines in a large amount for a long time, the natural enemy of the pest have wounded greatly, the pest produce the resistance to the action of a drug , and this increases the difficulty of prevention and cure.

3. Because the training of the trees of improved variety and replies strong working are bad, the quality of the poplar is degradated, the resistance against diseases is weakened. Even there are trees of good quality, we do not pay attention to popularizing, introducing a fine variety either.

4. The administrative staff lays stress on imposing instead of make light of defending, it is not enough for us to know the importance and arduousness of the prevention and cure the plant diseases and insect pests.

5. The means of prevention and cure are backwardness and not complete.

India Calamities like physiological disorders, adverse climatic conditions, pest and diseases of trees, water resource depletion are commonly occurring. Better planting material is not available, proper cultural practices are not followed, protection against adverse conditions not taken, Improper drainage facilities, etc.

Fig. 12.1: A ganoderma fungus attack in India. Photograph: Chauhan, pers. comm.

Fig. 12.2: Attack of defoliator on poplar plantation.

Fig. 12.3: The heavy top of a tree may break - pruning during the 1st year is not recommended. Photograph: Chauhan, pers. comm.

Fig. 12.4: Apriona larvae makes tunnel in the shoot.

Fig. 12.5: Collar rot damage

Fig. 12.6: Bark damage by pathogens.

Fig. 12.7: Bark eating caterpillar attack on poplar.

Fig. 12.8: Leaf feeding larvae.

Kenya Insect pests and diseases are the main risks to SRF plantations. These forests are established as monocultures and if attacked by an insect pest may suffer heavy damage. They cannot be integrated in areas where biodiversity is the main objective as they normally suppress regeneration of other vegetation. Introduction of a foreign insect pest that has no local predator to control its population in a monoculture forest provides a suitable ground for prolific increase of such a pest. Alternatively, a foreign insect pest may attack a local species that hitherto had no problem of pest incidences. There are also wider factors influencing successful SRF production, including: adverse climatic conditions and water resource depletion. Improved planting material is not always available, proper management practices are not always followed, and protection against adverse conditions not taken. Many of the commonly used SRF tree species are exotic and therefore may not be as well adapted to local conditions as indigenous species would be.

12.2 What are risks of pests and disease regarding SRF?

China

Fig. 12.9: Insect pest on forest.

Take *poplar* as an example, the poplar is mainly distributed in the plain afforestation area of China. In China, the varieties of trees are single, the structure of age of stand is unreasonable, the afforestation area is too big and most is the pure forest, these are the main reason of causing poplar ulcer disease, the boat moth, little boat moth, longi -corn, and so on. In addition the administrative staff has not taken the effective measure, some places break out and cause disaster by a large scale year after year. Not only the y have not merely influenced the normal growth of the *poplar*, but also make the economic benefits greatly reduce, and influence the construction process of the ecological environment. In China, the main prevention and cure method is as follows:

1. Increasing the variety of the varieties of trees
2. Arranging the structure of age of tree rationally
3. Reducing the afforestation area appropriately
4. Biological control (Mainly direct against the larva)
5. Prevention and cure in the chemical way Take pine as an example, the pine is distributed more extensive in China. In China, pine nematodiasis is the main reason for endangering growth of pine. Pine nematodiasis is a kind of crushing epidemic disease of the *pine*. Loose black longicorn is its importance propagates insects in our country. The danger of this disease lies in: Pathogenic strength is strong, host's death is fast, spread quickly, and often make no adequate defense; Once happen, it is great to manage the difficulty. According to the incomplete statistics, during 10 years since this disease happened in 1982 in China, the area happens have nearly reached 3800 hectares, cause more than 1400000 of *pine* death, the timber 50000m^3 of loss. The prevention and cure funds used in the disease reach 6,450,000 Yuan too. It has not only caused enormous losses to national economy but also destroyed the natural landscape and ecological environment.

In China, the main prevention and cure method is as follows:

1. Strengthening prediction
2. Prevention and cure in the forest technology of camp
3. Biological control (mainly directly against the larvae)
4. Prevention and cure in the chemical way

India Insect pests exert substantial losses in terms of growth and productivity of plantations and stored timber, species specific disease and pests of SRF species have been listed and some of them are given below.

	1	2	3	4	5
	Tree species	**Diseases**	**Control**	**Pest**	**control**
1	Populus deltoides	Leaf spot	Blitox	Clostera cupreata, Clostera fulgurita and stem borer	monocrotophos, quinalphos or methyl parathion at 0.05%
2	Leucaena leucocephala	Gummosis, black spots in leaves, pods and stem, root diseases	Spraying fungicides, removal of decade stumps	Borers	endosulphan
3	Eucalyptus tereticornis	Root collar canker Ganoderma root rot, gummosis	Bavistin Avoid monoculture, Avoid ingenious to plants	tolerance to insect pests	
4	Acacia mangium	root rot, brown rot pink disease	Destroy all diseased roots and woody debris. copper fungicides	root feeders twig borers termite coffee borer	carbofuran and chlorpyriphos remove and burn all broken branches in which breeding takes place. chlordane 1% or dieldrin 0.5% inject insecticide into the holes where larvae push out their frass
5	Gmelina arborea	Necrotic spots,foot rot, Canker	Bavistin and Dithane M-45	Calopetla leayana, termite	Chlorophyriphos
6	Casuarinas equisetifolia	Stem-wilt or bark blister,stem canker, pink disease, root rot, heart rot	Carbendazim	Root and Stem borer	monocrotophos, quinalphos at 0.05%
7	Bamboo	rhizome bud rot, Bamboo blight, rhizome decay and basal culm decay	fungicidal treatment, Bavistin, Dithane M-45	shoot borers and sap suckers	monocrotophos, quinalphos or methyl parathion at 0.05%
8	Ailanthus excelsa	leaf spot powdery mildew light brown leaf spots	Blitox Karathane Cu based fungicides	Ailanthus webworm Batocera rufomaculata	formothion and fenvaluate Spraying of kerosene or fuel oil
9	Robinia pseudoacacia	Defoliation of young seedling	Aldrin	Sap suckring bug, twig borer, leaf minor	Metocid
10	Cryptomeria joponica	White grub, cut worms, grass hoppers, criket	Cultural practices and trapping of white grub, use phorate and furadan, endosulphon, malathion	Damping off, root and butt rot	Removal of dead, disease and drying trees.

Kenya Pest and diseases pose a serious risk to SRF especially where SRFs are established as monoculture as is normally the case for large plantations in Kenya. Insect pests and diseases can cause substantial losses in terms of growth and productivity of plantations and stored timber. Although there isn't much data available for African countries, the pests and diseases that afflict the most common SRF species are given below. Some of the pest/disease information is relevant for other countries where the trees are found, rather than the African countries.

Tab. 12.2: Tree species used for firewood and timber in Africa and associated pests and diseases. Source: Agroforestree Database, ICRAF.

Tree species	Distribution across Africa	Pests and diseases
Eucalyptus deglupta	Congo, Cote d'Ivoire.	Termites are the most serious pests in both natural stands and plantations. Young trees are sometimes damaged by the cossid moth and a ring bark borer. The coreid bug causes tip die-back of young trees. In Papua New Guinea and the Philippines, a stem borer and a bark borer (Agrilis spp.) have attacked trees of some provenances. The wood, particularly the sapwood, is liable to termite and lyctus attack and to marine borers. In the nursery, E. deglupta seedlings are susceptible to damping-off. Regular application of a fungicide can control this problem. Heart rot is sometimes found in older trees of E. deglupta but is unlikely to be a problem in trees grown on a short (e.g. 10-year) rotation. Field observations suggest that heart rot is more common in trees growing on less well-drained sites.
Eucalyptus globules ssp. globulus	Angola, Eritrea, Ethiopia, Kenya, Lesotho, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Uganda, Zambia, Zimbabwe.	One of the most serious pests of the species is a defoliator, the eucalyptus snout beetle, Gonipterus scutellatus, which has been imported from Australia and found damaging in both larval and adult stages in Kenya, Zimbabwe, South Africa, Uganda, New Zealand and South America. The wood boring beetle Phoracantha semipunctala, which caused severe damage to E. globulus ssp. globulus in South Africa, has also attacked young plantations of the tree in western Australia. In Spain, Pencillium spp. and Fusarium spp. are important seed diseases, with the latter being highly destructive to stored seed. Damping-off, seedling blights such as Botryis cinerea, and other nursery diseases have been problematic in many countries but fortunately can largely be controlled by proper phytosanitary techniques. Other diseases, such as diplodia cankers and armillariella root disease, have been detected in plantations in various countries. In India, the tree is susceptible to the 'pink disease' fungus, Corticium salmonicolor.

continued on next page ...

Tab. 12 2 continued.

Tree species	**Distribution across Africa**	**Pests and diseases**
Eucalyptus grandis	Angola, Ethiopia, Kenya, South Africa, Tanzania, Uganda, Zambia, Zimbabwe.	Browsing by wallabies, particularly black wallaby and the red-legged pademelon, can seriously affect height increment and even cause death of young plants. Young trees of E. grandis in the 1st year or 2 after planting are extremely susceptible to termite attack where they occur. In Zambia, the old trees are attacked by the borers Phoracantha semipunctata and P. recurva. In Angola, the lepidopteran defoliator Buzura abruptiara has caused some damage to the tree, and in Australia, the beetle Anoplagnathus has caused defoliation. In Brazil, the fungus Diaporthe cubensis causes stem cankers and death in plantings of E. grandis. In Kerala, India, the fungus Corticium salmonicolor has caused severe losses in low-altitude plantations. Some heart rot has been observed in trees grown on a saw-log rotation in Zambia and South Africa. Several fungi are associated with this decay.
Pinus caribaea	Gambia, Ghana, Kenya, Madagascar, Malawi, Mozambique, Nigeria, Sierra Leone, South Africa, Sudan. Tanzania, Uganda, Zambia, Zimbabwe.	One of the most important insect pests is a bark beetle, the southern pine beetle (Dendroctonus frontalis), found in the southern USA and Central America. A related species is D. mexicana, whose outbreak caused damage to several hectares of P. caribaea var. hondurensis in Honduras. Other bark beetles include Ips calligraphus, which is widely distributed in Canada and Central America to West Indies. Aphids such as the pine aphid (Pineus laevis) and Cinara carolina (North American aphid), leaf cutting insects such as Atta spp., and termites also attack the tree. P. caribaea diseases are the nursery diseases, which include 'damping off' and seedling blight, and plantation diseases such as foliage blight, stem rot, stem die-back, cone rust, sap stain, heart rot and root rot.
Populus euphratica	Kenya.	In the Near East, the tree is subject to attack by various beetles of the genus Capnodis and by Cuscuta monogyna. It is also attacked by a number of other defoliators, borers and gall-forming pests.

continued on next page . . .

Tab. 12.2 continued.

	Tree species	Distribution across Africa	Pests and diseases
6	*Sesbania grandiflora*	Benin, Burkina Faso, Cameroon, Chad, Cote d'Ivoire, Djibouti, Eritrea, Ethiopia, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, Somali, South Africa, Tanzania, Togo, Uganda.	A major problem in raising S. grandiflora is its susceptibility to severe pest attacks. Major pests are leaf webbers, leaf feeders and stem borers. In India, the stem borer Azygophleps scalaris has caused some damage. Larvae of the insect Bruchophagus mellipes infest and damage seeds. Susceptibility to nematodes has been reported. Reports on the fungus Pseudocercospora sesbaniae (grey leaf-spot) are only from India, as is the occurrence of the sesbania mosaic virus.

End of **Tab. 12.2**: Tree species used for firewood and timber in Africa and associated pests and diseases. Source: Agroforestree Database, ICRAF.

	Tree species	Pest
1	Cupressus lusitanica	Cypress aphid
2	Eucalyptus species	Blue gum Chalcid
3	Pinus radiata	Dothistroma blight
4	Grevillea robusta	Stem canker
5	Casuarina equisetifolia	Bark blister
6	Leucaena leucocephala	Leucaena psyllid

BWCDMSpecificsTables.*specificDiseasesPestsKenya*

Tab. 12.3: Specific SRF tree species' pests and diseases for Kenya. Source: J. Kimondo 2010.

12.3 How to prevent and reduce the emergence of these calamities?

China The general principle prevented and cured as to plant diseases and insect pests is: Recommend building the mixed forest, pay attention to the nursery stock and quarantine, do the work of preventing from predicting in plant diseases and insect pests well, comprehensive administration, the joint defence is united and managed. Take *poplar* as an example: one county in Hebei, China, it takes the following method to prevent and cure: Camp's forest:

1. Remove serious injured trees: like cutting down the dry up trees and half dry up trees in time in order to reduce the source of disease.

2. Build the median, pay attention to mixing imposing rationally.

3. Strengthen the management of water manure, strengthen the trees: like carrying on rational manuring, pouring water to SRF to improve the ability to resist disease worm of the trees

4. Foster and prune, improve the environment.

Organize the measure

1. Set up the network of predicting of the county, township and village .
2. Biological control: like attracting woodpecker.
3. Mechanical prevention measure of physics:like Catching and killing artificially
4. Prevention and cure in the chemical way

India Using better planting stock, apply cultural practices, maintain proper drainage facility, planting of tree according to their adaptability and creation of public awareness, putting up signs and posters, maintaining broad genetic base, sanitation measure, etc. For protection against pests/disease/insect: silvicultural, biological, mechanical and chemical control approaches are followed. Sanitation, eradication, isolation trenches, chemical control, improvement of site, insect pest/disease tolerant spp./clones, etc. are common practices and selected on the basis of their cost effectiveness.

Kenya Through the control of the importation of germplasm into the country, either in form of seed or vegetative material or wood products from neighbouring countries, emergence of risks is prevented or reduced. Phytosanitary conditions are enforced by passing all imported material through the quarantine station for inspection. Other control measures: applying best management practices (especially preparing the land properly before planting), planting of trees according to their local suitability and adaptability, maintaining broad genetic base, and using biological control methods.

12.4 How to appraise the losses that these calamities produce? What are the influences to the environment and to the society?

China 1) Wind breaking

	1	2	3	4		5
	Place	**Date**	**Wind power**	**Damage**		**0**
1	0			Damage 1	Damage 2	Economic loss (Yuan)
2	Yangchang town, Danleng county, Sichuan province	09/11/09		The " Quit plough to woodland " project 1000 acres, Giant eucalypt 4000 acres,Bamboo 500 acres,Chinese red pine 1000 acres, Others 500 acres.		Direct 12,000,000 Indirect 50,000,000
3	Dongpo district, Sichuan province	08/09/09	Fierce thunderstorm	Woods for industry material near upon 30,000 acres.	Lots of young trees of giant eucalypt	21000000
4	Yu an district, Liu an city, An hui province	10/09/09	Typhoon "The morak"	405,000 trees.		23278000
5	Part of Dongling district, Liaoning province	27/08/09		Fruit trees more than 3000 acres.		4000000
6	Jingzhou village, Jixi county, An hui province	13/08/09	Typhoon "The morak"	Bamboo 13,585 acres, Commercial woods 23,747 acres,Flower woods 85 acres, Woods of forestry park 1280 acres, Commonweal woods 13,800 acres, Woods 168 kilometres by roads.		10880000
7	Pingyang city, Zhejiang province	10/08/09	Typhoon "The morak"			Total 32,811,000 nursery base 720,000 flower base 4,320,000; commercial woods 18,343,000; greenhouse woods 225,000 woods for protecting 420,000; highway in woodland 465,000
8	Tianchang city, An hui province	14/06/09	Strong wind of level 9-11	20,000 quick growing alamo and 20,000 young trees broken.		5640000
9	Quanjiao county, An hui province	05/06/09	Strong wind, level 10 in some part	Woods of 30,000 acres damaged	91,500 trees broken	More than 10,000,000
10	Liu an district, An hui province	05/06/09	Strong wind, speed of 26m/s	20,956 alamo broken	Fruit trees and young trees for nursery	4191200
11	Qianjiang city, Hubei province	11/04/09	Strong wind of level 8-9	9,100 young trees broken		3114500
12	Littoral of south part of Guangxi province	24/09/08	Typhoon" The hagobi"	Woodland of 1,213,000 acres damaged		About 900,000,000
13	Yichun city, Heilongjiang province	05/08/09	Tornado	Red pine woodland of 2,506 hectares damaged (About 82,696 steres, including 97,281) and cumulation amount 82696 m3.		
14	Yingjisha county, Xinjiang province	04/05/07	Fruit trees (Such as apricot trees)			6500000
15	Huangshanjiao village, An hui province BWCDMSpecificsTables.*windCatastrophiesEtCChina*	10/06/06	26 trees with age of more than 30 years			

Tab. 12.4: The results of wind damage on forestry in China in recent years.

From the table above, we can see that wind breaking has great influence on China forestry. It takes place in a large-scale, from north to south, as well as the coast areasin China. Wind breaking includes tornado, strong convection weather and tropic storm, and the tropic storm (such as typhoon) makes the serious damage.

2) Snow breaking

It is worth to mention that the unusual frost and snowfall weather in south part of China which lasted for two months (January to February, the year of 2008) did a lot of damage to local forestry. According to the statistics, the total damaged woodland in 19 provinces (Hunan, Guizhou, Jiangxi, Hubei, Guangxi, Zhejiang and so on) reached 19,300,000 hectares. 1,781 national woodlands, 1,200 nurseries were seriously damaged and 30,000 national protected wild animals died and injured in the frost. Some forestry infrastructure also experienced a great loss, with direct economy loss of 57,300,000,000 Yuan. 2,630,000 people related to the forestry sector suffered in the disaster, and same thing happened to a large number of forestry farmers.

3) Pests and diseases.

China is one of the countries with forestry pest and disease seriously occurs in the world. The whole country has more than 8000 kinds of forestry pests, and with over 200 kinds rodents that have strong harmfulness. Forestry pest has arisen in area accounts for 8.2% of the entire forestry area, 23.7% of the plantation area. The main forestry pests in China include pine moth, bark beetle, blight caused by bursaphelenchus xylophilus, lymantria dispar, apochemia cinerarius erschoff, pests that eat into poplar and folivore pests. Other important forestry pests occur in plantation is pine sawfoy, leaf brown in pine needle, spruce moth, cenangium ferruginosum, poplar die-back, pine pestalotia and so on. These main forestry pests have a lot of harm to the sustainable development of forestry. For instance, the caterpillar in Chinese red pine is the most destructive forestry pest and it exists in the maximum area–13 provinces of south China, with a perennial acreage scale from 2,000,000 to 3,300,000 hm 2 . It decreases the growth of timber with about 3,000,000 m^3. Besides, in the year of 1982, the bursaphelenchus xylophilus was first found causing a great lot of Pinus thunbergii Parl's death in the Zhongshan tomb of Nanjing. Now this pest has occurred in 7 provinces of mainland and HongKong and Taiwan, covered a area over 7 hm 2 , caused 16,000,000 pine trees died. In recent years, folivore pests in poplar (mainly clostera anachoreta and micromelalopha troglodyta) break out in Henan and Jiangsu and spread to large acreage. In the year of 1999, 200,000,000 poplars in Henan province were damaged by them, reached to 50% of the whole poplars in the province, in which, 120,000,000 poplars were damaged severely, 30,000,000 were eaten all leaves up. This caused a loss over 300,000,000 Yuan.

India The mono-clonal plantation are big risk through the reduced genetic base however, precaution is taken to broaden the genetic base to avoid any risk of outbreak of disease/pest. Normally SRF risk due to outbreak of insect/pathogens attack has not been reported and event the risk of other calamities has not been recorded.

Kenya Big SRF plantations are not so common in African countries compared to smallholdings with on-farm niches for trees grown on short-rotation; therefore, the impact of pest/disease outbreaks in plantations is minimal and affects big business rather than small farmers.

12.5 Does planting trees as short rotation on agricultural land attract new insect/pests?

China Yes, aggressive weeds can grow here, most harmful plant in Chinese forestry is often appeared as invasive species. They have strong disturbing and breaching effect on primary productivity of forestry ecosystem. They also do harm to soil nutrition standard and moisture balance, as well as to climate, biological variety and human production, as well as human life.

India Yes, insect/pests are species specific but many pests are polyphagus and their diversity on farm increases with the introduction of SRF species.

Kenya No.

12.6 Do trees act as an alternate host? State any specific species where such information applies.

China No.

India Yes, trees serve as alternate host for pest and pathogens.

Kenya No.

12.7 What is the risk of erosion in short rotation tree cultivation compared to cropland?

China The risk is lower in short rotation tree cultivation. The material protect the covered from aeolian erosion by increasing the surface roughness to lower the surface wind speed, adjust the soil temperature by cutting off the solar radiation, reducing the dissipation of soil moisture; enhance the adhesion of soil particles and reduce soil erosion. Different cover measures can improve the situation of moisture, temperature and nutrient, prevent soil erosion and degradation and promote the growth.

India SRF as such does not increase risk of erosion rather helps in soil conservation on its establishment. However, initially soil working for plantation certainly increases soil erosion on sloppy lands, where as ploughing for crop cultivation increases soil erosion until and unless some conservation measures are followed.

Kenya The risk is higher in SRFs. This is because the trees shade off all other vegetation emerging on the ground and curtail their development. Consequently, the ground is left bare and prone to suffer soil erosion in case of a heavy rain incidence. On arable land, there are various different crops and weeds that cover the ground and thus reduce soil erosion incidences.

13 Interaction with other ecosystems

13.1 What influence do SRF/agroforestry systems have on the environment?

China Take Duerbote Mongolia autonomous county, Heilongjiang province in Northwest China for example: In the livestock breeding station of Duerbote Mongolia autonomous county, Heilongjiang province in Northwest China, there is a mode of planting sparse Pinus sylvestris forest in meadow and pasture. Here the SRF/agroforestry system is mainly to plant grass, raise chicken and graze under the trees. The grass can be used as the main feed source for chickens, so that we can save feed and reduce production costs. And the grass can be also used as the feed source for cattle, sheep and some wild animals, and the SRF/agroforestry system provides a good habitat for the animals, this promotes the survival of animals. In addition, the SRF/agroforestry system can prevent the loss of soil and water, reduce wind speed and water evaporation, increase air humidity and soil temperature, adjust the soil temperature and improve soil structure within the forest to provide a good environmental condition for survival and growth of grass and form a virtuous circle of grass and soil. In addition, there are a lot of rats in the woodland, they harm the growth of trees, we need manual weeding and rat poison to eliminate rats, and the natural enemies of rats (such as foxes, snakes, eagles, hawks, stoats) would be poisoned after eating the poisoned rats. After using the SRF/agroforestry system, the cattle and sheep damage the environment of the survival rats, interfere with the normal habits of mice and survival habitats, reduce the density of rats, so that the rats can not damage to the forest. This system avoids the lack of wildlife food chain, which protects the balance of forest ecosystems and biological diversity.

India Replacement of less stable system, reclamation of degraded soil, employment generation,environmental amelioration, socio-economic upliftment, etc. have been influenced through SRF/agroforestry.

Kenya Reclamation of degraded soils, employment generation, environmental amelioration, and socio-economic benefits are some of the positive impacts that short rotation tree cultivation can have on the environment. This is highly dependent, however, on the species planted and the context in which they are situated.

Brazil The cultivation of Eucalyptus spp. in Brazil has developed quite well in the past years and the Brazilian forestry sector has adopted the use of forest mosaic, also known as ecological or biological corridors. The forest mosaic is the practice of planting forests in native forests areas, creating a corridor between pieces of land with natural forest. This allows the transit of wildlife, increasing its available habitat. Local studies have shown that there is a higher flow of wildlife in areas with mosaics of 50-100 ha when compared to non mosaic practices.

13.2 Is the aesthetic effect of SRF/agroforestry systems on the landscape an issue in your country?

China This problem can be ignored .The SRF/agroforestry systems are mostly in the suburbs, the purpose of the system is mainly to nurture trees, the system will not affect the layout of urban construction and affect the aesthetic and so on.

India No, agroforestry is encouraged for sustainable management of land. The esthetic effect of SRF/agroforestry is not an issue, it is economics driven and other benefits like environmental amelioration, sustainability of system, etc. are associate benefits.

Kenya The aesthetic effect of SRF in plantations or as part of agroforestry systems is not an issue in Kenya. It is more about the environmental and economic impact of the trees that is taken into consideration rather than the appearance of the trees.

Brazil The visual impacts caused by large scale plantations, even though they are not considered a relevant problem, are minimized by mosaic planting practices. The same can be applied to agroforestry practices.

13.3 Are there SRF/agroforestry areas not exclusively used for the cultivation of plants but as well for other purposes such as bee breeding, or as recreational areas?

China No, the purpose of the system is mainly to nurture trees, and others are additional benefits like sericulture, beekeeping, rearing, herbs and so on, there is no real susceptibility with regard to the area being used for these purposes. The time of growing short-rotation forestry is not too long in China, and the use of SRF is still in the exploratory stage, maybe we will develop some areas used in other uses in the future, like sericulture, beekeeping, rearing, herbs, building amusement area and so on.

India No, mainly raised for wood and other are additional benefits like sericulture, honey bee rearing, pharmaceutical, lac culture, etc.

Kenya This is not the case in Kenya. Short rotation tree cultivation is for the benefits that those trees can give in terms of utility for domestic consumption and monetary income from the timber and firewood. The trees provide multiple benefits rather than being exclusively for justone product or use.

Brazil Some companies that foster their forests usually give incentives to bee breeding activities within their property limits, as a way to improve the producer's income, although this cannot be considered the common practice in the country.

14 Harvesting

14.1 What are the main methods for felling trees? Manually, by semi-mechanization or all mechanized?

China Harvesting was done mostly by manual with chain saw. The major advantages of manual harvesting are: Easy to operate, flexibility, low cost and applicability. Besides, the main reason for using manual harvesting is lack of such harvesting machinery in China, meanwhile the price of such machinery overseas are very high and may not be suitable for our actual forestry situation. In China, the forestry is mainly distributed in the mountain area, the weather there is changeful, and the traffic is unfavorable to the transportation of the heavy-duty equipment; In addition, China has a large population, felling by manual can increase the employment opportunity, and reduce the economic cost.

India Harvesting is done manually however at a very limited scale petrol driven saw is also used. Axe, saw, power chain saw are used for harvesting of tree manually.

Kenya When facing a large plantation, the main methods of tree cutting trees are either clearing the whole forest at once at the end of the rotation or cutting the small trees (thinning) during the course of the rotation. The trees are cut manually or semi-manually using mainly chain saws and occasionally power-saws (although these have to be hired and used by a skilledoperator). The thinned trees may be small such that axes are used to allow more people to participate in the operation. The trees to be thinned are marked prior to the operation to ensure the remaining stock is well distributed and the trees left are the healthy and vigorously growing ones. For smallholding systems, trees will be pruned or cut whenever the income need or domestic need calls for the timber/firewood to be harvested; farmers will use fully manual or semi-manual methods, i.e. chainsaw or power-saw, axe and machete.

Brazil Plantar adopts the full harvesting for its harvesting activities, which is completely mechanized. The harvesting process occurs with the use of a tractor called feller. Dragging of the cut trees out of the stand is executed with a skidder. Slashing of trees, which consists of the slashing the merchantable volume of the tree, is executed with a machine called "Garra Traçadora" (Slasher Claw). These three harvesting operation activities occur in the following order:

1. Harvesting
2. Dragging
3. Slashing

14.2 Does tree felling affect the soil or other plants nearby negatively?

China Yes, especially the damage to the soil which mainly caused by the harvest activities such as building the road, tramp on the ground, and the extracting by of truck, livestocks and machinery on the ground. cracking and compacting resulted in the damage to the soil . Usually there are two kinds of damage: fracture and compact. The fractured soil loses its epidermis and protection on storey of vegetation, the ore quality soil uncovers, until stronger rainwater erode, especially in slope that cut down all, a large amount of soil to have production capacity well loss , thus cause land fertility to decline. Compacting makes the physical performance ofsoil obviously worse, exert an unfavorable influence on the nutrient, moisture, transmission in the soil of air, influence the activity of the fungus root and microorganism in the soil, too, and then influence the weathering course of the mineral, change the chemical state of the soil. In addition, before the forest felling, the internal environment is relatively moist, there are relatively less illumination hours, overall after being cut down, the forest land uncovered, penetrated directly by the sunshine, which changed the forest environment and local conditions, the average temperature of top layer of soil increases notably, the harvesting act has reduced the content of average moisture of top layer in the forest land, and has changed the space heterogeneity characteristic of the moisture of top layer, in addition it will change microorganism, nutrient and enzyme content of the forest land, too .

India Normally clonally propagated material is harvested in a clear feeling system thus not affecting the other plants however, in mix plantation or agroforestry systems precaution is taken that the other trees are not affected but certainly the associated plants are affected. Soil is disturbed due to digging of roots (roots removed for fuel purpose).

Kenya The soil is not destroyed by the actual cutting exercise but rather destroyed during the removal of the cut trees. This happens if the trees are skidded down the slope where top soil is loosened and becomes prone to erosion. The skidding lines become gullies during rainy season, washing away top soil and any accumulated organic matter. During thinning operations, trees marked for retention at times are destroyed during the cutting due to either being hit by falling trees or during the skidding of logs from the site. Generally, cutting of trees is carried out during the dry season to avoid road destruction during wet season. The tree cutting operation is also risky for the chain saw operator if carried out in the rains due to the wet ground. In a plantation system, clear felling or block by block will not affect other trees nearby. In an agroforestry system, the felling of trees can damage other crops but it would be carried out with care not to cause too much damage.

Brazil If minimum cultivation techniques are applied, the soil and other plants will not be affected. Most of forestry companies adopt the minimum cultivation planting technique which seeks to preserve the environmental integrity of the area where the project activity is implemented. It includes soil preparation techniques and monitoring of nutrients consumed in order to prevent erosion; minimum use of fertilizers as per the best practices in silviculture; and the practice of leaving the harvesting remainders in the soil to function as a protection cover among others. The adoption of the minimum cultivation planting technique, with the reduction of soil disturbance for the planting activities and the complete elimination of fuel burning practices, has resulted in an effective solution to prevent soil's direct exposure to erosion effects. It has also promoted residual organic m atter incorporation in the soil.

14.3 How are trees finally debarked?

China The ratio of debarking is relatively low in China, most of which was done by manual with the tool of spud, chopper and reaping hood etc. Debarking can be done before or after harvesting, like fir trees, debarking was done in summer on the standing tree before its harvesting in autumn, while the other tree species debarking after harvesting.

Fig. 14.1: Peeler.

India Manually, either at the harvesting site or in the industrial unit.

Kenya After cutting, the main stem is cross-cut to a specific length, depending on the size of truck used to carry them out of the forest and also in compliance with the traffic regulation of carrying heavy and extended loads. For trees targeting sawn timber and pulp, cut trees are removed from the forest immediately without any peeling of the bark. The bark remains attached to the off-cut which is sold as a by-product from the mill. The bark may fall off during processing and is then put together with other wood waste. Among trees cut for electricity transmission poles, which are normally cut from Eucalyptus species, they are left for 2 to 3 weeks after cutting to reduce the moisture content during which time, the bark peels off naturally. For trees cut for posts and small poles, the bark is removed manually with machetes immediately after cutting to enhance their treatment.

Brazil Not applicable.

14.4 Does harvesting generate employment?

China Yes, in China it can help to provide a lot of operating posts for people, especially for those laid-off workers

India It cost a pproximately 20 % of the timber cost. Harvesting is done manually therefore harvesting followed by peeling, and loading of timber generates employment.

Kenya Yes, t his cost is minimal and the activity is normally carried out by the buyer of the wood
material and his workers. But this was even more the case before the general ban of tree harvesting in public forests. Harvesting involves the actual cutting of the tree which is carried out by teams of two people. There are then those people involved in carrying of the logs to the truck and generally loading on to the trucks. Once at the processing point, there are other people to manually down load and arrange the logs ready for processing.

Brazil There is no specific number on the jobs generated in the harvesting process. But if you consider all activities related to forestry, the total estimate of job (primary and industrial processing) in the planted forests segment in 2009 was 3.9 million, including direct (535,0 thousand), indirect (1.26 million) and jobs resulting from the income effect (2.16 million).

15 Transport, storage

15.1 How is timber transported after felling?

China

1. The ways of moving the timber from forest to the edge of the forest are animal-drawn

   vehicles, tractors, slide, aerial cable way, winch machine tools and so on, and the main reason to take these methods are:

   (a) The distance is short, the distance from the forest to the forest edge is relatively short

   (b) The condition of the road is complicated, the slope is long, and some road need to cross ditch, cross over fields or small pieces of reverse slope, and manual operation and mechanical operation is not conducive;

   (c) The amount of each transport timber is small, mechanical operation is not required;

   (d) The cost of manual operation and mechanical operation is high, so take the way by listing

2. There are two main ways of moving the timber from the forest edge to the destination or log

   yard: land transportation and waterway transportation, land transportation modes which include: road transportation and railway transportation; waterway transportation which include: river drift delivery, river transportation and shipping;

   (a) In China, timber transport is still the main form of domestic transportation . The distance of transport is far. The advantages of railway transportation are large capacity,fast speed,little effect by natural conditions of far distance, low energy consumption, and Low-cost.

   (b) China is vast, transportation is convenient, the pace of highway construction is fast, timber transport by road transport can have a "'door to door"' transport and improve the mobility of transport. In addition, for ordinary road, the investment is little, the maintenance is easy, and the transport costs low.

   (c) China is a large country with rivers, at the same time, China has a long coastline and numerous excellent port, which provide convenient water transportation, In addition by the way of waterway transportation can save a lot of transportation costs. Waterway transportation can alleviate the unbalance of north-south railway transport capacity, and have little influence by natural conditions.

Fig. 15.1: Transportation after felling in China.

India The market and depots receive large part of timber supplies by surface transport (truck/tractor-trolley). The rates are mostly competitive but accurately determined by taking the cost into account (distance, weight, depreciation, taxes, road conditions, interest, fuel cost, etc.). Capacity of truck is generally 10 ton.

Kenya From the field to the vehicle, people will carry the cut logs on their backs. If there is a distance to the nearest road accessible by truck, logs will be carried by a smaller vehicle or bicycle to the truck. Timber or logs are transported by road using open trucks that allow loading from either side or from the back. The logs are cut to the size of the truck and secured on either side after loading. Except for few big timber companies, all timber is loaded manually in Kenya. The load weight is controlled by the traffic act of Kenya.

Brazil Transport of the wood is usually done by trucks.

15.2 How to store the timber after felling?

China Storage methods can divide into storage before drying and storage after drying. For storage before drying, timber should be configured according to the main wind direction, the timber easy to dry should put on the side of the windward, the timber harder to dry should put on the side of the leeward, and the timber difficult to dry should put on the middle of the two before. Timber stacking should be boosted and stamped. Timber stacking to be boosted is to ensure that the bottom of the timber have good ventilation, so that the air can move freely and the wet air is not advisable to stay. Timber stacking to be stamped is to prevent rain and direct sunlight, avoid defects caused by often sudden changes of wood moisture content. When stacking wood, we use the skids to separate layers to keep wood straight, so that air can cycle freely. Here the size of the crib is related with wood species, size, specifications and equipment used for accumulation. The height of the crib is related with the uniformity of the drying rate closely. In addition, when stacking wood, gap should be left between the wood and be up and down corresponding to form a vertical air channel. For storage after drying, it can be divided into storage after natural drying and storage after artificial drying. The timber of natural drying can take the method with close-packed to store, under normal circumstances, wood piled on the plate under the hospital or hut, and the top of the heap should be covered to prevent the infiltration of rain water. The timber of artificial drying, its moisture content is low, and the best choice is to keep in indoor or take other covering Methods to avoid contact with the atmosphere in order to avoid wood moisture expansion. And during the storage we should take proper and scientific management methods, always check for defects and the risk of fire and so on. Here we should be especially stressed the need to pay attention to fire. In the log yard or courtyard and the place where a large number of timber deposits, fire lines should be stayed out around the timber. And the timber should keep a distance from Residential and flammable plants. The roads in the Storage locations should keep open, once a fire, vehicles can pass unimpeded. Around the log yard or courtyard, there should have enough water and fire hydrant, once a fire, we can put out fire easily.

India Depots are used to store the timber. Logs, sleeper, poles, fuel wood, etc. are stored in stacks form and all these stacks are classified, usually numbered and labeled properly for easy inspection by the purchasers. Depots may be owned by Govt. or industry/private
agencies/agents

Kenya Logs meant for sawn timber are usually harvested and transported immediately to the processing mill without keeping them in the field. They are arranged purposely to ease the work during processing but not for any other purpose. Those meant for the transmission poles are left lying on flat ground where they were cut so that they do not bend and to give them time to lose moisture to reduce load weight.

Brazil The wood that has been felled is left on the planting sites for at least 90 days in order to get the desired humidity for the carbonization process.

15.3 What are the main methods for drying the wood?

China Wood drying can be divided into natural drying and artificial drying. For natural drying, although it is difficult to control the conditions of drying, the time of drying is long, and occupy larger space, during the drying bacteria wood is easy damaged by insect, the final moisture content can only dry to equilibrium with the atmosphere of the air-dry state level; butthe method is simple , easy to implement, energy conservation, more economic. Therefore, the
natural drying is currently being widely used in China. There are many types of artificial drying methods, characterized by the use of appropriate drying equipment, drying process can be artificially controlled, drying cycle is shorter than the natural drying, the drying process doesn't affect by region, season and climate, the final moisture content of drying can be artificially controlled according to actual needs, which can guarantee the quality of wood drying.

Fig. 15.2: Vacuum drying.

Fig. 15.3: Steam drying.

Fig. 15.4: Microwave drying.

India Air drying (Stacking) and kiln drying.

1. *Horizontal stacking:* This is the most common method of stacking timber for air seasoning and is suitable for all forms of sawn timber.

2. *Vertical stacking:* This is done for the rapid surface drying of non-refractory woods, which are liable to develop mould and discoloration soon after sawing. The planks stacked should be turned frequently to prevent warping. After the partial drying by vertical stacking, the timber can be air dried by horizontal stacking too.

Air drying method is commonly followed because it does not require a large initial investment for buildings and equipments, but requires timber to be held in yard storage for a considerable time before it is ready for market. In contrast, kiln drying requires a comparatively large capital investment, but dries the wood in a short time and can provide dry timber for all seasons of the year where it is not possible through air drying.

Kenya Wood is air dried after the processing. For most processing sawmills, they stack their processed timber by size without too much consideration about the drying aspect. This is because the demand of timber does not allow any appreciable time to lapse before sale. However, at timber yards, beside timber being stacked in sizes to allow ease selection during sale, gaps are left between different sizes to allow drying; although, no sticks are placed between individual planks of timber as would be expected in a long term drying process. Some few companies have kilns that they use to dry timber for specific end products; as this process uses electricity and is expensive, it is limited in use.

Brazil For the carbonization processes, wood is left on the site to get dried naturally.

15.4 How long is the drying phase usually? In what form is the wood dried (whole stems, chips)?

China Here China has its own standard. Drying duration of wood is dependent on two parameters which are the initial moisture content of the logs and the size of processed timber. Wood is normally dried in form of planks of various sizes. Poles and posts are dried after peeling the bark.

India Time required for air drying depends on the species of wood being dried, prevailing climatic conditions of the locality and which type of material (log/chips) is used. Wood is also air dried in chip form.

Kenya Drying duration of wood is dependent on two parameters which are the initial moisture content of the logs and the size of processed timber. A 15cm wide and 2.5cm thick plank of timber normally takes 3 months to air dry while a 10cm by 5cm plank takes up to 6 months.This however may vary with tree species and the time the tree was cut. Wood is normally dried in form of planks of various sizes. Poles and posts are dried after peeling the bark.

Brazil For charcoal production, the wood is left outdoors for 90 days.

16 Utilization of wood

16.1 What are the different ways for using different parts of wood from short rotation tree cultivation in plantation and agroforestry systems?

China The tree stems of the harvested tree are used in wood-based panel industry and pulp and paper industry. Generally speaking, the utilization ratio of remainders after logging in forest areas is above 90% now. The branches are used as fuels wood for local residents and the materials of woodchips, block boards, edible fungi, carbon for industry and wood products such as sanitary chopsticks. The treetops, barks and roots are used as fuels wood. The leaves are abandoned in logging areas. In some places, leaves are used to produce green foods such as beverage and tea; roots are used to make root-carving artworks. In recent years, there are some new ways of usage of harvested trees. For instance, remainder after logging is used to manufacture pellet fuel; harvested trees are used to manufacture bio-oil through the method of thermo-chemical conversion and the bio-oil could be used to produce high value chemical products or liquid fuel.


Fig. 16.1: Used as a fuel.


Fig. 16.2: Root carving.

India

1. Wood- wood is use for fuel, pulp, timber, plywood, packing cases for fruit and food stuffs, furniture, door/ window, crates, pencils, toys, walking sticks, wood carving, etc.

2. Branch-sources of fodder and fuel
3. Bark-bark constitute one of the most important tanning material, bark yields a fibre which is locally

   utilized for rope making and also used as fuel.
4. Root- used in native medicine or fuel
5. Tree top- use as fodder and fuel
6. Leaves – can be utilized for production of biogas, excellent fodder, medicinal purpose, mulching, needles

   of conifers are used for packaging purpose.
7. Saw dust-fuel or packaging purpose.

Fig. 16.3: Chipping of pruned poplar material for fuel.

Fig. 16.4: Peeling of poplar for ply wood making.

Kenya The bottom part of the main stem is used for timber, the top for poles or posts, the branches and tops as fuel wood while the foliage remains as mulch or if the trees species is palatable, the foliage is used as fodder for the animals. Left over stumps and roots are used for charcoal.

Brazil Not applicable to CDM.

16.2 What are requirements and quality criteria of clients to the delivered wood?

China Yes, beyond the specific standard of companies, we have serious national standards such as:

1. GB887-89 Log for direct use - wire poles
2. GB11716-89 Logs of small diameter
3. GB11717-89 Logs for pulp & paper
4. GB/T15106-94 Log of sliced veneer
5. GB142-95 Logs for direct–pit-props
6. GB/T144-95 Log inspection
7. GB/T155-95 Defects in logs
8. GB/T4812-95 Logs of special grade

India No standard for biomass based power plants or other industrial units are available. However, tree wood is classified as timber (>60cm girth above bark) small wood/sokta (45-60cm girth), fuel wood (<45cm girth), etc. but as mentioned above, due to scarcity of biomass even stem wood less than 45cm girth is also used in plywood/paper/ power generating plant/packaging cases, etc.

Kenya Companies actually harvest and collect their wood from farms and even from public forests and therefore take material that fits their requirement. Where the sale of wood involves determining the sale price per size of material removed, companies are governed by the size, which is diameter at both ends and length of a log. Other criteria are the presence or absence of heart rot among logs. The logs affected are left on site. Logs infected with wood borers are either sold as low quality logs or left at the harvesting site if intensity of infestation is too high. Section of logs affected by canker are cut and left in the field. There are no standards upheld by companies in Kenya, they usually will have their own specific requirements.

Brazil Most of forestry companies have FSC – Forestry Stewardship Certification, as the main certification scheme for their products.

16.3 From what resources is paper produced?

China The pulp in our country includes recycled pulp, wood pulp and non-wood pulp. The 2008 statistical result shows that the recycled pulp occupies 60% of total pulp. Meanwhile, the wood pulp occupies 22% and the non-wood pulp occupies 18%. The main wood materials used for pulping and papermaking include coniferous wood (such as spruce, fir, red pine, larch and masson pine) and broad-leaved wood (such as poplar, birch, maple, eucalyptus and zelkova). The main non-wood materials used for pulping and papermaking include bamboo, straw, wheatstraw, reed, cornstalk, cotton stalk, hemp and so on.

India

1. *Soft woods:* Eucalyptus, *Leucaena*, *Casuarina*, *poplar*, *wattle*, *bamboo*, *pines*, etc.
2. *Agricultural waste:* wheat/paddy straw
3. *Non-conventional biomass: Saccharum*, *Arundodonax*, *Eulaliopsis*, etc. Recycled pulp

Kenya In Kenya, paper is produced from logs of mainly *Pinus patula* grown in short rotations of 15 years that are not subjected to pruning and thinning operations.

Brazil The pulp and paper industry in Brazil is 100% based on forest plantations, mostly *Eucalyptus* species.

16.4 Which parts of which trees are used for medicinal purposes?

China Various parts (especially bark, leaves, roots and fruits) of many trees can be used to medicinal purposes, such as the leaves, roots, fruits of *acacia*; bark and roots of *Phellodendron amurense Rupr*, bark of *Eucommia ulmoides*, bark of *ground hemlock* and bark or swigs of *Ailanthus*.

India Ayurvedic way of medicine is traditionally followed in India and species-wise information is available in literature (plant part used and the purpose/disease for which it is used). All plant parts have got some medicinal value. However, some specific parts depending on the species are used commercially. For example, all the plant parts of neem have pharmaceutical value

Kenya Different parts of trees species are used for medicinal purposes mainly depending on specific tree species. These parts include the roots which are dug out, the stem bark which is normally peeled from living trees, the twigs and leaves, flowers, seeds and fruits. Among sometrees, sap collected after inflicting some injury to the stem is utilized for medicinal purposes. Below is an example of some of the short rotation forest species and their medicinal uses:

1. Acacia mearnsii - leaf and bark "Medicinal plants used in the treatment of fungal and bacterial infections in and around Queen Elizabeth Biosphere Reserve, western Uganda";
2. Cupressus lusitanica –powdered dry gum resin applied as a drying agent for wounds (F.N Gachathi 2007);
3. Calliandra calothyrus – honey produced by bees that forage on the species has bitter-sweet flavour;
4. Eucalyptus camaldulensis - honey produced from its nectar is clear pale in colour, with a mild pleasant flavour;
5. Grevillea robusta – flowers are attractive to bees thus an important honey plant;
6. Prosopis juliflora – flowers are a valuable source of nectar for high quality honey;
7. Gmelina arborea – produce abundant nectar which gives high quality honey (Sciences (NAS) 1980), and
8. Melia volkensii - bark is used for cure of pains and aches in the body (Kokwaro 1993).

Brazil Not applicable to CDM.

16.5 What is the main purpose of SRF?

China Panel, pulp, chips, block board, industrial charcoal and fuel wood. Recently, there are some new purposes of SRF such as making pellets, producing chemicals or transport oil using thermo chemical transformation.

India

1. Fuel: direct use of wood is as fuel for thermal/electricity purpose.
2. Construction and Furniture: door and windows frames, crates, pencils, toys, walking sticks, wood carving.
3. Decoration: decorative features in wood like figure, grain, colour and set up of the cells or tissues. Cells

   constituents or tissues which ultimately impart decorative properties to wood.
4. Paper making: SRF timber is an important raw material for the production of paper and pulp soEucalyptus plantations have been raised to serve as raw material for paper and pulp.
5. Artificial board: SRF wood is a source of ply wood industry for domestic and industrial use including packaging.

Fig. 16.5: Finished product-plyboard.

Fig. 16.6: Pruned material for fuel use.

Kenya Fuel wood and timber, although there are the added benefits of fodder, mulch material and medicines.

Brazil In Brazil, SRF are mostly used for the following purposes: Pulp and paper, Reconstituted Wood Panel, Timber Industry, Charcoal, Industrial Fuel wood.

16.6 What is the percentage of utilisable wood/biomass of the whole tree?

China The main part of the tree was used for wood based panel, pulp and paper making. The utilization of residue was almost reach 90% in China, in which, branches mainly used for chips, block board, industrial charcoal, edible fungi, chopsticks and fuel wood of local residents. Treetop, bark and roots are for fuel, leaves will be leave on the site. Also, in some places, the leaves were used for making drinks, tea or other green foods, and the roots were used for artworks. Recently, some innovative utilization methods turns up, such as makingpellets, producing chemicals or transport oil using thermo chemical transformation.

India All plant parts are used for one or the other purpose. However, on an average 42-45% stem wood is converted to products of long life (plywood, timber, etc.). Normally, stem wood represents approx. 60% of the total biomass, which means only 25% of total biomass goes to durable products. But with the refinement in technologies, the per cent usage of biomass has increased substantially and the remaining biomass is used for fuel/energy. And 40-42% is the utilizable wood/biomass in the tree.

Kenya Most of the tree is used for different purposes. Deeper roots and stumps may be left, but otherwise all will be used – whether for timber, fuel wood, mulching material, fodder and/or medicines.

Brazil According to ABRAF, the industrial wood processing is divided into primary, secondary and tertiary, each with its own flow in the respective forest sectors segment. The primary processing refers to log transformation into a number of products: wood chips, sawn wood, veneer, chemically treated logs, and charcoal, besides energy. These subsequently will give rise to other differentiated products, according to the specific industry segment. The subsequent phase is the secondary processing, which is the processing of primary products into final or intermediate products for other processing. The first products from sawn wood, which can be destined directly to final consumers, are beams, rafters, battens, treated wood and wood boxes. Another product base of the secondary processing veneers, either veneer peeling or slicing, which might follow the process in order to manufacture decorative or structural plywood. Veneers can also be used in laminate flooring. The wood chip, another primary product of the processing chain, is the raw material for the manufacture of reconstituted woodbased panels, such as Medium Density Fiberboard (MDF), Medium Density Particleboard (MDP) and Oriented Strand Board (OSB). Wood chips are also the main raw material of pulp mills. In addition, wood chips and tree bark are widely used in direct combustion to meet the demand of different energy-generation processes. From solid wood, resulting from second processing, the high value-added wood products (VAWP) are manufactured, including clears, blocks and blanks (solid wood planed on all four sides, free of defect), from which are produced machined wood products: finger-joint frames, doors, staircases, flooring and EGP (Edge Glued Panel). The VAWPs, which differentiate into more value-added level, are related to the furniture sector, in addition to solid or reconstituted wood-based panels. Fuel wood is used to produce charcoal, widely utilized for production of pig iron and steel. Moreover, firewood can be directly used in power and steam generation, such as the energy utilization of grain dryers, ceramic industries, among others. The tertiary processing adds the highest economic value to solid wood products, and also the closest to consumer's needs.

Products made from wood pulp have also a high added value, such as various types of printing paper, cardboard, corrugated packaging, among others. Currently, it is possible to find fabrics made from pulp, the result of high technologies and applied research in the forest products sector. The wood residues arise at all stages of the production process and are considered by products. As a common practice, they are not discarded in the manufacturing process along the planted forest production chain. The industrial sector, (not only the forest-based sector) values residue utilization, integrating them into the production process, which increases industrial productivity and reduces environmental impacts or potential environmental liabilities. In the timber industry, wood residues from mechanical processing, including bark, slabs, sawdust, among others, are destined for burning in boilers to produce steam used for wood kiln drying, or in furnaces for generating hot gas or heating fluids. There is also the recovery of wood residues through the wood chip production for further commercialization, currently a booming market. Another industrial use of wood residues is the manufacturing of wood pellets and briquettes, and in semi industrial processes the production of wooden utensils, interior designwooden objects, adding value and creating an alternative market for the material that otherwise would be discarded.

17 Recirculation to cropland

17.1 How to solve the problem that soil productivity and biodiversity decline due to SRF?

China Take poplar for example: a) Studies show that mixed plantation of poplar and black locust, poplar and amorpha fruticosa, poplar and hippophae rhamnoids can promote the stand growth. b) Intercropping of poplar and crops is an effective way to increase the volume of forest tree growth and develop large timber. c) Replacing the sand with soil can increase soil nutrient content and enzyme activity, change the microbial community structure, thus can improve the overall soil microbial environment and promote tree growth. Take eucalyptus for example:

1. Choosing the species suitable for introduction Only choosing the species for site conditions suitable can become healthy forest stand, form a good ecosystem.
2. Reduce the intensity of site preparation Adopt a lower strength way to site preparation. For example, using ripper-for-dozer soil preparation, strip soil preparation, etc. in plains region and low hilly areas, using digging trench, etc. in mountain areas can minimize the damage of soil structure and vegetation and reduce soil erosion.
3. Change the stand structure and tree structure Establish the mixed forest and afforest with multi-species, multi-clones, such as mixed plantation of eucalyptus and acacia, mixed plantation of eucalyptus and pine. It can avoid soil degradation caused by long-term homogeneous species planting.
4. Increase the fertilizing amount As a fast-growing species, eucalyptus consumes soil fertility inevitably. Only increase the amount of fertilizer can meet the needs of growth of eucalyptus.

India Excessive exploitive species may be avoided like farmers prefer poplar over eucalyptus. Supplementation of fertilizers (in agroforestry normally 50% extra nutrition is applied than recommended for sole crops). Invasive species may be restricted or managed properly, for example leucaena regarded as invasive is due to excessive seed bearing twice a year and its profuse natural regeneration. But proper selection of site for leucaena and lopping the branches for fuel/fodder at the flower/pod formation stage, helps in checking its wild growth. Judicious use of SRF, for example Prosopis juliflora regenerate profusely and may be a threat for native flora. After Tsunami in India in Dec. 2004, cost all areas were covered with excessive regeneration of Prosopis, but its management and utilization for bio-energy checked its invasive nature and saved the native flora also. Green manuring is a sustainable option to add nutrition to soil and check weed growth.

Kenya SRF should be practiced in specific areas where management systems shall be put in place to ensure that during harvesting, biomass from the tree top, twigs and foliage is left to decompose on site. The litter fall from such forests should not be collected during the rotation to leave the site clean as this amounts to removal of nutrients that are being recycled from deep soil horizons. Specific sections of the forests must be left to naturally regenerate where indigenous tree and shrub species grow. Such areas should be protected from both human and livestock activities for a specified period so that even palatable tree and shrub species regenerate and survive future biotic and abiotic interference.Another way of addressing soil productivity is through growing trees or intercropping trees with agricultural crops that improve the soil fertility. These would be mainly leguminous trees/crops that are nitrogen fixing in nature.

17.2 Does it affect the benefits of farmers to recirculate SRF to cropland after a few rotations?

China According to Forest Law of the Peoples Republic of China and Regulations for the Implementation of Forestry Law of the Peoples Republic of China, forest lands should not be changed to non-forest land.

India Yes, in many plantations, fast growing species may place a heavy demand on soil moisture, nutrient losses may be excessive, adverse chemical/biological effects may result from certain tree species, leading to acidification, allelopathy, accumulation of toxic exudates, etc.

Kenya This has not been practiced by individual farmers in Kenya. However, companies such as East African Tanning Extract Company (EATEC) used to grow Acacia mearnsii for four to five rotations before growing agricultural crops for two to three seasons. During the growing of crops, shrubs and bushes that could have established were cut to eliminate competition for nutrients and soil moisture. Among the pulp wood plantations crops were grown at the end of the rotation mainly to prepare the ground for new planting. The forest department benefitted in that the field was prepared at no cost while the farmers benefitted through harvest of crops without paying land rent. For farmers growing Casuarina at the coast, crop harvests in fields that were previously plantations of Casuarina are better than from fields continuously planted with agricultural crops. The benefits accrue from the improved nutrients status of the soil due to N fixing natureof Casuarina and the extensive litterfall accumulated in such plantations during the rotation. For plantations grown with E. saligna or E. grandis, the land needs time to recover before growing productive crops. In some cases, farmers will burn the land of the remaining debris and stumps to prepare the land for planting crops; otherwise it can take many years for the land to be productive again for anything other than trees. It can be that fast growing species place a heavy demand on soil moisture, nutrient losses may be excessive, and adverse chemical/biological effects may result from certain tree species, leading to acidification, allelopathy, accumulation of toxic exudates, etc. Therefore, the farmer should be cautious before planting crops on that land too soon after the SRF cultivation.

17.3 Are there some laws and policies imposing restrictions when recirculating SRF to cropland after a few rotations?

China There are no laws or policy restrictions.

India No such law/policy restrictions of SRF exist.

Kenya There are no laws or policy restrictions.

17.4 Are there any other factors influencing the recirculation of SRF areas to cropland after a few rotations?

China This question is not applicable for China.

India Absent land owners shift from annual crop cultivation to SRF to protect their land from illegal encroachment and avoid regular cultivation of crops (cannot afford to attend farm operations) because of other commitments.

Kenya The main factor that farmers consider in determining what to plant in a given site is productivity. Once productivity of one item declines, farmers shift to the other. In areas where crop productivity has declined, the tendency is to plant trees in such areas. The market forces seem to be becoming a major factor. With depressed prices of agricultural produce and the ever increasing prices of farm inputs, farmers are opting for SRFs as these are considered to require low inputs and minimal management and tending.

18 Economic, financial issues

18.1 Are SRF systems already in place purely based on the market price rather than relying on subsidies?

China No. Forestry is a specific industry of forest resources management and it not only provides the necessary timber for economic development, but also plays an important role on safeguarding the environment, such as sand fixation, preventing soil erosion, CO 2 absorption and so on. At the present stage of China's economic development is still in the depletion of resources and the environment type, mostly based on resource consumption and environmental damage for the price. Its ability of sustainable development lies in the common development of economic, resources and environment. So in recent years China have developed a series of policies to protect the social and economic sustainable development and the forestry policy is mainly for forestry production subsidies, such as improving forest cover percent, and vigorously advocating returning farmland to forest land and so on. Although SRF has developed rapidly and also has quite a broad market space, these still rely on government subsidies.

India Yes. As mentioned above, short rotation forestry plantations are not getting subsidy andfarmers are raising these plantation due to their market demand.

Kenya Yes, farmers do not receive subsidies for tree planting and grow them according to market demand and domestic necessity.

Brazil The establishment of tree plantations requires large amounts of investment. Although the productivity of eucalyptus plantations in Brazil is currently considered one of the best in the world, the first harvesting period for most economic uses, including charcoal, cannot occur be fore the 7th year, within a plantation cycle of up to 28 years. Thus, industries that can be based on wood plantations, such as the project activity, have no income until the full maturity of the trees, which is reached in 7 years. In order to cope with the intrinsic characteristics of this in dustry, loans must have at least a 7-year grace period, and a minimum duration of about 10 years, which is almost non-existent in the Brazilian financial market and in most developing countries. The situation is worsened by the fact that these types of loans are not offered by Brazilian private banks. As a result, the entire debt-funding demand relies on governmental bodies, which have competing developmental priorities and limited resources. In 2000, the Brazilian National Government was working on the establishment of the National Forestry Pro gram (PNF), with the objective of alleviating the ongoing forest plantations deficit. Although the current government has launched the program in 2004, no additional large-scale funding has become available. As detailed below, the funding structure is still inappropriate to supply the sector's demand and the project activity.In 1988, The Minas Gerais Development Bank (BDMG) has created the only applicable funding facility to which the project entity had access (Proflorestas). The fund started its operations in 1994 with limited resources (US$28 million). In addition, most companies are not able to meet the collateral requirements and other governmental restrictions. At the time the project activity started, and in the subsequent years, the total amount of annual resources made available by this facility has only covered a very minor
portion of the sector's needs . In 2005, only R$16 million were available and, in 2006 and 2007, R$10 million and R$8 million were available to the entire forestry based sector in the state of Minas Gerais (BDMG, 2008). Even the Brazilian Development Bank (BNDES), which is the main source of long-term funding in the country - and is a major alternative for these producers - cannot supply the sec tor's debt financing needs. Four out of the five long-term forestry loans offered by the Bank have duration of five years or less. Some funds available to forestry plantations are exclusively devoted to small-scale enterprises (i.e. BNDES Pronaf - for rural households only, and BNDES Propflora) or are only dedicated to the pulp and paper industry. The Propflora facility has been created to support the implementation of plantation activities. However, it is capped at R$150 000, which is negligible considering the investment requirements of large-scale planta tions. Likewise, the location of the plantation activity in the state of Minas Gerais also makes it ineligible for other sources of official funds, including the special funds structured for the less developed regions of Brazil, which also lack sufficient resources (e.g. North, Center-West and Northeast regional funds) and exclude the project region .In addition to the scarcity of funding, most companies, including the project entity, have serious difficulties in providing collaterals and loan warranties. The plantations per se are not accepted as collaterals or perma nent real assets, which significantly limits the access to debt resources. The severe shortage of debt-financing and the prevailing double-digit real interest rates in Brazil also have a dominant role in the risk-aversion for investors in creating long-

term assets. In Brazil, investors have struggled with high real interest rates (the highest in the World), sustained by the implementation of a strict monetary policy aimed at curbing inflation since the early 1990's. Integrated activities to supply charcoal-based iron production are particularly affected, since they are mostly dependent on the long-term credit availability.

18.2 What is the historic development of such subsidies and what are the main lessons learnt?

China After 1998, the government of PRC has implemented six key forestry projects, which are the Natural Forest Protection project, Returning Farmland to Forest project, Beijing and Tianjin Sandstorm Source Control Projects, Fast Growing Forest Project and Protection Forest Project. The government has taken measures such as subsidizing the farmers in the reserve region, restricting (Prohibiting) logging, implementing concessional loans and so on, which have directly or indirectly affected the income of the farmers. In 2008 the State Forestry Administration, the National Development and Reform Commission, Ministry of Finance, Ministry of Commerce, State Administration of Taxation, China Banking Regulatory Commission, China Securities Regulatory Commission jointly issued the 'Key Policy Point on Forestry Industry '. This is the first elements of a forest industry policy since the founding of PRC. 'Points' has put forward a series of policy measures in leading, regulating and supporting the development of forestry industry, improving the quality of forestry industry and expanding the scale of forestry industry. The main lessonsare mainly reflected in the following aspects:

1. 'Non-equilibrium' of forestry subsidy system. Forest subsidy mainly focuses on public services and environmental programs, micro-distributed in the natural disaster relief and regional assistance. Direct payments not linked to production, financial participation in income insurance and income safety net programs, producers retirement subsidies etc. have not included in forestry support budget items.

2. 'Overplus' of forestry subsidy policy, which reflects in heavy taxation of forestry policy, forestry subsidy policy offside, over-supply of forestry ecological public goods.

3. Instability of forestry subsidies policy path. As any work has certain implemented time, under the lack of clear guidance, the options of new path of forestry subsidy policy andthe level of subsidies are difficult and the change of relevant policy may also affect the stability implementation.

India Subsidies to the poor section of the society are essential for their welfare in the developing world. Economists feel that still these subsidies should be focused one otherwise the unfocused subsidies help the undeserving beneficiaries and increase burden on the government. It has been emphasized that the farmers must get the right prices for their produce instead of subsidies on inputs like fertilizer, water, electricity, etc. so that the benefit flow to the intended and deserving people.

Kenya There are no subsidy systems in place in Kenya.

Brazil Brazil holds the largest concentration of forests proportionally to its territory, covering 64.3% (544 million hectares) of the land area. Tree plantations or silviculture practices represent only 0.9% of the country's total forested area, the remaining 99.1%

refers to native vegetation (*O setor florestal no Brasil*). In addition, the total forest plantation areas, including those for other industries represent 0.5% of the national territory. Historically, natural forests have supplied the country's demand for wood, which resulted in the large-scale degradation of several of the country's original biomes, specially the Atlantic Rainforest, the Cerrado (Brazilian savanna) and a significant proportion of the Amazon Rainforest. The development of forest plantations in Brazil has only started in 1967, in response to a federally subsidized reforestation program, enacted by the national government under law 5.106, on September 2, 1966. In response to the growing demand for wood-based industries and to limit deforestation practices, a fiscal incentives program (which was later referred to as FISET) was implemented to stimulate the establishment of plantations. The program lasted until 1988 and the state of Minas Gerais accounted for over 70% of the plantation projects. The plantation area has grown
in response to the program. The total area of plantations in Brazil, almost non-existent before, increased to 6.5 million hectares in 1992 (Reis et al. 1994 and). With the discontinuation of the Program in 1988, plantation establishment decreased, while harvesting of existing plantations continued at a rapid rate. The replacement of the Brazilian Institute for Forestry Development (IBDF) with the Brazilian Institute of Environment and Natural Resources (IBAMA), in 1989, also emphasized a focus away from plantation forest establishment to native forest preservation and its sustainable management. As a result, charcoal consumption remained at rates similar to pre-1989 values and the area of plantations declined from 6.5 millions hectares in 1992 to 4.8 million in 1998 (Reis et al. 1994 and).The declining trends in plantation activity were strongly observed in the state of Minas Gerais (the project region), as it has historically dominated the Brazilian plantation sector, especially in terms of plantations for charcoal supply. The plantation forestry sector in the state has evolved hand-in-hand with the iron and steel industry. The rich-deposits of iron ore and the need for a thermal reduction agent (carbon) have led to the rapid depletion of the regional native forests. The end of the FISET led to a marked drop in area under plantation establishment in Minas Gerais. This was followed by a reduction in the forest cover in the state, as the harvesting levels continued high, with almost no replanting. In 1992, the state was covered with over 2.6 million hectares of forest plantations. By 1998, this figure was reduced to 1.67 million hectares (Reis et al. 1994 and). In 2003 and 2004, the forest plantation stock in Minas Gerais respectively accounted for 1.16 and 1.15 million hectares, 75% of which were established for charcoal supply . Recognizing the threatening deficit of plantations in Brazil, the Federal Government created the National Forestry Program (PNF) in 2000. The program's objective was to expand the forestry plantation base through multipurpose initiatives, such as increasing funding, removing regulatory bottlenecks and strengthening governmental institutional capacity. In 2004, the PNF was re-launched by thefederal government. However, as per the trends presented below, the recent measures are far from resolving the current and projected wood supply deficits in the long-run due to prevailing barriers, e.g. insufficient funding, the difficulties associated with the high-interest-rates of the Brazilian economy, and the resulting risks and high opportunity costs to long term investments, such as the establishment of dedicated fuel wood plantations with production cycles of up to 28 years in comparison with the use of global commodities such as coal coke. In fact, as the fiscal incentives program put in place by the government in 1967 terminated in 1987, a sectoral trend towards the increasing use of coal coke has been strengthened.

18.3 What subsidies are available for SRF/agroforestry in your country?

China

1. National protection forest system construction project, mainly supports the forest system construction in coastal and river areas, which is in accordance with the standard subsidized by 1493 Yuan per ha.

2. National forestand seedling project, mainly supports national and provincial forest seedling demonstration base, forest improved varieties breeding centres and the like, which is in accordance with the standard subsidized by 1.5 million Yuan per project.

3. National financial discount interest to forestry loan project, mainly grants four types of loans. The discount rate ranges from 1.5 to 6.0 percent, with a period not exceeding 3 years.

India Directly, no subsidy is available on SRF, however, farmers can avail the subsidies on crop production for the inter-cultivated crops along with fast growing trees (farm forestry/agroforestry).

Kenya There are no subsidy systems in place in Kenya.

Brazil The establishment of tree plantations requires large amounts of investment. Although the productivity of eucalyptus plantations in Brazil is currently considered one of the best in the world, the first harvesting period for most economic uses, including charcoal, cannot occur before the 7th year, within a plantation cycle of up to 28 years. Thus, industries that can be based on wood plantations, such as the project activity, have no income until the full maturity of the trees, which is reached in 7 years. In order to cope with the intrinsic characteristics of this industry, loans must have at least a 7-year grace period, and a minimum duration of about 10 years, which is almost non-existent in the Brazilian financial market and in most developing countries. The situation is worsened by the fact that these types of loans are not offered by Brazilian private banks. As a result, the entire debt-funding demand relies on governmental bodies, which have competing developmental priorities and limited resources. At the time the project activity started (2000), the Brazilian National Government was working on the establishment of the National Forestry Program (PNF), with the objective of alleviating the ongoing forest plantations deficit. Although the current government has launched the program in 2004, no additional large-scale funding has become available. As detailed below, the funding structure is still inappropriate to supply the sector's demand and the project activity. In 1988, The Minas Gerais Development Bank (BDMG) has created the only applicable funding facility to which the project entity had access (Proflorestas). The fund started its operations in 1994 with limited resources (US$28 million). In addition, most companies are not able to meet the collateral requirements and other governmental restrictions. At the time the project activity started, and in the subsequent years, the total amount of annual resources made available by this facility has only covered a very minor portion of the sector's needs . In 2005, only R$16 million were available and, in 2006 and 2007, R$10 million and R$8 million were available to the entire forestry based sector in the state of Minas Gerais (BDMG, 2008). Even the Brazilian Development Bank (BNDES), which is the main source of long-termfunding in the country - and is a major alternative for these producers - cannot supply the sector's debt financing needs. Four out of the five long-term forestry loans offered by the Bank have duration of five years or less. The other funds that were available to forestry plantations are not applicable to the project activity, as they are exclusively devoted to small-scale enterprises (i.e. BNDES Pronaf - for rural households only, and BNDES Propflora) or are only dedicated to the pulp and paper industry. The

Propflora facility has been created to support the implementation of plantation activities. However, it is capped at R$150,000, which is negligible considering the investment requirements of large-scale plantations. Likewise, the location of the plantation activity in the state of Minas Gerais also makes it ineligible for other sources of official funds, including the special funds structured for the less developed regions of Brazil, which also lack sufficient resources (e.g. North, Center-West and Northeast regional funds) and exclude the project region .In addition to the scarcity of funding, most companies, including the project entity, have serious difficulties in providing collaterals and loan warranties. The plantations per se are not accepted as collaterals or permanent real assets, which significantly limits the access to debt resources. The severe shortage of debt-financing and the prevailing double-digit real interest rates in Brazil also have a dominant role in the risk-aversion for investors in creating long-term assets. In Brazil, investors have struggled with high real interest rates (the highest in the World), sustained by the implementation of a strict monetary policy aimed at curbing inflation since the early 1990's. Integrated activities to supply charcoal-based iron production are particularly affected, since they are mostly dependent on the long-term credit availability. For more than 10 years, the project entity has not been able to make such large investments in the establishment of plantations for the production of iron, following the sectoral trends (see Step 4 below for further analyses). Therefore, structural lack of and the difficulties in the access to appropriate debt-funding are major barriers to the implementation of the project activity.

18.4 Are regulations/availabilities of these subsidies varying across the nation, e.g. between provinces?

China Yes, these subsidies vary across China. The government implements "Key points on Forestry Industry Policy" as aregional development policy and then each provinces set down the rules for implementation according to the actual situation in their own provinces.

India Yes, the subsidies vary between the states. However, some of the issues are governed by the central government i.e., subsidies on fertilizer/agro-chemicals, financial support by nationalized banks, etc. In addition, states can decide about the subsidies at their level also . (for example free electricity/irrigation water for farm activities in Punjab state)

Kenya There are no subsidy systems in place in Kenya.

Brazil Since the 1930's, different regulatory mechanisms have affected the establishment of wood plantations for the production of renewable charcoal or the use of non-renewable charcoal in Brazil. The Brazilian Forestry Code, issued in 1934 (Decree 23.973/34) and reedited in 1965 (Law n.4771/65), was an important instrument to regulate the forestry activities, establishing a minimum percentage for the preservation of native forests, and introducing the concept of permanent preservation areas and legal reserves. The transportation of, acceptance and storage of wood, firewood or charcoal originated from native forests, as well as the production of charcoal using first quality native wood without proper licenses have all been qualified as criminal offenses. These contraventions are punished with three months to one-year imprisonment and fines. In 1989, the Decree 97.628/89, under the Brazilian Forestry Code, required all large-scale wood consuming industries to be responsible for creation of therequired plantation sources to supply their production activities. The 1988's Federal Constitution had established a new role for the Federation, States and Municipalities in the preservation and maintenance of forests, fauna and flora. It allowed States to simultaneously legislate on environmental issues. In 1991 Minas Gerais became the first Brazilian State to have its own forestry regulation, with the creation of the State Forestry Law (Law n.10.561/91), revoked and replaced by Law n.14.309/2002, which obliged all organizations that consume or commercialize forest products to use a minimum of 90% of wood coming from planted forests. It allowed a maximum of 10% for native forests consumption, provided a fee is paid. Forestry products coming from other states shall present documentation guaranteeing the origin of the wood. However, there are no mandatory provisions on the use of coal coke. Whereas, the vast majority of the Brazilian iron production is based on coal coke (see Figure 23) the minor part often relied on illegal practices to sustain their production in the past, e.g. illegal logging and falsification of licenses for the production and transportation of charcoal. Approximately 50% of the Minas Gerais cerrado (Brazilian savannah) has been depleted for 20 years to supply charcoal for part of the iron industry. Technical and human resources for thorough inspections were not sufficient to cover the national territory. The effects of such a lack of enforcement over public property rights have often lead to a classic common pool resource problem (see Olson, 1971), posed by the availability of native wood and its obvious economic attractiveness vis-a-vis any alternatives that require major new investments, i.e. renewable charcoal from forest dedicated plantations. This has resulted in market failures in the sustainable production of renewable charcoal-based iron and most of the iron industry that complied with legal requirements has been basing their activities on the use of coal coke. Over the past 10 years law enforcement and inspection operations have significantly grown both in terms of frequency and strictness, making the use of non-renewable charcoal increasingly difficult. Criminal and financial penalties have been applied, such as apprehensions,embargoes, fines and imprisonment of the involved people. In the state of Minas Gerais, the culmination of this trend has taken place when the executive branch proposed a new law, gradually banning the use of non-renewable sources of charcoal for the production of iron. The same bill explicitly recognizes the role of carbon finance mechanisms, namely the CDM, in stimulating and supporting the use of renewable charcoal from dedicated plantations. Within this context, it would be unrealistic and non-conservative to assume that project entities would plan new and long-term investments in production of iron, based on illegal and unsustainable practices involving the use of non-renewable charcoal.

18.5 Are there calculations available on the contribution margin of crops which are competitive to SRF/agroforestry systems?

China Yes. SRF/agroforestry systems are throughout our country with different types. They not only let the productive potential of the existing cultivated land have been fully play because of light and heat resources and ecologicalspace were utilized, but also changed the large areas of degraded land into high-yield farmland. Some tree species can efficiently absorb nitrogen from the air and transferred to soil, so fertilizer can be reduced up to 75% and lead to a substantial increase in crop production.

India These are usually annual crops. Not sure (market fluctuations), still better than sole agricultural crops. However, small farmers cannot afford because of long gestation period. Tree-crop interaction more specifically poplar/eucalyptus based agroforestry system are economically more profitable than traditional crop rotation, which drive farmers to adopt the same. More over the demands are increasing and like to increase in future also.

Kenya This information is not available, therefore was not included in the report.

18.6 Specify on the average price of wood.

China

1. The average price of ordinary pulp wood is 1,500 Yuan per m^3. (Free on board)
2. The average price of ordinary timber wood is 3,500 Yuan per m^3. (Free on board)
3. The price of ordinary fuel wood ranges from 290 to 320 Yuan per m^3. (Free on board)

India Average price for

1. Pulp wood Rs. 3500/- per ton on fresh weight basis;
2. Timber wood Rs 5000/- per ton for ply wood on fresh weight basis;
3. Fuel wood Wood rates on fresh weight basis at the site itself (Rs.2000/- per ton).

Kenya This information is not available and will vary widely according to market and end use. There is no common or 'average' price held across the country.

18.7 Is there data on the average cost of labour force in the agricultural sector?

China District administration decides the monthly rates (current rates has increased 17.5% from 2003 to 2005, from 560 Yuan per month to 658 Yuan per month) in rural areas, which are strictly followed in Govt. organizations, however, these rates vary for farm labour and normally they are higher than Government rates instead of accommodation, food, etc is provided. Situation of no monetary payment to workers not happened and can be negligible. However, the income of forest workers is still at a low level, which is less than the half ofaverage level of the urban area. For example, Heilongjiang Forest Industry Group, although the average annual income of employed workers has increased from 2 ,490 Yuan in 1997 to 5,626 Yuan in 2005, which has increased by 9.48%, the income is only of 27.58% of wages for workers in the town. Because of the subsidy standards not changing, the forest management staff, government personnel which depend on Natural Forest Protection Project Fee are difficult to have more wages. Even more badly, at some regions, surplus workers are unemployed, living a very poor life.

India District administration decides the monthly rates (current rates of Ludhiana district, Rs 151 per day equivalent to approx. Euro 2.3), which are strictly followed in Govt. organizations, however, these rates vary for private farm labour and normally they are higher than Government rates, provided additional facility of accommodation, food, etc. are not provided. Situation of no monetary payment to workers is negligible.

Kenya The data is not available but according to common knowledge, farm labour will cost between 200-400KES per day (2.5-5 USD per day).

Brazil The forestry sector does not have such data, but the total estimate of job (primary and industrial processing) in the planted forests segment in 2009 was 3.9 million, including direct (535 thousand), indirect (1.26 million) and jobs resulting from the income-effect (2.16 million).

18.8 Are there rather transparent financial analyses (providing a contribution margin per hectare as a result) on defined production cycles/chains available in your country?

China Yes. Details can be available in national forest financial status in the year 2006.In 2006, the national forestry fund budget invested 58.45 billion Yuan, of which government invested 42.85 billion Yuan (including invested 4.95 billion Yuan used in infrastructure), local inputs 15.6 billion. The actual capital is 54.08 billion Yuan and the actual expenditure is 52.11 billion Yuan.

India Yes, in traditional rice–wheat rotation, farmers are earning Rs 40-50 , 000/- per ha per year whereas the poplar based agroforestry adopters are earning more than twice the amount of ricewheat rotation (only the payments are received after five years).

Kenya It is not available in this area.

Brazil The financial analyses are done in the project level and should be analysed case by case.

19 Agroforestry

19.1 Is agroforestry an issue in your country? Are there relevant policies, laws and regulations to support agroforestry development?

China Yes, the research of agroforestry involving almost various fields from breeding to utilization, and farm machinery producing, and it also regards the forestry, agriculture and animal husbandry as a whole to study. The current study mainly focuses on the following aspects: Select the excellent spices of trees suitable for agroforestry and the most reasonable combination of agroforestry, the research of the appropriate management techniques that be used in agroforestry, ecological benefit, economic benefit, diagnosis and evaluation of agroforestry.

India Yes, it is an important issue of sustainable process in agriculture and to reduce the pressure from traditional forest area. Agroforestry is a sustainable land use system that maintains or increases total yield by combining food crops with tree crops on the same unit of land. Apart from ensuring food production, such systems also would enhance economic returns to the growers. Moreover, diversified production is a form of risk avoidance, which is of special significance in the context of current agricultural crisis that the many countries in are facing. Diversified products are available year around in the systems such as home gardens of Kerala in India. Moreover, under the present regime of WTO, farmers have to look for the market and change their mindset towards commercial agriculture rather than traditional agriculture. There is a mismatch between what is being produced and what the buyer market is demanding. Farmers of irrigated agro-ecosystem in India have tried alternatives to rice-wheat rotation like other agricultural crops, poultry, fishery, etc. but much success has not been achieved. The only option which finds some ray of hope is integration of crops for higher productivity with differential outputs with fast growing timber species on their farm land. Agroforestry is win-win approach to enhance productivity and provide environmental services. The advantage of agroforestry systems compared to forests is that the land can remain in agricultural use whilst sustaining a greater phyto-mass than a purely arable system. Directly it can sequester carbon in cultivated land and indirectly on the forest land also by decreasing the pressure on the conventional forests by meeting the wood demands outsides forests. Productivity of agroforestry plantation is much higher than natural forests e.g.: productivity of Eucalyptus in natural forest is 4-5 m^3/ha/year, whereas, in agroforestry, the productivity is 20-25m^3/ha/year (raising one ha on agricultural land is equivalent to 5ha in forest). Trees are also expected to improve the soil fertility though depends upon the tree species, growth rate, stocking level and input through litter. Agroforestry would remain issue in the times to come. However, we have to developexpertise (capacity building) in tree crop combinations with evidence based designs, encourage agroforestry adoption with policy support, strengthen post harvesting wood processing and international trade, encourage interdisciplinary-inter-institutional research, etc.

Kenya Agroforestry is a major means of livelihood for smallholder farmers in Africa. In Kenya, the agroforestry systems vary depending on region and farmers' household needs. Markets heavily influence what is grown and interactions between species influence the on-farm niche in which they are planted. Not only is agroforestry important for farmer livelihoods when they are operating at a small-scale (two acre/0.8ha land size is common), but it can also benefit the surrounding environment to a higher degree than plantation systems due to species diversity and low input management practices (Lamond 2007). Even in cases when trees are not integrated with annual agricultural crops in the same plot, trees are often grown along boundaries, around the homestead, and/or in woodlots – thus, making up parts of the whole farm system. Branches and leaves are used for livestock fodder and either used on their own or mixed with manure to apply to agricultural crop plots. Trees on farms are a vital part of the farming system, particularly in areas where people rely on the fruits/timber/fuelwood and other products for a sustainable livelihood. By carrying out agroforestry practices, farmers are able to provide a variety of goods for their domestic needs as well as bring in cash income for school fees and other necessities. Diversified production means there is not reliance on just one crop that could potentially fail; it is a way for smallholder farmers to limit their exposure to risk and market failure. Fast growing timber trees are an important part of the smallholder system because when they are sold, individual trees can bring in a significant amount of money in one go. They are seen as an investment because they do not require a lot of inputs and they can provide in times of need.

Brazil The Brazilian Government launched in June 2010, the Low Carbon Agriculture Program (ABC), which has the objective of reducing the greenhouse gas emissions from the production of food and bioenergy. The actions of the ABC Program foresee the use of US$ 1.2 billion in techniques that improve the efficiency on the fuel, with a positive outcome on CO_2 removals and emissions. The resources are guaranteed to smallholders and cooperatives, up to a limit of US$ 600,000 per beneficiary. The interest rates applied are 5.5% per year with a 12-year reimbursement contract. Among the activities that could be financed, it can be found SRF and Agroforestry. Embrapa Forestry (Brazilian Company of Agricultural Research) develops several researches in agroforestry with multiple species for the subsistence of smallholders since the 80's. The agency also develops researches for SRF and for the disclosure of forest practices for small producers. There are also state level entities, such as EMATER (Company for Technical Assistance and Rural Extension), who provide technical assistance and develops researches directly with rural producers in several types of agroforestry systems.

19.2 Are there approaches of organic farming in the SRF/agroforestry sector?

China Organic Agriculture is a such mode of production that following the standards, the order of nature and the theory of ecology, get organism and the products without genetic engineering, do not use the material such as chemosynthesis pesticide, fertilizer, growth regulator, and feed stuff additive, coordinate the balance between crop farming and aquaculture, using a series of sustainable development to maintain stable of agricultural production system. This mode of production has well environmental and ecological benefits, can improve the soil fertility, and protect the wild resources and natural environment, so it can increase the yield and quality of SRF/agroforestry.

India No, organic farming in the agroforestry as such is rarely followed in SRF/agroforestry sector.

Kenya Organic farming is not explicitly followed in the SRF/agroforestry sector in Kenya; however, many trees are generally viewed as low maintenance because they require little inputs in comparison to agricultural crops. Most smallholder farmers do not apply fertilisers/pesticides/herbicides directly to the trees but will be applying these to any intercrops so the trees benefit as a side-effect.

Brazil Researches on organic agriculture and agroforestry systems can be found since the 1980's in some Brazilian states. These systems give priority to the use of several species without the use of herbicides, combining the benefits of every component for the environment in order to increase the productivity of the system as a whole. Some leguminous species are used for nitrogen fixation in the soil and can be used as fertilizers after harvesting, as most of the residues are left on the field. The forests offer shadow and protection from heavy rains and winds. The natural herbicides from oils of some forest species are used for other cultures.

19.3 What is the main concern of farmers about SRF/agroforestry?

China

1. High investment cost.

   For one thing, the maturity age for SRF is general around 5 years. There are a lot of problems to be solved prior to harvest year in such a long cycle, such as eating problems, source of forest management fees and daily expenses assurances. For another, high taxes and many categories of taxes are unreasonable. Plus harvesting costs and forest value, planting SRF is almost unprofitable, which frustrates the enthusiasm of the farmers

2. Lacking information and experience with trees.

   For one thing, lacking of local government'shelp or development of related organizations, farmers are short of adequate information or services in all the stages of cultivation. These may lead to ineffective distribution channels and divorce between market demand and cultivation. For another, to some extent, it is the management technology that leads to success of cultivating SRF. Tree species selection, the rational use of herbicides, appropriate timing of tree pruning, fertilizing, pest and disease control are essential.

Some planters have doubts about managing the wood scientifically. Therefore, they hesitate to plant SRF.

3. Lacking trust into a new 'crop' (trees).

   In respect of micro-factors of risk: compared with crops, firstly the forest restricted more by site conditions, management, protection technique and variety choice. Investors will not get a good economic benefit once a mistake is made. Secondly, forest get a longer growth cycle which means unpredictable price decided by the market at harvest time. Therefore, the level of production efficiency is uncertain. In respect of macro-factors of policy: firstly, forest owners cannot cut trees in accordance with the market demand but limited by the cutting quota institution established by the nation. That is to say they cannot achieve the best economic benefits. Secondly, the state has adopted a strict policy of land protection since 2004. SRF development is constrained to some extent. Thirdly, factors of grain prices going up, polices of phasing out agricultural tax and direct subsidies to grain producers, make the comparative benefits of SRF decrease. To sum up, many farmers lack trust into SRF because they believe that the future development of SRF is difficult to grasp with high risk.

4. Reluctancy to bind one's agricultural areas for several years to a single crop.

   For the agricultural crops, even due to disasters, inappropriate species selection, management and other factors have led to poor benefits or even a loss, its characteristic of shorter growth cycle (typically less than one year) determine its lower production costs and less loss. Besides, such losses could be offset or reduced in the next growth cycle by switching to another crop. Therisk is low overall. But for the forest, even for SRF, the age of maturity is general 5 years. Once the market price is lower than expected a few years later, a great loss to planters will be brought as the high cost of inputs in such a long growth cycle. However, unlike crops, such losses cannot quickly be compensated or reduced by switching to another crop in another growth cycle. To sum up, due to various risk factors, farmers may have wait-and-see attitude on planting the forest.

5. No access to good clones.

   For one thing, R&D and production are seperated on the cloning technology of SRF because of low technology transferring ratio. Many forest products are in low-grade with poor quality resulting in a shortage of high-quality wood and over-supply of common varieties. For another, mangy seedling farmers used to engage in mixed industries with little experience on clone. Besides, usually there are not professional technician to instruct the farmers so that intensive level of the nursery is not high with low rate of emergence and good ones. Thus it directly affects the quality of the final quality and benefits of SRF.

India Farmers certainly have many questions for tree domestication under agroforestry

1. Does trees compete with crops for different resources and decrease crop yield?
2. Does trees recycle nutrients? Do they need supplemental nutrition?
3. What role does trees play in soil and water conservation?
4. Whether agroforestry systems are sustainable?
5. How does agroforestry put cash in farmer's products?

6. Whether agroforestry help in carbon payments, etc.? Farmers normally perceive the following problems.

1. Demand-supply forecasts
2. Regulated/assured marketing
3. Non-availability of planting stockiv. Barriers in tree harvesting/transport
4. Agroforestry technology dissemination
5. Bank credit facilities
6. Matching species/clones with site conditions and associated crops

Kenya Farmers have some concerns about incorporating trees onto their farms and choose to grow them in specific niches depending on the trees' attributes and associated impacts on crop production. When looking at coffee agroforestry systems in Central Province, Kenya, the main tree found to be intercropped and grown on boundaries was Grevillea robusta; there was a lack of diversity in terms of agroforestry trees used with coffee because of the perceived impact on coffee productivity and space available for planting. Plantation owners have their own concerns about selection of good genetic material suitable for the relevant site conditions as they rely more heavily on just one or two species unlike smallholding farmers. Some of the major concerns are:

1. Competition for soil nutrients and moisture between trees and agricultural crops.
2. Risk of damaging crops when harvesting the trees.
3. Uptake of water by trees.
4. Matching species with site conditions.

Brazil The small producers in Brazil are the most important actors in the existing agroforestry systems. There's still a lot of resistance to SRF from some of these producers due to myths related to Eucalyptus spp.. Several studies have proved that SRF use less water per unit of production throughout its cycle when compared to other cultures such as sugarcane and potato. The SRF are mostly planted by medium and large producers located in areas near pulp and paper mills and iron and steel mills. The fostering forestry programs have clarified some questions related to Eucalyptus spp. and have helped to avoid many misunderstandings related to these plantations.

19.4 Illustrate some typical agroforestry systems in your country.

China

1. *Forest and crops interplanting type:* According to the different biological characteristics and different levels of management between trees and crops, there are two main forms of interplanting: interplanting in the young stand and interplanting in the mature stand.
2. *Forest and medicine interplanting type:* in order to achieve the purpose of "Quick profits to support long-term development", herbs are planted under the trees.
3. *Forest and bacterium complex system type:* Cultivating mushroom under forest, such as bamboo fungus, Lentinus edodes, Poria Cocos, Auricularia auricula ,etc.

4. *Forest and tea complex system type:* Cultivating tea under forest can improve the light conditions of tea garden, withstand the wind, lower the temperature, increase the humidity. It is good for improve the quality and yield of tea.

5. *Forest and herding complex system type:* It is warm in winter and cool in summer, a little windy and moist under the forest. The fresh grass and variety of insects under the forest and can become the food for chicken and other poultry.

Fig. 19.1: Forest and medicine interplanting

Fig. 19.2: Forest and bacterium complex system.

India Agroforestry systems/models are site specific and need based. Therefore, no common recommendation is justified. A model may be highly productive and sustainable in nature but it's success depends upon the adoptability. For example, Leucaena based silvipastoral models are highly productive with least competition with inter-cultivated crops and fix atmosphericnitrogen but there are very few takers of such models due to poor quality fodder (high mimosine content) and its invasive nature. Therefore, a system should be productive/sustainable with good adoption potential. In general, agri-silvicultural, silvipastoral, agri-silvi-pastoral, alley cropping, multipurpose forest tree production systems, etc. are followed in India with variable options of inter-cultivated components (trees and crops) suitable in different agro-ecosystems. Horticultural component is finding much favour among the farmers to make use of wider inter-space among fruit plants and initial juvenile fruiting period of 4-5 years. As soon the fruit plants start bearing commercial crop, the trees inbetween row/plants are harvested and new SRF trees are raised along the orchard boundary as windbreak/shelterbelt.

Fig. 19.3: Various agroforestry systems in India. Photograph: Chauhan, pers. comm.

Fig. 19.4: Bee rearing under poplars in India. Photograph: Chauhan, pers. comm.

Fig. 19.5: Poplar based agroforestry system with a pond (aquaculture) in India. Photograph: Chauhan, pers. comm.

Fig. 19.6: Poplar based agroforestry system in India. Photograph: Chauhan, pers. comm.

Kenya Most smallholder farms consist of a variety of agroforestry practices but do not tend to be systematically organised in terms of spatial arrangements. Trees are found scattered within agricultural crop plots, along boundaries, around the homestead (usually fruit trees), or in separate woodlots. There are usually only well organised agroforestry systems in places where projects have been initiated and farmers have been given specific training of different agroforestry practices. Coffee agroforestry systems, dominated by Grevillea robusta interplanted with Coffea arabica and sometimes banana/beans/potatoes/pumpkins. Tea and scattered Grevillea robusta. Banana and maize. Crops and boundary trees (mixed species).

Brazil One of the most common agroforestry systems in Brazil is the integration among agriculture, cattle and forests. In this system, some annual cultures are planted during the first 02 years of the Eucalyptus spp. plantation lines. During the third year, the Brachiaria spp. is implemented and then the cattle are brought to these areas. The agroforestry systems with higher diversity of species are observed for small producers, with the use of annual cultures, fruit species, forestry species and grass. EMBRAPA has a model with more than 2[illegible] species:

	Common name	Scientific name	Utilization
1	Pineapple	Ananas comosus	Fruit specie of Short rotation
2	“Açaí”	Euterpe oleraceae	Fruit specie of Medium rotation
3	“Açoita cavalo”	Luehea divaricata	Forest specie
4	Amaranthus	Amaranthus caudatus, A. cruentus, A. hypocondriacus	Forage specie
5	“Andiroba”	Carapa guianensis	Biopesticide
6	“Alpínia”	Alpinia purpurata	Ornamental
7	Banana	Musa cavendish, M. paradisiaca	Fruit specie of Medium rotation
8	“Bastão-do-imperador”	Etlingera elatior	Ornamental
9	Coffe	Coffea arábica	Fruit specie of Medium rotation
10	“Canafístola”	Peltophoriium dubium	Forest specie
11	Cedar	Cedrella odorata	Forest specie
12	“Copaíba”	Copaifera langisdorfii	Forest specie
13	“Crotalária”	Crotalaria breviflora, C. juncea, C. paulinea	Cover crop
14	“Cupuaçu”	Theobroma grandiflorum	Fruit specie of Medium rotation
15	Beans	Phaseolus vulgaris	Annual crop
16	Wild beans	Canavalha brasiliensis	Cover crop
17	Pig beans	Canavalha ensiformis	Cover crop
18	“Gliricídia”	Gliricidia sepium	Forage specie
19	“Helicónia”	Heliconia bihai, H. psittacorum, H. chartacea	Ornamental
20	Papaya	Carica papaya	Fruit specie of Short rotation
21	Cassava	Manihot esculenta	Annual crop
22	“Maxixe”	Cucumis anguria	Fruit specie of Short rotation
23	Corn	Zea mays	Annual crop
24	Mahogany	Swiethenia macrophylla	Forest specie
25	Neem	Azadirachta indica	Biopesticide
26	Cucumber	Cucumis sativus	Fruit specie of Short rotation
27	“Pupunha”	Bactris gasipaes	Fruit specie of Medium rotation
28	Ginger	Zingiber spectabilis	Cover crop
29	Tomato	Lycopersicon esculentum	Fruit specie of Short rotation

BWCDMSpecificsTables.*Tabelle21*

19.5 Is sustainability an issue in agroforestry for the farmers?

China Yes, sustainability of agroforestry systems is important in the long term. sustainability of agroforestry practices management is more significant than short-term to some extent. As it has good economic returns such as more farm production and forestry production, has ecologicalbenefit such as improvement of soil and water conservation capacity, protection of biological diversity, improvement of soil fertility and improvement the utilization of waste recycling, agroforestry practices have made the land use pattern more easily accepted by farmers.

India Yes, sustainability of agroforestry systems is very important in the long term. In the absence of which, the land could become severally degraded and farmers could face acute problems. In this way agroforestry practices have to be conservation oriented, designed to sustain the productivity of the land on a long term basis, otherwise also poplar based agroforestry is suggested to replace rice from the traditional crop rotation, which drains the water resources and resultantly lower down the water table significantly.

Kenya Sustainability is a major reason for maintaining agroforestry systems. The main impetus for carrying out agroforestry practices is sustaining smallholder livelihoods by providing for domestic needs through food crops, products to be sold for cash on the market, firewood for cooking, timber for building, fodder for livestock and mulching material to apply to the land.

19.6 Is allelopathy an issue?

China This issue does not exist on SRF in China.

India Number of exotic tree species have been introduced in India and their adverse effects on the environment have raised several questions regarding the sustainability of the ecosystem suitability. Ecologist/conservationist feel that they pose serious threat to the local community and integrity of the native eco-system by their invasive/allelopathic nature (degrading native flora). However, soil is a big buffer, the allelo-chemical exert less influence on under storey vegetation.

Kenya Many of the dominant SRF species are exotics and the main trees facing criticism for environmental impact has been Eucalyptus species. It has been blamed for drying up water sources and it also is known for its negative impact on soil productivity after cultivation; it takes time for the land to recover after planting with eucalyptus. Not only this, but exotic trees are often criticised for their impact on natural vegetation and biodiversity, and efforts have been made to encourage more planting of native tree species.

19.7 Is food security an issue?

China According to relevant laws, Land can not be used for other purposes. although food security is an important issue, agroforestry does not threaten food security in China.

India No, agroforestry systems offer significant opportunity for livelihood improvement through nutrition and economic security of the people. It is a sustainable management system. Though the crop yield reduces due to competition for resources/loss of land to trees but still it is not a threat because the area under agroforestry at present is less than one per cent. Therefore, there is no threat to food security due to inter-cultivation.

Kenya Agroforestry presents more opportunity to smallholder farmers for multiple goods and services than monocropping does. Smallholders often rely on their farms for food crops and other goods, so by integrating trees with crops, their needs are more likely to be met than if they only rely on one or two crops. Food security is threatened more by cash crops that can be unreliable due to market fluctuations and cannot be utilised at a domestic level; in coffee agroforestry systems, we see that when coffee is not providing sufficient cash income smallholders will intercrop more to sustain themselves (Lamond 2007).

19.8 Where is SRF preferredly established: in natural forests, in plantations, in agroforestry systems, outside the forest?

China SRF trees are most likely playing an important part in prevent water loss and soil erosion, so in China, they are grown outside of natural forests. Also, most SRF are found as part of government owned.

India SRF are preferred outside forests due to their fast growing nature, high biomass productivity, easy to manage for many rotations, increased demands, etc. SRF species to express their full potential needs intensive management, which is not possible in the natural forests. The productivity of SRF species remain quite low in forests due to lack of post planting cultural practices, therefore, the SRF species are preferred outside forests including on-farms plantations. In last 20 years, tree cover out side forest has increased from one per cent to three per cent of the geographical area of the country and investment cost itself is also less than that incurred in the forests.

Kenya SRF trees are grown outside of natural forests as they need to be managed in a way that would not be possible in the forests and the objectives conflict with the interests of natural forest management. SRF is found as part of government owned or private plantations, smallholding woodlots or incorporated in various spatial arrangements on farms.

19.9 Has SRF become more attractive for fuel wood/bio-energy?

China Because SRF tree species have emerged as a viable option to meet the growing renewable energy requirements.

India SRF tree species (Eucalyptus, Prosopis, Leucaena, Casuarina, Acacia, etc.) have emerged as a viable option to meet the growing renewable energy requirements. Many wood based industries like plywood/board, paper/pulp and power plant are dependent upon SRTs. The bioenergy power plants, which were established to target agricultural produce failed to achieve their targets due to shortage of raw material and compatible machinery. Resultantly, for assured raw material, industries have started generating their captive plantations of SRF species for energy or ensuring farmers for the marketing of their farm produced wood.

Kenya Fuel wood is the main source of energy for rural domestic use, tea factories and hotels. Trees grown on short rotation, therefore, are essential for providing the necessary amount of wood to meet industrial and domestic needs.

19.10 Does intercropping increase tree productivity?

China Intercropping can benefit trees because they can get fertiliser from other crops like soybean, and people do not need to fertilize the trees so much as planting trees individually. But in China, there is only a little part of the SRF being intercropped.

India Yes, due to better cultural practices during crop cultivation like soil working, regular irrigation, weed management, nutrition, etc., the survival and growth of the associated trees are automatically benefited. The introduction of Taungya system in 19th century is an important example for the establishment of teak plantations by allocating land to landless for intercultivation to ensure survival and better growth of teak trees.

Kenya Intercropping can benefit trees because of the cultivation practices carried out, forexample weed management and fertiliser application. Farmers do not tend to manage trees to the same degree as they do agricultural crops, so by intercropping the trees inadvertently benefit.

Glossary

A/R afforestation and reforestation. 26–29, 31, 32, 34, 91

Afforestation/Reforestation (A/R) A project type of the Kyoto Protocol with according methodologies for the due project development. 8

agroforestry *Agroforestry is a collective name for land-use systems and practices where woody perennials are deliberately integrated with crops and/or animals '*on the same land management unit. The integration can be either in spatial mixture or temporal sequence. There are normally both ecological and economic interactions between the woody and non-woody components in agroforestry.*' (ICRAF (International Centre for Research on Agroforestry) 2010). Fast-growing trees grown in SRF can be part(s) of an agroforestry system

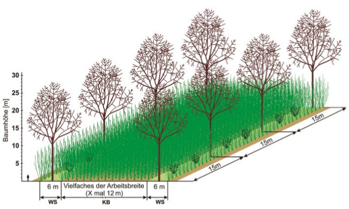

Fig. 19.7: Agroforestry (Morhart, Springmann, and Spiecker 2010)

. 8, 11, 12, 22, 139, 140, 142

Annex I Countries 'Annex' refers to the according Annex I of the United Nations Framework Convention on Climate Change (UNFCCC). Countries listed in the annex signed and ratified the Convention. Having signed and ratified also the Kyoto Protocol these countries have to submit accordingly inventories on their emission performance.A literal explanation of 'Annex I' as drawn from a publication of the secretariate of the UNFCCC (UNFCCC (United Nations Framework Convention on Climate Change) 2008) is: '*The annex to the Convention specifying which developed country Parties and other Parties to the Convention have committed themselves to limiting anthropogenic emissions and enhancing their green house gas (GHG)* *sinks and reservoirs*'. The complete list of these countries can be found at the website of the UNFCCC secretariate at http://unfccc.int/parties_and_observers/parties/annex_i/items/2774.php. 7, 8, 10–13, 17, 19–21, 140, 141

cash crop Relates to subsistence farming. (Annual) crop grown for selling it at the market in exchange for cash. For instance in western Tanzania tobacco is the farmers' main cash crop whereas other crops grown for both food and cash include maize (Franzel 2010). See also food crop. 8, 22, 140

CDM methodology A project development methodology eligible for the development of a CDM project. In particular such methodologies describe eligible approaches how the *carbon impact* of a project may be calculated as well as, in general, how environmental integrity may be guaranteed. 'Eligible' means that they have been approved by the according Executive Board. An overview on available CDM methodologies can be found here http://cdm.unfccc.int/methodologies/index.html and are summarized as a printable in UNFCCC 2010. Since methodologies are continuously updated one should always consult the website. 8

Central and Eastern Europe Abbreviation: CEE. Describes the European states formerly communist before the collapse of the iron curtain in 1989/90. Here understood as the EU12. The acronym 'CEEC' is accordingly used for Central and Eastern European *Countries*. 17

Clean Development Mechanism (CDM) As a westernised state, e. g. Germany, take some money and provide it as a sponsor to somebody who replaces the coal-firing of a power plant in India by biomass firing. This project reduces the CO_2 emissions of that power plant in India with a co-financing by German money. The according emission reduction is accounted for in your national balance, i.e. in the balance of the state who has provided the co-financing to the project. You do this as a state because with the same amount of money you would have achieved less emission reductions with a project in your own country (measures achieving the same CO_2 reduction would have been much more expensive). In reality there are several actors involved in such a project, such as foremost a *project developer* who also trades the according emission reductions on an international market. This project-based trade in GHG emission reductions across countries is the logics of so called CDM projects. This project type is foreseen in the Kyoto Protocol as an eligible means of westernised countries to fulfil part of their emission reduction obligations. Within Europe and also in other regions of the world according internal trading schemes and obligations have been established in line with the Kyoto Protocol framework. India, in the above example is called a 'host country' (hosting the project). 24, 26, 28, 29, 31–34, 91, 115, 117, 127, 138, 141

companion crop The annual crop which is combined with trees in agroforestry systems, e.g. wheat in poplar-wheat systems. 140, 142

dead wood Adapted from IPCC (Intergovernmental Panel on Climate Change) 2006: 'Dead wood encompasses coarse woody debris, dead coarse roots, standing dead trees, and other dead material not included in the litter or soil organic carbon' and from the glossary part of the document: 'Includes all non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Dead wood includes wood lying on the surface, dead roots, and stumps, larger than or equal to 10cm in diameter (or the diameter specified by the country)'. 141

dry matter (DM) Material without water content (absolutely dry state). The process of assessing the dry matter of a sample is described in standards. To assess the dry matter the sample is heated up to a moderate temperature so water evaporates while other volatile substances remain within the sample. Once the mass of the sample does not change any more in weight over time all water is assumed to have evaporated and the sample is weighed. The assessed mass is the dry matter. 10

EU10 The 10 countries having joined the European Union (EU) in 2004. These are the Czech Republic, Hungary, Poland, Slovakia, Slovenia, Latvia, Lithuania, Estonia, Cyprus and Malta. The EU10 has been completed to form the EU12 in 2007 when Romania and Bulgaria accessed the EU. 8, 139

EU12 The 12 countries that have joined the European Union (EU) since 2004. The EU12 have emerged from the EU10 in 2007 when Romania and Bulgaria accessed the EU. 138, 139

European size unit (ESU) From Eurostat (statistical office of the European Union) 2010: A unit to measure in economic terms the size of a farm. The unit specifies a standard gross margin ('profit' of the farm) of 1200 €. For each activity (or 'enterprise') on a farm (for example wheat production, dairy cows or the output from a vineyard), the standard gross margin (SGM) is estimated based on the area used for the particular activity (or the number of heads of livestock) and a regional coefficient. The sum of all such margins derived from activities on a particular farm is its economic size, which is then expressed in European size units (by dividing the total SGM in € by 1200, thus converting it to ESU). 144

FAO Food and Agriculture Organization of the United Nations. 142

food crop Relates to subsistence farming. (Annual) crop grown for feeding the family of a farmer. See also cash crop. 8, 138

food scarcity Food scarcity is generally a relative gap between the supply of food in relation to its demand in a given time at a given place. Scarcity mostly stresses the fact of deficit in production to meet the need. The need is not only expressed in terms of nutritional energy (which is around 9 MJ/d/cap) but also refers to all other components of food valuable for the human development such as carbohydrates, proteins, vitamins etc. Food scarcity is different from food insecurity, which is inaccessibility to food caused by a variety of factors. 8

green house gas (GHG) Any gas contributing to the global green house effect. In a stricter sense the six gasses as listed in Annex A of the Kyoto Protocol:

1. Carbon dioxide (CO_2)
2. Methane (CH_4)
3. Nitrous oxide (NO_2)
4. Hydrofluorocarbons (HFCs)
5. Perfluorocarbons (PFCs)

6. Sulphur hexafluoride (SF_6)

. 138–141, 145

iron curtain Border during times of the cold war separating European democratic countries run under the capitalistic regime and eastern countries run under the communistic regime. 138

kharif crop Expression used for annual crops in India and Pakistan to specify their vegetation period and harvesting time. A kharif crop grows during the rainy summer and monsoon time and is harvested in autumn. These crops are more affected than rabi crops in yield reduction in agroforestry systems by shading of deciduous trees because during the main vegetation period of the companion crops the trees have their leaves. 11, 142

Kyoto Protocol At the 'Third Conference of the Contracting Parties' to the UNFCCC, which took place in Kyoto/Japan in December 1997, the participating countries adopted a protocol additional to the UNFCCC. This 'Kyoto Protocol' came into effect legally in 2005 and expires in 2012. The protocol sets a specific time period – known as the *first commitment period* – for Annex I Countries to achieve their GHG emission reduction and limitation commitments: 2008-2012. The protocol has put in place an accounting and compliance system, in particular, laying down specific rules concerning the *reporting of information* by Annex I Countries that have to demonstrate that they meet their commitments. Rules have also been established for the accounting of assigned amounts and the trading of Kyoto units. The compliance system established by the Protocol is one of the most comprehensive and rigorous systems to be found in international treaties. 137–141

landed cost Cost of a delivered good including all previously accumulated cost, such as transport, insurance etc. and also the purchase price itself. The term is used to avoid misunderstandings in price specifications on 'hidden cost', e.g. when transport would not have been considered in the price when making an offer. 17

legume Plant belonging to the family of Fabaceae (or leguminosae). Legumes are able to convert atmospheric nitrogen to nitrogen which is fixed to the soil via bacteria (rhizobia) which live symbiotically in root nodules of the legume. Legumes can be agricultural crops such as beans, fodder crops such as clover or alfalfa but as well trees such as *Robinia pseudoacacia*, *Sesbania sesban*, *Erythrina fusca, E. poeppigiana* or *Inga spp.* Do not mix the English 'legumes' with the French 'legumes' which means 'vegetables'. 12, 13

litter (litter fall or forest floor) Debris such as leaves and twigs falling off a tree to the ground thereby recirculating nutrients to the soil. To be precise, 'litterfall' is actually the process of litter falling off the tree not the material itself, however it is often used as a synonym for the material 'litter'. Parts of litter are listed in IPCC (Intergovernmental Panel on Climate Change) 2006 as 'leaves, twigs and small branches, fruits, flowers, roots, and bark'. Adapted from the glossary part of IPCC (Intergovernmental Panel on Climate Change) 2006 it reads: 'Includes all non-living biomass with a size greater than the limit for soil organic carbon (suggested 2mm) and less than the minimum diameter chosen for dead wood (e.g., 10cm), lying dead, in various states of decomposition above or within the mineral or organic soil. This includes the litter layer as usually defined in soil'. See also turnover (biomass). 12, 144

managed forest All forests subject to some kind of human interactions (notably commercial management, harvest of industrial round-wood (logs) and fuelwood, production and use of wood commodities, and forest managed for amenity value or environmental protection if specified by the country), with defined geographical boundaries. Source: Penman et al. 2003. See also natural forest. GHG reporting within the Kyoto Protocol regime covers only managed forests. 141

natural forest Forest regenerated through self sown seed or by coppice or root suckers. See also managed forest. 15, 141

Non Annex I countries 'Annex I' refers to the according annex of the UNFCCC. Non 'Annex I' countries are countries not listed in this 'Annex I'. Sometimes also referred to as 'CDM countries'. Mostly this term is used in the Benwood project for indicating countries with a *low share in mechanisation and low labour cost*. The complete list of these countries can be found at the website of the UNFCCC secretariate at http://unfccc.int/parties_and_observers/parties/non_annex_i/items/2833.php. 7, 8, 10–13, 15, 17, 20, 22, 144

opportunity cost Cost that is incurred because of income that could have been generated if another decision had been taken. E. g. if a farmer plants trees on a field instead of growing wheat on the same area the opportunity cost is the lost potential income from growing wheat (the alternative scenario). 12

Project Design Document (PDD) A Project Design Document, understood within the framework of the Kyoto Protocol. It describes an project according to a template predefined by the UNFCCC. Submitting a project for validation and registration, beforehand a PDD has to be submitted by the project developer. To get an idea, already submitted CDM PDDs (existing project proposals) may be downloaded at http://cdm.unfccc.int/Projects/projsearch.html. 24

rabi crop Expression used for annual crops in India and Pakistan to specify their harvesting time and vegetation period. A rabi crop is harvested in spring (also known as winter crop). Rabi crops are less affected than kharif crops in yield reduction in agroforestry systems by shading of trees because during the main vegetation period of the companion crops the trees will have shed their leaves. 11, 140

Secretariat of the United Nations Framework Convention on Climate Change An organisation managing the issues of the UNFCCC. Headquarters are in Bonn/Germany. Website: http://unfccc.int. 138, 141, 145

short rotation coppice (SRC) Intensive SRF practice using fast-growing tree species with an ability to coppice from harvested stumps, i.e., new shoots can emerge from the rootstocks or stools. Harvests are performed in short intervals (2–6 years) depending on plant material, growth conditions and management practices. Planting, maintenance and harvesting is predominantly done by established agricultural practices allowing farmers to use methods and machines already known from annual crops. According to this definition, SRC falls within SRF and simply represents a more specialized practice of SRF. 142

short rotation forestry (SRF) A forest production practice for dendromass, here (i.e. in the BENWOOD project) mostly for energy purposes, with the basic principle to grow fast-growing deciduous tree species on forest or agricultural land at a denser spacing and with elevated maintenance (e. g. regarding weed control, irrigation) than in traditional forestry. The biomass is harvested when the trees have reached a size that is easily handled and economically sound, typically after c. 2 to 25 years. The size at harvest depends on plant material, growth conditions, culture technology and desired end-product, and is frequently between 10 and 20 cm diameter at breast height. SRF may be regarded as forestry or agricultural practice, depending on whether the plantations are grown on forest or agricultural land. To make a sharp distinction between forestry and short rotation forestry is often impossible. A subcategory of short rotation forestry is short rotation coppice (SRC). 11, 12, 138, 142

Sloping Agricultural Land Technology (SALT) An agroforestry technique developed in the 1980es in the Philippines on the hilly areas involving hedgerows along contour lines against soil erosion. More information can be found at this Food and Agriculture Organization of the United Nations (FAO) online resource: `http://www.fao.org/ag/AGP/AGPC/doc/Publicat/Gutt-shel/x5556e0y.htm#labour%20management`. Find a small instructive film clip on the usage of SALT in Latin America at `http://www.youtube.com/watch?v=y9D-gWk4S5U`. 52

soil organic carbon Carbon contained in soil organic matter with a grain size < 2 mm. The grain size limit relates to the analytical method which involves sieving (removal of coarse material such as pebbles) of the homogenized soil sample after macroscopic plant remains (mainly roots) have been removed manually. In most soils in non-arid regions soil organic carbon coincides with the total carbon in the soil because the majority of soils has negligible contents of elemental or inorganic carbon (Schumacher 2002, p. 5). Soil surface layers (0-20 cm depth) seldom contain more than 5 percent soil carbon (Buringh 1984). Soil carbon contents are higher in humid climates and lower in hot and dry climates (Buringh 1984).

Adapted from the glossary part of IPCC (Intergovernmental Panel on Climate Change) 2006: Includes organic carbon in mineral soils to a specified depth chosen by the country and applied consistently through the time series. Live and dead fine roots and DOM within the soil, that are less than the minimum diameter limit (suggested 2mm) for roots and DOM, are included with soil organic matter where they cannot be distinguished from it empirically (sieving). The default for soil depth is 30cm'.

The following example (Buringh 1984) gives an idea about the quantity of soil organic carbon contained in one hectare.

> A soil with a bulk density of 1.5, and a carbon content of 3 percent in the 0 to 25 cm layer, 1 percent in the 25 to 50 cm layer, 0.3 percent in the 50 to 75 cm layer and 0.1 percent in the 75 to 100 cm layer, contains 165 t C/ha; the 0 to 25 cm layer contains 113 t/ha, or 68 percent of the total.
> In a true chernozem (black earth, or mollisol) the total soil carbon is more than 200 t/ha and the surface layer of 0-25 cm contains only 25 percent of the carbon because the humus layer is very deep. Also histosols (peat soils) contain a considerable amount of organic carbon. In the analysis on 400 soils performed in Buringh 1984 the maximum soil carbon content was 801 t C/ha in a hydromorphic volcanic soil and the minimum soil carbon content was less than 10 t C/ha in a desert soil. More than half of all the soils studied had a soil carbon content of *less than 150 t C/ha*.

Soil organic carbon is closely related to soil organic matter with carbon accounting generally for about 58 percent of the organic matter content ('van Bemmelen factor', although in the tropics this factor often comes down to 45 to 55 percent, Buringh 1984, p. 93).

Instructions on how to measure soil organic carbon are provided in Pearson, Walker, and Brown 2005, p. 23, or in greater detail in Schumacher 2002. The majority of the large spectrum of available analytical methods is based on the destruction (chemical, thermal) of the organic carbon compounds and then measuring the residues of the destruction (e.g. measurement of the generated CO_2 or of chemical residues remaining from the chemical destruction of the carbon compounds). 139, 141, 143

soil organic matter Organic part of the soil. Soil organic matter is closely related to soil organic carbon because it is usually via the assessment of soil organic carbon that the amount of soil organic matter is determined (Schumacher 2002). Soil organic matter consists of (Buringh 1984)

1. living plant roots (however, when it comes to determine the soil organic carbon see the according remark there on the max. diameter)
2. dead but little-altered plant remains,
3. partly decomposed plant remains,
4. colloidal organic matter, being the humus proper-often some 60 to 70 per cent of the total organic matter in soils,
5. living microorganisms (bacteria, fungi, protozoans, etc.) and macroorganisms (worms, ants, termites, etc.),
6. inactive or inert organic matter (coal, burned vegetation or ash fertilizer).

Organic material lying on top of the soil (e. g. dead leaves and litter) is not included in the calculation of organic carbon and has to be accordingly removed during sample taking.

Further from Buringh 1984: Although organic matter is often present in the soil to a depth of 1 or 1.5 m, most is in a surface layer of from 1 to 20 cm.

Under *natural conditions* the content of organic matter in soil *is constant*; the rate of decomposition is equal to the rate of supply of organic matter from plants.

The equilibrium is disturbed when forests are cleared and the land is used for agriculture. There is also a decline in organic matter when grassland in the tropics and subtropics is transformed into cropland, or when savannahs are burned. The decline is rapid in the first few years after deforestation and gradually slows over the next 10 to 50 years. Organic matter is also lost through misuse or deterioration of land (soil erosion, salinization, alkalization and soil degradation), and because of the increasing non-agricultural use of land (urbanization and highway construction).

On the other hand, there may be an increase in organic matter when good farm management is practised and organic manure and compost are used, when arid land is irrigated, or where agricultural land is reforested

On organic matter and carbon in forest soils (from Penman et al. 2003):

Because the input of organic matter is largely from aboveground litter, forest soil organic matter tends to concentrate in the upper soil horizons, with roughly *half of the soil organic carbon* of the top 100 cm of mineral soil being held in the *upper 30 cm layer*. The carbon held in the upper profile is often the most chemically decomposable, and the most directly exposed to natural and anthropogenic disturbances . 142, 143

subsistence farming A farming practice where goods at the farm are produced majourly for the own needs of the farm (mostly food for the farmer's family and animal feed) and are only sold to a minor extent to thirds. Subsistence farming was the dominant (in terms of numbers of farms) practice in the first half of the 20th century in many parts of Europe and is still practiced and is typical for the agriculture in many Non Annex I countries. Various definitions for judging if a farm is based on subsistence farming can be found in literature. According to Buchenrieder et al. 2009 a definition may depart from three different criteria of the farm: 1. economic size (e.g. up to one European size unit (ESU)) 2. surface of the farm (e.g. between 0.5 and 2 ha) and 3. market participation (e.g. selling up to 10% of the total production of the farm to thirds)

The following passage from Sommers 1982 describes well the role of home gardens in developing countries in subsistence farming:

> It is important to distinguish between mixed home gardens and those that are intended primarily for commercial use. Commercial gardens may be modelled on the Western "market garden". Raising a few varieties of produce in quantities larger than the family can consume means that the produce can be sold. The mixed garden, however, is diverse; its crops are generally non-commercial and grown primarily for home consumption. In periods of staple crop shortages, the diversity of the home garden's produce helps to supply the family with staple food while at the same time limiting the household's need to borrow money for food. However, when surpluses occur, households will sell or trade the produce. Fruit trees, for example, bear such a large quantity of fruit over a period of weeks or months that households can sell some of the yield and still have enough left for home consumption. Often the garden produce sold is exchanged for food that is not grown in the garden. Nutritional objectives are perfectly compatible with economic objectives.

. 8, 138, 140

tobacco curing Drying of tobacco. 15, 22

turnover (biomass) Annual rate of mortality of the biomass component in question (foliage, branches, roots). A turnover rate of 0.3 means that 30% of the total biomass of the component is converted to litter (litter fall or forest floor) (where 'litter' here also applies to dead roots) every year. Modified from: Schelhaas et al. 2004. 141

United Nations Framework Convention on Climate Change (UNFCCC) `http://unfccc.int`. The UNFCCC was one of three conventions adopted at the 1992 'Rio Earth Summit'. It is a frameworking convention to stabilize GHG concentrations at an 'acceptable' level. Most important element of the convention is the assignment of emission reduction caps to countries. In expert papers the UNFCCC is also sometimes only briefly referred to as 'the Convention'. The implementation of the convention is managed by the according UNFCCC secretariate. 138, 140–142

Vesicular arbuscular mycorrhizal (VAM) fungal inoculation An arbuscular mycorrhiza (plural mycorrhizae or mycorrhizas, aka AM Fungi) is a type of mycorrhiza in which the fungus penetrates the cortical cells of the roots of a vascular plant. Arbuscular mycorrhizae (AMs) are characterized by the formation of unique structures such as arbuscules and *vesicles* by fungi of the phylum Glomeromycota (AM fungi). AM fungi (AMF) help plants to capture nutrients such as phosphorus, sulfur, nitrogen and micronutrients from the soil. It is believed that the development of the arbuscular mycorrhizal symbiosis played a crucial role in the initial colonisation of land by plants and in the evolution of the vascular plants. Source: *www.wikipedia.org*. "VAM" refers to the according inoculation process with such fungi. 80

Registry of tree species

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