Information about Cashew Nut
(*Anacardium occidentale*)

Compiled for DANIDA by

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CONTENTS

Foreword

This report gives an overview on the cultivation of cashew (*Anacardium occidentale*), its uses and trade.

The first chapter is a brief introduction to the species, the information for this is pieced together from a number of sources. The second chapter describes the cashew nut industry in Benin, the data for this is mainly from a report that was produced in connection with AGRO-IND 2002 a EU-West Africa Agro-Business Sector Meeting that took place in November 2002 in Dakar, Senegal.

Appendix 1 contains statistical data on production and prices on cashew. Appendix 2, which is the larger part of this report, consists of selected chapters from Rüdiger Behrens book "Cashew as an Agroforestry Crop – prospects and Potentials", one of the most thorough studies done on cashew. The chapter (chapter 2) on trade is unfortunately rather outdated, the latest data being from 1993. However, it provides a good overview on the development of the cashew industry and trade. The list of references has been omitted but can be provided on request.

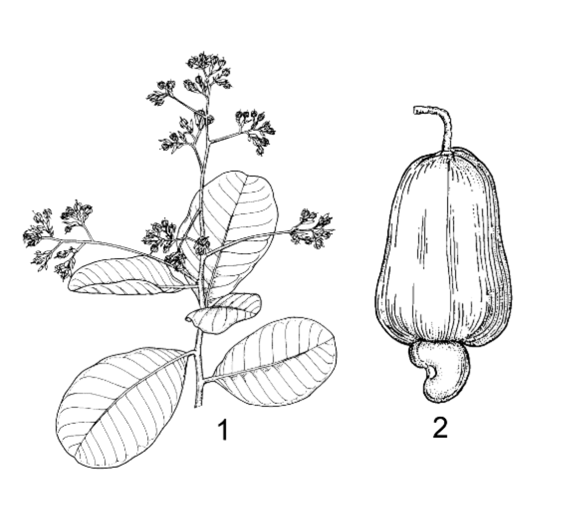
In connection with this report, a number of texts, project reports and scientific papers were compiled and scanned for relevant information. These can be provided on request from Danida Forest Seed Centre.

1. Brief introduction to cashew

1.1 General

A. occidentale is a fast growing, hardy and drought resistant multipurpose tree species cultivated in many tropical countries. It is one of the most well known species for its nut in the world, although all parts of the tree are useful. It is an important tropical tree crop and in terms of international trade for major edible nuts it ranks second or third. It is also a well-known agroforestry species. The trees produce fruits when they are about 4 years old and maximum production is from 10 to 30 years.

Trees are also suitable for use in the rehabilitation of degraded lands, afforestation of barren, slash-and-burned farmland and coastal saline sandy lands. The trees are easily cultivated, vigorous and require little care.



The prospects for *A. occidentale* plantations are very good due to domestic and international demand for cashew tree products. The main producer countries are Brazil, India, Mozambique and Tanzania. Limiting factors for the species are the inability to tolerate frost and extreme cold for a long time, reduction of nut yields due to anthracnose fungal disease, and the damaging effect of heavy rain during the flowering period.

1.2 Description of fruit

The nut is attached to the lower portion of the cashew apple which is conically shaped. The cashew nut (seed) hangs at the bottom of the apple, and is c-shaped. The cashew seed has within the outside shell the edible kernel or nut. In its raw form the cashew kernel is soft, white and meaty. When roasted it changes colour and taste. Cashew apples and cashew nuts are excellent sources of nutrition. The cashew apple contains five times more vitamin C than an orange and contains more calcium, iron and vitamin B1 than other fruits such as citrus, avocados and bananas. Cashew nut shell oil (CNSL) extracted from the shells is caustic and causes burns on the skin. The mucous membranes of the mouth and throat are severely affected when it comes into contact with shell oil or the irritating fumes emitted during roasting. The oily shell liquid has many uses.

1.3 Climatic and soil requirements

Cashew trees are genuinely tropical and very frost sensitive. The trees grow in a wide spectrum of climatic regions between the 25 °N and S latitudes. Although the cashew can withstand high temperatures, a monthly mean of 25 °C is regarded as optimal. Yearly rainfall of 1 000 mm is sufficient for production but 1 500 to 2 000 mm can be regarded as optimal. The cashew tree has a well-developed root system and can tolerate drought conditions. Rain during the flowering season causes flower abortion due to anthracnose and mildew. During harvesting, while nuts are on the ground, rain and overcast weather causes the nuts to rot or start germinating. Nuts germinate within 4 days when lying on wet soil. The cashew is a strong plant that is renowned for growing in soils, especially sandy soils, that are generally unsuitable for other fruit trees. For the best production deep, well-drained sandy or sandy-loam soil is recommended. Cashew trees will not grow in poorly-drained soils.

1.4 Flowering to harvest time

Flowering is affected by weather conditions and also varies from tree to tree, but continues for a period of 3 months. High temperatures lead to earlier flowering. Both male and bisexual flowers are borne on one cluster. The flowers are very susceptible to mildew and control thereof on the leaves and flowers is a prerequisite for good production. Pollination is mostly by insects. After pollination it takes 6 to 8 weeks for the fruit to develop. The nut develops first while the apple develops and enlarges only 2 weeks before fruit fall. Nuts should be harvested as soon as possible, especially under wet conditions and should be dried before storage.

1.5 Establishment

Self-pollination and cross-pollination play an important role in the formation of cashew seed. Seedlings therefore show great variation and no "true to type" trees can be grown from seed. Selected trees should preferably be multiplied by grafting or air layering because vegetative propagation will ensure the best production and quality. Trees that are precocious bearers and grow vigorously are selected. Nuts should weigh between 8 and 9 g with a density of not less than 1,0. Trees with yellow to grey-brown apples have exhibited the most resistance against anthracnose and are associated with the best production.

1.6 Planting

Fresh seeds that sink in water are planted in an upright position in a planting bag containing a loose, sterilised soil mixture. Three to four seeds can be planted directly in the planting hole. The weakest ones are thinned out later and the strongest left to develop further. The seedlings are very susceptible to *Phytophthora* root rot. The plant bags should be 350-400 mm deep, as the tap-root grows very fast and bends around as soon as it touches the bottom. Cashew seedlings are grown under shade (45 %) and hardened off before planting in the orchard. It is important not to disturb the root system during planting. Young trees should be supported for the first 2-3 years so that wind will not blow the plants over.

Two grafting techniques, namely side grafting and wedge grafting are practised with success. Grafting should commence as soon as possible (seedlings of 3-4 months old) and planted out in the orchard to prevent the tap-root from bending.

Planting distances of 8 x 5 m is recommended. The trees grow vigorously in the first 3 years and as soon as the crowns touch each other alternate trees should be removed until the permanent planting distance of 10 to 12 m is reached. Branches hanging on the ground should be removed because they interfere with harvesting. In other parts of the world cashew trees bear well, in spite of the little attention devoted to the orchards. Growth and production of cashew trees can be enhanced by establishing clonal orchards, and improving fertilising and irrigation practices

1.7 Fertilisation

The application of nitrogen and phosphate are important. Approximately 75 g LAN and 200 g superphosphate per year age of the tree is applied annually with a maximum of 750 g LAN and 2 kg superphosphate. Cashew trees are subject to zinc deficiency that can be treated with 200 g zinc oxide/100 l water applied as a leaf spray.

1.8 Irrigation

Irrigation is important during establishment of young trees because it doubles the growth tempo of young trees in a dry season. Due to the deep root system the trees can survive several months without irrigation. Mature trees should receive 1 800 l of water per tree every 2 weeks.

1.9 Processing

The objective of cashew processing is to extract the healthy, tasty kernel from the raw nut in the shell. Most modern factories are designed to obtain the maximum number of whole nuts and as much shell oil as possible. Processing can be subdivided into a series of steps.

1. Drying Harvested nuts are dried in the sun for a few days. Properly dried nuts can be stored for 2 years before being shelled. Nuts are roasted to discharge the caustic shell oil and acrid fumes. Hand shelling is impossible if the shell oil has not been removed previously. Kernels must be protected from contamination by the shell oil because it would cause blisters in the mouth and throat when eaten. Before the nuts are roasted they must be soaked in water—the moisture in the shell facilitates the rupturing of the cells containing shell oil and retaining it in the shell. Moisture makes the kernel slightly rubbery and limits breakage of the kernels. The easiest method to wet the shells is to heap the nuts into big piles and to use sprinklers intermittently. Steam may also be used. The simplest roasting method is to heat the nuts for about a minute in an open pan with holes. Acid fumes are released and if the nuts should catch fire the flames can be doused with water. A more efficient method is to use a slanting perforated cylinder that is rotated above a fire. The shell oil flows through the holes in the cylinder and is collected in a catch through. After the roasting process the nuts are dumped into ash or sawdust to remove the excess shell oil still clinging to the shells.
2. Shelling This is the most difficult operation in cashew processing. In India shelling is mostly done by cheap female labour. Shelling is carried out by using special wooden mallets and pieces of bent wire, at a rate of about 200 nuts per hour. Mechanical shelling methods are difficult to design because of the irregular shape of the nut, hardness of the shell and brittleness of the kernel. In some mechanical processing plants compressed air is used to crack the nuts. The latest method is to cut a groove around the shell and to place the shells in a modified centrifuge fitted with metal plates. The nuts are thrown against the plates and cracked by centrifugal forces when the machine spins. It is possible to obtain 85 % whole kernels with this method.
3. Removal of the testa Before the thin, papery seed coat (testa) can be removed, the kernels must be dried. Nuts are dried on big racks in an oven at 70 °c. The testa becomes dry and brittle and is easily removed. The remaining traces of membrane are removed with bamboo knives. Modern factories use electronic machines to detect nuts with pieces of remaining testa which are then sorted and cleaned by hand.

After processing, kernels, whole and broken, are sorted into 6 grading schedules. There is only a small demand for broken or dark and unevenly roasted kernels. Kernels are dried to 3 % moisture content before they are packed. Drying is necessary to extend shelf life and prevent fungal and other infections. Dried kernels do not become rancid. Nut kernels of export quality are vacuum packed in tins.

1.10 By-products

Shell oil represents about a quarter of the mass of an unshelled nut and approximately equal to that of the kernel. This fluid, that is not an oil as the term "shell oil" indicates, but a mixture of anacardic acid and cardol is the main by-product.

There are more than 200 registered patents of different uses of shell oil. One of the most important uses is in the manufacture of brake linings. Shell oil is used in the manufacture of numerous materials that have to be resistant to heat, friction, acids and caustic products, for example clutch plates, special isolators, varnish and plastic materials. The wood is insect repellent and used in making book cases and packing crates. The gum is a replacement for gum arabic and used as insect repellent glue in book bindings. In the nut and the apple, a compound has been found that combats tooth decay.

The apple is highly perishable but very healthy. It can be eaten fresh or juiced. Syrup, wine, brandy, gin, preserved fruit, pickles and glazed fruit are also made from the cashew apple. In Brazil, fresh cashew-apples are packed in trays and marketed in retail fresh produce outlets.

The indigenous people in cashew-producing regions use different parts of the plant such as the leaves, bark, gum, wood, juice and roots for the preparation of local medicines or insect-repellent mixtures. The bark is rich in tannins and is used in leather tanning. The papery seed coat around the kernel can serve as cattle feed.

2. The Cashew Nut Industry in Benin

2.1 General remarks

In the wake of the cotton crisis, and as part of the diversification of agricultural production and rural revenues, the cashew nut industry presents attractive development opportunities for Benin.
Cashew nut production in Benin takes place in three districts: Atacora, Borgou and Zou. In terms of climactic conditions, the most favourable area is between Gamia in the north and Abomey in the south.
Apart from the very noticeable increase in activity at the end of the nineties, due to the rapid rise in prices paid to growers, this crop, which is Benin's biggest export after cotton, remains comparatively little known. The area planted for the 1999-2000 harvest consisted of more than 15,000 hectares, of which:

- 5,323 hectares are old national plantations established between 1961 and 1976. These are generally in poor condition, and some have disappeared in fires. There are an estimated further 2,100 hectares available that need either maintenance or complete rehabilitation.
- 10,000 hectares of private plantations, of which 40% have been planted since 1995.

Almost the entire production is exported, untreated, to India. India dominates the world market in all areas: production, export and industrial processing.

Production of cashew nuts has a number of advantages:

- the cashew tree plays an important role in maintaining the ecological balance of the dry regions of Benin, contributing to a brake against the greedy desert; valorisation of the cashew would significantly contribute to the willingness of the population to preserve this source of income and protection.
- the cashew tree is multi-functional: apart from exportable cashew nuts, it supplies timber, firewood, medicines, fodder, etc.
- by-products (cashew balm, cashew apple and shell) offer opportunities for development of local industry
- Benin has an urgent need to diversify its exports, more than 80% of which depend on cotton.
- cashews are grown in West Africa predominantly by small farmers.
- the world market for cashews is dynamic, with sustained growth rates of approximately 10% per year.
- once Benin had its own cashew processing industry, like many other African countries. There is only one factory, which has been closed for 13 years due to mismanagement and tough competition by Indian traders. These traders are aggressively seeking complementary sources of raw nut supply to feed into their own cashew processing industry and to maintain their position as dominant supplier of the world market.
- the nuts produced in the region are particularly appreciated for their taste
- the nuts produced could receive the "organic" label as they are chemical free

Weaknesses are:

- poor yields due to low yielding varieties, a high plantation density, poorly conducted cleaning operations and a total absence of fertilisation
- the poor harvesting procedures used by farmers have a negative impact on quality
- the length and complexity of the distribution channels of the raw nut lead to falling prices and harm unorganised producers
- the consumer countries' demands as regards traceability might lead India to reduce its imports of raw cashew nuts. This would seriously harm cashew producers in the region in the absence of alternate purchasers. It is therefore urgent to develop a local nut processing industry
- the weakness of the processing industry in is partly explained by the lack of available credit to finance expanded industrial activities.

2.2 Statistics for production, marketing and product prices

The volume of production can be estimated from export figures, although these are not entirely accurate due to large undeclared transactions with bordering countries.

Cashew Nut Exports (untreated nuts)

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000
Tonnes	4,373	8,482	9,475	8,731	11,195	19,174	14,162	29,393	36,714

The last recorded statistics show 36,000 tonnes exported in 2000, which represents a 320% increase since 1995. However, the export figures for recent years seem unlikely: if the uncultivated national plantations are not counted, then the figures correspond to an average yield of 2.4 tonnes per hectare for 1999. This is too high, and so either plantation areas have been significantly underestimated, or nuts are being imported from Nigeria and mixed with the nuts from Benin before export, in order to profit from the higher prices that Benin's traditionally high quality nuts command.

In 2000 cashew nuts accounted for more than 9% of the country's total exports, generating revenues of 12.5 billion FCFA. . Declared FOB [*]prices were on average 340 FCFA/kg for 2000, and 320 FCFA/kg for 1999. However the main operators declared higher prices, of the order of 500 FCFA/kg. The CIF price for India at the beginning of 2002 was 525 USD/tonne, or 398 FCFA/kg, which does not match declared FOB prices either, but does suggest a severe tightening of the exporter's margins.

Growers' prices typically vary widely for the same harvest:

- initial sales are negotiated before the harvest has begun, around the comparatively low price of 150 FCFA/kg, which some growers are obliged to accept due to cashflow demands, particularly paying for the maintenance of the plantations.
- as soon as the harvest season officially opens (15th March), prices rise steadily, rapidly reaching 250 FCFA , and eventually 350 to 375 FCFA/kg or even more.

Prices generally rose until 1999, which was marked by particularly high prices (up to 420 FCFA/kg at the end of the harvest). Prices were pushed up by strong bidding from numerous operators, a situation triggered by a delay in production in India, which obliged the processing industry to purchase raw materials elsewhere in order to maintain production. On the basis of figures quoted by businesses, there has been a slight decline in prices since 1999, despite high demand for the product.

Grower's Price (pre-purchased)

Year	1999	2000	2001	2002
FCFA/kg	300-450	200-400	250-300	200-350

According to some operators a reasonable price from growers would be between 350 and 400 FCFA/kg, 400 FCFA being the maximum acceptable to an Indian processing company who must pay: 400 + 120 (transport and FOB costs) + 45 (CIF cost) = 565 FCFA/kg. On this there is then 35% import tax to pay in India. The processor uses 4 kg of nuts to make 1 kg of butter, which has a value on the international market of 3,600 FCFA/kg. The processor's gross profit is thus 3,600 – 3,051 = 549 FCFA/kg, out of which all other operational costs must be paid.

[*] The f.o.b. price (free on board price) of exports and imports of goods is the market value of the goods at the point of uniform valuation, (the customs frontier of the economy from which they are exported); it is equal to the c.i.f. (cost, insurance, freight) price less the costs of transportation and insurance charges, between the customs frontier of the exporting (importing) country and that of the importing (exporting) country.

2.3 Organisation and main operators within the sector

a. Exporters

There are very few export companies (less than ten), all of which are based Cotonou. Two Indian companies dominate the market. Exporters buy through a network of suppliers, or use wholesalers, who have their own supply networks.

b. Supply network

There are a large number of possible intermediaries between the grower and the exporter. The longest chain would consist of an exporter, a wholesaler (who is sometimes also an exporter), a local dealer, and then the growers and pickers. Transactions must be settled immediately and in full for the chain to function; exporters and wholesalers generally have sufficient working capital to make this possible. Some will offer to purchase a crop before it has been harvested, at a heavily discounted price.

The industry has attracted so many intermediaries because prices have risen spectacularly in recent years.

c. Growers associations

The growers have formed associations in an attempt to improve their negotiating position both with pickers and at the beginning of the season when prices are at their lowest.

Created in 1999 to replace the APAB (which was dissolved as a result of charges of corruption), and affiliated to the GEAB (*Groupements des Exploitants Agricoles du Bénin*), the Union of Cashew Nut Growers of Benin (UNAPAB) has as its objective the collective marketing of the harvests. The aim is to guarantee growers a minimum price (which was 350 FCFA in 2000).

d. Local processing

There is an artisanal roasting and shelling industry that is carried out mainly by women and which supplies the domestic market. There are also several rapidly expanding industrial plants for nut processing.

The first industrial plant was installed by the state at Parakou, and equipped with Italian machines, at the beginning of the seventies. The plant was privatised at the end of the nineties, but the new owner, *Agrical Bénin*, has suspended activities, and did not buy any raw materials in 2001.

At the end of the nineties the *Société d'Exploitation des Produits Tropicaux* (*SEPT SA*) set up a second industrial plant at Savé, with a capacity 2,500 tonnes per year. The plant used a method whereby the nuts were softened with oil before being shelled. The company may have under-estimated the amount of working capital required to perfect the process. The supply of raw materials has become problematic because the factory cannot run profitably if the price of nuts exceeds 400 FCFA/kg. *SEPT S.A.* is attempting to set up partnerships with growers, but is running into difficulties despite Benin law, which favours local industries.

The processing industry is nevertheless proving to be very attractive to investors. *Anfani Garbi SA* is planning the construction of a plant near Tchaourou, in partnership with a Dutch group, which requires an investment of 0.75 billion FCFA.

A consortium (*Cashew Bénin SA*) is expressing an interest in investing 7.5 billion FCFA in Benin for the construction of three factories.

2.4 Development prospects and constraints

The cashew nut industry is already well developed in Benin. The constantly rising export prices have created considerable interest, and the sector shows great promise, particularly for diversification:

- the market is growing, and prices should continue to rise for several more years;
- production, primarily exported, enables the Benin government to diversify its foreign currency revenue;
- there are sizeable profits for growers: the total annual cost of producing a harvest is about 60,000 FCFA/hectare; at current prices the expected return is 105,000 to 175,000 FCFA, for yields of 300 kg and 500 kg/hectare respectively; a well managed plantation can produce yields of from 1,500 to 2,000 kg/hectare per year;
- the trees are not demanding in terms of climactic conditions, and new plantations have positive environmental effects in that wooded areas may be created on comparatively poor soil, and erosion reduced.

However, these positive points must not be allowed to mask several problems that threaten the future of the industry, and which could effect the growth, or even the maintenance, of current levels of production, and future profitability. There is a great deal of interest in the sector, but chiefly in obtaining the maximum profit in the short term from the existing plantations. This has led to a lack of transparency in marketing, and to inflation of prices.

- The formerly state owned plantations, which account for about a third of the area cultivated, are ageing, and in poor condition. In addition, they were planted in very close rows, the objective at that time being to reforest the country, and this does not produce good yields per hectare. In any case, yields from cashew trees begin to drop after 25 years and so, in 5 to 10 years from now, all of these plantations will have ceased to produce.
- new plantations are planned without appropriate technical skills, and using poorly selected seeds. In the absence of any research, there is very little knowledge about cashew nut cultivation in Benin. These gaps must eventually effect the yields of new plantations, and therefore their profitability, given the likelihood that the current upward trend in prices will reverse in a few years.
- the main cashew nut producing countries (India, Brazil, Mozambique, and Tanzania) have all recently planted new plantations which, despite the continued growth in world demand, could result in over-production when they start to produce.

Appendix 1

FAOSTAT Agriculture data

Cashew nut production – Benin and world-wide

Cashew Nuts Area Harv (Ha)	Year								
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Benin	65,000	100,000	130,000	165,000	165,000	180,000	190,000	185,000	185,000

Cashew Nuts Yield (Hg/Ha)	Year								
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Benin	1,538	1,500	1,538	1,515	1,515	1,667	2,105	1,892	1,892

Cashew Nuts Production (Mt= metric tons)	Year								
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Benin	10,000	15,000	20,000	25,000	25,000	30,000	40,000	35,000	35,000

Cashew Nuts Area Harv (Ha)	Year								
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
World	2,160,910	2,296,768	2,341,636	2,560,018	2,684,210	2,792,312	2,855,116	2,915,011	3,010,360

Cashew Nuts Yield (Hg/Ha)	Year								
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
World	4,867	4,905	5,602	5,207	4,607	5,187	5,842	5,458	5,039

Cashew Nuts Production (Mt= metric tons)	Year								
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
World	1,051,792	1,126,452	1,311,867	1,332,945	1,236,487	1,448,270	1,667,993	1,591,031	1,516,935

Producer prices

Cashew Nuts	Year								
Producer Pr (Lc)	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Brazil	72,637	379	358	380	384	479	822	762	644
Sri Lanka	36,285	49,923	57,591	60,590	40,310	42,750	51,700	61,780	64,800
Dominican Rp	7,089	7,243	9,437	7,976	8,828	9,693	11,452	10,449	8,344
El Salvador	10,569	9,074	5,042	13,372	13,161	9,564	10,217	7,616	7,466
India	17,575	21,269	22,835	27,759	22,634	26,428	27,154	24,765	22,582
Indonesia	7,183,300	9,134,940	10,949,200	11,261,400	12,649,200	21,963,600	28,383,000	25,004,600	26,938,400
Côte dIvoire	212,000	200,000	250,000	300,000	307,270	240,000	230,000	300,000	300,000
Madagascar	1,682,710	2,027,180	2,322,870	2,578,940	2,100,340	1,646,130	1,890,000	1,929,690	2,033,890
Mexico	1,815	2,000	20,000	2,811	4,000	3,971	4,021	4,219	4,296
Nigeria	24,753	36,335	62,415	81,872	88,601	94,175	92,662	97,407	124,698
Philippines	13,620	11,300	15,230	18,590	17,950	12,530	24,620	21,560	26,870
Thailand	13,620	17,755	16,503	14,644	16,655	18,400	18,097	17,566	18,893

Appendix 2

Rüdiger Behrens: Cashew as an Agroforestry Crop – prospects and Potentials
Tropical Agriculture No 9,Margraf Verlag
Chapters 1, 2, 4, 5, and 6

1. Introduction

The cashew nut tree, *Anacardium occidentale* L. belongs to the family Anacardiaceae which contains a number of ornamental and fruit trees like sumach *(Rhus),* pistachio *(Pistacia),* mango *(Mangufera) and African* plum *(Sclerocarya birrea* (A. Rich.) Aubr. *A. occidentale* is one of eight species of *Anacardium* - all indigenous to tropical America (Purseglove 1968; Mabberley 1986).

A. occidentale is a tree that can grow up to a height of 20m with a diameter at breast height (dbh) of 1 m under good growing conditions. However, under poor conditions growth stagnates. Healthy trees have oval leaves 10 to 20 cm long and up to 10 cm wide, reddish or light green while young and dark green when mature. The bark is grey. If trees are not pruned or browsed, lateral branches touch the soil and may even root. Cashews grow in the tropics up to 1000 m, under a mean annual rainfall from 500-4000 mm the optimum being 800-1200 mm (Purseglove 1968; Ohler 1979; Maydell 1983). NOMISMA (1994) states that cashew trees grow at latitudes as high as 31°, mentioning some trees in Florida. However, this is a clear exception and does not lead to commercial production. The optimum rainfall regime is unimodal with a dry period of 6-9 months long. Flowering starts about 3 months after the rainy season ends- on the new branches. Fruits ripen 2-3 months later, normally at the end of the dry season.

The Tupi Indians of today's north east Brazil where the species originates (Schery 1954, Smith *et al.* 1992) called the tree "acajou" and the fruits were an important part of their diet. They did not need any other food during the harvesting period in December. Andre Thevet was the first European to describe cashew (in 1558) and its uses by the Indians. He stated that the fruit was hardly edible because of its "unripe" taste, but that a juice could be made from it and the nuts could be eaten if cooked. He also described the cashew nut shell liquid (CNSL) as oil of the nut shell that is extracted by the indigenous (Ohler 1979). Unfortunately there is no account of how the nuts were opened by the Indians. It can be assumed that they burnt them in fires as it is still done today.

Portuguese travellers took the cashew tree to colonies in India [first recorded in Cochin by 1578, in Goa by 1598, (Smith *et al.* 1992)] and Africa from where they spread more widely. Rosengarten (1984) states that Spanish sailors introduced cashew to Panama and Central America in the 16th century, though Carib natives had presumably taken it to the West Indies somewhat earlier. Cashew trees are easy to multiply by seeds that can germinate immediately after the harvest or even after 1 or 2 years, depending on storage. Harvesting and sowing are easy. Direct seeding is feasible where the rainfall exceeds 800 mm during the 3 months following sowing. They can grow on poor sandy soils and withstand salty winds from the sea. Sometimes cashew trees are found on beaches beside mangroves. They were often used as a cheap means to fix dunes or to reafforest depleted forest reserves, for example in India and in Senegal. When the nuts became a commercial product, responsibility for the crop was disputed between forest departments and departments of agriculture/horticulture which sometimes hindered the development of the cashew resources (Ndiaye, 1979). Differing perceptions of the cashew tree arose accordingly: in some tropical countries they were seen as forest trees and little effort was made by farmers to plant them. In India, Mozambique and Tanzania, however, the cashew nut was recognised as a very valuable product and farmers planted the trees as a crop. Intercropping practices are reported by many authors, but the deliberate integration of cashew trees and annual food crops on a piece of land seems to have been ignored by many researchers and there are few references to integration of cashews in farming systems. The main exception seems to be the home gardens of India and Sri Lanka. In Brazil, the apple was originally the main trade product. It was either sold fresh for consumption or processed into a beverage. In the mid-1980s, however, the nuts gained more importance. Cashew nut shell liquid as a cheap source of phenol was a strategic material during the second world war and the USA then linked the import of nuts with a certain quantity of cashew nut shell liquid used for the war industry. Ohler (1979) describes cashew wood as termite resistant and useful for boat building, but argues against use as firewood because of sparking (caused by the CNSL content). He nevertheless confirms that it produces a good charcoal.

It is astonishing that the many uses of cashew are still not combined. The cashew tree can offer more than only fruits and nuts. It produces copious litter and could therefore be used to reduce soil erosion. It grows well in rows and is amenable to coppicing, making it ideal for windbreaks and hedges. Cashew trees provide shade and shelter for many species including humans. Wastelands with deep soils can be reclaimed with cashews, whose deep roots bring nutrients to the surface. Experience has shown that once farmers are aware of the economic value of the cashew crop, they plant more trees and participate in the efforts of reforestation. Their objective, however, is not always profit maximisation but is frequently risk reduction, as the cashews produce few fruits even in dry years or when other crops are damaged by locusts (Cisse 1990, H. Ohmstedt 1991).

This study examines, in the context of today's land use pressures and trading practices, the economic value of the cashew tree and its by-products and the incentives leading farmers to plant them. It also attempts to provide information needed to decide about the promotion of cashew on national level and touches on the implications of different production levels for marketing and the use of by-products (cashew nut shell liquid, apples and wood).

Flowering, pollination and fruit setting have been studied intensively. As this is a crucial aspect of the tree's biology, this information is later considered in more detail and the implications are examined. Rapid progress has been achieved in the field of vegetative propagation within the last 15 years. It is now possible to produce clonal material for planting on-farm. Heterosis, strains and clonal material are discussed in relation to breeding and selection. Husbandry practices are influenced by many factors, among others small farmer's socio-economic situation, environment, available planting material and market requirements. This study shall indicate how cashew can be integrated in the farming system to achieve an optimal benefit for the farmer. Less attention is given to large scale commercial operations.

2. Cashew uses, trade and processing

This chapter is divided into three main parts. The first two, uses (2.1) and trade picture (2.2) are subdivided as appropriate. A shorter section (2.3 - processing methods) completes the chapter.

2.1 Uses of cashew nuts and by-products

Uses of cashew kernels

Most cashew kernels are probably used in snacks, as roasted and salted nuts alone or in mixture with other nuts. In Bangor, raw cashew kernels are sold in several shops, mostly packed, sometimes as brand "Indian cashew kernels". No reference is made to grades, only broken kernels are sold as "splits". Chinese restaurants sell a variety of meals with cooked cashew kernels. Broken kernels are used in confectionery and sometimes as substitute for almonds. Ground cashew kernels can replace peanut butter in exotic dishes. In Kenya cashew kernels are integrated in delicious chocolates. Most uses are, however, restricted by the relatively high price of cashew kernels, but a wide variety of local uses including soap making is reported from Mali (Traore 1988). Recipes for cashew uses are given in each number of the Indian Cashew Journal.

Table 1: Composition of cashew kernels

Author	Proteins (%)	Fat (%)	Carbohydrates (%)
Franke (1976)	21	47	24
Ohler (1979)	21	47	22
Ohler (1979)	21	44	29
NOMISMA (1994)	22	45	27

Nutritive value of cashew kernels

The composition of cashew kernels given in the literature varies greatly, probably due to varietal variation and differences in analyses as shown in Table 1 and Table 2. (Water and ashes make totals up to 100%). The protein content varies depending on the genotype. Values between 13-25% were found (Ohler 1979). In Table 1 the protein content is around 21%, - high compared with the value given in Table 2.

Table 2: Composition and calorific value of 5 major tree nuts (per 100) g

	Calories	Protein	Fat	Carbohydr.	Fibre
Almond	598	18.6	54.2	19.5	2.6
Amazonia nut	654	14.3	66.9	10.9	3.1
Cashew	561	17.2	45.7	29.3	1.4
Pistachio	594	19.3	53.7	19.0	1.9
Walnut	628	20.5	59.3	14.8	1.7

There is no discrepancy in the fat content, cashew has 10-20% less fat than the other nuts and might therefore be preferable to other dessert nuts for the well nourished consumers. About 77% of the fatty acids are unsaturated and ideal for heart diets, according to the American school[*]. The protein count lies between 10% (maize, Franke 1976) and 38% (soybeans, Relim *et al.* 1984) and could help to reduce malnutrition in cashew growing countries. In countries with bad cashew marketing channels the nuts are often eaten by children.

2.1.2 Cashew nut shell liquid (CNSL)

CNSL is contained in the mesocarp of the cashew nut shell, making about 15-30% of the nut weight. It is a viscous, oily or balsam like substance with a specific weight of 1.013 (g/cm^3). It has a pale yellow to dark brown colour, a bitter taste and caustic properties. It also occurs in other parts of the cashew tree (Table 3).

Table 3: CNSL levels in various parts of the cashew tree (ppm)

Roots	Wood	Bark	Leaves	Apples	Kernels
75	25	85	250	60	35

CNSL is a by-product of commercial cashew nut processing. The most widely used method, the hot oil bath (see chapter 2.3), extracts about 50% of the CNSL (7-15% of nut weight) from the shell (Russell 1969, Ohler 1979, Gedam *et al.* 1986). Several special treatments before roasting can bring the rate up to 90-95%, and with solvents 100% can be achieved, but these methods are expensive and their use depends on the CNSL price (Ohler 1966). Any sales add direly to the profit of the factory. If CNSL is not sold, it can be burnt or it has to be discarded thus creating additional costs. Natural CNSL consists of anacardic acid, cardol, cardanol and 2-methylcardol in various compositions (Table 4).

Table 4: Composition of cashew nut shell liquid

Author	Anacardic acid (%)	Cardol (%)	Cardanol (%)	2-methyl cardol (%)
Cornelius (1966)	90	10		
Hammonds (1977)	82	13.8	1.6	2.6
Tyman *et al.* (1978)	74.1-77.4	15.0-20.1	1.2-9.2	1.7-2.6
Ohler (1979)	90	10		
Tyman (1980) -	80	15	small amount	small amount
Chemical Data (s.d. after 1986)	82	13.8	1.6	2.6

[*] The ideal heart diet in America changes often with the marketing strategies of the Soy bean industry and it could be a marketing argument for cashew nuts.

During the commercial extraction (hot oil bath) the liquid undergoes decarboxilation, the anacardic acid is converted into cardanol and polymer. Therefore commercial CNSL consists mainly of cardanol (60-65%), polymer (20-25%) cardol (10-12%) and a small amount of anardic acid (Ramaiah 1976, Tyman 1980, Chemical Data s.d.).

CNSL Uses

About 90% of the CNSL imported by the USA, the UK and Japan was used as friction dust for drum-break linings and clutch facings in motor cars. It is expensive compared with asbestos but the superior friction modifying properties make it economic. Since disc brakes replaced break shoes in motor cars, the use of CNSL has decreased (Wilson 1975). Still then, a huge variety of other products can be made from CNSL (Table 5).

Table 5: Some uses of CNSL

Use	Authors
Wood protection against insects (raw CNSL)	Wolcott (1944)
Binders in particle boards	Dhamaney *et al.* (1979), Hughes (1995)
Special cements, resins for modification of rubbers, surface coatings, insulating varnishes and plasticisers	Evans (1955)
Germicides, fungicides, insecticides and photographic developers	Ramaiah (1976)
Lacquer	RUDECO (1989)
Medicines (including cancer treatment)	Duke (1989), Kubo *et al.* (1993), Muroi *et al.* (1993)

A breakdown of CNSL consumed by various industries in India in 1978 is given in Table 6 (Murthy *et al.* 1984).

Table 6: CNSL consumption by various industries in India (1978, in t)

Brake linings	1500
Cardanol	2280
Chemical resistant cement	160
Filter paper	150
Foundry core oil	1600
Oil tempered hardboards	100
Paints and varnishes	1000
Resins	50
Water proofing compound	32
Total	6872

The Indian Standards Institution has fixed specifications for untreated CNSL, treated CNSL and cold pressed CNSL, based on specific gravity at different degrees, viscosity, ash, moisture and acid values and others (Cashewnut Shell Liquid 1994). It should be possible to produce CNSL for specific purposes, depending on the relations of producers and buyers, and on the price of the product. Currently the price of CNSL is about one third of the price for phenols from other sources, increased use could increase prices and therefore the profit of the cashew industry.

2.1.3 Cashew kernel testa

The testa (1-3% of nut weight) contains 25% tannin. A factory treating 1000 t of nuts/year would yield about 2 t of testa containing 400 kg tannin (Ohler 1979). Trials with cashew testa tannins as wood adhesives have been promising (Naraymiamurti *et al.* 1969). Extraction depends on markets for the product.

2.1.4 Cashew apples

The cashew apple is the peduncle of the nut. The stages of its development are reported in chapter 3.3..4.2 (page 48). The colour of ripe apples is usually red or yellow, but mixtures of both colours exist and greenish ripe apples are reported from Ghana (Amaning 1995). Many cashew apples have an astringent taste, probably due to CNSL traces and tannins (0.1-1.7%, Sastry *et al.* 1962).

Table 7: Composition of cashew apples from selected varieties in Kerala.

Colour	Shape	Weight (g)	Juice recovery (%)	Total soluble solids (%)	Acidity (%)	Reducing sugar (%)	Ascor. acid mg/100 g juice
Red	Cylindrical	54.3	63.8	14.13	0.42	11.80	290
Yellow	Cylindrical	50.3	59.6	12.88	0.38	10.83	282
Yellow	Pyriform	43.6	61.2	12.91	0.42	12.80	328
Red with yellow shade	Oval	40.6	48.9	12.89	0.43	12.81	291
Yellow with red shade	Conical	39.1	49.6	13.18	0.32	13.28	322
Range (India)		13-140	47-84		0.1-0.7	5.3-17.7	17-455

Ripe fruits can easily be removed from the tree and they are normally sweet and juicy. Both the apple and the nut are ripe at the same time. The apple represents about 89% (range 85-90%*)* of the complete fruit weight (Albuquerque *et al.* 1960). Cashew apples are juicy and rich in vitamin C. The composition of fresh fruits is shown in Table 7 and Table 8. Huge variations are typical. The high vitamin C content is outstanding, compared with other fruits which can be grown under the same conditions.

Table 8: Composition of cashew apples compared with other tropical fruits (per 100 g fresh weight)

	Moisture	Carbohydrates (g)	Calcium (mg)	Phosphorus (mg)	Iron (g)	Ascorbic acid (mg)
Cashew	88	12	10	10	0.2	262
Guava	80	13	15	27	1.0	200
Mango	87	11	14	10	0.4	30
Orange	86	10	40	24	0.3	55
Papaya	90	7	11	9	0.4	50
Tamarind	20	71				

Apple storage

Fresh cashew apples cannot be stored for more than a day in ambient temperature. Microbial decay can be slowed down by various methods (Table 9).

Table 9: Shelf life of cashew apples under different treatments

Method	Shelf life	Author
dipping: 1% mustard oil	4-6 days	Chattopadhyay *et al.* (1993)
dipping: 0.25% citric acid and 500 ppm SO2	3 weeks	Wardowski *et al.* (1991)
cooling: 0-1.5°C, rel. humidity 85-90%	4-5 weeks	Abbott (1970)
deep freezing	4-5 months	McEvans (1980)

Deep freezing also reduces the astringency, frozen apples can be used for apple pies or ice cream (McEvans 1980).

Apple processing

Cashew apple processing is constrained by three biological features: the short production period (about 70 days per year), the low transportability and the natural astringency. In many cashew growing areas the industrial processing of cashew might not be possible because of missing infrastructure and no alternative uses of equipment for the rest of the year.

Steaming under pressure or cooking of the apples in a 2% salt solution are recommended to remove the astringency. Additions of gelatine, pectin or lime juice to the cashew juice clear it from remaining undesirable contents (Central Food 1963). Products that can be made from cashew apples are numerous and listed in Table 10. Most products are easily made. Preconditions are the availability of fresh water and a clean working environment.

Table 10: Products made from cashew apples

fresh fruits	clarified juice	jam	chutney
dried fruits	cloudy juice	wine	curried vegetable
candy	syrup	spirit	pickle
canned apple	carbonated juice		

Cashew wine is the most widespread use of the apple in non-Muslim countries. Cashew apple jam was in vogue in Europe during the 18th century (Rosengarten 1984). Dried fruits (15% of fresh fruit) are sweet and can be eaten like figs. In Senegal one kg of dried fruits was sold at 800 FCFA (appr. 3 US$) in 1989 (RUDECO 1989).

2.1.5 Cashew wood

Cashew wood is greyish-yellow, light with a specific gravity of 0.437 for stems and 0.485 for branches, slightly lighter than the rubberwood (0.543 and 0.494) (Bhat *et al.* 1990) that is now traded on the world market. The density decreases with increasing age (distance to pith) (Bhat *et al.* 1983). In Kerala the wood is used by small scale wood industries for packing cases, plywood and match manufacture (Florence 1989), for pulp (fibre length <900 æm, Bhat *et al.* 1989) and paper making (Gnanaharan *et al.* 1982). Ohler (1979) reports that cashew wood is termite resistant (because of its high resin content) and used as fence posts and in house and boat building. Cashew wood can be used as firewood but the resin provokes sparks. therefore it is not liked by cooks. It is good for charcoal (Eijnatten 1979, Maydell 1983), but it is not accepted by all users due to its light weight (75% of commercial charcoal).

2.2 World cashew trade

2.2.1 Overall market picture

Importance of cashew

Cashew nuts belong to the same market sector as groundnuts, almonds, pistachios, macadamia nuts and pecan nuts (all dessert nuts) and products used in confectionery as hazelnuts, walnuts, and Amazonia nuts. Despite the fact that cashew trees have generally a low productivity and that serious research on the crop did not start until the 1970s, they accounted for 26% (marginally less than the main nut, almonds, 27%) of the world trade during the 1962-1966 period. The share increased to the same level as almonds (26.5%) from 1971-1975 (Ohler 1979). The main competitors of cashew nuts are almonds and pistachios. Groundnuts are not in direct competition with cashew nuts because of a huge price difference. The present aggressive marketing policy of US producers could reduce the share of cashew nuts (RUDECO 1989), but alternatively India and Brazil as main exporters of cashew kernels might improve product promotion and marketing in the main markets in North America and Europe and maintain the market share.

Table 11 shows the quantity and the market share of traded tree nuts, separated for "5 major nuts" and "other nuts". Cashew had a share of 16% in 1979 to 1981 that fell to 13 % from 1989 to 1993 and ranks fourth after almonds, walnuts and hazelnuts. Compared to all traded nuts, the share fell from 6.8% in 1979-1981 to 5.8% from 1992-93 (YB92 figures). if the higher figures from YB93 are considered, the share increased to 7.1%. However, for a crop that is exclusively produced in developing countries, a share of 6% of all nuts is quite important and deserves the attention of policy makers and researchers.

Table 11: World production (Mt.) of edible tree nuts

	Cashew nuts	Almonds	Pistachios	Hazelnuts	Walnuts	Total 5 nuts	Other nuts*	Grand Total
1979-81	440 038	988 790	91 546	472 662	788 097	2 781 133	3 648 000	6 429 133
%	16	36	3	17	28			
%	6,8	15,4	1,4	7,4	12,3		56,7	
1985	426 581	1 188 327	135 772	373 909	818 256	2 944 830	3 794 000	6 736 845
%	14	40	5	13	28			
%	6,3	17,6	2,0	5,6	12,1		56,3	
1986	437 873	999 618	152 918	480 701	828 905	2 902 001	3 728 000	6 628 015
%	15	34	5	17	29			
%	6,6	15,1	2,3	7,3	12,5		56,2	
1987	398 263	1 303 024	179 877	467 351	893 331	3 243 833	4 167 000	7 408 846
%	12	40	6	14	28			
%	5,4	17,6	2,4	6,3	12,1		56,2	
1988	434 038	1 135 051	207 584	596 278	780 946	3 155 885	4 217 000	7 370 897
%	14	36	7	19	25			
%	5,9	15,4	2,8	8,1	10,6		57,2	
1989	497 742	1 305 963	213 146	743 023	933 821	3 695 684	4 581 000	8 274 695
%	13	35	6	20	25			
%	6,0	15,8	2,6	9,0	11,3		55,4	
1990	450 097	1 293 321	250 550	553 256	906 039	3 445 253	4 316 000	7 769 263
%	13	37	7	16	26			
%	5,8	16,6	3,2	7,1	11,7		55,6	
1991	542 591	1 197 895	302 794	515 007	951 995	3 512 273	4 675 000	8 185 282
%	15	34	9	15	27			
%	6,6	14,6	3,7	6,3	11,6		57,1	
1992	486 670	1 284 302	287 777	700 085	918 180	3 679 006	4 924 000	8 601 014
%	13	35	8	19	25			
%	5,7	14,9	3,3	8,1	10,7		57,2	
1993	479 804	1 194 497	345 303	565 157	1 006 547	3 593 301	4 579 000	8 170 308
%	13	33	10	16	28			
%	5,9	14,6	4,2	6,9	12,3		56,0	

Figures from FAO Production Yearbooks 1987-1993
Percentages own calculations, shaded area refers to 5 major nuts, unshaded to total nut production

Supplies of cashew

Ohler (1979) gave estimates of cashew production for the major producing countries Mozambique, Tanzania, India, Brazil, Kenya and Madagascar. World cashew nut production increases from 125000 tons in 1955 to 470000 tons in 1975 at a rate of about 6.9%/year were predicted. From 1975-2005 Ohler projected an average growth rate of 3.3%, bringing production to 1.25 million tons, excluding home consumption*. However, he expected a reduced harvest in 1978 from East Africa because of

* The production of nuts relates to nuts in shells. FAO admits that these statistics are very scanty and refer only to crops for sale. Other nuts include nuts used as dessert and table nuts as for Amazonia nuts, pili nuts, sapucaia nuts and macadamia nuts, but not nuts used as spices or for oil extraction as cola, karité and coconuts.
* Ohler mentioned growth rates or 14% for the period 1965 to 1975 and 6% from 1975 to 2005, but these percentages do not match the figures provided in the referring tables. The growth rates were reconsidered using the

infrastructural problems and adverse climatic conditions, resulting in rising prices that would stimulate replanting programmes in several other countries. In fact, cashew output from East Africa dropped from 350000 tons in 1975 to 140000 tons in 1980 (Table 12, Table 13 and Table 15).

Table 12: Cashew production (Mt.) for five major producing countries including home consumption

Country	Kenya	Mozambique	Tanzania	India	Brazil	World
Year						
1945	1 000	16 000	7 000	45 000	4 000	73 000
1950	1 000	75 000	11 000	55 000	5 000	147 000
1955	2 000	64 000	23 000	60 000	5 000	154 000
1960	5 000	78 000	42 000	65 000	5 500	195 500
1965	8 000	139 000	71 000	100 000	8 000	326 000
1970	13 000	140 000	120 000	125 000	37 000	435 000
1975	25 000	196 000	130 000	150 000	51 000	552 000
1980	30 000	180 000	142 000	177 000	93 000	622 000
1985	35 000	250 000	160 000	190 000	218 000	853 000
1990	40 000	275 000	252 000	200 000	245 000	1 012 000
1995	45 000	300 000	275 000	220 000	282 000	1 122 000
2000	50 000	350 000	290 000	250 000	317 000	1 257 000
2005		400 000	325 000	300 000	335 000	1 360 000

The figures in the shaded area of Table 12 show a scenario that could have happened if conditions had remained ideal in the five countries. Kenya and India nearly maintained the production level of the 1970s. From 1975 the civil war in Mozambique hampered nut collection, with a dramatic fall from 80000 t (1982) to 20000 t (1983). In Tanzania, the villagization program (ujamaa, started since 1974), drove farmers away from their fields (Shomari 1988) and, in addition, powdery mildew destroyed the cashew flowers which led to a dramatic drop in the cashew nut production. Brazil has increased its cashew production, but not to the estimated levels. Peak production in 1991 was followed by a drop of two thirds by 1993. Reasons for a decline in production may have been adverse weather conditions, pests. and diseases, over-aged or badly maintained plantations or simply low producer prices combined with late payment to producers. In Ivory Coast, a price increase from 15 to 25 FCFA/kg (1975-1976) stimulated an increase in the harvest from 300t to 560t (Ohler 1979). Table 13 shows various production estimates. For the years 1970 and 1975 Ohler's figures match the other sources, assuming a home consumption of 10%. However, there is a difference of 20% between FAO/E&SD (1988) and the FAO/PY (1993), of 15% between NOMISMA (1994) and FAO/PY (1993) in 1980 and of more than 20% in the year 1985. The discrepancies might result from different countries and different sources considered by the authors. Initially, 5 countries produced 95% of the of the crop (Date 1965), nowadays many other countries produce considerable amounts of cashew nuts and it becomes more and more difficult to predict a future production. In the last ten years, world production ranged from 400000 t in 1987 to 726000 t in 1992 (Table 15, FAO/PY 1987-1993), with variations of more than 200000 t from one year to another. Home consumption seems to have become more important in countries with a fast growing economy like India and Brazil. Home consumption itself can be divided into processed and traded products within a country and nuts consumed directly by the producers. Estimates of these values are even more difficult.

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values from the tables.

Table 13: Production estimates by different sources (in Mt.)

Year	Estimates Ohler (1979) excl. home consumption)	NOMISMA (1994)	FAO-Production yearbooks	FAO-Economic and Social development(1988)
1955	125 000			
1960	160 000			
1965	280 000			
1970	370 000	407 500		
1975	470 000			518 200
1980	°535 000	390 200	*446 000	367 800
1985	°750 000		**427 000	352 800
1990	°910 000	471 300	***450 000	
1995	°1 000 000			
2000	°1 120 000			
2005	°1 260 000			

estimated data
*FAO Production Yearbook 1993, ** FAO Prod. Yearbook 1987, ***FAO Prod. Yearbook 1992

Prices

Within the last 15 years, the highest price obtained for cashew kernels of the grade WW 320 was about 7 US$/kg CIF (cost - insurance - (sea)freight paid by supplier) New York in 1981 and 1986 (NOMlSMA 1994, FAO/E&SD 1988), equivalent to 1.60 US$/kg of raw nuts. The highest export prices from Tanzania, 1.385 US$/kg were also achieved in the same year (1981) leaving a margin of only 15% for the processing and transport. Such small margins may reflect government interventions in India that encourage exports (Kumar 1995), but they are not realistic in private trade.

Table 14: Trend of import and prices for cashew kernels

Year	t	US$/lb.	US$/kg
1975	95 826	1.120	2.469
1976	94 893	1.220	2.690
1977	74 685	2.120	4.674
1978	60 584	1.850	4.079
1979	68 503	1.924	4.242
1980	69 676	2.650	5.842
1981	67 064	3.157	6.960
1982	70 596	2.378	5.243
1983	63 231	1.973	4.350
1984	55 498	2.365	5.214
1985	71 596	2.425	5 346
1986	67 192	3.178	7.006
1987	65 713	3.185	7.022
1988	62 594	2.975	6.559
1989	70 599	2.458	5.419
1990	90 523	2.387	5.262

Source: NOMISMA 1994

According to RUDECO (1989) the farm gate price for raw nuts in Senegal is about 30-40% of the FOB price (free on board, supplier pays transport to the harbour and loading on the ship). In Tanzania, the price paid to producers was 25-73% of the export price (1972-1990) (NOMISMA 1994, Jaffee *et al.* 1995), whereas for producers in Mozambique the share was 65-85% of the price paid by the processors (1978-1989) (NOMISMA 1994). The FOB price for raw-nuts is based on the kernel C&F (cost and freight) price in London or New York. Taking a kernel price of 7 US$/kg (1981, 1986) the FOB raw nuts price would be calculated as follows: 7 x 50% x 22.5%* =0.788 US$/kg. If the kernel price is 4 US$/kg (1983), the FOB price would be 0.450 US$/kg. Taking the Senegalese rates, the farmgate price would be 0.13-0.32 US$/kg, in Mozambique 0.26 US$/kg were paid in 1989, 0.25 US$/kg in 1990 and 0.42 US$/kg in 1991. Experience has shown that too low prices do not encourage farmers to collect their nuts, US$ 13/kg seems to be the lower limit.

Production trends

To get a more precise picture of the recent changes and prospects in cashew nut production world-wide, it is necessary to compare the production from different countries. The data may not be very accurate, as many of them are based on estimation by FAO or other sources, but the trend of a more diverse production is clearly shown figures 2 and 3 in colour annex): 6 countries produced 98% of all cashew nuts in 1970. Today (1989-1991) the biggest producers are India and Brazil with a share of 56% of the world market. Mozambique (7%) is still the third greatest producer of cashew nuts, accounting for 50% of the agricultural exports, followed by the newcomers Vietnam (6%) and Indonesia (5%). Tanzania, Nigeria and Guinea Bissau hold equal by the sixth position with 4% each, Kenya, Sri Lanka, Malaysia and Thailand follow with 2% each. All the other countries together have 6%. In Nigeria, the crop has been neglected during the oil boom. Prices were too low and there was no incentive to harvest. When oil money became scarce, people remembered other ways of generating income and cashew was rediscovered (Udofia 1995). Guinea Bissau gains 52.8% of its convertible currency earnings from exports of cashew nuts (Arnold 1994), the increase from 660 t (average from 1966-1968, Ohler 1979) to current levels was supported by a policy that encouraged farmers to barter cashew nuts against products they needed (NOMISMA 1994). In Figure 4 the most recent available production data from 1993 are shown. Imports Review (1994) mentions Equatorial Guinea, Ghana and Guinea as sources of raw nuts, as well as the Netherlands (100 t), Pakistan (1 760 t), Singapore (610 t) and Spain (146 t). The last 4 countries do not grow cashew nuts, they act as interim traders. Musaliar (1994) mentioned that Australia had produced 1 200 t of raw nuts in 1991, but profitability can only be reached if the yields are around 4-5 t/ha due to high labour costs (NOMISMA 1994).

The export price obtained for all grades depends very much on the processing quality. The Indian processors achieved an average price of 4 835 US$/t, Brazil 4 205 US$/t, Mozambique 3 577 US$/t, Tanzania 3 673 US$/t, China 3 568 US$/t, whereas Kenya got only 3 662 US$/t or 68% of the Indian price in the period from 1989-90. Wilson (1975) states a price differential of 88 US$/t between W210 and W320 and 67 US$/t between W320 and scorched whole, unfortunately without giving a price or a reference period. Examples of prices for different grades from Brazil are listed in Table 16. The difference of 35% between SLW1 compared to W1 (320) seems to encourage selection towards larger nuts, but Wilson (1975) thinks that the market for the highest quality is narrow and prices will fall if the offer increases.

Table 16: Average price. by quality grades exported by Brazil, 1991.

Grade	Price in US$/t - FOB Fortaleza
SLW1	6967
LW1	5798
W1(240)	5578
W1(320)	5159
W1(450)	4365
W2	4916
S1	3946
P1	2557

* This calculation is based on the assumption that the FOB raw-nut-price should be at least 50% of the kernel (end product) price and on a recovery rate of 22.5%

Table 15: World cashew nut production (FAO Production Yearbooks 1987-1993)

	YB93	YB87	YB88	YB89			YB90			YB91			YB92			YB93		
	79-81	1985	1986	1987	1988	1989	1988	1989	1990	1989	1990	1991	1990	1991	1992	1991	1992	1993
Angola	1200	1200	1200	1200			1200			1200			1200	1200	1200	1200	1200	1200
Bangladesh	15	60	64	70	76	84	50	80	80	80	80	86	80			50	50	50
Benin	1087	1200	1200	1200			1200			1200			1200	1200	1200	4000	1500	1200
Brazil	71333	111800	120000	75000	142867	177719	133335	136130	168916	143991	99367	193002	107664	175628	96757	185965	107955	62421
Burkina Faso	367												1074	1000	1000	1000	1000	1000
China	5967															9500	9700	10000
Dominican Rep.	870	910	920	920			920	926	931	930			930	930	930	930	930	933
El Salvador	2208	2162	2208	1895	1872	1900	1858	1900	1900	2024	1900	2000	2098	2000	2000	2000	2000	2000
Guadeloupe	3	4	4	4			4											
Guinea Bissau	3833	8500	9000	10000			10000	10000	10000	17000	20000	20000	30000	30000	30000	20824	30000	30000
Honduras							300			344			350	350	350	350	350	350
India	159000	151800	159000	150000	130000	165000	130000	150000		150000			130000	140000	150000	294589	350000	150000
Indonesia	10094	25887	25000	24660		28500	26000			28000	30000	30000	27991	29683	30533	29683	30533	32000
Ivory Coast	750	3500	6000	6000			6000			6000			6000	6000	6000	9000	10000	10000
Kenya	15763	10000	10790	10000		10000	12000	10000	12000	12400		15000	7000	15000	15000	15000	15000	15000
Madagascar	3400	4000	4100	4200			4300			4400			4500	4600	4700	4600	4700	4800
Malaysia	4267	335	290	290	300	324	9860		14400	13546			10000	11000	12000	11000	12000	12000
Mali	248																	
Mozambique	69400	25000	30000	35000		40000	40000			45000			49000	40000	40000	31000	54000	54000
Nigeria	25000	37000	37000	37000	37000	37000	3000	3000	3000	25000			25000	25000	25000	25000	25000	25000
Phillippines	3752	3873	4275	5350			6114			6500			6800	7000	7200	3686	4000	4000
Senegal																3000	500	500
Sri Lanka	8400	950	1222	9184		10000	10892		10400	9771			10000	10000	10500	10000	10500	11000
Tanzania	54181	32400	19200	18490	22470	22000	24285	19275	20000	20000	28000	33000	17060	29850	40150	29850	40150	37000
Thailand	4867	6000	6400	7800	7800	7800	12500	10000	8500	10000			11850	11850	11850	15000	15000	15000
Togo					250	250	200			356			300	300	300	356	350	350
Total	446005	426581	437873	398263			434038			497742			450097	542591	486670	707583	726418	479804

Relevant are the first columns for each report, the other columns where left in to illustrate the changes in the estimations over the years and the progress of some countries.

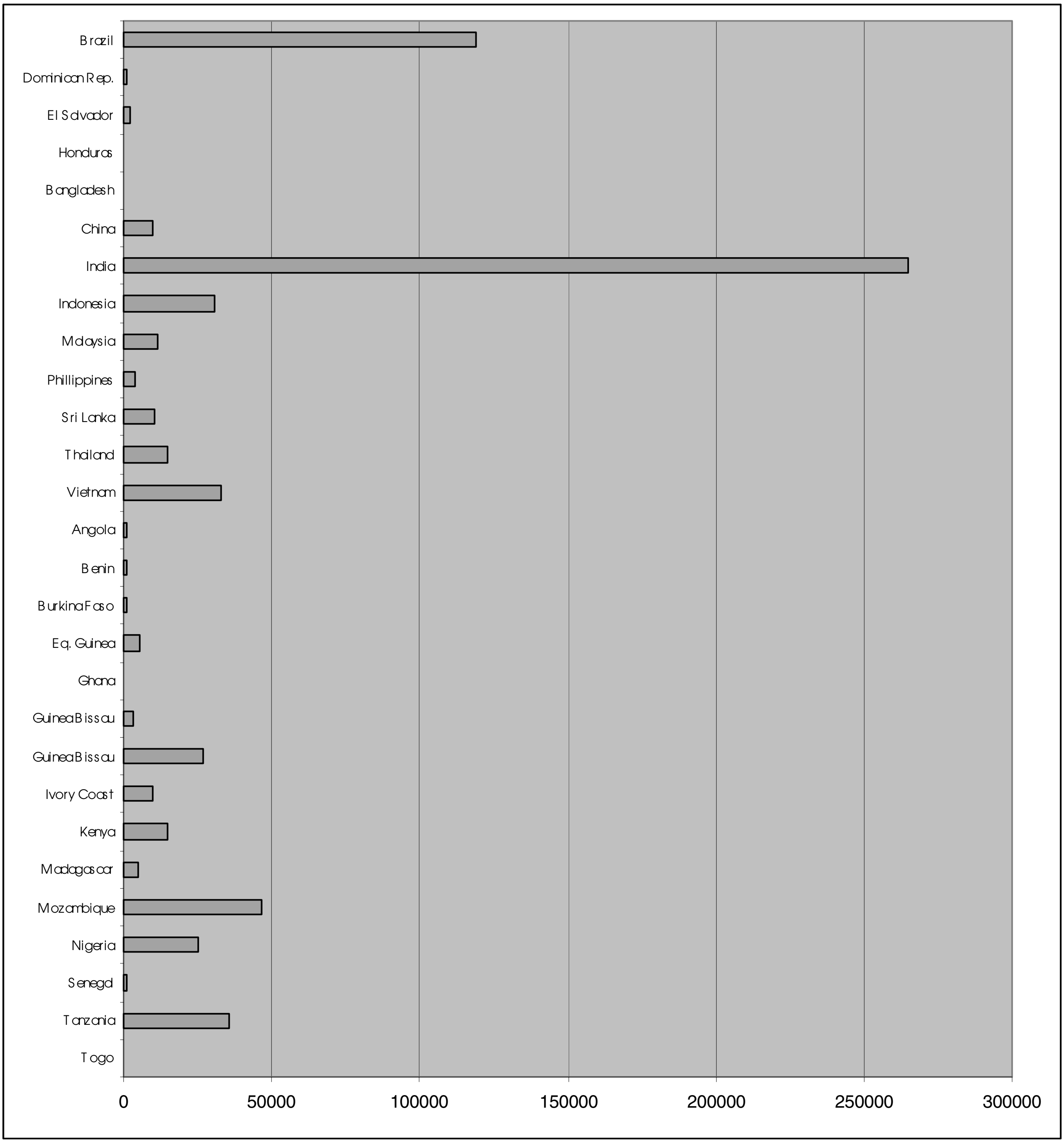

Figure 4: Cashew nut world production In t per country. (Average 1991-1993)

2.2.2 Cashew products: The market view

Processing industry

Until the 1960s India had a quasi-monopoly on export of cashew kernels and the Indian specifications have become a norm on the world market (Date 1965). Mozambique was the first country to set up its own processing factories (in 1960), followed by Tanzania, where the TANITA factory in Dar es Salaam was set up in 1965 (Ohler 1979, NOMISMA 1994). Despite massive investments in processing factories in Africa with financial aid from the World Bank, Italy or Great Britain, these produced low quality products or have failed for several reasons:

- the management was appointed from the government and was often unfamiliar with the industry,
- supplies of raw nuts were inadequate because of too low prices (Senegal),
- ineffective staff training and poor running of the machinery,
- bad nut-grading and neglect of sanitary measures.

Even when everything went well in the beginning, political interference sometimes hampered profit making. When plants needed repair, spare parts were often missing. The factory in Senegal only worked for 1 year, 2 of 12 factories in Tanzania did not even achieve test runs. From the remaining 10, 7 are currently not working and 3 operate only at low capacity (Jaffee *et al.* 1995). With this picture in mind, and the possible profits for the various national economies, Kumar (1995) suggests the installation of small scale Indian equipment in African producer countries. This equipment is cheap and its use labour intensive. He is also of the opinion that they should produce for the European market, mainly because of the ACP- trade agreements that could facilitate market access.

Trade in cashew kernels

Contrary to raw nuts, cashew kernels are traded in pounds (1b.), because of the traditional American market, Standard specifications for Indian cashew kernels have been laid down by the Indian government under the Export Act of 1963 (Commercial information 1994). Kernels are classified according to physical properties and weight. Whole white kernels are the best, followed by splits, bits and pieces. International price quotations are based on the most common Indian output, whole whites, 320 kernels per lb. (705/kg), referred to as WW320, W320 or count 320 (Wilson 1975*)*. Formerly, the largest whole nuts exported from India (250/lb., 550/kg) were called "jumbos" and the largest nuts from Brazil *(*150/lb., 330/kg) 'mammoths'[*]. The Indian standard and the Brazilian standard were combined in the ISO 6477 standard in 1988 to unity the classification for cashew kernels. The most important details are shown in Table 17. For more information NOMISMA (1994) should be consulted.

Consumption

The USA was the first country to import small quantities of cashew nuts from India in 1905 while real trade began in 1923 when 45 tons were shipped from India to the USA, The first load was infested by weevils when arriving in New York and no further shipments were made until 1928, when airtight containers filled with carbon dioxide gas were used to keep the nuts in good condition. Cashew kernel exports from India mainly to USA increased to 18000 tons in 1941. Small quantities were shipped to the UK and the Netherlands. The war interrupted exports until 1943, when the USA linked the import of 1½ lb. (0.681 kg) kernels with the supply of 1 lb. (0.454 kg) CNSL to be used for break linings for war vehicles. Unrestricted cashew trade resumed in 1944 (Ohler 1979). The USA-need for CNSL also gave a fillip to commercial production and processing in North East Brazil (Parry 1970).

From 1966-1971, an average of 72 800 t (ITC 1973) to 74 300 t (Mathew *et al.* 1983) was exported. In the 1970s, the USA (40000 t) and the USSR (18000 t) were the main importers of cashew kernels, the latter mainly because of bilateral trade agreements with India who paid industrial goods with cashew kernels (ITC 1973). Other major importers over the same period were Canada (3100 t), United Kingdom (2 500 t), GDR (2300 t), Australia (2 100 t), FRG (1 500 t), Japan (1000 t), Belgium, New Zealand and Sweden (600 t total) (ITC 1973). Since the 1970s, the world import of cashew kernels has changed as much as the nut production. The major importing countries and the quantities imported are shown in Table 18. The import level reached in 1990 was the highest for most countries (except USSR) since 1980. The latter had its highest imports (30029 t) in 1975 and the lowest (108 t) in 1984 and is thus not a very reliable importer. The USA (49257t), Canada (6583 t) and Japan (6599 t) also reached peak imports in 1976 (NOMISMA 1994).

[*] Parry (1970) refers to Brazilian cashew kernels as Jumbo and Extra Jumbo, Morton *et al.* (1972) report a “Jumbo” clone in Trinidad.

Table 17: classification of cashew kernels (NOMISMA 1994)

1. General classification: Cashew kernels shall have been obtained by shelling and peeling cashew nuts *(Anacardium occidentale* L.*)*				
2. Special classification:	Indian/African grade	Brazilian grade	No. of kernels/lb.	No. of kernels/lb**
A: W, white wholes: they must be kidney shaped, free from infestations, insect damage, mould, rancidness, testa residues extraneous material; white, pale ivory, or ash coloured; corrugated kernels are allowed if the kernel shape is not jeopardised. Up to 5% lower category is accepted		SLW1	160-180	
	W 180	LW1	180-210	120-180
	W 210	W1	180-200	190-210
	W 240	W1	200-210*	220-320
	W 280	W1	220-240*	
	W 320	W1	260-280*	400-450
	W 400		300-320*	
	W 450		350-400*	
	W 500		400-450*	
			450-500*	
B: SW: Scorched wholes as above, pale or dark ivory, slightly burnt due to scorching	SW 180-SW 500	SL, W2, WW2, W2	as above	
C: Dessert cashew kernels				
Scorched wholes seconds, as above, but scorching, small spots and fading are allowed	SST	W3		
Dessert wholes, as above, but fading, scorching, black spots and corrugations are more evident	DGW	W4		
D: White pieces				
Butts: white kernels broken crosswise and cotyledons attached	B	B1		
Splits: white kernels split lengthwise	S	S1		
Large white pieces, kernels broken into more than 2 pieces that do not pass a ¼ inch mesh sieve	LWP	P1		
Small white pieces as above, not passing through a 1/10 inch mesh sieve	SWP	SP1		
Baby bits plumules and broken kernels, not passing through a 1/14 inch mesh sieve	BB	G1		
E: Scorched pieces Several divisions	SB, SS, SP, SSP	B2, S2, P2, SP2		
F: Dessert pieces Several divisions	SPS, DP, DSP	P3		

* figures from Wilson (1975), ** Codex Committee (1985)

A more differentiated picture of cashew imports is shown by the Indian Cashew Journal (Increased Export, 1994). The Indian exports to USA increased from 6785 t in 1990191 to 24487 t in 1992/93, the exports to CIS (USSR) decreased from 21349 t to only 46 t during the same period. Compared with the figures from NOMISMA (1994), there was apparently an increase from 1990 to the period 1990/91 referred to by the Indian Cashew Journal. It is very probable that the CIS will come into the market again as their economy recovers. Other countries that imported an average of over 50 t in the period 1990/91 to 1992/93 cashew kernels from India are Lebanon (55 t), Italy (56 t), France (60 t), Spain (61 t), Korean Republic (86 t), Bahrain (121 t), Kuwait (132 t), Saudi Arabia (163 t), Israel (229 t), Taiwan (333 t), Canada (369 t), Poland (560 t), Czech Rep. (912 t), U.A.E. (1077 t), Hong Kong (1234 t) and Singapore (1 547 t) and others (296 t), totalling 7231 t or 14,4% of the Indian export (Increased Export 1994).

RUDECO (1989) predicted that an increased production could be taken up by the market if the price fell from 5500 US$/t to about 5250 US$/t, citing an unnamed leading nut processor. Currently, the prices are

Table 18: Cashew kernels imports into major markets (Mt.)

	1988	1989	1990	Average 1989-91
Australia	2 014	2 720	2 808	2 930
Belgium	362	295	363	
Canada	3 299	4 377	4 730	4 309
France	1 176	1 065	1 202	
Germany	3 380	3 261	3 737	3 661
Japan	3 718	3 783	4 303	4 520
New Zealand	324	350	350	
Netherlands	2 883	3 058	3 873	3 669
Sweden	65	70	70	
UK	4 212	4 855	5 100	4 919
USA	38 016	41 338	54 600	48 372
USSR/CIS	3 151	5 849	9 807	3 328
Total	64 582	72 590	92 513	75 708

Source: columns 2, 3 and 4 NOMISMA (1994), column 5 Jaffee *et al.* (1995)

at 5200 US$/t (Kumar1995) and apparently the market could cope with the increased quantities in 1991 and 1992. As the economies of the so-called "Tiger Nations" of South East Asia develop very fast, their demand will probably increase. The same can be predicted for China and Latin America. Home consumption in the producing countries might rise as well and countries with fast developing economies might abandon or decrease their cashew production. Therefore it seems still worthwhile to develop the cashew industries in countries that have appropriate growing conditions.

Trade in CNSL

Table 19 below shows the trend of CNSL exports and imports during the past 30 years. The quantities entering the market have risen steadily, but the price varies enormously, from year to year and from export country to export country. The highest earning for CNSL was 1510 US$/t, achieved by Tanzania in 1979 (mean 1367 US$/t). 1979 was also the year of peak export with a total of 36350 t. The lowest price (10 US$/t) was paid to Mozambique in 1984 (mean 313 US$/t) (NOMlSMA 1994). Higher prices stimulate the recovery of CNSL by the shelling factories, and the future of the market will depend on other uses than friction dust. Indian CNSL fetches higher prices (by 10-70%) than CNSL from other countries.

Table 19: CNSL export, import and mean price (in t)

	CNSL export					CNSL imports (major markets)			Price** in US$
Year	India	Brazil	Mozambique	Tanzania	World	USA	UK	Japan	
1962	7 400	800	1 400	0	9 600	5 393	2 559	1 128	350
1967	9 400	1 600	3 700	600	15 300	7 789	4 284	2 518	180
1972	5 000	7 300	12 200	400	24 900	12 232	4 984	5 279	175
1977	2 970	7 600	10 000	870	21 440	10 625	5 937	5 396	336
1982	5 800	6 700	7 100	2 000	21 600	6 518	4 559	7 137	205
1987	5 500	15 250	3 500	0	24 250	9 513	5 813	4 705	459
1990	4 400	26 300	1 700	0	32 400				298
1994	3 482								287

Sources: Wilson (1975), NOMISMA (1994), RUDECO (1989),
** All time record (1995) - data only available for India
* Mean fob price (listed) for CNSL entering the world market, prices per country differ.

The main importing countries are USA, UK and Japan, but South Korea, The Netherlands, Spain and Mexico are other main importers of CNSL (RUDECO 1989, NOMISMA 1994). India used a total of 6900 ton their own in 1978 and there is active research to increase the use of CNSL in the country (Murthy *et al.* 1984).

2.3 Cashew nut processing methods

The raw nuts should be sun dried for one to six days (Nair 1984) to reduce moisture content from about 25% to 9% or less for safe storage and to mature the seed through the infra red and ultra violet rays of the sun. Correctly dried nuts are pinkish in colour and when shaken together will make a sharp rattle. No impression can be made with a thumb nail into the exocarp (Russell 1969). They should only contain few impurities (0.25% Tanzania; 1% Mozambique) (Ohler 1979), and not more than 10% of the nuts should be damaged (RUDECO 1989). Dry raw nuts can be stored under dry conditions for at least 2 years (Morton *et al.* 1972) without losing their flavour, but they are generally processed within one year of harvesting. Kumar (1995) mentions that 3 year old stocks are of inferior quality for processing.

The decortication of cashew nuts is hampered by CNSL contained in the honeycomb structure of the mesocarp. CNSL blisters human skin unless precautions are taken and it will spoil kernels on contact.

In traditional artisanal cashew processing the nuts are put in an open pan over an open fire and stirred continuously to avoid scorching (Tropical Products Institute, 1961) until they start burning, then they are thrown on to sand to be extinguished and to remove the remaining liquid on the outer skin (Behrens 1993). In industrial processing the nuts are graded in different size classes and rehumidified to about 16% moisture by spreading water over them for about two days to make the kernel elastic and to fill the cells of the shells with water. Then they are "roasted" in a "hot oil bath" (CNSL) that is heated to 192ºC for about 90 seconds, depending on the size of the nuts. Ohler (1966) mentions other methods as steam processing at 270ºC, quick roasting in rotary ovens at 300ºC or cold methods that involve peeling of the outer shell, but these methods did not gain wider acceptance. Through the roasting process the cells of the mesocarp and the endocarp break and about 25% of the CNSL contained in these tissues flows into the bath. The remaining liquid on the outer shell is removed with sawdust. Both methods, the artisanal and the industrial, make the shells brittle so that they can be broken easily.

Another method to avoid contamination of the kernel with CNSL is to deepfreeze the nut and split the shell while frozen. This is a method suggested by R. Ralseier, a Swiss engineer, who developed a cashew shelling machine (Widmer & Ernst, later Buhier, currently Oltremare (Ohler 1995) that cuts the shell by two specially designed horizontally mounted sawblades The nuts are held by two rubber belts that hold and convey the nuts to the sawblades and consequently to two small wedges that separate the shell halves. The freezing method works and produces white kernels from which the testa can easily be removed. Disadvantages lie in the high cost of freezing and the fact that nuts and shells cannot be separated by air-blowing because they have the same specific weight. Nevertheless, with modern, laser operated separation equipment this might be a good method to produce very large white kernels for the luxury market. The quality of CNSL obtained through this type of processing is much more uniform than through hot-oil-processing (Ohler 1995).

There are different methods for manual cashew shelling. The most simple consists of placing the prepared nuts on a stone and using a hardwood stick to crack the shell. An average sheller can shell 10 nuts per minute or 21 kg/day yielding about 5 kg of kernels. Experienced shellers in India can shell twice as much with 90% whole kernels. Semi mechanised processes using a pair of knives shaped in the contour of half a nut were developed in Brazil and India. The equipment is simple and allows two persons to produce 15 kg of kernels/day (Ohler 1979).

The Italian Oltremare system and the Japanese Cashco systems used the knives in an industrial plant. The nuts are forwarded on a chain and automatically cut. In the first system the nuts are fed in by hand and the knives twist after coming together and separate shell from the nut. The latter process is fully automatic and uses pins for separation. Theoretically, 85-90% whole nuts are obtained by Oltremare and 75% by

Cashco. The Swiss system combined with traditional roasting can also obtain 90% whole kernels. A British system developed by Fletcher and Stuart in co-operation with the Tropical Products Institute (IPI, now National Resources Institute, NRI) works with centrifuges to crack the shells. Shells and kernels are then separated in an air stream, heated shells are lighter and blow away. The method can, under perfect operation, obtain up to 75% whole kernels. The advantage of this system is its simplicity it was specially designed for local maintenance in developing countries.

After shelling, the nuts have to be dried to about 6% moisture content, thereafter the testa can be peeled off easily. They are then graded to the different categories described above, rehumidified to 8% and packed in 25 lb. (11.34 kg) tins (or other airtight containers), filled with CO_2 and sealed. The CO_2 inhibits infestation by insects and is slowly absorbed by the nuts thus producing a vacuum that prevents shaking and breaking of the nuts during transportation.

4. Cashew cultivation

This chapter covers five topics related to cashew in the field. These are: objectives of growing cashew (4.1), cashew agronomy (4.2) that is subdivided as appropriate and three shorter sections about socio-economic considerations (4.3), selection (4.4) and vegetative propagation (4.5).

4.1 Objectives

The first cashew plantations in many countries were established by the forest departments as an easy way of afforestation. Cashew trees in India were planted for the protection of coastal dunes, sometimes in combination with *Casuarina equisitifolia* R. & G. Forst and *Cocos nucifera* L. (Patro *et al.* 1979) and for wasteland recovery (Chopra 1990, Chowdhury 1992), almost exclusively on poor soils unsuitable for other crops. In Brazil, plantations exist with more than 40000 ha (Rudat 1995). In the countries south of the Sahel with 600-800 mm annual rainfall, cashew is important as a tree to counterbalance desertification. Plantations under forest department management reached sizes of more than 200 ha., but farmers individually have only about 1-2 ha under cashew. Main objective for farmers is additional income from cashew (H. Ohmstedt 1991, Musaliar 1994). Table 26 shows cropping systems in different countries. Yields are very low, except for Kerala where >1000 kg/ha are achieved because of good soils and enough water. Reasons for low yields lie in no genetical improvement, use of unselected planting material, poor management, poor soils and unstable climatic conditions.

Table 26: Cropping system and yield of cashew in selected countries

Country	Plantation size (ha)	Spacing (m)	Objective	Intercrops	Yield (kg)
Mozambique	plantation: farmers 0.3	12 x 12	fruits	y	100-150
Senegal	forest >50 “ “ 1 ha farmers	3 x 3, contour 1 m in rows 3 x 3 12 x 12, 5 x 2	 wind breaks village wood fruits	n y n y	100-150 <2000 100-150 400-500
Tanzania	farmers <1	12 x 12, 14 x 14	fruits	y	400-500
India Kerala Karnataka Tamil Nadu Tripura Other	farmers	7 x 7, 9 x 9, 7.5 x 7.5, 10 10	fruits waste land recovery erosion control	y*	348 1058 336 126 100 221

* Intercropping is advised in the first two years after establishment

4.2 Agronomy

4.2.1 Soils and climate

Cashew suffers from its image of thriving on the poorest soils where no other crops can give an economic return. As a result, the worst soils are chosen for cashew. The yield potential has never been evaluated on good soils. In typical poor cashew sites, yields are low, even with good genetic material (Ohler 1979). The interdependence of soil conditions and water availability has been confirmed by several authors. Venugopal *et al.* (1991) stated that temperature, humidity and sunshine hours prevailing in different cashew growing regions in India do not appear to influence the yield of cashew as compared to rainfall distribution. The criteria listed in Table 27 represent only the most suitable conditions. Cashew can grow beyond these and even on lateritic soils -provided there are no crusts - this crop does well. Because of this Mathew (1984) suggests blasting lateritic crusts with explosives to make them permeable for cashew plantings. It also tolerates shallow soils (Plate 8) and altitudes up to 1000 m. However, it will not tolerate stagnant water or arid conditions (mean annual rainfall <600 mm) without supplementary water supply (Ohler 1979).

Table 27: Criteria for land suitability classification for cashew

	Characteristics	Suitable conditions
Soil	Soil texture (surface)	fine sand - sandy loam - silt loam
	Soil texture (subsoil)	fine loamy-coarse loam
	Coarse fragments in the soil	<20%
	Soil depth	>90 cm
	Salinity	<1 mmhos/cm
	Soil reaction	pH 5.6-7.3
	Water holding capacity to 1.80 m	> 14 cm
Topography	Slope	<5%
	Rockiness	< 10% of rock exposed surface
	Stoniness	<3%
	Altitude	<600 m
Drainage	Water table dry season	2-6 m
	Water table rainy season	1.5-4 m
	Depth of impermeable substratum	>5 m
	Soil drainage	well to moderate

Detailed land classifications were made by Mishra (1985a&b) for Orissa (India) and by Zech *et al.* (1992) for Senegal. Five site classes were determined, depending on soil and rainfall. Table 28 shows the example of Senegal where 13 principally suitable soil classes in different regions were assessed. Unsuitable soils (not mentioned in the table) are all soils with low depth (<90 cm), stagnant water during the rainy season, lateritic crusts that reduce the potential rooting volume and soils with >42% clay and high bulk density (> 1.95 g/cm^3)

Field studies in Senegal (Krebs 1991) confirmed that available water was the limiting factor for cashew growth, despite low soil fertility. The annual precipitation and the potential root depth are significantly related to growth and Krebs concluded that soil depth should be 220 cm under precipitation of 600 mm/year to a minimal depth of 90 cm under 1400 mm/year (Table 28). Acute deficiencies in mineral nutrition were not found in the cashew trees, although the above mentioned soil types are not regarded as particularly fertile.

Table 28: Evaluation of potential cashew sites in 4 climatic zones in Senegal

Climatic zone →	1	2	3	4
Soil ↓	< 600mm	600-800 mm	800-1000 mm	> 1000 mm
A) Ferrogenous tropical soils slightly lessivated				
1. Quartz rich sands	II*-III	III		
2. Clay sands		III		
3. Clay sands, shifted		III		
B) Ferrogenous lessivated tropical soils Ba) Soils without or with few rusty patches				
4. Lessivated clay sands		III-IV		
5. Lessivated quartz rich deep soils		II		
6. Alluvial lessivated soils, gley in lower horizon (salty)		III		
Bb) Soils with rusty patches and Fe/Mn concretions				
7. Lessivated clay sands rich in Fe/Mn concretions		III-IV	II-IV	
8. Lessivated sands or clay sands rich in Fe/Mn concretions		III-IV	II-IV	
9. Lessivated sands rich in Fe/Mn concretions from granite				II-IV
Bc) Lessivated soils with Fe/Mn concretions and crusts				
10 Lessivated clay sands rich in Fe/Mn concretions and crusts			III-IV	II-IV
C) Slightly ferralitic soils				
11. Slightly ferralitic clay sands		II	II	I
12. Slightly ferralitic colluvial sands			II	
D) Raw mineral sediment soils				
13. Deep quartz sands (dunes)	II*, V			

I = very good   II = good   II* = good if groundwater can be reached by roots in 2-3 m depth
III = suited   IV = suited with limitations   V = unsuited

4.2.2 Field establishment

Direct sowing
Direct sowing in the field is possible if the annual rainfall is above 800 mm/year. Planting holes (30 x 30 x 30 cm) can be dug before the rainy season to allow water to be held while it infiltrates. Top soil mixed with manure [if termites are not attracted by organic matter (Ohmstedt 1991b)] should be filled in the hole. In fertile sandy loam soils this is not necessary. Usually 3 seeds are sown per site in upright positions, the 2 smaller seedlings are removed after a certain period, depending on the growing conditions, but at the latest before the next rainy season.

Table 29: Mean percentage of survival 2 month after transplanting

Age of seedling (month)	No. of batches transplanted	Percentage of survival	
		Range	Mean
one	12	60-100	95
two	11	20-100	66
three	10	0-60	34
four	9	0-100	33
five	8	0-80	28
six	7	0-20	10
seven	6	0-40	14
eight	5	20-80	60
nine	4	60-100	84
ten	3	80-100	94
eleven	2	100-100	100
twelve	1	80	80

Planting
Successful transplanting of cashew is possible, even if they were not sown in containers. The success rate of transplanting bare rooted seedlings varies with the age when it is done. The best results were obtained 11 month after sowing with shoots that had been cut back to half or to a third of their original length (Hassan *et al.* 1957, Table 29). Today, cashew are sown mainly in plastic containers or tubes with a diameter of 6-8 cm and length of 20-30 cm. Transplanting is done after 2-3 months, except for grafted seedlings which are transplanted after 4 months, without major setbacks. The water supply should not be interrupted during the 2 weeks immediately following transplanting.

Spacing
Spacing of cashew for fruit production should consider root growth and canopy growth and not be too densely planted depending on the site. On good sites roots grow 4-6m from the stem in 2½ years, extending outwards about twice as far as the canopy itself (Ohler 1979, Satpathy *et al.* 1986). The number of trees/ha varies with the objective and conditions and range from 42 to 2500. Mathew (1982) favours high initial densities (1000 trees/ha) for early high yields/unit area, followed by selective thinning from the seventh to the twelfth year with a final density of 200 trees/ha. Ohler (1979) supports this. This method might be good for plantations, but farmers do not cut productive fruit trees. Therefore the current recommendation on farmers fields in Tanzania is a spacing of 14 m x 14 m combined with intercropping (ODA 1995). In Senegal farmers use distances of 5 m x 20 m with intercropping (Behrens 1988).

4.2.3 Interventions

Protecting cashew plantations
Young cashew trees are very vulnerable to damage by animals. In areas with a pronounced dry season they are often the only green plants in the field and therefore an easy target for wild and domestic animals. The Senegalese-German Cashew Project (PASA) used barbed wire fences to protect the fields, with a cost of 70000 FCFA/ha (appr. 240 US$) for a 4 ha plantation. The high cost finally stopped this way of protection and farmers were urged to use fences made from local material (Table 30). Vegetal fences from different plant species (thorns or palms) are also recommended as cheap and efficient protection of cashew plantations in India, to be preferred to barbed wire or trenches (Satpathy 1986).

Another problem is the protection of cashew from wind damage of trees (Satpathy 1987) and/or flowers (Krebs 1991). Windbreaks with species like *Azadirachta indica* Juss. and *Senna siamea* (Lam.) Irvin & Barley are proposed to reduce such damage (Sapathy 1987).

Fertilisation
Cashew responds well to fertilisers (Ghosh *et al.* 1986) if the ecological conditions are adequate. In a fertiliser trial in Senegal on 20 year old trees with 600 mm rainfall no reaction could be found to several doses of NPK applied at the beginning of the rainy season. On trees growing on poor soils fertiliser certainly has a positive effect (Table 31). The findings from Ghosh (1989) that the nut quality was improved, are interesting for processors as it could increase their margin. The dosages depend on the site conditions and have to be determined for each locality. Mathew (1982) suggests applying recommended fertiliser dosage on intercrops and adding the quantity needed for cashew, as farmers rarely fertilise the cashew trees alone

Weeding
Weeding (circles about 2 m in diameter around the tree) of cashew until taller than the weed community of the area is absolutely necessary to facilitate initial growth. If the tree grows vigorously, weed growth under the crown will be suppressed after 3-5 years and weeding is only important to facilitate nut collection and to prevent fire damage.

Table 30: Protection of young cashew trees with local material

Method	Comments
Individual protection	
Gabions made from branches, 70-90 cm high, 40-45 cm diameter	Too dense, no air circulation, seedlings suffering, termites
Gabions made from palm leaves 120-135 cm high, 60-65 cm diameter	Good if woven with wide spaces, resist 3 years, best plant development
Thorny branches around the seedling fixed like a tent	Cheapest method, good protection
Thorny branches around the seedling fixed on supporting sticks	Better than above, because fixed in the soil
Circle planted with 10-15 *Jatropha curcas* L	Not very efficient (60%)
Circle planted with 10-15 *Euphorbia balsamifera* Ait.	90% cashew survival
Life hedges around the field, immediate protection	
Euphorbia balsamifera cuttings planted in one row, 15 cm between plants, with support	98% recovery, 80-120 cm high, 70-125 cm deep
Euphorbia balsamifera cuttings, one row, *Agave sisalana* one row	Combination improves protection
Jatrropha curcas one row	99% recovery on light soils, good protection after 1 year
Jatrropha curcas one row, *Agave sisalana* one row	Combination improves protection
Life hedges around the field, protection after 2-3 years	
Agave sisalana one row	95% recovery, 35-70 cm high, 30-85 cm deep
Agave sisalana one row, *Parkinsonia aculeata* L. one row	Combination improves protection
Parkinsonia aculeata in one row	88% survival, 40-100 cm high, 60-120 cm deep
Ziziphus mauriuana Lam. in one row	preferred by farmers, low recovery (42%) 20 cm high

Table 31: Fertiliser recommendations for cashew trees

Author	Fertiliser dosage (g/tree/year) and application	Effect
Mahanthesh *et al.* (1994)	500 N, 100 P,250 K, 1 application	produced highest yield of cashew apples,
Mathew (1982)	250 N, 125 P, 125K, 1 application	raised nut yield level from 5 kg to 8 kg/tree
Khader (1986)	500 N, 125 P,125 K 2 applications in 2 m radius from stem	early and higher yields
Radhakrishna *et al.* (1993)	500 N 125 P, 125 K applied in circular trench, 25 cm deep at 1.5 m from trunk	significantly higher yield compared to other methods of application
Badrinath *et al.*(1988)	500 N, 250 P, 250 K, 2000 Ca, 50 Zn (foliar spray)	raised yield from 5.3 kg (250 N, 250 P ,250 K) to 8 kg/ tree
Ghosh (1989)	500 N 200 P, 200 K :	flowering period increased, number of nuts increased, nut yield (weight) increased, kernel percentage increased

Pests and diseases

Ohler (1979) describes 21 diseases and nearly 100 pests on cashew nuts. Some are of local importance, others are widespread. Powdery mildew *(Oidium anacardii)* affects cashew flowers in vast areas in Tanzania, reducing yield by 80% (Tsakiris 1990). Selected diseases are listed in Table 32. The tea mosquito *(Helopeltis antonii* Mill.*)* and its close relatives *H. shoutedeni* Reut and *H. anacardii* Mill. belong to the most important insect pests in India and Africa. They have a number of host plants and this complicates the control. Cotton is the main host for *H. shoutedein* and should therefore not be interplanted with cashew (Ohler 1979). Selected pests are listed in Table 33. It is useful to screen pests and diseases when embarking on a large planting program to minimise later damage.

Table 32: Selected major cashew diseases (1980-1994)

Disease	**Damage caused**	**Treatment and comments**	**Country**
Anthracnosis *Glomerella cingulata* (Stonem.) Spauld. et Schrenk (syn. *Colletotrichum gloeosporiorides* Penz.)	Most common pathogen, attacks shoots, reddish brown shiny lesion, can kill trees	fungicides and foliar fertiliser, copper hydroxide	Tanzania, Malaysia
Powdery mildew *Oidium anacardii* Noack	Attacks inflorescences, causes losses of 50-70%	Varietal differences observed. Treatment with sulphur powder at offset of flowering and twice more, removal of mildew harbouring tissues (water shoots)	Tanzania
Blossom blight *Glomerella cingulata*	Petals turn black, floral shoot dies starting from tip	Fungicides	Malaysia
Die-back *Phomopsis anacardii*	Young vegetative shoots die from tip downwards	Fungicides	Malaysia, Tanzania
Bacterial wilt *Pseudomonas solanecarum* (E.F. Smith) E.F. Smith	Root rot and leaf fall, death of tree		Indonesia

Table 33: selected major cashew pests (1980-1994)

Pest	Damage caused	Treatments and comments	Country
Tea mosquito *Helopeltis antonii* Signoret	Sucks on new shoots and nuts, causes black lesions and die-back. Wound pathogens enter through lesions, die-back caused by *Botryodiplodia theobromae* Pat.	Varietal differences in attack observed, seasonal differences, various insecticides, single and in combination, application includes aerial spraying, egg parasitoids and ants feeding on nymphs were found	India Goa Karnataka Kerala Maharasthra Tamil Nadu West Bengal Sri Lanka China Hainan
H. anacardii	As above, occurs on newly formed shoots	Increased where water is available	Brazil, Bahia Senegal
Tree borer *Plocaederus ferrugeneus* L.	Eggs laid in bark up to 1 m from the ground, larvae feed on bark and wood, interrupt sap flow, branches on trees can die	Up to 25% of trees affected (SL), chemical soil treatment, manual killing of larvae, severely attacked trees to be destroyed	Sri Lanka Andhra Pradesh, Karnataka Kerala, Tamil Nadu
Selonothrips rubrocintus Giard	Attacks seedlings, young leaves, older leaves, shoots, inflorescences, flowers	Threshold for treatment: 240 adults on 6 weeks old seedlings	Nigeria Trinidad
Scirtothrips dorsalis Hood	Cause premature shedding of flowers	Feeds also on *Prosopis*, *Acacia*	Goa
Lamida moncusalis Wlk.	Webs leaves and flowers together		Tamil Nadu Goa
Hypatima haligramma (Meyr.)	Pupation inside folded leaves, caterpillar feeds on unfolded leaves	Insecticides	Goa
Cashew whitefly *Aleurodicus cocois* Curt.	Live on underside of leaves, larvae produce wax, leaves fall	Biological control, organosynthetic insecticides	Brazil, Cera
Leave miner *Acrocercops syngramma* Meyr.	Larvae mine tender leave, 26-80% trees infested	Insecticides	India Tamil Nadu Goa
Nephopteryx spp.	Larvae move to joint of apple and nut, spoil both	Insecticides	India, Hainan
Carpenter moth Salagenea sp.	Larvae feeds on bark and bores galleries in wood	Removal of larvae, pruning, insecticides	Zambia

4.3 Selection and breeding

The priority in cashew selection is to find germplasm having the capacity to yield as many nuts as possible of an acceptable size and above average kernel content under local conditions. This implies that a tree (clone, line, variety) that does well under specific conditions may not be as good under other conditions. Therefore it is important to select within the environment where the cashew trees will be grown - from healthy high yielding trees.

Table 34: Parameters for the selection of mother trees

Parameter (Manoj *et al* 1993)	Indicators or minimum requirement
Growth	height, girth, canopy spread, compactness, (leaf area)
Flowering	Duration (short or long), period (early or late), panicles/canopy area, flowers/panicle, %perfect flowers, "high" fruit set
Nut production per tree	depends on size of tree, (see table 35) number of nuts/panicle better: yield per CGCA* >250 g/m^2
Nut size	>5, better 6 g or more
Nut shape	regular, flat, no hollows
Kernel content	>25%, better >30%
Protein content	18-40 %, not essential
Disease resistance	Powdery mildew, Anthracnosis
Pest tolerance	*Helopeltis* spp.
Apple qualities	Weight, colour, shape, juice content, sugar content, taste

* CGCA = Canopy Ground Cover Area (see page 70)

The simplest selection method is to throw the nuts in water and to select only those that sink. Auckland (1961) found that nuts with a density of >l.025 g/cm^3 (sinking in a solution obtained by dissolving 71 g sugar per l water) germinated faster, had a higher survival rate and produced more vigorous plants and more flowers in the first season than nuts below this density. Nuts that float in water should be discarded. A better selection can be made if good trees are observed and selected. Table 35 shows, for selected material in different countries, nut yield parameters to give an orientation on the yield potential. Unfortunately not all parameters are given by the authors, and there are gaps in this table. For the comparing trees, the canopy ground cover area (CGCA) gives a better indication of performance than the nut yield/tree than current descriptions (Table 36).

Table 35: Characteristics of selected cashew varieties

Location	Origin	Age	Mean yield/ tree (kg)	Nut weight (g)	Kernel content (%)	Kernels /lb.	Comments
Anakkayam	Hybrid	15-25	12.43	8.8	-	-	Hybrids for big nut size
Kerala	Hybrid	15-25	11.72	10.8	-	-	Hybrids for big nut size
	Hybrid	15-25	0.74	9.5	-	-	Hybrids for big nut size
Bapatla	Selection	33-48	57.82	4.6	28	365	Yield/ha extrapolated from 1 tree
Andhra Pradesh	Selection	33-48	13.57	5.0	27	335	Yield/ha extrapolated from 1 tree
Andhra Pradesh	Hybrid	25	19.00	4.0	26	435	Released varieties
Maharashtra	-	28	23.00	6.0	31	245	Released varieties
Tamil Nadu	-	17	7.40	5.0	20	454	Released varieties
Karnataka	Selection	25	19.00	7.0	31	210	Released varieties
Kerala	Selection	7-14	17.14	7.3	26	240	Released varieties
Karnataka	Selection	-	6.69	4.5	33	305	Selection for high kernel content
Anakkayam	Selection	-	3.29	3.6	46	(280) 330	Selection without CNSL in kernel (calculation based on provided figures)
Ullal	Selection	11-20	14.68	7.0	30	215	New selection from released variety (used as example in table 36)
Senegal	Seedling	29-32	36.48	6.9	-	-	Trees from farmers fields
	Seedling	15-19	25.24	5.8	-	-	Trees from farmers fields
	Seedling	7-11	17.04	5.6	-	-	Trees from farmers fields
	Seedling	59-64	164.16	5.7	25	318	Single tree covering 425 m^2 including 1 m space around tree

The following points from Table 35 are noteworthy:

- a released variety with only 20% kernel content is featured - this cannot be accepted by the processing industry. Nuts below 5 g in weight are uneconomic to harvest for farmers.
- the yield of 11 560 kg of nuts per ha is suspiciously high (see page 63, discussion).
- trees older than 15 or 20 years can still give high yields
- most released varieties have relatively small kernels and this is an obvious scope for improvement.
- cashew researchers do not use a standardised system to describe germplasm. Seedlings, hybrids and selections are mixed up and it is not clear whether varieties are based on the transfer of characteristics from parent material in seed gardens or whether clones are used. A standard would be helpful for comparison of germplasm for different purposes or sites.
- Special lines without CNSL could be interesting for homestead growing, but attract rodents that can destroy the total yield.

Breeders responsible for the selection of cashew material should be aware that the economics of cashew cultivation and processing depend to a great extent on the planting material supplied to farmers. As a cashew tree produces for more than 20 years, the effects of selection will last long and care should be taken to supply only the most suitable germplasm for any extension program.

4.3.1 Breeding

Trees differ for their quality as parents. Some transfer characters to progeny, differently with pollen than with ovules or if selfed. The best way to assess compatibility and heritability is through hand-pollinated crosses between selected germplasm in efforts to find optimal combining ability and consequently good breeding material (Harries 1993, Nalini *et al.* 1994b). This is only of valuable use if a long term breeding program can be assured. If financial or manpower resources are restricted, efforts should be concentrated on selection of available material and import of grafted plants from other cashew research centres for screening.

Table 36: Description of a cashew clone with suggestions for improvement

Description of the new cashew variety "Ullal 3" (Kumar et al. 1994)		**Comments**
1. Plant height	3-4 m	
2. Branching	intensive	CGCA* after 3, 5, 10 and 15 years
3. Canopy	highly spreading	would be useful to compare with other trees and to plan intercropping
4. Leaf length	17 cm	
5. leaf breadth	10 cm	
6. No of laterals/leader	4-5	Very important to assess compactness
7. Flowering time	Nov. 1st week - Jan.4th week	Useful for plant protection measures
8. Flowering duration	60-70 days	Climatic data should be added, as well as suitable sites
9. Harvesting time	Jan.-March	Allows to plan length of harvesting season
10. Panicle shape	conical	
11. Panicle length	31 cm	Of botanical interest only
12. Panicle breadth	27 cm (at base)	
13. Av. No of perfect flowers/panicle	152	
14. Av. No of flowers/panicle	1005	Allows pre screening of selections
15. Male: perfect flowers	6.61:1	
16. No of fruits/panicle	8-10	
17. Coherence of nut to apple	Medium attachment	Important for harvesting
18. Cumulative yield for last 10 years	146.83/tree	
19. Mean yield/year	14.68 kg/tree	Shows yield development

20. Annual mean yield for last 5 years	21.98 kg/tree	
21. Highest yield recorded	34.52 kg/tree/year	
22. Nut size	6.99 (medium)	
23. Number of nuts/kg	143	Linked to nut size, not essential
24. Shelling percentage	30%	
25. Kernel count/pound	W 210 (52%) W 240 (36%)	
26. Apple colour	pink red	
27. Apple shape	conical	Taste, juice content, sugars could be added
28. Apple size	medium (60 g)	
29. Tea mosquito tolerance	not tolerant	Disease tolerance were important

*Canopy ground cover area

4.4 Vegetative propagation

Vegetative propagation is the fastest method for producing high yielding plants. Progress has been rapid in the last 20 years. Today, vegetative propagated material should be used for mass multiplication for farmers' fields wherever possible. Clonal seed gardens are an alternative but there is need to screen mother trees for compatibility. A period of 3-5 years would be necessary before good material is available from selections.

4.4.1 Propagation by division

Air layering (marcotage)
Air layering was the first successful method of vegetative multiplication in cashew (Argles 1976). With air layers, rooting rates between 40% and 100% are reported during the rainy season, but less or even none during the rest of the year. Sawdust (Rao, -SN 1985) and sphagnum moss (Shetty *et al.* 1990) and peat (Ohmstedt, 1991a) were used as rooting media. Hormones like IAA (indole acetic acid) at 250 ppm, IBA (indole butyric acid) at 250, 300 and 2000 ppm and NAA (naphthalene acetic acid) at 500 ppm) improved rooting. Callus formation started after 10 days and root initiation after 25 days during the best season (Rao, -SN 1985). Rooting was found to take 60 to 80 days and was related to shoot growth cycles. Non-flowering shoots gave higher rooting than flowering shoots (Damodaran 1985; Palaniswami *et al.* 1985; Valsalakumari *et al.* 1985; Suryanarayana *et al.* 1989; Rao *et al.* 1989a; Shetty *et al.* 1990). Acclimatisation under mist increased survival rates. Damodaran (1985) confirms van Eijnattens (1980) view that air layers developed better root and shoot systems than seedlings.

Stooling
Nagabhushanam (1985b) covered shoots three months after stooling and allowed 40 days further growth, then the shoots were cinctured at the base, treated with IBA and again covered with sand. Six months after stooling, rooting success varied between 44% and 64%, depending on the season. Suryanarayana *et al.* (1989) found a significant difference in rooting depending on the age of shoots. Rooting rate and root characters decreased with increasing age from 100% at 4 months to 77.5% at 6 months old shoots which had been girdled at 3½ months.

Cuttings
Cuttings are cheap and easy to produce if the species has the potential to develop roots. Muhs (1992) made cuttings from young seedlings (10 to 20 cm high) and cut just above the cotyledons. He cut the leaves in half to reduce transpiration and put the stems into a mixture of 50% peat and 50% sand (without growth regulators). They were covered with a transparent plastic sheet and watered regularly. Rooting was 90-95% after 8 weeks. The decapitated seedlings developed 2 new shoots that were used again for cuttings. Rootability after the third cycle declined to 40-60%. Rao *et al.* (1989b) achieved 78% rooting of cuttings when dipped in 1% IBA and grown in a vermiculite medium kept under 7 hours mist per day. The phenolic compounds in the vegetative material did not influence rooting capacity (Shetty *et al.* 1990).

Ohmstedt (1991a) found that the rootability of semi-lignified cuttings varied within the time of the year. Best results were obtained during the dry season (during flowering period) with 15-20 cm long cuttings from juvenile shoots. Best rooting media was a 1:1 mixture of vermiculite and peat. Rooting under a plastic cover was 35% (plants that could be transplanted). Non juvenile-material did not root or survive. Other rooting media were not suitable, hormones had no effect.

Pre-treated cuttings
Semi-hardwood cuttings of cashew, taken from ringed and etiolated shoots, produced adventitious roots in 30% of the cases. The rooting rate was increased to 80 % by soaking cuttings in 10 ppm calcium carbide for 24 hours followed by a 5-second dip into NAA + IAA, each at 5000 ppm (Sen *et al.*, 1991). Rao *et al.* (1989b) used cuttings (ringed 90 days before harvesting) of 4-, 8- and 16-year-old trees. They were examined for auxin activity and phenol content before putting into vermiculite medium under mist. Total phenol content declined from 3.45% in cuttings of 4 year old trees to 3.0% and 2.7% in cuttings of the 8 and 16 year old trees; the corresponding rooting percentages were 52.5, 22.5 and 0.0 respectively.

4.4.2 Grafting and budding

Grafting is a widespread and well known technique. When rootstocks and scions are of the same diameter, whip grafting is the easiest grafting method (Garner 1958). It does not require any capital investment other than a sharp knife and strips to fix and protect the scion on the rootstock. Sawke *et al.* (1986) and Ohmstedt (1991d) reported a strong seasonal effect (over a period of 3 years) with the highest grafting success obtained in August (84%), attributed to matured budsticks coupled with low temperatures and high humidity. Grafting success was lowest in December (22%) due to temperature changes between day and night which retarded the formation of new cambial cells. The availability of scion wood seems to be the limiting factor for successful grating, coupled with such unfavourable climatic conditions as extreme low humidity and temperature changes between day and night (Nagabhushanam 1985a).

4.4.3 Micropropagation

Plantlet formation from embryos, cotyledonary explants, apical cuttings and axillary buds from seedlings, is reported by several authors with differing media and hormones used to initiate callus formation and root differentiation. Most tissue sources were either seeds or seedlings (Philip 1984; Falcone 1987; Sy *et al.* 1991; D'Silva *et al.* 1992; Hegde *et al.* 1990). D'Silva and Lievens *et al.* (1 989) obtained plantlets with roots under in-vitro conditions which were true to type and transferred successfully to the soil. Falcone (1987) concluded that tissue culture could be a useful alternative to conventional propagation of cashew.

Table 37: Grafting methods and success rates obtained

Grafting method	Time and success rate
Cleft Grafting used for top work on old trees	54% in August (rainy season) 58% in September
"	90%
Patch Budding	41% (rainy season, shaded)
"	17% in July(rainy season), sprouting after 25 days
"	61% on seedlings, (dry season) 62% (rainy season)
"	23% on 1 year seedlings in situ
Side Grafting	25% in situ (rainy season)
"	53%-58% (March, dry season) 54%-56% (July/August, rainy season)
"	60-80%
Whip Grafting, on seedlings in polybags	September 40% August 44% (mid rainy season)
"	>50% in the nursery
Wedge Grafting, under mist, 8-month old seedlings	March 75% (dry season)
Modified "Epicotyl" Grafting, two bottom leaves of rootstock left intact after removing the top. The stem was cut longitudinally so that each half had a leaf	45/% (6% with all leaves removed)
Veneer Grafting	96% in July (rainy season)
leaves were removed from the scions a week prior to grafting	92% (rainy season)
Inarch Grafting	52%-96% (graft union defective)
"	80%-100%% (both seasons, but very cumbersome)

4.5 Socio-economic considerations

In most countries cashew is a typical smallholder crop (table 26). In India vast areas are planted in the frame of soil conservation by the department of agriculture and as a source of income in social forestry and waste land recovery programs (Sapathy 1987, Chopra 1990, Chowdhury 1992). As these programs aim to plant vast areas in a short period of time, seed quality cannot be assured. Nevertheless, in the Arabari social forestry project (West Bengal) the collection of cashew nuts carried out by men, women and children was by far the most remunerative of all forestry operations and thus important for the success of the project (Chopra 1990).

Large private plantations are rare, high harvesting costs reduce the profit to nothing where the cashew apple is not the main product. Morton *et al.* (1972) reports about a frustrated Brazilian cashew manager who was disillusioned about cashew as a paying proposition, advising people to grow anything else than cashew.

The greatest limitation to cashew production is the large amount of manual labour to harvest the nuts. An experienced worker can collect about 525 nut/hour (Morton *et al.* 1972), equal to 2.6 kg for nuts weighing 5 g each. With an average wage of 150 FCFA/hour (in Senegal) and a farm gate price of 100 FCFA/kg (RUDECO 1989), harvesting costs take nearly 60% of the revenue (nuts weighing 8 g each = 4.2 kg/hour = 28%). This figures underline the importance of careful selection of planting material, bigger nuts reduce harvesting costs. This limitation offers a chance for smallholder farmers whose aim is not profit-maximisation per area of land or per man hour but to raise overall family income. The cashew harvest usually starts during the last 2 months of the dry season, when fresh food becomes rare and money from cash crops dwindles. This indicates an ideal period for additional income! Children and old people can collect apples for direct consumption and nuts for sale without creating harvesting costs.

Economic analyses of farmers' cashew plantations are often very positive, despite the fact that they all deal with different inputs and yields. Economic results are generally shown by such parameters as net present value (NPV), benefit cost ratio and internal rate of return, but the figures reflect the local situation and are therefore not directly comparable. Examples of economic evaluations of cashew plantations are summarised in Table 38. Despite the application of different methods, the cashew crop was found to be interesting for the farmer, whether the apples are used too or not. However, better planting material and increased use of apples improve the economics of cashew growing for smallholder farmers considerably.

Table 38: Economic analysis of cashew cultivation in selected countries

Basic conditions	Considered costs and revenues	Results
Planting in rows 5 x 20m Final density: 63 trees/ha Yield:6.25kg/tree,400kg/ha/year Yield: apple 10% of potential	Investment cost incl. barbed wire fence, 2.5 man-days planting/replanting 2.4 man-days maintenance 28 man-days harvesting soil cover considered, opportunity cost soil: gross margin/ha, annual crops, opportunity cost labour: gross margin/man-day	Gross margin/man-day higher than from traditional crops. Gross margin/ha reaches 196% (of traditional. crops) with full yield. Rate of return responds strongly to apple utilisation. Demands labour when family is underemployed. Provides financial liquidity when needed. Interesting crop for diversification, income increase in medium term, improvement of food situation of family. No substitution of traditional crops found. Intercropping highly appreciated by farmers. (Senegal)
Life span:25 years Intercrops: year 1-3 (groundnut, pearl millet) Trees/ha:175 Yield: 200-250 kg Rainfed conditions	Cost incurred: establishment incl. watering in 1st year, maintenance, harvest, cashew yield from year 4. Calculation based on 15 years, mean nut yield of 300 kg and includes wood value but apparently no felling costs	Positive net income each year. More profitable than other rainfed crops. Tamil Nadu, India
Compared seedlings and grafts Seedlings: age 35 years 1,17 ha/farm, 121 trees 103 trees/ha, yield/ha: 391 kg Grafts: age 6 years 0.83 ha/farm, 181 trees 219 trees/ha yield/ha 785 kg	Yields of nuts and apples (100% use) considered, Value of all apples 1/3 of nut value	Cashew orchards planted with grafts of high yielding varieties are more profitable for farmers than seedling material. Maharashtra, India
Pre bearing period: 5-7 or more years. High yielding trees (20-28 kg/year) Yield/ha: 2000 kg, Production increases up to 15-20 years, stable production up to 40 years, thereafter decline	Considered cost of land, field preparation, marking, digging of pits, filling, planting, shading, watering, fertiliser, plant protection, planting material, capital costs.	Cashew is most remunerative crop in the Konkan area, improves income of rural people, employment through cashew factories, more remunerative than other crops, all economic parameters positive. Maharashtra, India

5. Discussion

Much uncertainty affects prediction of the development of the world market for cashew. Extensive planting programs are going on in India and massif increases in areas plated with cashew are reported from other countries (table 39).

Table 39: Area under cashew in major growing countries

Country	Area under cashew (ha)	Year
Brazil	650 000	1991
India	532 000	1991
Indonesia	(138 500)	1981
"	207 300	1985
Thailand	56 400	1988
Vietnam	104 500	1991
Kenya	51 000	1991
Mozambique	500 000	1970
Tanzania	400 000	1991
Total(approximate)	2 500 000	1990

Sources: Eijnattm (1991), NOMISMA (1994).

Eight countries already have a total of 2.5 million ha under cashew, very often mixed with other crops. Rapid expansion of cashew nut areas using improved planting material is not yet possible. It can therefore be assumed that the average nut yield at least until 20l5 will be around 400 kg/ha. This would give a total of about 1 million tons, as predicted by Ohler for 1990 (table 13), but from different countries. FAO/PY (1993) (table 15) simply mentions a record production of 726000 t in 1992 but it fell to only 480000 t in 1993, due to climatic hazards in India and Brazil. The important point is that the market was able to absorb the kernels (181 000 t) produced in 1992. Mathew *et al.* (1983) had predicted a total growth rate (demand) of 4.9% (based on the rate from 1950-1979 and 98500 t in 1980) per year and just for the USA, Japan, Netherlands, Germany, Australia and Canada a kernel demand of 330 000 t by the year 2000. This demand could not be met by the current cashew production potential in the 8 countries of Table 39 even if a growth rate of 5%/year is considered (table 40). The economic development in China and the "Tiger Nations" in South East Asia (not considered in this calculation) is rapidly expanding the market for cashew products. This is because cashew nuts are part of the diet, not merely dessert nuts. In China, the local price is higher than the world market price. Growth in income in these countries will further increase demand.

Minor producing countries should therefore be able to sell their cashew nuts on the world market, provided the quality is adequate. The ACP countries have the advantage of close trade relations to the European Community which represents a potential market for cashew kernels. Adequate (small scale) processing facilities in the producing countries could create employment and additional foreign currency earnings (Kumar 1995).

The price of CNSL in 1995 is about 320 US$/t - synthetic phenol is traded at 960-1600 US$/t (Bolton 1995). Nobody can foresee the price of petroleum which is the source of synthetic phenol, but it is sure that the price will rise within the next 15-20 years and thus influence the price for substitutes such as CNSL. The value of CNSL might not reach the value of the kernel, but it is likely to get a bigger share of the profitability of cashew shelling operations.

At present cashew apples do not have a market. Due to the problems described in Chapter 2.1.4 it might be difficult to create processing facilities exclusively for cashew apples in areas where production is scattered However, the example of Goa shows that a large part of the apple supply can be used and thus increase the profit of the farmer. In Senegal farmers make higher profit from only 10% of the apples than from the nuts. The nutritional value of the cashew apples is much appreciated by people and influences farmers in their decision to plant cashew. Development projects must promote the use of this valuable product for local needs as well as for the market. Alcohol, dried fruits, juice or jam have a market under all circumstances. The combination of small scale nut processing and apple processing can be a solution to overcome the problems related to short production periods.

Table 40: Potential cashew kernel production and exports*

Year	Potential cashew kernel production (growth rate 3%)	Potential kernel export (home consumption 20%)	Potential cashew kernel production (growth rate 5%)	Potential kernel export (home consumption 20%)
1990	250 000	200 000	250 000	200 000
1995	289 819	231 855	319 070	255 256
2000	335 979	268 783	407 224	325 779
2005	389 492	311 593	519 732	415 786
2010	451 528	361 222	663 324	530 660
2015	523 444	418 756	846 589	677 271

* based on the potential production in 1990

Since the beginning of the cashew kernel trade, cheap labour of women in India compensated for the complicated process of cashew nut shelling and made it a profitable business. Attempts for large scale hand shelling in Africa have failed. Semi-mechanised processing is favoured by Kumar (1995), and doubtless represents the future. The deep freezing method could be used to produce high quality grades of kernels if the technology would become cheaper possibly due to new developments.

Cashew nuts have become one of the most important tree nuts without any serious attempts to improve husbandry practices. A concern for treatments arises only if diseases or pests hamper yield (Tanzania, India) and it is only during the last 20 years that serious research has been done to select varieties and to promote clonal propagation. High yielding varieties with big nuts and high kernel contents (tolerant to major pests and diseases) increase the economic return in all levels of the cashew industry, from the grower to the roaster/packer. Joint ventures between importers, processors and growers to improve selection and cultivation suit all concerned. However, the yield potential of cashew trees is limited - as for all other crops. Anybody promoting cashew should use realistic yield estimations.

Table 41: Maximal annual yields of selected crops

Crop	Highest yield (t/ha fresh weight)	Conditions
Cashew nuts (India)	15	Extrapolated
Cashew nuts (Brazil)	8-10	Long term yield target
Cashew nuts (India)	12	extrapolated from 1 tree
Mango (Karnataka, India)	22(5th year)	1600 dwarfs/ha, farmyard manure, NPK fertiliser, irrigation
Banana (India)	l28.56	Black polythene mulch, irrigation, fertiliser
Wase satsuna mandarin (Japan)	60	Ploughing, fertiliser
Apple (Germany and Netherlands)	19-92	Intensive orchards
Cassava tubers (Trinidad and Tobago)	63 7	Rainfed with NPK fertiliser (no fertiliser)

The yield potential (fresh weight) of cashew and selected crops is shown in Table 41. Banana is the only crop yielding more than 100 t/ha, but normal yields are around 60 t/ha. Intensively cultivated selected mango produced 22 t/ha. A cashew fruit production of 22 t is equivalent to 2.4 t/ha of nuts. If the

European apple (Malus spp.) with a mean yield of about 60 t/ha is taken as a reference, the potential nut yield would be 6.6 t/ha. A nut yield of 15 t/ha is equivalent to a total fruit yield of 136 t/ha, thus more than banana under most sophisticated management. I conclude from these figures that a realistic achievable nut yield is about 6-7 t/ha (or about 60 t/ha of apples and nuts together) under good site conditions (chapter 4.3).

Two other important selection parameters are nut size and the kernel content. Abreu (1995) reports of new Brazilian cultivars with a kernel component of 85%. This figure was probably confused with the percentage of whole nuts after shelling and therefore misleading as a result. The highest realistic kennel content reported is about 46% in nuts without CNSL (Nalini *et al.* 1994a). For normal nuts a range from 23-38% is reported from breeding material by Manoj *et al.* (1993). Hybrid H419, apparently the best identified, is reported to have a mean nut weight of 9.6%, a kernel content of 31.6% and a nut yield of 21.5 kg/tree/year (Manoj *et al.* 1993). The yield per canopy ground cover area (CGCA) was not indicated.

Table 42: Requirements for selected planting material

	Minimum - short term	Medium to long term
Tree	healthy, compact, adapted to environment, tolerant to diseases and pests	different clones for special purpose, e.g. dwarfs for home gardens, big trees for hedgerows
Nut yield	>150 g/m^2 CGCA	400-500 g/m^2 CGCA
Nut size	>6g	8-10g
Kernel content	>26%	≥30%
Apple	sweet and juicy	good taste, juice, vitamin rich

Countries embarking on cashew growing should try to obtain clonal material from elsewhere (India or Brazil) for screening. Locally selected material should have minimum requirements indicated in Table 42. Yield could best be expressed as kernels per m^2 CGCA. For the moment there is no need to look on CNSL properties, but this might become more important in the future. Trees with CNSL-free nuts should only be grown if tree climbing rodents can be excluded.

Vegetative propagation of cashew is now standard practice in India and other countries (Tanzania, Senegal). In Brazil special clones for apple or nut production are recommended according to the choice of the farmer (Parente 1991). Grafted mangoes and citrus are quite common, even for smallholder farmers in the same areas where cashew is grown, so that there is no reason for not using this technique for cashew field establishment. Topworking (cutting of the old crown and grafting with good clones for improvement of existing stands is also recommended (Rao, -V.N.M. 1985; ODA 1995). Various propagation methods produce high success rates (Table 43).

The grafting routine probably increases success. Local grafting skills should be considered when choosing a multiplication method. Most of the propagation methods are strongly influenced by the season. The best time and method for each locality therefore have to be determined before mass propagation can start. Micropropagation of cashew is possible and independent of season. More research is, however, needed to develop a method that allows the use of material from adult (elite) trees at low costs. The vegetative propagation of high yielding, disease-resistant material for plantation establishment should allow at least a five-fold increase in nut production compared to propagation by seedlings.

Table 43: Success rates for vegetative propagation

Method	Success rate
air layering	up to 100%
stooling	up to 100%
cuttings from seedlings	up to 95%
cuttings from watershoots under field. conditions	up to 35%
pretreated cuttings	4 years old trees: 52.5% 8 years old trees: 22.5%
veneer grafting	92%
cleft grafting	90%
side grafting	80%
patch budding	71%
Whip grafting	under mist: 75% nursery: >50%

As biotechnology develops very fast, I assume that it will influence the improvement of cashew within the next 20 years. As a comparison, pathogen resistance against the potato disease *Phytophthora infetans* (Mont) de By has been achieved in several transgenetic lines (Knogge *et al.* 1992). Resistance against powdery mildew through biotechnology in cashew should be feasible and might depend mainly on financing.

It is often stated that most cashew fields are not monocultural but intercropped in various ways (Ohler 1979, NOMISMA 1994). Some authors see cashew only as a crop and propose interplanting with other trees such as *Melia azedarach* L., *Leucaena leucocephala* (L.) de Wit., *Dipterocarpus alatus* Roxb., *Casuarina junquiana* Miq. and *Eucalyptus* spp. (Watanabe 1988). Results are usually not satisfactory. When *Eucalyptus tereteconiis* was interplanted with cashew, the incidence of *Helopeltis antonii* Sign. rose from 20% to 80% and the nut yield was reduced by 75% (Ghosh 1993). Jacob (1989) suggests interplanting of 2 rows of *Eucalyptus* (and other species) in (10 m) interrows of cashew as possible agroforestry system. This practice cannot be recommended for smallholder farmers, cashew as treecrop should be interercropped with annual plant species.

In Orissa, an area with frequent hurricanes, 20 rows of *Casuarina equisetifolia* Forst. were planted to form a shelterbelt and to provide fuel. These were followed by 20 rows of cashew on the lee side as a soil binder and for the nut crop and combined successfully. Coconut palms were also interplanted and irrigation and fertilisers were applied. Economic returns from the cashew trees were obtained from the 5th year (Patro *et al.* 1979, Reddy 1979, Kumar 1981).

In areas where hurricanes are rare cashew trees alone can serve as windbreak, even if they are planted around farmers fields. Much has been published about the benefits of wind breaks, mainly in temperate climates. The grain yield in fields protected by hedgerows in northern Germany is 10% higher than in unprotected areas. This includes the space taken by the hedgerow (Eigner 1975). Wind protection is given about 5 times the height before the hedgerow and 15-20 times the height on the leeward side. Cotton yield increased by 4-10% in northern India (Puri *et al.* 1992) and by 10 % in south Yemen (Raussen 1990) due to the effect of windbreaks (lowering evapotraspiration). Even higher yield increases where obtained in protected fields in the Majjia Valley in Niger where yields were 23% higher during a year with above average rainfall and still 16% higher in a year with rainfall 46% below average (Rocheleau *et al.* 1988). Steiner (1984) stated that advantages of intercropping are greater in a climate with high insolation (semi arid tropics) where wind brakes change the microclimate considerably. He also mentions that mere 15 trees/ha provide sufficient shade and wind protection to improve the yield of field crops. At first glance cashew trees might not be ideal for windbreaks because they grow very dense, but they can be pruned if necessary. Some strains of cashew grow to 12 m high. Assuming a protection by a cashew hedge, a belt of 12.5 x tree height (12m) wide (150 m) would be protected by one row. If the crop yield increases by 5% due to the wind protection over a unit area of land the total crop yield should remain stable compared to a non protected area. This includes the space taken by the cashew hedgerow (800-1000 m^2) and adverse effects on crops by shade and lateral cashew roots. The yield realised from cashew would represent additional cash income.

Eijnatten (1991) argues for growing cashew in hedgerows. He states that hedgerows (2-3 m spacing within the row) at 12-15 m intervals double the canopy surface area per ha and result in doubled yield over the first 10 years.

Experience in Senegal has shown that farmers do not substitute their traditional crops with cashew (RUDECO 1989). They prefer planting systems that allow permanent intercropping. Therefore they should be encouraged to plant cashew in widely spaced rows against the main wind direction to protect their fields.

Asare (1995) reports that farmers in northern Ghana practise a 20 years fallow period that has been reduced due to population pressure. In such systems, cashew takes the role of a forest tree, planted in strips, with some natural vegetation left between the rows. This vegetation can be cleared in year 16 to crop and plant new cashew trees. The first rotation of cashew should be felled at an age of 21 years and the land made available opened for cropping. Aweto *et al.* (1994) found that soil under 20 year old cashew plantations was similar to soil under logged rain forest. The same findings were made by Kögel *et al.* (1985) in Senegal who concluded that cashew had no adverse effects on the soil despite popular belief to the contrary. A rotation system can, however, only work if the farmers agree and if livestock is excluded from the area while there are cashew trees younger than 5 years.

Some natural vegetation left in the cashew field might be suitable for deleterious insects. Predatory ant species can protect cashew trees from *Helopeltis* damage: the best known are red weaver ants *(Oecophylla longinoda* Latr.) that provide efficient protection against the coconut bug *Pseutheraptus wayi* Brown on coconut palms in Tanzania (Varela 1991). The role of ants in pollination is unclear, it is unlikely that they act as regular pollinators.

Honey bees *(Apis melifera, Apis spp.)* are accepted pollinators of cashew. In north east Brazil a colony placed in an cashew orchard could yield 1240 kg of honey per season that starts from the first flower opening until the last fruits ripen (the first honey is light red and turns black with time because the bees forage the apple juice at the end). Bee keepers in Brazil have to pay a fee to the plantation owner despite improved pollination (Freitas 1994). Nevertheless it is useful for cashew farmers to place bee hives in their cashew field to enhance the overall output.

We have found that most cashew trees are grown by smallholder farmers who have generally inadequate resources for making large investments. On wastelands with free ranging livestock, protection of young trees is a major problem. Fencing of large areas is not feasible under smallholder conditions and it is too expensive to fence small areas. Therefore, farmers should not plant cashew in one go, but according to their ability to protect and care for the young plants (including watering if there is a dry spell during the rainy season after planting). It is better to plant 20 healthy trees of good genetic material with 80-100% success rather than 200 trees of bad material with 10% success.

High density planting in the beginning is often favoured to suppress weed growth and to realise high and early yields. There is, however, the danger that farmers will not fell trees as required if they grow and if canopies close yield reduces. It would be better to plant 100 trees/ha at 5m x 20m spacing, intercrop and get a final density of 40-60 trees/ha (normal mortality included).

It would be profitable if private nurseries could be established to produce and sell improved (grafted) planting material to farmers. This would guarantee quicker and more controlled improvement of the crop.

In areas with more than 800 mm mean annual rainfall direct sowing of cashew can be done, followed by grafting during the next season.

The tree planting tradition of farmers should be considered in the extension approach. Field layout should be as flexible as possible. It depends largely on site conditions (slope, soil, main wind direction) and farmers own perception. With normally growing planting material a density of 40-100 trees/ha is adequate. Planting should be in rows to allow future mechanisation, should it become feasible and desirable. The rotation periods of cashew might be longer than 20 years as 40 years old trees have shown good performance. Bad yielders should be removed from the field as soon as their yielding behaviour is confirmed. A final density of less than 40 trees/ha is not in itself a problem as the remaining trees produce and the interspace can be used for other crops or grazing. Densities over 100 trees/ha are also possible if dwarf material is used and labour and site conditions allow intensive cashew farming. It has to be borne in mind that high yielding crops remove nutrients from the site, - that have to be replaced if to maintain high outputs over a long period of time. Fertilisation will then become a necessity.

In India cashew is grown very often in schemes for "wasteland" (rangeland) recovery, with fruit production as the second objective. Positive effects of cashew growing on sandy areas in Brazil have been confirmed by Ohler (1995). In the marginal cashew growing areas (600-800 mm rainfall) a government might be interested to stop the desertification process. Fruit trees are preferred by farmers and cashew is a low demanding fruit tree perfectly adapted to long dry periods. The promotion of cashew growing in these areas makes sense if farmers are accepted as responsible partners who invest their own resources and knowledge into their plantations. The role of donors and governments is to provide the best possible advice and planting material as well as economic conditions that allow the farmer to reach their own targets from their cashew intervention.

6. Conclusions and recommendations

This study shows that demand for cashew kernels is higher than the current nut production and prospects for an increasing demand in the traditional import countries and the opening of new markets in East Asia are bright. Progress in selection and vegetative multiplication make it possible to use high yielding planting material on farmers fields. Cashews can grow under low rainfall conditions (600-800 mm/year) on poor sandy soils, but fruit production is then low. In such eases the ecological effects of cashew planting should then be considered through economic evaluations, including added values as windbreaks and positive fertility influences due to litter and shade. Higher yields are obtained under higher rainfall regimes (800-3000 mm/year) and on deep (>1.5 m), fertile, sandy loamy soils. Increases in nut yields from currently 0.4 t/ha to 2-3 t/ha should be achievable within the next 10-15 years. Potential maximum nut yield will not be more than 6-7 t/ha until at least 2020. The integrated use of all parts of the cashew tree including apples, CNSL and wood can increase the overall economic benefits from cashew. Adapted planting systems are preconditions for sustainable production. Smaller family managed units using agroforestry techniques are favoured against large plantations for fruit production. If cashew is used in large scale forestry programmes the seeds should be selected from high yielding stands or clonal seed gardens to assure rapid spread of improved material. Improved and reliable marketing channels and fair prices are necessary to sustain farmers' interest in the cashew crop. In order to be able to use the given potential as indicated in the preceding paragraphs, the following recommendations can be made:

1. Cashew production per unit area of land should be increased by:

- use of improved planting material
- adoption of improved husbandry practices
- placing of bee hives in orchards(plantations or creating good conditions for other potential pollinating insects by leaving natal vegetation
- integration of adapted plant protection measures

2. The rentability of cashew for farmers (and processors) can be increased by:

- planting material that has larger nuts and a higher kernel content
- enhanced use of the apple.

- enhanced use of CNSL
- enhanced use of wood

3. Cashew planting promotion must not aim at large areas/unit of time but on sustainable husbandry, with farmers as responsible partners both for investment and decision making. The role of development agencies should be limited to ensure that optimal planting material is provided for farmers and adequate knowledge is available to the farmer to allow an informed decision by her/him on which material to use and how to plant it. This can best be done through adequate nursery development

4. To make use of the positive attitudes of farmers towards the integration of cashew with annual crops, programs of research should be adopted and more emphasis given to it. Mechanisms of communication between farmers and extension should be introduced and where existing, improved.