Introduction and Management of Neem (*Azadirachta indica*) in Smallholder's Farm Fields in the Baddibu Districts of The Gambia, West Africa.

By

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The project report: "Introduction and Management of Neem (*Azadirachta indica*) in Smallholder Farm Fields in the Baddibu Districts of The Gambia, West Africa." is hereby approved in partial fulfillment of the requirement for the Degree of MASTER OF SCIENCE IN FORESTRY.

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Table of Contents

List of Figures

List of Tables

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Wa Gambia, duma leen fateh. Yangeen nekka sumal xol. Yangeen borom bopam, jappal sa jot. Damye contan si suma xarit yi ak suma jobot yi fofou. Sa teranga du jex. Nemena la. Jere Jef! Jamma ak Jamma.

Chapter 1: Introduction

When I was preparing to go to The Gambia, I read Under the Neem Tree, a gloomy account of a Senegalese Peace Corps volunteer, I had no idea that neem would play such a role in my experience. To Gambians and Senegalese, neem is the archetypal compound shade tree, often with rough boards underneath forming a large bench for rest, a communal place for discussions and hot afternoons spent drinking *attaya* and listening to *balax*. In many villages, and in particular in northern Senegal, if there were no neem, people would have few trees in their landscape.

Indigenous to India, neem is used in cultural ceremonies, revered for its properties. It has been utilized for over a thousand years in agriculture, food storage, and for its medicinal properties. It has been used in commercial products such as shampoo, soaps, bug repellant, and toothpaste.

Neem is an immensely useful tree, widely known for its medicinal properties and use as an organic insecticide. In the US, products containing azadirachtin are sold for gardening, fertilization and fighting insects, fungi, and bacteria (Peaceful Valley Farms 2004). There are many websites devoted to the miracles of neem or selling its products; one website states: "spearheading the neem revolution ". Pharmaceutical companies are fighting for the right to patent neem's active ingredients for medical purposes. Thirty patents have been granted for neem products, including the use as a spermicide (Neem Foundation 2004).

The purpose of this study is to understand how farmers have adapted neem to their farms and compounds, how neem is managed and how is it integrated into their farming system. I hypothesized that although neem was widely adopted by farmers during the 1970s and 1980s, today farmers do not like the tree. I intend to show how neem is invading their farms, and find out how farmers are managing neem that gets into their farms.

In the following chapter, I will discuss general country and regional background for the study area, covering the geography, history, and people. It will also give a background of the farming system practiced by farmers in the study area. This information should give readers a broad understanding of the country, and make them aware of the main problems and constraints of farmers living in The Gambia.

In the third chapter, the concept of the fuelwood crisis will be explained, showing why exotic trees are being introduced to meet the needs of Gambians. The advantages and disadvantages of introducing exotic species, and problems with species invasion will be discussed. The chapter will conclude with a review of *Azadirachta indica's* characteristics, potential benefits, problems, and agroforestry potential. Neem's many benefits and its harmful affects will be described. Having both positive and negative aspects may seem contradictory. However, this duality exists in The Gambia, it is neither completely good nor completely bad in the local context.

In chapter four, I will explain how I came to the topic of this paper while working as a Peace Corps volunteer, and problems encountered while developing this study. I present the methods that I used to understand farmers attitudes toward trees in their farms and how I collected information from the farm fields.

After the reader has an understanding of the methods, chapter five will report my initial, casual observations. Then I present data collected from Njawara's farm fields, and discuss their meaning.

In chapter six, results from farmer interviews will be presented and a discussion of how their responses relate to the field data follows. Next, a discussion of how tree's role in the farming system evolves as farming becomes intensified, and how neem might be integrated into the farming system. Finally, conclusions and recommendations for this study are discussed in chapter seven.

Chapter 2: Study Area Background

General Description of The Gambia

The Gambia, officially known as the Republic of The Gambia, is bordered by the North Atlantic Ocean on the West and Senegal on the North, South, and East. It is in West Africa approximately 13° 28 north and 16° 34' west (Figure 1). The Gambia is the smallest mainland country in Africa at 11,295 km^2 in area, 10,000 km^2 in land area and 1,295 km^2 are covered in water (CIA 2004). The Gambia River divides the country into two: the North and South banks (Figure 2). It is approximately 48km at its widest along the coast and about 24km at its eastern end, 320 km inland (Baldeh et al. 1997). The Gambia River is navigable the entire for the entire length of the country.

The capital of The Gambia is Banjul, located on St. Mary's Island, a peninsula at the river's mouth. The Gambia is divided into five administrative divisions: Western (WD), North Bank (NBD), Lower River (LRD), Central River (CRD), and Upper River (URD). Each division is divided further into several districts (Baldeh et al. 1997).

Gambian incomes remain low: in 2002 the annual average Gross Domestic Product (GDP) per capita was US$270, dropping from a high of US$340 in 1999. Annual GDP growth has fallen in the last few years. From 1999 to 2001 growth was 6%, but in 2002 it was -3% (World Bank 2004). Poverty is widespread, 59.3% of the population lives on US$1 per day or less and 82.9% lives on US$2 per day or less (UNDP 2004). Twenty-six percent of children younger than five years of age are considered underweight for their age (World Bank 2001).

Figure 1: Map of Africa; Gambia is indicated with a red arrow (Source: CIA Factbook 2004).

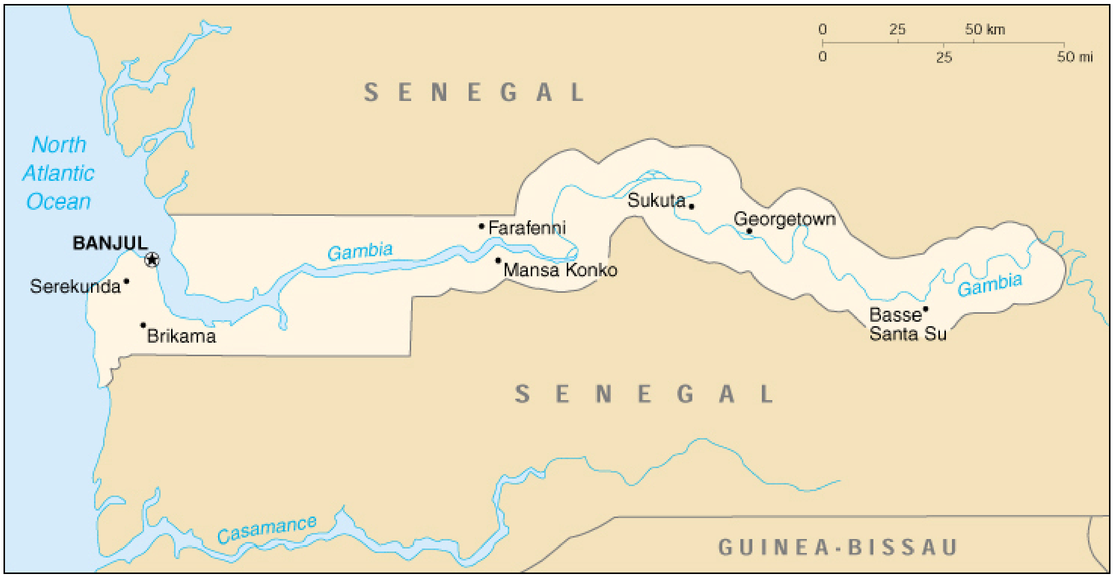

Figure 2: Map of The Gambia (Source CIA Factbook 2004)

People

The population of The Gambia is an estimated 1,546,848 people, with an annual growth rate of 3% and life expectancy of 53 years (CIA 2004; World Bank 2004).

Gambian households are large and lack the ability to feed themselves adequately through subsistence agriculture. Statistics and information available on The Gambia better represents urban settings. Rural families are larger, have less access to healthcare and education, and are less financially secure. The fertility rate is five children per adult woman (World Bank 2004). Polygamy is common in The Gambia, 27% of male household heads practice polygamy, and among the poorest families, 89% of households practice polygamy (World Bank 2003). Average monthly expenditure for the household is 392 dalasi per month or about US$13.79, two-thirds goes towards food (World Bank 2003).

The Gambia is densely populated, with 4.3 people per hectare of arable land. Sixty-eight percent of the population lives in rural areas, and three-quarters of the total population depends on agriculture for work (Encyclopedia 2004; The World Bank 2001). Groundnut processing and exports make up 22% of the GDP. The other major industries are tourism, fishing, cotton, and re-exportation of textiles (CIA 2004; Kasasa 2001).

The Gambia has over twenty culturally distinct ethnic groups or tribes, and each group speaks a separate language. Mandinka (42%), Fulani (18%), Wolof (16%), Jola (10%), Serahuli (9%), make up the majority of the population, Serer, Manjago, Bambara, Bassari, and others comprise the remainder of the population (CIA 2004). English is the official language of The Gambia, used by the government and schools. Wolof is most widely spoken in the urban areas near the coast in Banjul and Serre Kunda, as well as the North Bank Division. In other areas in the provinces, especially the CRD and URD, many people do not speak either English or Wolof, but commonly Pulaar or Mandinka. Ninety percent of the population is Muslim, 9% is Christian, and 1% animist (CIA 2004).

The compound is the normal family unit. It contains several households related through the male head, led by the eldest male. When daughters marry, they move to their husband's compound. Wives are the backbone of the compound, doing most of the cooking, cleaning, laundry, water collection, care of animals raised for food, purchases of clothing and supplemental food for their children, and childcare. Men are responsible for fencing, construction, maintenance, management of resources outside the compound, care of work animals, and *depans* (or money to cover purchased food requirements for meals), and other payments.

History

Before European explorers, Serers, Wolofs, and Jolas subsisted in the river regions of the Senegambia. In the seventh century, Arabic traders reported major West

African empires including the Jollof Empire in what is now the northern half of Senegal (Fletcher 1977). Portuguese explorers reached what is now present-day The Gambia by way of the Atlantic Ocean in the middle of the 15th century (Encyclopedia 2004).

The Portuguese gave England trading rights in 1588, and by 1816, the British established Banjul on Saint Mary's Island. The Gambia was the first British colony in Africa (Kasasa 2001). The Gambia realized self-government in 1963 and became an independent nation in 1965. From 1965 to 1994, Dauda Kairaba Jawara of the Peoples Progressive Party (PPP) was president, re-elected five times. On July 22nd 1994, Yahya H. Jammeh a lieutenant in the army overthrew President Jawara and assumed head of state. Yahya Jammeh was elected President in 1996; however, all significant opposition parties had been banned. Jammeh was re-elected in 2001, at which time opposition parties were allowed, and foreign observers deemed it free, fair, and transparent (The State Department 2004; Encyclopedia 2004).

Geography and Climate

The Gambia has a four-month rainy season from the middle of June to early October and a longer hot dry season without any rainfall from November to June. Rainfall varies significantly by location and year in The Gambia. The country receives an average of 1020 mm of rainfall annually, ranging from 800mm in the eastern most parts of the country to 1700mm at the western end (Baldeh et al. 1997). Intense localized storms occur with strong winds, precipitation exceeding 40mm per storm, and most of the rain falling in the first hour (Jones 1994).

The Gambia lies on a Tertiary sandstone plateau called the Continental Terminal composed of iron-rich quartz and kaolinite. The Continental Terminal is the result of erosion from the African landmass that was washed back up from the ocean. This deposition contains a series of hardened iron pans, exposed from drier periods. The Gambia River cut a channel through the Continental Terminal depositing clay and sand. Overall, the country is flat, the highest point being 50 meters above sea level (Jones 1994)

Soils

Two types of soils have developed in The Gambia: alluvial deposits near the river, and those that formed from the Continental Terminal. Soils produced from the Continental Terminal are iron-rich, sandy, tropical soils above a thick layer of laterite rock low in fertility. They formed plateaus and colluvial slopes that have a pH of 5.8 to 6.4 with a high bulk density, low organic matter, little available phosphorous, and a low cation exchange capacity (Baldeh et al. 1997).

Soils from the alluvium deposited by the river Gambia commonly are hydromophic, composed of 80% or more of silt and clay throughout, and vary significantly in physical and chemical characteristics (Jones 1994; Baldeh et al. 1997). All soils are affected by aeoilan deposits from the Harmattan, a seasonal hot wind containing dust particles (Posner et al. 1989).

Vegetation

The Gambia lies within the Sudan and Guinea vegetation zones, dominated by grassland with scattered trees. The ocean, the river, its tributaries, and dry uplands all affected by land use, drive the development of many different habitats. There are six different habitats within The Gambia: forest, forest-savanna mosaic, parkland, swamp forest, mangrove, and freshwater wetlands (Jones 1994).

Forest. Only 2-3% of the land could be classified as forest, along the coast in the North Bank and Western Divisions, where higher rainfall and reliable groundwater reserves can be taped. *Pterocarpus erinaceus, Combretum glutinosum, Elaeis guineense,* and *Chlorophora regia* occur here. Much of the forest areas have been degraded due to bushfires, land clearing for agriculture, and exploitation. Few *Azadirachta indica* trees would be found here.

Forest-savanna mosaic. Open woodland with grassland areas are considered to have been forest, transformed by clearing, grazing, and burning. Forest-savanna mosaic typically receives 900-1100mm of rainfall. It includes tree species such as *Pterocarpus erinaceus, Vitex doniana, Terminalia albida,* and *Combretum spp. Azadirachta indica* is occasionally present.

Parkland. Savanna woodland vegetation in farmed areas. Parkland is the type of vegetation in the study area. It includes *Parkia biglobosa, Bombax costatum, Faidherbia albida* (also known as *Acacia albida*)*, Khaya senegalensis, Adansonia digitata, Mangifera indica,* and *Azadirachta indica*.

Swamp forest. Areas of forest near the river become seasonally inundated by rains. Species include *Mitragyna inermis*, *Elaes guineensis*, and *Ficus spp*. *Azadirachta indica* are abundant in swamp forest near villages.

Mangrove. Mangrove grows along the shoreline of the Gambia River from the mouth to Kaur, 220 km from the coast. *Rhizophora racemosa* is the pioneer species, which stabilizes the shoreline and encourages deposition of alluvium. *Avicennia* *germinans* replaces *Rhizophora*, as the soil level rises. Barren flats formed from wind deposition are too saline for most vegetation and too dry for *Avicenna*. Mangrove is often harvested from these areas for roofing (*Rhizophora*) and firewood (*Avicenna*).

Freshwater swamp/wetlands. Few freshwater habitats exist due to the long dry season in The Gambia, and standing water is usually seasonal. These areas are sometimes used for lowland rice cultivation and dry season gardens. Neem is not present here.

North Bank Division

The North Bank Division (NBD) is on the north bank of the Gambia River starting at the coast running approximately 110km inland. The NBD is made up of six districts, each are headed by a *seyfo* (chief) who are elected by the *alkalo* (village heads). The NBD headquarters are located in Kerewan, which includes the area council, and regional branches of the government ministries (Baldeh et al. 1997).

The North Bank has long been a remote place ignored by the government and separated by geography. The NBD is separated from urban areas of Banjul and Sere Kunda by the Gambia River, several kilometers wide between Banjul and Barra on the coast. A feeble ferry system runs across the river at the coast and a second crossing is available further up country between Mansakonko and Farafenni. Until 2002 when the Yahya Jammeh Bridge was built (Figure 3), it was also necessary to take a ferry to cross Njawara creek to reach Kerewan and the Baddibu districts. Only recently, a paved road was built to connect Barra to Kerewan. The road from Kerewan to Farafenni remains unpaved, it is a difficult bumpy road to take, becoming impassible for days during the rainy season.

During the Prime Minister Al-Hajji Sir Dawda Jawara's administration (1965-1994), the Baddibu districts were the home to opposition to the largely Mandinka PPP. The NBD was often ignored or neglected: Kerewan was considered a "hardship post" for government civil servants, a place where civil servants who fell out of favor were sent. Until 1990, there was no running water, electricity, paved roads, or a vibrant market with fresh vegetables or meat. Kerewan is known among Wolof speakers from outside the community as *Kerr Waru* or "place of frustration" (Schroeder 1997).

Figure 3: Kerewan Bridge

The research areas are located in Kerr Katim Wolof in Central Baddibu District and Njawara Village in Lower Baddibu District (Figure 4). Njawara is located 10km North of Kerewan, by way of a washed-out sandy road. Kerr Katim is about 25 km

Northeast of Kerewan, accessible by the main, unpaved road to Farafenni, then a two-kilometer walk on a two-track road used by horse carts.

The North Bank Division has an estimated population of 133,245 people, composed of Mandinka (51.1%), Wolof (23.7%), Fula (12.2%), and other groups (11.4%) (Freudenberger 2000). Both Kerr Katim Wolof and Njawara villages are predominantly Wolof. Wolof living in Baddibu migrated from the Sine-Saloum region of Senegal during the 1800s, most Wolof villages were founded between 1860 and 1865 in wooded terrain (Pélissier 1966 as quoted in Freudenberger 2000). Social status of village members is linked to title and role in the village: the *alkalo*, *imam*, village committee leaders, and compound heads (Freudenberger 2000). The *alkalo* makes all decisions for the village, representing the village at regional and national levels, creating and enforcing rules, and settling disputes within the village with the aid of the *imam* and the council of elders.

The *imam* leads prayer in the mosque and is the spiritual leader of the village. All villages have a village development committee: they give NGOs and government sponsored projects access to the village, they also seek out projects, decide which projects to accept, and negotiate how projects will be carried out. Many villages have several other committees, usually organized by age and gender (for example, an unmarried women's group), or by purpose (for example a beekeeping group). All village committees have several leaders: a president, vice-president, treasurer, and secretary.

A compound is a collection of houses enclosed by a fence. They contain one or more households all related to the central figure, the compound head, who is the eldest male in a compound (Figure 5).

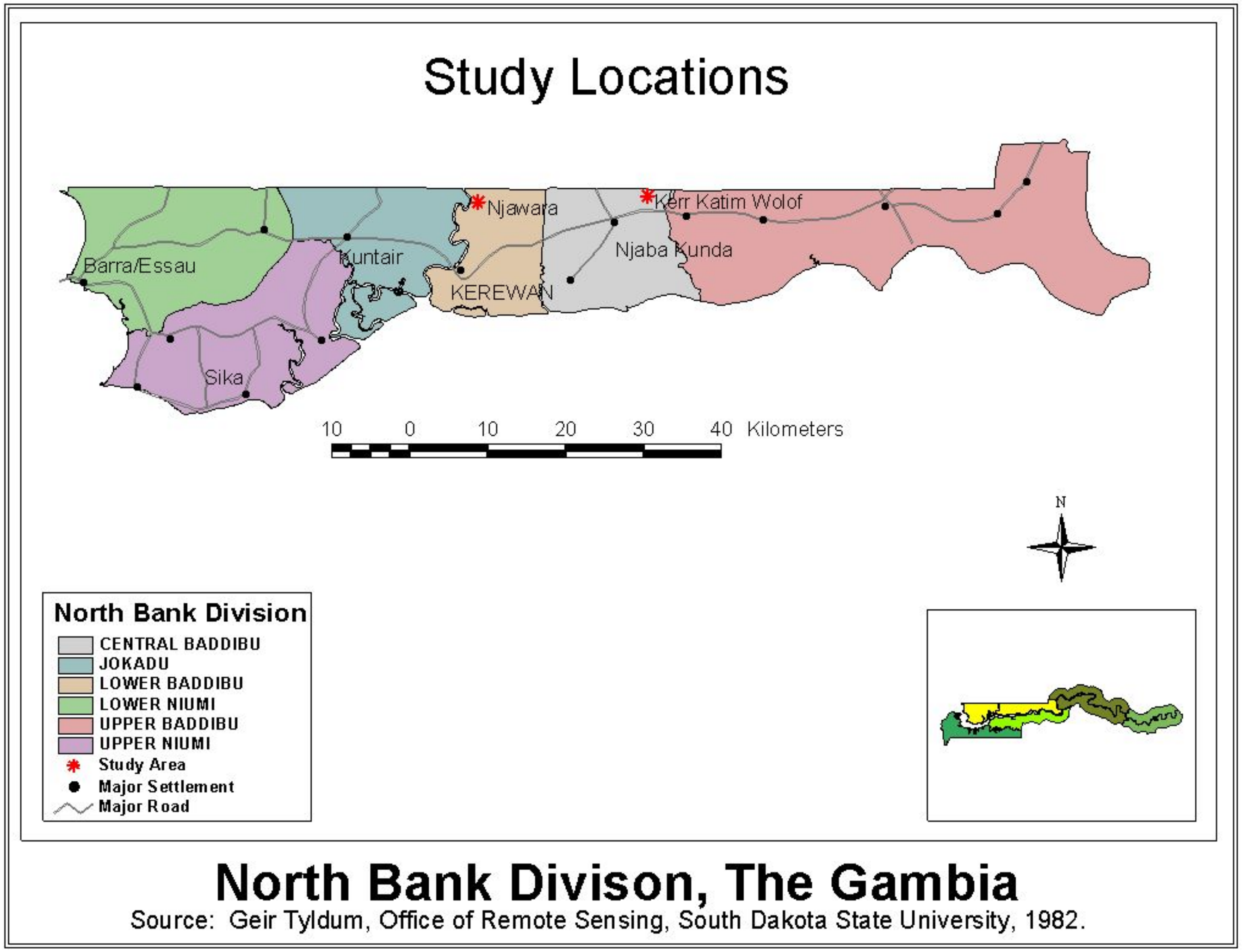

Figure 4: Map of the North Bank Division indicating the study area.

Figure 5: The Compound Head inside his Compound

Farming System and Agroforestry

Njawara village has two main types of agro-ecological zones: seasonally inundated lowland areas near the river's barren flats used for growing lowland rice (*Oryza sativa)* and irrigated gardens, and upland areas used to grow cereal crops millet (*Pennisetum americanum*), maize (*Zea mays*), and sorghum (*Sorgum bicolor*) alternated annually with groundnuts (*Arachis hypogaea*). Kerr Katim Wolof has only an upland cereal based system. This study will focus on upland farm areas. A family's upland holdings are held collectively and managed by the compound head. Every year the land is divided into parcels by the compound head, allocated to individual cash crop production and communal staple production. Areas set aside for communal cultivation by all the working members of the family produce millet, maize, and sorghum. He divides the remaining land between his brothers, sons, and elder women to grow crops as they please, but is invariably used to grow groundnuts. Individuals must supply their own inputs: seeds, fungicide, and labor. After next year's seeds are set aside and the *zakat* (charity) is given, groundnuts are sold to either a trader or the government cooperative as income earned for the individual. Tops of the groundnut plants will be kept as fodder for horses, donkeys, and sometimes sheep through the long dry season. After harvest, ownership of the land reverts back to the compound head (Freudenberger 2000).

If an individual wants to cultivate more land, he or she will have limited options. No new land is available for clearing, and land clearing is now illegal, though it still occurs in some areas. Farmers who require more land can negotiate with other landowners to borrow land on a year-by-year basis. In Kerr Katim, borrowing land is usually free if a subsistence crop (millet) is to be grown. If a cash crop, usually groundnuts is to be grown, the farmer must supply the owner with something in return: seed nuts, groundnut hay, or a payment. If a new family immigrates to a village, the *alkalo*, who normally owns a substantial amount of land, will give the family land for building a compound and farming staple crops.

Farms are cleared in May and June, the months preceding the rains. Shrubs, weeds, and seedlings are cut. The most common shrub, *Guiera senegalensis* is coppiced annually and moved to the compound for firewood during the rainy season, when firewood is scarce due to weather and time constraints (Louppe 1991). Any remaining crop residues are raked into piles and burned (Figure 6). Occasionally an entire field is simply burned without control, burning into neighboring fields covering several hectares, killing most tree seedlings in the process.

Fields are plowed against the contour to drain water quickly, increasing water erosion. Millet is sown first with an animal driven mechanical seeder before the rains or right after the first good rain, followed by groundnuts once the rains become more reliable (Figure 7).

Figure 6: Clearing Farm Fields in Lower Baddibu District.

Women and children hand-weed all the fields, whereas adult men use animal powered equipment. Hand weeding is done with a *daba* or locally constructed hoe. Horses, donkeys, and cattle are used to pull seeders, sine plows, and regular plows. Other farm equipment includes machete, axe, and a large *daba*.

Every year villagers will organize their production so that millet will be grown in one area and groundnuts in another area. Children stay in the millet farms, throwing rocks to drive out bird pests. By clustering the millet in one area, it reduces the risk that one individual farmer will lose a large portion of his crop.

Figure 7: A Groundnut Field, Near Kerr Katim Wolof.

The two primary limiting factors of yield for upland farms are adequate and reliable moisture and lack of soil fertility. In the upland system, farms closest to the compound are cropped most intensively with no fallow. Often maize is alternated with groundnuts every year. Maize is grown here because of problems with theft, and because these fields tend to receive more manure. Fields that are more distant are usually millet, and small amounts of sorghum grown for animal feed. Sesame is occasionally farmed and is used for cooking oil.

Rainfall records from Kerewan, ten kilometers south of the Njawara study site, show an average of 699.7mm of precipitation from 1972 to 1985, and 1074.5mm from

1946 to 1965. All upland farms are strictly rain fed. Receiving an adequate amount of moisture over a season does not necessarily illustrate how effective it is for crops. June has unpredictable weather, one or two good rains might fall to germinate crops, but it might be two weeks before another rain. At these times, elders of Njawara and Kerr Katim would pray at the mosque all day, in hope of rain.

It is important to know the history of land use and farming in the Baddibu area to understand what is happening to trees in farm fields. According to the elders of both Kerr Katim and Njawara, sixty years ago, a forest-savanna mosaic surrounded the fields that lay directly outside the village proper. Forested areas that separated villages were full of monkeys, a larger variety of trees, and bush animals that supplied meat for the village. Since that time, most of the forested land has been cleared for agriculture, driven by an increasing population and rise of commoditized agriculture.

Land directly around the village was used for growing millet, fonio (*Digitaria exilis*), and sorghum every year, and kept fertile with inputs of animal manure from the village. Land was cleared inside the forest, most trees were cut and burned, and other trees remained because they were either useful or harbored *gins* (spirits). Land could be planted with groundnuts and cropped for two or three years, then left to fallow. Under the traditional land tenure system in The Gambia, land that is cleared has usufruct tenure, passed down from father to eldest son.

Over the last 50 years, cropping patterns have changed with increased dependence on groundnuts for cash, population pressure, and loss of soil fertility. During colonial times, France encouraged farmers to grow groundnuts for export to feed Europe's growing demand for vegetable oil during the years after World War II. The French created infrastructure for the groundnuts to get to market, developed credit systems, and made chemical fertilizers available. Prices for groundnuts rose, as a result a greater emphasis was placed on the cash crop over millet, and more land was being cleared for groundnut production (Posner and Gilbert 1989, Franke et al. 1980). The focus of these incentives was in the groundnut production basin, centered in the northern half of Senegal. The Baddibu districts make up the lower parts of the production basin and were thus heavily influenced by French Colonial policy.

Groundnuts are well suited to the ecological conditions of the North Bank. They prefer light sandy soils, warm temperatures, and 650mm of effective precipitation within the growing season, followed by two weeks of dry weather for ripening. Before cash cropping of groundnuts, millet and groundnuts were alternated yearly in a more ecologically sound manner. However, with the increase in production of groundnuts, crops are not always rotated in the fields (Frank and Chasin 1980). Although groundnuts do fix nitrogen, very little benefit is realized. When groundnuts are harvested, the ground is ripped to pull the groundnuts up. The entire plant is removed from the farm leaving nothing to hold soil in place from the strong winds and powerful first rains of the next season or to rebuild organic matter in the soil. Women and children dig through the soil using hoes looking for *kise-kise* (or groundnuts missed by the plows during harvest), which are sold back to the owner at a low price. In the Cassimance region (in Southern Senegal), after two successive years of groundnut farming 30% of the organic matter in the soil will be depleted and 60 percent of the soil's colloidal humus (Moss 1968, in Frank and Chasin 1980).

When the soil was depleted, it was necessary to clear new land to repeat the process. Today, there is no land left to clear, forcing farmers to grow on the same soils with no fallow, and ever decreasing yields. Although old, the Frank and Chasin (1980) data hold true today, the situation is getting worse: a larger population now depends on smaller amounts of land (due to destructive practices on marginal land) with fewer inputs available than were available in 1980.

Farmers believe not enough money can be earned from farming groundnuts to afford chemical fertilizers: one 50kg bag of NPK 15-15-15 costs D500 or US$17, and a kilo of groundnuts are sold for D4/kg or US$0.13. One could expect to get 1.2 tons or D4800 on a very productive farm with good soils and timely weeding, or US$165/ha. A harvest of one metric ton of groundnuts takes from the ground 70kg of N, 10kg of P, 28kg of K, 12kg of Mg and 18 kg of lime (Frank and Chasin 1980). Several bags of fertilizer would be needed every year to cover this nutrient loss, a cost that the average farmer cannot afford.

Average yields in 1988 were 1 ton/ha for cereals and 1.2 ton/ha for groundnuts for the Central Baddibu District, which should be representative for all of the Baddibu districts. Three quarters of the farm fields had not been fallowed in the past six years (Posner and Gilbert 1989).

During the cropping season, all animals must be tethered by order of the *alkalo*. If an animal damages the crops, the animal is brought to the *alkalo's* compound and will remain there until a fine is paid. After crops are harvested, lands become open to grazing by animals. Goats and sheep are managed by women, left to forage during the day and are tied up in the compound at night. Other animals grazing on farms include donkeys, horses, and cattle. Goats often damage young saplings, which cannot recover over the long dry season. Few people can afford to build barbed wire fences and nobody has a successful living fence to exclude the animals.

Mortality of remaining old trees and poor regeneration rates have diminished the number and diversity of trees in upland farm areas. Regeneration of trees does still occur despite clearing and burning, animal depredation, lack of nearby seed trees, and plowing.

Native trees in areas outside the compound area can be harvested for fruit, fodder, wood, or medicine so long as no harm comes to them. These trees are individually owned, however, and the owner can choose to harvest all of the fruit for sale or home consumption. Trees inside the compound or trees or planted trees are owned by the individual who plants and cares for the tree and controls all rights over the tree.

Cutting of living trees is prohibited, unless a permit has been issued from the forestry department. Women often do cut living trees outside forest parks for fuel wood because the distance to find dead wood or a preferred species justifies the risk of getting caught (Freudenberger 2000). Planting of fuelwood in woodlots occurs in both Kerr Katim Wolof and Njawara, with limited success. The next chapter explains the loss of fuelwood in The Gambia, and what the NGO's, government ministries, and people of The Gambia are doing to cope with the situation.

Chapter 3: Fuelwood, Reforestation, and Exotic Species.

This chapter provides a background on the fuel wood crisis and the efforts of non-governmental organizations (NGO) working in development. An overview of the merits of introducing exotic tree species to new areas versus the use of local species for reforestation and agroforestry will follow. Finally, a background on the species *Azadirachta indica*, its botany, characteristics, and uses will be provided.

The 1970's Fuelwood Crisis

Although developing nations are concerned with securing enough oil to provide a stable future economy, the majority of people in developing countries depend on wood for their fuel needs. In The Gambia, fuelwood is used for 84% of all primary fuel consumption in the country (Sallah 2000). It is needed for cooking fires, bread ovens, fish smoking, brewing tea and medicinal herbs. Ninety-three per cent of North Bank Division households use wood for cooking (Sallah 2000).

A rising awareness among development organizations of a shortage of fuelwood became the impetus for reforestation projects beginning in the 1970s (Eckholm, et al 1984; National Academy of Sciences 1980). There is an imbalance between production and consumption of fuelwood in The Gambia. Several studies to determine estimates of fuelwood consumption in The Gambia generated consumption estaimates from 0.34 to $1.44m^3$ per capita per year (Steiner, 1996 and NARI, 1999 in Sillah 1999). Sallah (2000) estimates fuelwood consumption surpasses wood production by more than 100,000 m^3 annually in The Gambia.

Land Conversion

Due to increasing land pressure and cash cropping groundnuts, significant amount of land has been converted from savannah and fallowed land to permanently cropped fields. The German-based technical organization GTZ has used satellite and aerial photos in order to quantify land use change in The Gambia. GTZ estimated that the North Bank Division had 100,900 ha of land under cultivation in 1988, or 47.7% of the total land area, an increase of 15%, since 1980 (GTZ 1980; GTZ 1988). Between 1980 and 1988, approximately 15.5% of The Gambia's total land area has been converted from savanna, fallowed land, and closed forest to permanently cultivated uplands (Table 1). Closed woodlands decreased from 58% in 1945 to 1.2% in 1980 (Posner and Gilbert 1989).

Table 1: Land Use in the North Bank Division (GTZ 1998).

Land Use	**1980 (Aerial Photos)**		**1988 (Satellite Imagery)**	
	Percent	**Area (ha)**	**Percent**	**Area (ha)**
Savanna/Fallow Land	31.1	66,200	17.5	37,00
Cultivated Uplands	32.2	68,000	47.7	100,900
Open Forest	3.5	7,500	1.7	3,600
Closed Forest	1.2	2,500	1.2	2,600
Mangroves	13.3	28,100	13.3	28,000
Swamps	11.9	25,200	11.9	25,200
Water Surface	2.4	5,100	2.4	5,100
Other (roads, settlements)	1.1	2,400	1.2	2,500

NGOs, the Environment, and Development

There are over 40 NGOs operating in The Gambia (Tango 1996). Much of their efforts are focused on improving health and nutrition, education, and agriculture and environment of The Gambia and its people. One strategy used by both the Government and NGOs is to provide better technologies to Gambians.

Agroforestry is a solution to many of Gambia's agricultural problems. Agroforestry is "a land-use or farming system in which trees are grown on the same land as crops and /or animals, either in a spatial arrangement or in a time sequence, and in which there are both ecological and economic interactions between the tree and non-tree components" (Beets 1989 as quoted in Beets 1990). By planting trees in farm fields, farmers can produce wood for their needs, while protecting their soil resources. Many fast growing multipurpose trees can provide products for the farmer such as food, a secondary cash crop, fuel, fodder, and timber. By introducing a fast growing tree that is easy to propagate, farmers could plant trees in their farms to ameliorate some of their soil fertility problems and at the same time produce a new supply of fuelwood that is readily available. Difficulties with propagation and protection of native species make introducing a new species another form of technology that can be beneficial to Gambians.

Native and Exotic Trees

There is considerable debate among international foresters regarding the use of native species versus exotic species. Some foresters support the introduction of imported species not native to a given area (exotic species), while others advocate the use of local tree varieties (native species). Trees that are not indigenous are sometimes well suited to the ecological conditions in a given area. Non-native trees may increase productivity of a site, where climatic and human pressures have degraded the soils. They may be easy to propagate, or provide products not available locally. Introduced exotic trees are usually early successional species, which colonize bare ground. They are suitable for harsh conditions in degraded soils, they transform difficult sites, establishing a microclimate more favorable to native vegetation by shade and increasing organic matter in the soil from leaf litter (Bergner 1998).

Several international foresters have argued against the careless introduction of species. The National Academy of Sciences (1980), state that "...in more equable environments and where no fuelwood shortages exist, such potentially invasive plants should be introduced only with great care and serious consideration for the threat posed by their weedieness. **In any trials of fuelwood plantations local species should always be given first priority** [emphasis theirs]." In addition, Maydell (1990) makes the argument, "Although some exotic trees may offer greater advantages under specific conditions, they should be introduced with caution and on condition that they fit into the existing ecosystems and yield products and benefits which cannot be obtained otherwise. They should on no account be the forester's quick and only response to solving afforestation problems. In particular, large-scale plantations should be restricted to emergency situations, or to meeting acute demand such as urban fuelwood needs."

Introduced exotic trees may become weeds, colonizing large areas of natural habitat and disrupting the effected ecosystem (Versfeld and van Wilgen 1986). However, many foresters are untroubled with the introduction and proliferation of trees in degraded areas in badly need of tree cover: "one would be only too happy in certain very degraded, not to say denuded, regions to find an invasive plant with as many qualities as *Prosopis*" (Baumer 1990, p.170).

Advocating local species reduces the dependence on outside assistance. Seeds are locally available; they do not need to be imported as exotics do. Indigenous people already know local species; they know their uses and have a traditional basis in the culture. Local species have a proven record of producing products in their native environments.

Probably the best-known debate is over the planting of *Eucalyptus* species, particularly in India. Is it invasive (Randall 2002 in Richardson et al. 2004; Henderson 2001; Forsyth et al. 2004 in Richardson et al. 2004), nutrient intensive, or allelopathic (Rizvi et al. 1999)? Does it increase erosion (Shiva and Bandyopadhyay 1983), or cause conflicts with local social and cultural interests (Ummayya and Dogra 1983), or effect hydrology (Saxena 1994)? *Eucalyptus camaldulensis* is planted in Gambia is grown as a fast-growing timber crop usually around fields as a windbreak, or together in a monoculture (woodlot).

Other "miracle" trees have been introduced in The Gambia that, although useful, could bring more problems than benefits. Mesquite (*Prosopis juliflora*), a tree from Central America is considered invasive (Sharma and Dakshini 1998), and has had negative environmental and human impacts where it has been introduced (Pasiecznik et al. 2001). Neem is another tree that could be a potential threat to The Gambia's environment.

Neem

Neem, known botanically as *Azadirachta indica* A. Juss is a member of the mahogany family (Meliaceae), and order Geraniales, and is synonymous with *Melia azadirachta* Linn and *Melia indica* Brandis. *A. indica* originates from the arid and semi-arid areas of Burma and Northeast India (Ajmere 1963; Maydall 1990; Ketkar and Ketkar 1997). It has several different names in English: Indian lilac, White cedar, Holy tree, Paradise tree, and Margosa tree. In The Gambia, it is known as *Cassia* and *Sangamar* in the local dialect. Neem is found throughout South-East Asia, India, tropical North America, Australia, South and Central America, and Africa. It grows well in the Sahelian and Sudanian zones of Africa (Ketkar and Ketkar 1997).

Neem is a large evergreen tree 12 to 20 meters tall and may reach a girth of 1.8 to 2.5 meters with a round, dense crown. The trunk is straight with moderately thick bark. Leaves are alternate, compound, with 7 to 17 toothed leaflets that are alternate or opposite 6 to 7 cm long. Neem is open pollinated; small white hermaphroditic flowers borne in clusters attract bees. Fruit is a drupe 1.25 to 1.8 cm long, greenish in color turning yellow when ripe and contains a sweet pulp. The fruit contains a hard shell with a seed. Neem bears fruit at three to five years and a single tree can produce up to 50 kg of fruit annually. Flowering and fruiting periods vary by location; in India, fruit ripen in May to September, though some publications state that it flowers in two periods from May to June and August to September (Benge 1986; Ketkar and Ketkar 1997). The recalcitrant seeds are viable for two to three weeks (National Academy of Sciences 1980).

A. indica is a hardy tree; it can be coppiced, is drought tolerant, flood tolerant, fire resistant, salt tolerant, and termite resistant (Benge 1986). Neem can grow in very difficult soil conditions such as shallow, dry, and nutrient-poor soils. It will grow vigorously in soils with a pH between 6.2 and 7, and survive in soils with a pH between 3 and 9 (CAB International 2004). Neem grows best with 400 to 1200mm of annual precipitation, but will grow in areas with as little as 130mm (National Academy of Sciences 1980).

Neem is a light demanding tree species, and as an adult grows best in direct sunlight, but is shade tolerant in young stages. Rawanski and Wickens (1981) have found that neem develops chlorosis in insolation (exposed to direct sunlight). Since neem grows best in shade at young stages, it has a capacity for pushing through scrub in young stages (Benge 1986).

Silviculture, Growth and Management

Seed, stump planting, and stem cuttings are all successful propagation methods of neem. If sown by seed, *A. indica* is commonly raised in a nursery in plastic bags, and then transplanted. Direct sowing is also an option, with good results with more than one plowing done during the pre-monsoon rains. Stump planting, is considered to have a better success rate than direct sowing. Using two-year-old stumps raised in seedbeds one can get better survival rate than transplanting seedlings. Air layerings and stem cuttings can be planted with an application of growth hormones (CAB International 2004).

Wild neem in India grows in mixed stands. Growing trials in India and Africa have shown that *A. indica* tends to grow better in single tree and mixed tree plantings than in monoculture. Benge (1986) states and Gorse (1986) concurs it is not a very sociable tree, and plantations often die after 3-10 years because neem is very "demanding on both water and mineral nutrients" (Benge 1986).

There are two major silvicultural management techniques for neem: to coppice (or pollard) harvest, or felling and replanting. If felled, regeneration from seedlings and root suckers will often revegitate the area. Growth rates of a total yield 20 cubic meters per hectare per year have been reported in Uganda and Nigeria (National Research Council 1992). Maximum yields in Nigeria amounted to $21m^3$ per hectare per year of fuelwood. Ghana recorded between 13.5 and $17m^3$/ha/yr (National Research Council 1992). Both sites used a spacing of 2.4x2.4m on an eight-year rotation with a coppice harvest (Benge 1986). Twenty-three years is considered to be the best economic rotation for wood production in a felled harvest method (Luna 1996 in CAB International 2004).

Pests and Diseases

Fruit, seed, and leaves of *A. indica* contain compounds that inhibit, kill, or repel insects, and slow the development of fungi, and limit infectiveness of viruses. Hence, neem is very resistant to pest problems. Few insects cause damage to neem: 8 orders and 32 families are known. In Nigeria, goats (*Capra hircus*) cause damage to neem, consuming the shoots and leaves; this is not a problem in The Gambia. Several diseases can attack neem: such as damping off, which is common in the nursery (*Fulsarium spp*.) (CAB International 2004).

In Africa, two pest and disease problems dominate. First is a decline or disorder of unknown causes known as "neem decline". Symptoms include yellowing of older leaves, distorted branches, branch dieback, dry foliage, and exudation of sap from branch tips. Neem decline has been reported in Burkina Faso, Cameroon, Chad, Mali, and

Nigeria. Foresters believe this problem's source is site-related stresses such as low soil moisture and competition. African neem might have a low genetic variability, which would mean the tree population has very little diversity to cope with environmental stress (CAB International 2004). The second major problem is Oriental yellow scale insect reported in the Lake Chad Basin (*Aonidiella orientalis* Newstead). Heavy feeding by *A orientalis*, appears to result in poor viability of neem seed and death of the tree (Lale 1998).

Uses

In India neem is revered for its usefulness, people use nearly every part of the tree. It is a fast growing, multipurpose tree for timber, firewood, shade, shelterbelts, fodder, insecticide, oil, fertilizer, rehabilitation of land, bee fodder, toothbrushes, and medicinal uses (Maydall 1990).

Wood is hard and resistant to termites. It can be worked with machine and hand tools, but planing is difficult. It closely resembles Cuban mahogany (National Academy of Sciences 1980). It is excellent for construction and furniture making. It is suitable for woodcarving (Obara et al. 2004). The wood is commonly used in India and Nigeria for fuelwood (6943 Kcal/kg) and charcoal.

An ad hoc committee of the board of Science and Technology for International Development, National Research Council called neem "a tree for solving global problems" (National Research Council 1992). It is called "a miracle tree" for its medicinal uses: it has been proven effective for birth control, fights STD infections, is an antiseptic, and reduces swelling of the gums (Nandal and Bahadur 1997). In India, the

Hindus hold the tree sacred; it is used for fevers, thirst, nausea, vomiting, and skin diseases (Ketkar and Ketkar 1997).

Most importantly, it controls field and storage pests (Singh et al 1997; Dhawn and Dhaliwal 1997; Ghewande et al. 1997). "In trials in The Gambia…crude neem extracts compared favorably with the synthetic insecticide malathion in their effects on some of the pests of vegetable crops (National Research Council 1992)."

How neem came to The Gambia

It is uncertain how neem arrived in The Gambia. Neem probably came to The Gambia by way of Senegal during the 1950's. Senegalese agronomist Djibril Sene went to India to gather neem seeds to bring back to Senegal (National Research Council 1992).

According to Kebba Sonko of the Ministry of Forestry, neem was introduced to Gambia in the 1950's. Neem cultivation was encouraged through the National Tree Planting days in the 1970s to the 1980s. The Ministry of Forestry distributed neem and *Gmelina arborea*, and people were encouraged to transplant wildlings and stumps. The impetus for the neem and gmelina plantings was fuelwood. The Ministry of Forestry no longer supports the propagation of neem, because it "spreads easily" (Kebba Sonko, Personal Communication).

The neem planting programs were successful, probably one of the most successful tree planting programs in West Africa. Forester Jean Gorse, who spent most of his career working in the Sahel states "The propagation of neem in West Africa in the '50s and '60s must be considered as the most successful (and cheapest) rural forestry operation ever implemented in this region. This was mainly due to the 'attractiveness' of neem (National Research Council 1992)."

In speaking to the village elders of Kerr Katim Wolof, they stated the first Neem tree in the village was planted at the *pencha* (public meeting place) for shade. It was planted by a man who brought it from Brikama, who died over 30 years ago.

Tree Tenure and the Exotic Tree Bias

Land and tree tenure system in The Gambia can be a confusing mess of systems to an outsider. There are often no written rules, but rather informal traditions. There are essentially two tree tenure systems in The Gambia, traditional tenure based in tribal and clan tradition, still followed at the village level, and statutory tenure, the official legal tenure system. The statutory system states that all trees are property of the state and are therefore protected. The state gives authority to the local government—the commissioner, *seyfo*, and *alkalo,* to collect taxes for the government for any tree harvest. The Ministry of Forestry is responsible for enforcing this law, ensuring that only people with a permit may harvest wood products. While there should be, there is no effective control on private use. For example, live mangrove is often cut for roofing poles. Naturally occurring native trees in farm fields are owned by the landowner of the farm that the trees grow. However, community members maintain usufruct rights for substance use if no harm comes to the tree. When the tree dies, the landowner has the right to harvest it.

Non-native trees and any planted trees are owned by the person who planted and cared for the tree. Baobab (*Adansonia digitata*) trees are often owned by a family, whose grandfather planted the tree. Often, the tree was planted or geminated by the *kabilo* (founding family's compound) years ago, and since that time, the land might have been given away to immigrating families, but the *kabilo* retains ownership of the tree. Rarely are contracts or documents written to explain the ownership of land or trees, because the literacy rate in The Gambia is low. Legal documentation is only beginning to emerge. Disputes are settled by elders who recall the village history and should know the ownership history of the farms and trees.

It is sometimes difficult to prove who owns a certain tree, especially if the tree is native. The state claims ownership of native trees. A landowner must rely on elders of the village to remember who owns and cared for planted trees in the case of a dispute. This creates a bias towards encouraging exotic species on private lands because with exotic trees, the owner retains full rights to the tree, therefore disputes are unlikely to occur.

Besides ownership, there are other reasons why there is a bias toward planting exotic trees. Exotic trees grow more quickly than native trees and require little input. Many trees are unpalatable to livestock, making survival more likely. Finally, in the words of many incredulous (and often hysterically laughing) farmers when seeing me trying to grow native species, "Why do you grow these? We already have them!"

Agroforestry Potential

Trees play an important role in agricultural production and substance. Before colonization by the British, farmers in The Gambia practiced shifting cultivation, clearing new plots of land to cultivate for several years, and then abandoning the plot as the fertility declines. During the long fallow periods, the land to reverts to forest allowing the soil to recover. This system remained sustainable as long as the population density remained low. As the population density increased, less land was available, which forced farmers to shorten the fallow periods, until farmers no longer fallow, known as continuous cropping (Raintree 1986).

The farming system is now out of balance, the soil is deteriorating, and the production base is vulnerable to catastrophic disturbance (Beets 1990). As the soils become less productive, the yields decline and a greater effort must be made on the part of the farmer to maintain their grip on subsistence. Farmers must also increase the intensity of production, by increasing the labor input, in order to maintain their yield over time. Alternatively, they may stabilize the system by adding tree crops to the farm, in order to maintain that balance (Raintree 1986).

Agroforestry systems manipulate the microclimate to create more favorable conditions for production. One example of this is increasing organic mater and nutrients in the topsoil. Trees can provide valuable products such as timber, firewood, fodder, and fruit. Trees can also protect the ecology of the site, thereby protecting the basis of production, the soil. Well-designed windbreaks can protect soil from wind erosion (Beets 1990; Baumer 1990).

Neem has been shown to improve red sandy acid soils in Nigeria, suggesting more nutrients are available to crops in the understory of neem trees (Radwanski 1969). Windbreaks of neem were planted around millet fields in Majjia Valley, Niger, where millet yield showed an increase of over 20% (Long and Persaud 1988).

According to the National Academy of Sciences (1980), when grown near other crops, neem requires precaution; it may aggressively take over neighboring sites. The root system appears to have an unusual ability to remove nutrients and moisture from nutrient poor, sandy soils. Radwansi and Wickens state, “neem cannot be grown among agricultural crops since it will not tolerate the presence of any other species in its immediate vicinity, and if not controlled, may become aggressive by invading neighboring crops (1981)."

Both bats and birds consume the seeds. They distribute the seeds afar, particularly under large native trees in which the birds roost. In Africa, India and Haiti individual trees and stands of neem were established in this manner (Maydall 1990; Benge 1986; Sahni, 1998). *Azadirachta indica* is a strong competitor, which could become a noxious weed under some site conditions. It is known to be invasive in Ghana (Chamberlain 2004), and is being evaluated as a potential weed in Australia (Csurhes and Edwards 1998). Neem is listed by several sources to be naturalized or an environmental weed (Randall 2002 in Richardson et al. 2004).

Neem is a productive tree, capable of yielding large volumes of wood fuel, while having many additional benefits. Neem is useful for pest control in dry-season gardens, reducing dependency on harmful chemicals. The tree has shown to improve red acid soils in Nigeria, increasing organic matter and nutrient content. It has also has medicinal value, provides shade, and timber. Neem also has the potential to do harm—it is known to be allelopathic, reducing yields of sorghum and maize. In several countries it has been found to be invasive. While the tree could have a great beneficial impact for the people of The Gambia, it is also a risk. The remainder of this paper will look at what the results of neem introduction have been in The Gambia.

Chapter 4: Methods

I was a Peace Corps Volunteer in The Gambia from October 2000 until August 2004. After ten-weeks of village-based training, I was assigned to a small village of approximately 240 people named Kerr Katim Wolof, in the Central Baddibu District. My official title was environmental extensionist. The Peace Corps environment program's project plan has three primary goals: to generate income and improve nutrition for women, create environmental awareness, and help manage natural resources (fields and forest). However, there is generally little specific direction given for particular assignments. New volunteers going into the field are told: "go find out what your community needs and help them". I was placed in Kerr Katim Wolof at the request of the village's young and progressive *alkalo*, who had begun planting cashew trees inside one of his farms, and an *Acacia holicera* windbreak around his farms with the help of a volunteer who had lived ten kilometers away a few years earlier.

The first six months in Kerr Katim Wolof were difficult due to the differences in language and culture. I socialized with villagers, trying to learn enough Wolof to understand what people were saying, observing social customs, and learning the politics of the village. It took one year to really learn the language and understand the community to work there effectively and feel comfortable.

I tried working with a tree-planting group, *Sama Miro Kaffo* that translates as 'A group that thinks to the future.' It is a men and women's group of about 40 farmers interested in growing trees. They met once a month to talk about what they have been working on, sharing problems, and successes. The *kaffo* (group) wanted to grow trees collectively in a central location for their personal orchards.

My interests were in forestry and agriculture. The *alkalo* and I created a larger tree nursery and encouraged others from the community to join us in the nursery to produce trees for their own farms. We tried growing several introduced trees new to the area. I worked with several other individuals, helping them start small nurseries for their own farms and compounds, usually helping grow fruit trees and eucalyptus woodlots.

By living and working in the community, I became familiar—people became comfortable with my presence. This allowed me to observe and record information about their lives, an anthropological technique called participant observation (Bernard 1994). I had made it clear from the beginning to villagers that I was there to learn and observe and when I returned to the United States, I would be writing about forestry in The Gambia based on what I see and hear in the village. I informed the *alkalo* and *imam* when I first arrived that I would be studying them and explained to acquaintances, family, and friends that I would be collecting research information.

I paid attention to how trees were used and managed. This was all part of my work as a volunteer, encouraging people to plant trees, so this was all normal. I watched and participated in farming activities: plowing, seeding, hand weeding, plowing with animal traction, and harvesting. I observed where trees were grown, how they were grown, who had ownership of certain trees and what their rights were, how trees were used, which trees were left in fields and which are eliminated.

Living and working in the community gave me an intuitive understanding of the community, through the language, conversations, and action. I became less of a curiosity (though I never was considered normal), reducing the amount of reactivity of the people observed. People opened up to me as a friend and confidant, building relationships and trust. The more difficult aspect of this type of research is remaining objective. Living the village life made it difficult to separate my life from the village, to analyze the meaning of what I saw in a western way.

I was interested in how farmer's beliefs affected tree management in the farm field. I became interested in neem, because people have strong feelings toward it: they either hated the tree, or thought it was useful. I devised a holistic survey of the compound and farm to understand farmer's use and attitude toward the tree.

I conducted face-to-face semi-structured interviews (Barnard 1994) with key informants in Wolof. A list of survey questions are in Table 2. I brought *attaya* (a national pastime and social drink of Muslim West Africa) to brew and drink in order to create a more social, relaxed atmosphere and to encourage a sense of good will toward the interviewee. Questions were asked and then responses written down, in a formal manner.

Table 2: Survey Questions.

Personal Information:

1. Name:
2. Village:
3. Ethnicity:
4. Position in Compound:
5. Age:
6. Sex: Male or Female
7. Religion:
8. Marital Status:
9. Highest Level of education reached:
10. Literacy:
11. English Proficiency:
12. Trainings:
13. Have you had any experiences with an NGO or Govt. Extensionist? Which? How often? Perceptions?
14. Do you have other personal income?

Compound Information:

15. # of able-bodied adults Male/Female in compound: /
16. # of dependent Male/Female adults in compound: /
17. Compound Wealth: Rich/Middle/Poor
18. # of people who migrate seasonally for money:
19. # of additional farmers:
20. Are there other sources of income for the compound? What are they?
21. Is there a labor shortage on the farm and for which activities?

Farming Background and Knowledge:

22. Did you have a surplus of crops for subsistence (out of 5 years)? Which Crops?
23. How much did you earn on your farm surpluses last year?
24. What are your agriculture-related problems? What solutions do you propose? Order them in importance.
    1.

    2.

    3.

25. Do you use chemical fertilizer on the farm? How much, which type? What was the source (who paid for it)?
26. What farm equipment do you own?
27. Does you compound have enough hand tools?
28. Source of animal traction? Enough feed year round?
29. Livestock Owned by individual (Spp., Number, Use)?
30. Who controls what (trees and crops) are planted?

Table 2 (Continued): Survey Questions.

31. What are the ways to protect the ownership of your farms?
32. Do you have any land disputes currently or in the past? How were they resolved? What were the disputes over?
33. How did you get your land? Who was the founder/who cleared the land, the settlement history of the compound?
34. Who has access to trees, who can harvest from them? What can be harvested? Is there free access or private use, how private?

Tree Information:

35. Do you personally grow trees? How? What is your source for seedlings?
36. What are the most needed forest products? Why?
    1.
    2.
    3.
37. Do you protect trees on your farm? How are they protected? Why? For which products/which trees?
38. What is your Source of Fuelwood (species, % by source, harvest method, adequate, distance to collect, seasonal changes)?

Exotic Species:

39. Are there native trees that provide the same products as neem and Eucalyptus?
40. Have you ever tried to kill a neem tree or a Eucalyptus? Were you successful?
41. What do you see as good and bad about neem and Eucalyptus?
42. What are the social effects of these exotic species? Have they created any social problems? Are there any cultural beliefs or adaptations to introduced trees?

Information from Fields:

43. Make a map on the back of the page to illustrate the fragmentation, location, size, soil types, and quality of your land.
44. Total size of land holdings in ha?
45. Amount of land fallowed?
46. Land leased/borrowed? Size and crops?
47. Which annual crops are grown in ha this year?
48. What is your rationale for the way you harvest trees?
49. Are there any soil/water management techniques used?

It became clear that this type of interview would not be effective: writing answers made most people uncomfortable, often eliciting terse and evasive responses. The interviews were conducted in a style of discussion that people were not used to—asking direct questions and giving direct and detailed responses is a western concept.

I began leaving my notebook and papers at home, using informal interview methods (Barnard 1994). I repeatedly visited the same informants, bringing up questions in conversation. I kept a master list of questions in my home, each day I would ask a few questions with my informant. At the end of the interview, I would return to my hut and write down the responses that I received. It was a slow way of getting the information I needed, and it was difficult to recall a high level of detail from each conversation.

Figure 8: Drinking *attaya* is an important social ritual (Photo courtesy of Katherine Whitman).

When my two years in Kerr Katim Wolof were completed, I did not have nearly enough information to give a clear picture of what was happening with neem. I had really enjoyed my time, finally had a grasp of the language and culture, and wanted to stay in The Gambia longer.

I extended my service in Peace Corps for an additional year in a new village. In November 2002, I moved to Njawara village, about 20 kilometers west of Kerr Katim Wolof in the Lower Baddibu District. I found my own work counterpart, and lived in his compound. I spent two days a week teaching agroforestry and soils at a community run agricultural center, called the Njawara Agricultural Training Center (NATC). The remaining time was spent working on projects with my counterpart.

Njawara has more wild neem when compared to most villages in The Gambia. I observed that neem trees have a particular way of growing in a farm field that was not as obvious in other Gambian villages. Here, neem seedlings usually grow under the large old trees left from clearing the land. I began collecting information about the structure and species composition of trees in farm fields.

A sample of fifteen compounds were systematically selected. A list of compounds was compiled by selecting every fourth compound while walking around the village until twenty-five compounds were selected. From these twenty-five, fifteen were selected for the final sample based on characteristics of the compound, based on ethnicity (tribe), wealth (a subjective measure of wealth indicators), land size, and education. This was done to ensure all types of compounds were represented in the sample. This method is known as a systematic random sample (Barnard 1994). Wealth indicators include the ownership of draught animals and farm equipment, construction materials such as corrugate roofing and cement, off-farm employment, and ownership of luxury items such as a radio, tape player, or gold jewelry.

A full survey of each compound's largest plot of cultivated upland farm field was conducted. The inventory included species name, the diameter at breast height (DBH) measured at 1.5 meters with a steel diameter tape, height using a Suunto clinometer (Avery and Burkhart 1994), the overstory density of mature trees using a spherical densiometer (Lemmon 1957), species and number seedlings under each mature tree, and total crown area. The total number of tree seedlings of each species throughout the farm was counted. To estimate the area of each farm field, the circumference was paced and the angle of the corners measured with a compass to calculate an estimate of the size of the farm.

In each farm a minimum of two soil samples were collected. One sample represented the entire field, collected by combining an auger plugs from the each corner of the field and one from the center of the field. A second soil sample was collected from under a tree in the farm, one auger core was removed from the soil taken at the approximate midpoint between the bole and crown edge on four sides of the tree. Each soil plug was collected using a soil auger to a depth of 18cm. In a few of the farms, extra samples were taken from the understory of mature trees. A total of 49 soil samples were collected. Soil samples were sent to NARI for analysis. Results for soil pH, electrical conductivity, texture, available phosphorous, total nitrogen, and organic matter content were all analyzed in the laboratory.

The compound head from each compound was interviewed to understand farmer's attitudes and interests toward trees in their farms and their farming practices. With the help of my graduate school advisor, a list of questions was drawn up, and my host father ensured that my translations were correct. These questions are listed in Table 3. The compound head was chosen for the interviews because he is responsible for ultimately making all management decisions in the farms.

Table 3: Farmer Interview Questions.

1. For each neem tree in your farm field, please tell me how the tree got there. Did it grow under a tree that was already there? Which species?
2. What is neem used for?
3. What is good and bad about neem in farm fields?
4. What are the best trees to have in your farm? Why?
5. What do you do to encourage and discourage trees?
6. How many hectares of land does your family own?
7. What is the most important crop to your family? Why?
8. Which crops is your family growing this year? How many hectares of each crop are you growing?

In order to get honest and detailed responses, I tried to make informants comfortable. Bringing paper and pens to the interview might intimidate the informant, because most cannot read or write. I found a small boy to brew *attaya*, and asked questions recalled from memory. All the questions were covered, but no strict format was followed: if an interesting topic came up, it would be pursued for a deeper understanding. I recorded the conversation for future reference, placing the recorder in view of the interviewee, and allowed them to listen to the interview at the end. I then checked to make sure that they did not want to add anything or to remove anything from the recording. I found that unlike paper and a pen, people did not seem as intimidated by having a recording device, and were thrilled with the novelty of hearing their own voice.

Farmers in Njawara were more comfortable with interviews than in Kerr Katim Wolof. Lebanese traders founded it at the turn of the century. Njawara, being on the river, was a natural port for exchange of goods. Peace Corps has been working in the village since they arrived in Gambia in 1967. Today quite a few foreigners visit the cultural center and agricultural center. Njawara is a more sophisticated town, with more exposure to western people and customs.

Finally, I interviewed four experts in the field of agriculture and forestry. I interviewed the director of the NATC, the Gambian technical trainer for Peace Corps environment program, the Director of Social Forestry at the Ministry of Forestry, and finally an agroforestry lecturer at the NATC and extensionist for Forut. I questioned them about neem and its role in farming and reforestation in The Gambia. Questions varied based on the individual's expertise, no set list of questions were followed.

It became apparent in interviews and conversations that farmers were well aware of how neem was spreading in their farm fields. Many farmers were actively fighting neem, trying to remove it from their fields, while other farmers were managing neem for specific uses. The next chapter will explain the process of how neem colonizes a farm field in The Gambia.

Chapter 5: Neem Field Observations

While living and working in the Gambia, I took notice where trees were in the landscape. Kerr Katim Wolof has few neem trees, most are transplanted wildlings. Only in one area, do neem trees appear gregarious—under a stand of baobab trees (*Adansonia digitata*). The neem situation in Njawara is clearly different. While living in Njawara, I began to notice that neem grows in clumps under the crowns of large trees that were left in farm fields after clearing. From casual observations, I believed neem was displacing native vegetation in the fields with the aid of farmers and birds. In this Chapter, I will describe my subjective observations and compare them with both quantitative data from field collections and comments from farmers.

Brief Description of Results

Fifteen farms were surveyed around Njawara village for a total area of nineteen hectares. Overall, 87 mature trees were measured, and 21 different species were found. Just under half the trees (45%) had neem growing under them (Table 4). As the total area of the study was nineteen hectares, there was an average of 4.4 trees per hectare.

Table 4: Number of trees with and without a neem understory, by species.

Species	No Neem Understory	Has Neem Understory	Total
Acacia albida	5		5
Adansonia digitata	1	1	2
Azadirachta indica	3	7	10
Bombax costatum	1		1
Borassus aethiopum	2		2
Ceiba pentandra		1	1
Claotropis procera	4		4
Cordyla africana	3	6	9
Kehku	3		3
Parinari excelsa		1	1
Parkia biglobosa	3		3
Piliostigma reticulatum	1		1
Prosopis africana	8	7	15
Pterocarpus erinaceus	2	1	3
Sclerocarya birrea	3		3
Tamarindus indica	1		1
Terminalia spp.	6	1	7
Combretum glutinosum	1		1
Ficus spp.	1	14	15
Total (% of Total)	**48 (55%)**	**39 (45%)**	**87 (100%)**

Description of Neem Succession.

Agroforestry species tend to be pioneers, colonizing new, unvegetated sites. This process is known in forest ecology as primary succession. Pioneers or early successional trees tend to be fast growing, light-demanding short-lived species. Secondary succession is "succession that follows a disturbance to an existing forest, disrupting ecosystem processes and destroying existing biota (Barnes et al. 1998)."[1] Neem is unusual in that someone might expect the tree to grow into open areas.

[1] Farm fields in the Sudanian parkland are not forested, nor are they natural ecosystems; however, ecology terms will be used to describe observations from the field.

I observed that neem trees were growing under a canopy of old, shade-tolerant, late successionary forest trees such as *Prosopis africana*, *Ficus spp., an*d *Cordyla africana*. These relic trees remained in the fields since the land was cleared from the bush two or more generations ago. Trees were left in the fields because they were either useful and did not affect crops (Figure 9), or they contained *gins* (sprits) which harm people who collect or kill the trees in which they reside.

Figure 9: *Prosopis africana* managed for pole timber in a fallowed farm field near Kerr Katim Wolof.

Neem fruit ripens in the months leading up to the rains, in April and May. Birds and bats, having eaten neem fruit, drop the seeds with their guano while perched in a relic tree. Farmers preparing their fields will clear the ground, removing any perennial plants, reducing competition with weeds. Then with the first rains farmers plow their fields two times, which is an ideal seedbed for neem (Nandal and Bahadur 1997). Neem then germinates under a mature native tree, creating a ground cover of vegetation (Figure 10).

Figure 10: Neem growing under *Ficus spp.* in a recently plowed maize field, Njawara.

At this point, the farmer can easily remove the tree, killing it. However, most neem trees escape the hand of the farmer until the following year during *ruuj* (land clearing), when trees, shrubs, and other perennials are cut back with a *daba* or machete.

It is possible to farm under certain trees such as *Prosopis africana, Parkia biglobosa,* and *Cordyla africana*. While land under other trees such, as *Ficus spp*. is not cleared (Figure 10). Neem regeneration was shown to be almost ten times more abundant by area under trees that are not cleared than under trees that were cultivated (Table 5). It was expected that trees with more shade would not be cultivated. However little difference in canopy cover can be seen between the cultivated and uncultivated tree patches. Farmers probably prefer certain species to others based on perceived tree-crop interactions.

Table 5: Number of neem tree seedlings under cultivated and uncultivated canopy trees.

Area Cultivated?	Data	Total
No	Average Canopy Cover (%)	38.9
	Sum of Neem Understory Trees	540
	Total Crown Area (m^2)	1115
	Total Neem Count/Crown Area	0.48
Yes	Average Canopy Cover (%)	38.3
	Sum of Neem Understory Trees	88
	Total Crown Area (m^2)	1758
	Total Neem Count/Crown Area	0.05
Total	Total Canopy Cover (%)	38.5
	Sum of Neem Understory Trees	628
	Total Crown Area (m^2)	2873

Once their root system is well established at one or two years in age, neem trees usually become difficult to kill. If a tree is cut at this stage, it often will spread, sending up many vigorous sucker shoots in the area (Figure 11).

Figure 11: Two neem trees, cut at the ground level now have several suckers at each tree site.

Neem will often overwhelm the understory of the older tree, competing for water and nutrients (Figure 12). The canopy trees are in poor condition or under stress, often damaged by fire (Figure 13).

Figure 12: A dense understory of two to three meter tall neem regeneration under *Prosopis africana*.

Figure 13: ***Ficus iteophylla*** **damaged from fire with a neem tree growing in its understory.**

The next step in the process of neem invasion occurs when the native tree dies, creating a crown gap (Figure 14). This can be caused by a number of things: fire, bee killing, old age, or insect attack. In Gambia, bee killing is a common practice, where farmers harvest honey from wild bee colonies. Wild colonies are common in hollow tree trunks; an axe is used to open the tree up for better access, and then fire is used to calm the bees while the honey is collected. The fire and axe often damage the tree.

Although there is no quantitative proof, the neem trees seem to play a role in the death of the canopy tree. As mentioned in Chapter 3, neem is allelopathic; having a detrimental effect on many types of plants and neem is known to be a strong competitor. The roots are sharing the same space, competing for nutrients, and water under the canopy of these native trees. It could be that neem is stressing these native canopy trees leading to an earlier death.

When the canopy tree dies, it creates the equivalent of a "forest gap". Neem trees that were under the canopy tree now receive full sunlight and are released to grow into the overstory. Farmers use two different management techniques once neem is established. Neem could be coppiced, repeatedly cut back at the ground level. This will cause the neem tree have several shoots, growing as a shrub. Usually, these farmers are trying to kill neem. Sometimes low shoots are used for making stick beds and fencing. Fences are built by weaving neem branches between larger vertically placed sticks buried every thirty centimeters. Some farmers give up cutting back the shoots, and let the area go fallow because they feel "if there are too many neem, they will destroy the farm. Millet, peanuts, they will not be good there" (Figure 15).

Figure 14: ***Ficus gnaphalocarpa*** **killed by bee hunters. The tree on the left is neem; on the right is** ***Bombax costatum*****.**

Figure 15: Neem growing in a shrub-like form (indicated by the yellow ellipse), the area was fallowed and is no longer considered a good place to grow crops.

Neem trees can also be left to grow tall (Figure 16), to provide roofing poles and timber. This technique is used rarely in Njawara, however. I believe this is because Njawara villagers have access to mangrove (*Rhizophora racemosa*) and Rhun palm (*Borassus aethiopum*) that, through casual observation, I have concluded are the preferred species for roofing timber. Jones (1994), states that Rhun palm is one of the most sought after timbers, stating that one palm trunk can yield ten to twelve rafters, and it takes approximately ten trees to build a standard sized house of twelve by nine meters. Several farmers in Kerr Katim Wolof showed their interest in managing neem, indicating its value there. They can be harvested up to twice a year if allowed to establish several years before the first cut (Weber 1986). One farmer who was busy harvesting, using this method explained, “I wait four years before the first harvest (Figure 17). Then every one and a half to two years I harvest the tree, producing twenty or more poles.” Each pole was about two to three meters long and five to eight centimeters in diameter.

The type of harvest used for neem is called pollarding (Figure 18). All the branches are removed, including the main stem. The trunk is left standing up to two or three meters tall. New shoots form at the top of the trunk, which can be repeatedly lopped, while the main trunk increases in diameter. When the tree looses its vigor, the main trunk can be cut as a large diameter pole.

According to Weber (1986), it is best to coppice trees during the dry season, while the trees are dormant. In The Gambia trees are harvested when needed for building, which normally occurs late in the dry season from February until the rains start, while the trees are dormant.

Another farmer explained why the trees were harvested at 2m and not at the ground: “neem trees are cut at the tops in order to provide shade. If they were cut at the ground they would be destroyed by children and goats.”

Not all people are aware of neem management: “Some people believe that there are two types of neem, but there is only one kind. If you cut [pollard] the tree correctly, you will get good straight branches. If you don’t, it gets bent up.” In other words, some people do not realize how management affects the form of the tree. A pollarded tree is said to be attractive, creating a round even crown, with straight poles all from the main stem, while the unmanaged neem can look quite different.

Figure 16: Adult unmanaged neem tree in a groundnut field. This tree germinated under a *Cordyla africana* tree.

Figure 17: Neem tree inside a compound was pollarded for roofing poles. Note the weaverbird (*Ploceus cucullatus*) nests in the managed neem trees in the background.

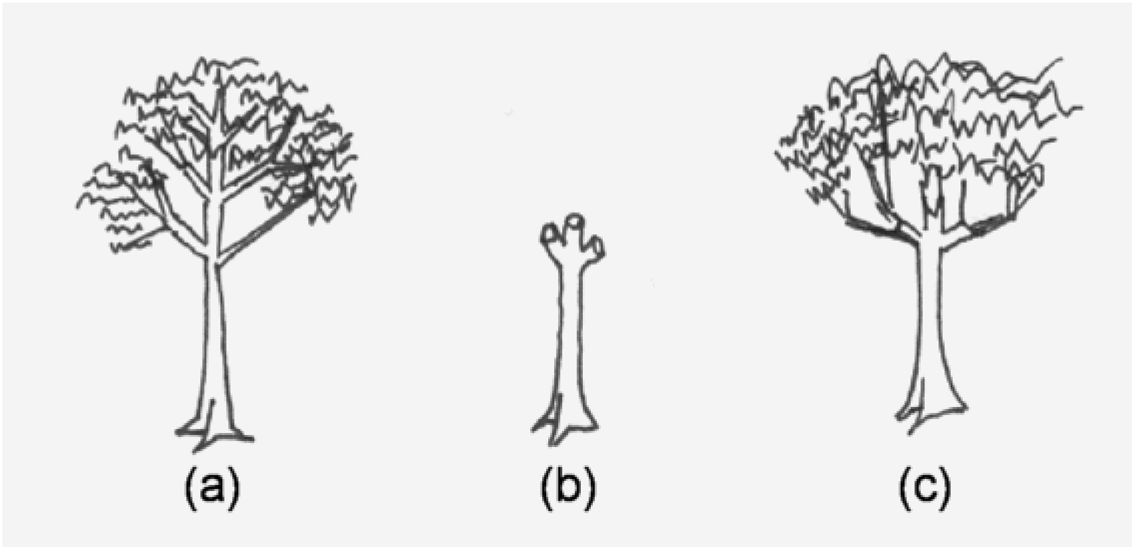

Figure 18: Pollard harvest of neem. (a) unmanaged neem tree; (b) all branches cut off at a height of two meters; (c) new growth from branches (Drawing by M. Judd adapted from Weber 1986).

Tree seedling regeneration in the study is shown in Table 6. All tree seedlings found in the study area are listed, by species on the left. Seedlings that were found under the canopy of another tree are listed under canopy tree, and trees growing in the open areas of the farm are listed under direct sunlight.

Neem grows almost exclusively under other vegetation. Six hundred and twenty-eight seedlings were found under the canopy tree, while only five were not. The next most numerous species found in the study area was *Faidherbia albida* (15) and *Terminalia spp.* (14).

Table 6: Tree seedlings in farm fields, under canopy trees and in open areas.

Tree Species	Under Canopy Tree			Direct Sunlight (Open Areas)		
	< 1m	> 1 m	Total	< 1m	> 1 m	Total
Acacia tortilis			0	2	2	4
Azadirachta indica	248	380	628		5	5
Claotropis procera			0		2	2
Celtis intergrifolia	0	2	2			0
Combretum glutinosum		1	1			0
Cordyla africana	1		1	3	1	4
Faidherbia albida		3	3	2	10	12
Ficus spp.	3		3			0
Lonchocarpus laxiflorus		1	1			0
Piliostigma reticulatum			0		1	1
Sclerocarya birrea		1	1	1	3	4
Terminalia spp.		5	5	1	8	9
Ziziphus mauritiana			0		1	1
Total	252	393	645	9	33	42

Neem regeneration is overwhelming in sites under trees. Neem seedlings are disproportionally represented under trees relative to the current number of adult neem trees (Figure 19). Unless action is taken against this, neem will dominate the farms in the future.

Because neem creates a thick mat of vegetation, other vegetation does not grow there. Neem could be displacing other native vegetation such as *gehran* (*Guiera senegalensis*), a very useful woody shrub common in farmlands, and is associated with soil fertility (Bationo et al. 2004; Louppe 1991). Gambian farmers state that farms that have *gehran* are good for farming, while if a farm has no *gehran*, the soil is dead.

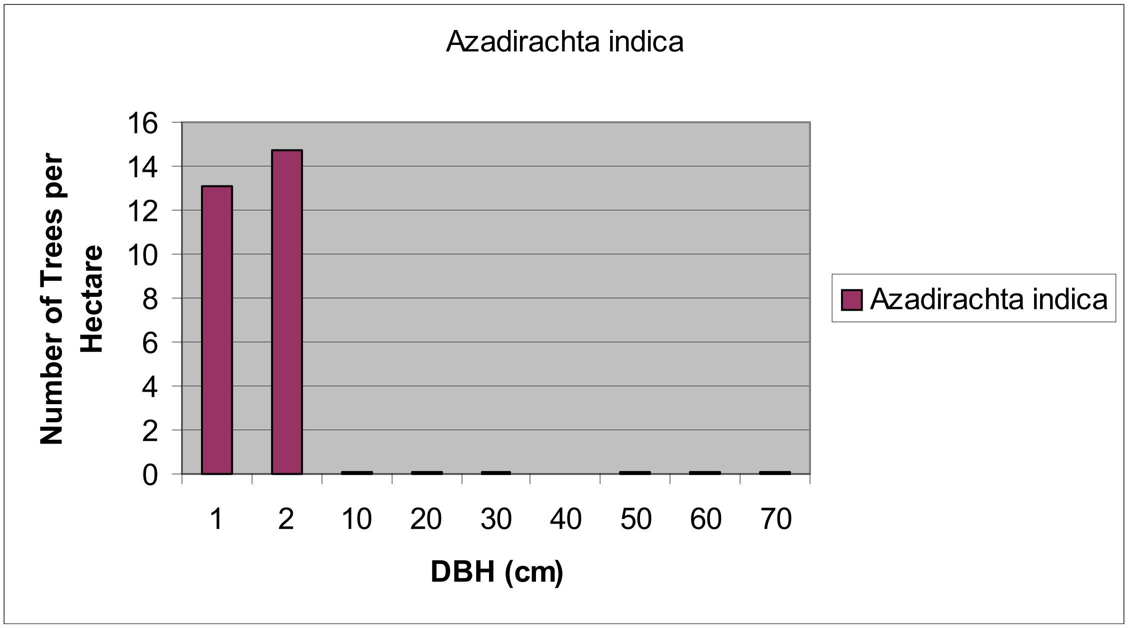

Figure 19: Number of *Azadirachta indica* trees per hectare.

Soil Test Results

Soils in the fifteen farm fields (49 samples) were sandy loam (44) or loamy sand (5). Although 49 soil samples are too few to make rash generalizations, a general idea about what the soils are like, and how they are affected by neem will be made. The results from all 49-soil tests were averaged to give an idea what the soils are like in the area (Table 7). They have an active acidity pH of from 3.7 to 7.3, with an average of 6.2, and an exchangeable acidity of pH 3.5 to 7.0, averaging 5.7. On average, organic matter was high for cultivated tropical soils, with an average of 1.2 percent, however the soils varied from 0.59 to 2.72 percent.

Table 7: Averaged soil property values for the study area.

Collection Site	Soil pH (Water)	Soil pH (.01 NaCl2)	EC (mmhos/c)	Bray-1 Avl. P (ppm)	Organic Matter (%)	%Sand	%Silt	%Clay
Open Field	5.4	4.5	0.04	3.5	1.3	75.6	13.9	10.5
Under Tree	6.4	5.9	0.05	6.8	1.2	75.8	13.0	11.2
Average	**6.2**	**5.7**	**0.05**	**5.7**	**1.20**	**75.7**	**13.3**	**10.9**

All soil samples were categorized into five different stages of neem growth at the sample location, with the exception of two samples taken under mature neem that had not germinated under the shade of another tree. The categories were: (0) no neem (open field sample), (1) neem seedlings (patches of neem seedlings less than two meters tall under a canopy tree), (2) neem over two meters in height under a canopy tree, (3) neem at a site where the canopy tree recently died, and (4) locations where neem had grown into the "canopy". An analysis of variance with unequal replication of the five different treatments (categories) of soil samples was conducted (Steel and Torrie 1960). The ANOVA statistical calculation was computed with SAS software. Results indicated that there was a significant difference for both phosphorous (P=0.001) and organic matter (P=0.002) between the different categories.

The statistical difference between the five different categories was analyzed using Tukey's ω-procedure (also known as honestly significant difference) for both phosphorous and organic matter content at the 0.05 percent error level (Table 8 and Table 9). Phosphorous showed significant differences between the adult neem and no neem, adult neem and neem seedlings, and adult neem and neem over two meters. Organic matter content in the soil also showed significant differences between adult neem and neem over two meters, and adult neem and neem under two meters.

Table 8: Tukey's ω-procedure results for phosphorous.

0	1	2	3	4
3.5	4.8	4.9	6.8	19.6

Table 9: Tukey's ω-procedure results for organic matter.

1	2	0	3	4
1.0	1.1	1.3	1.3	1.9

Key:
0 = Open field (no neem)
1 = Neem seedlings <2 meters
2 = Neem seedlings >2 meters
3 = Neem at site where canopy tree died
4 = Neem that has grown into the "canopy"

The mean values for phosphorous content showed a steady rise as neem matures at the site. Organic matter was actually higher in the open field than for sites where neem seedlings less than two meters tall are growing. Neem out competes other plants, completely dominating microsites. Young neem do not drop much litter when establishing at a site, and no other plants vegetate the site, the organic matter would be less for those locations. It is not surprising that neem increases phosphorus. As the neem grows older it changes the site, producing more and more organic matter, adding litter to the soil, thereby increasing the phosphorous and organic matter. The tree acts like a pump, bringing up phosphorous and other nutrients up from lower soil horizons and parent material.

Not only is organic matter important for improving soil fertility. Soil organic matter is important for managing soil moisture: organic matter maintains soil structure, and increases the soil's ability to store available water for plants.

Other research has been done on the soil effects of neem in Nigerian red acid soils. Radwanski found marked improvements in the top 7.5 cm of soil under neem than in cultivated plots (1969). Phosphorous, carbon (indicating organic matter), and nitrogen concentrations were much higher in the upper soil profile than in the cultivated fields.

Some farmers who have neem in their farm fields are managing it for poles or sticks, while other farmers are trying to remove it from their fields. In Kerr Katim Wolof, there were many trees pollarded, indicating that farmers are managing the trees for poles, primarily those used in roofing. In Njawara, few people are using this management system; it is more common to see neem coppiced at the soil surface, either for sticks used in the construction of beds, or to simply remove them from cultivated fields.

Neem competes with native vegetation in the farms, and appears to be displacing it. Neem seedlings outnumber all other tree regeneration. If the understory of the tree is cultivated or cleared, it appears that neem seedling survival is much lower than when it is left uncultivated. This shows that neem can compete with the other native grasses. It also indicates that with timely weeding, neem can be reduced in the field.

This chapter showed that Neem is both useful and detrimental to the people and environment in The Gambia. It improves the farm soils, which should theoretically increase crop yields. However, it is spreading in farm fields, replacing native species as they die. Evidence from farm fields indicates that it is invasive in disturbed environments.

Chapter 6: Results and Discussion

The previous section described the structure and composition of farm trees and other farm field observations. This chapter will begin by talking about the role of trees in farming systems. Then, farmer's opinions and attitudes toward trees in their farms will be reported and compared to field data.

Raintree (1986) describes how trees can be integrated into the farming system, as increasing levels of intensification in subsistence tropical farming systems develops, based on the intensity of land-use and labor input. At low population densities, shifting cultivation with long forest fallows commonly exists. As population density increases, the length of fallow period decreases until farmers are continuously cropping, with no fallow.

As the farming system evolves due to population pressure and other factors, the role of trees in the farms changes. With diminishing access to off-farm woody biomass, a increasing demand, declining site productivity, increased exposure to risk, as is the case in all of the Baddibu region, there is a general progression toward planted trees, and more intensive land uses (Arnold 1995).

According to the CIA (2004), the rural population is 68 percent of the total population (1.5 million people). With 10,000 km^2 of land, the population density could range from 102 to 204 persons/km^2, depending on the amount of arable land and regional variations of population. This classifies current farming practices within the annual cropping stage, the continuous cultivation of crops (Greenland 1974; Boserup 1981, in Raintree 1986).

Farmer Responses

Characteristics of the fifteen farmers interviewed in Njawara are compiled (Table 10). Looking at the farmer's characteristics, I feel that it is a representative population of Njawara, except there are quite a few who have received an exceptional education for typical villagers even for cosmopolitan Njawara. Unfortunately, no statistics are available for school enrollment for the village (or for the other characteristics). This may have created a bias in the sample. Two farmers have exceptional amounts of land, farmers eleven and fourteen. They were part of the *kabilo*, the first to found the village, and therefore, by tradition own all of the village's land, considered the *kabilo's* land. In practice, however, most individual farmers have permanent tenure over their cultivated fields.

Table 10: Njawara farmer interview characteristics.

Farmer No.	Sex	Age	Farm Size	Wealth	Literate?	Western Language	Education
1	Male	54	12 ha	Middle	No	None	Some farmer training.
2	Male	41	5 ha	Lower	Arabic	None	Some farmer training.
3	Male	40	15ha	Upper	English	English	Studied overseas for 6 months.
4	Male	45	3.5 ha	Middle	No	None	None
5	Male	45	4 ha	Middle	English	English	HS Diploma, Retired Teacher
6	Male	44	6ha	Middle	No	None	None
7	Male	23	1.5 ha	Lower	No	None	None
8	Male	25	4.5ha - borrowed	Lower	English	English	Completed 6th grade.
9	Male	51	1 ha - borrowed	Lower	No	French	None
10	Male	52	10+	Lower	Arabic	None	Farmer training
11	Male	40	"All the land is his family's."	Upper	English	English	HS Diploma, Ag Extensionist
12	Male	47	4 ha – borrowed 3.25ha	Lower	No	None	Some Farmer Training
13	Male	24	2ha - borrowed	Lower	No	None	Completed 3rd grade.
14	Male	32	30+ ha	Upper	English	English	Completed high school.
15	Male	34	3 ha	Lower	No	None	Completed 3rd grade.

Because the kabilo was the first family, they own the majority of the lands in Njawara. As a village is settled, lands are cleared and cultivated, becoming the property of the family who cleared it. Several farmers do not own land, because they have immigrated to Njawara recently. No new lands are left to clear. New immigrants can try to either cultivate abandoned lands with poor soils, or borrow lands on a yearly basis, usually from the *kabilo*.

There was no doubt as to whether farmers are aware of how neem is invading their fields. All fifteen farmers stated that neem gets into their fields by birds consuming the seeds and later eliminating the seeds while perched in the tree, confirming the field observations.

Responses from the farmer interviews are listed in Table 11. Eight out of fifteen farmers (53%) responded that there were no good reasons to have neem in their farm. Only two farmers stated that there was a benefit to having neem in their fields: that it improves the soil. When asked what is bad about having neem in the farm fields, ten farmers (66%) believe neem has a negative impact on surrounding crop yields. They stated that it reduced germination and crops did not look attractive near neem. A few stated “neem ruins the soil, makes it bitter.” This is similar in comparison to a study in Burkina Faso, where 33% of the farmers stated that the presence of neem is unfavorable to the development of associated cultures, notably millet and sorghum (Bationo et al. 2004). None of the farmers made any positive statements about neem in farm fields.

Table 11: Farmer Interview Responses

Farmer #	What is Good about having Neem on your farm?	What is Bad about having Neem on your farm?	What do you do to encourage trees in the field?	What do you do to discourage trees in the field?	Crops most Important	Crops Grown
1	Not good.	Ruins the soil. Difficult to kill.	Clear around it, protect from animals, tell children to leave it.	Only Neem. He would cut and burn.	All Important.	1.5 ha Maize and Sorghum, 4 ha Millet, 2 ha Groundnut
2	Not good.	Nothing grows well near it. It disturbs other plants, it kills other trees.	Leave the trees that germinate.	Cut it; use it for firewood.	Millet	2 ha Sorgum & Millet, 3 ha Peanuts Beans (small)
3	Not good.	It is a pest, spreads easily. Nothing will grow around it, too much shade.	Cut back branches so it grows up, mark them.	Burn millet hulls around the tree.	Groundnut	2.5 ha Millet, 7 ha Groundnut, 3 ha Maize
4	Not bad, but gave no reasons.	When many grow near a well, it makes the well water bitter.	Leave them while clearing.	Cut them.	All Important	2 ha Groundnut, 1.5 ha Millet
5	It's okay, but gave no reasons.	Too much shade.	Cut back branches so it grows up.	Cut at ground level during clearing	Rice	1 ha Groundnut, 2.5 ha Millet, 0.5 ha Mellon, Maize, and Cassava 0.125 ha Rice

Table 11 (Continued): Farmer Interview Responses

Farmer #	What is Good about having Neem on your farm?	What is Bad about having Neem on your farm?	What do you do to encourage trees in the field?	What do you do to discourage trees in the field?	Crops most Important	Crops Grown
6	No Benefit.	It will make cassava bitter if grown together.	Leave it during clearing.	Cut and burn.	Groundnut	2ha Millet , 4ha Groundnut
7	None.	Nothing grows under it. It ruins the soil. You cannot kill it.	Trees are not good in a farm- -shade.	Cut during clearing	Groundnut	0.5 ha Millet, 1 ha Groundnut
8	Not good.	Difficult to kill: it will just grow back.	Transplant or germinate trees in the field*	I would not kill a tree.	Millet	1ha Groundnut, 3 ha Millet, 0.5ha Maize and sugarcane
9	Not good.	Nothing will grow near neem, leaves ruin soil, snakes like neem	Should encourage family to grow trees. Plant new trees and leave wildlings to grow.	Trees are good.	All Important	0.25 ha Beans, 0.75 ha Cassava, Watermelon, & Maize
10	Shade	Will destroy the farm: Crops will not grow well and poor germination.	Plants trees, Removes upper branches to let light through to farm.	Would not do that.	Millet	4ha Peanut, Millet 3ha, <1ha Beans & Sorgum

Table 11 (Continued): Farmer Interview Responses

Farmer #	What is Good about having Neem on your farm?	What is Bad about having Neem on your farm?	What do you do to encourage trees in the field?	What do you do to discourage trees in the field?	Crops most Important	Crops Grown
11	Not good.	Bitterness-nothing will grow well near it, poor germination.	Just leave them to grow.	Cut and burn them.	Millet	3ha Groundnut, 5ha Millet, 2ha Maize Okra (small)
12	Improves soil	Killed Mango trees planted near it.	Leave the trees that germinate.	Would not discourage trees in farm. Not enough trees now.	All important.	2ha Groundnut, Millet 2ha
13	Improves soil	Crops will not grow well near it.	When a tree germinates, clear around it but leave it alone.	Cut at ground level during clearing	Peanut, Millet, Maize--All Equal	1ha Peanut, 1ha Millet
14	Not good.	Its Discouraging--crops wont germinate or grow well there	Protect w/ fencing, clear of fuel to protect from bush fire, tell family members not to cut it.	Uproot the trees of unwanted trees while young is easiest.	Millet, Maize	5ha Millet, 10ha Peanut, 0.5ha Sorrel, 0.5ha Beans, 1ha Maize, <0.25ha Cassava
15	Not good.	I’m just a farmer, I don't know anything.	Tell children not to cut it.	Cut them back, burn when dry.	Millet	1ha Millet, 2ha Peanut

Farmers all had similar methods for encouraging native trees in the farm. Most replied that they clear grasses around trees, so that bush fires would not harm them. Some farmers stated that they teach their children and tell family members not to cut the tree. Three farmers stated that they trim lower branches so that the tree could quickly grow tall.

There were many different techniques mentioned for killing trees. The simplest method is simply to cut the tree and burn it, or chop it up for firewood. Four farmers mentioned that they would not harm trees in their field or would only harm neem. The easiest method for removing trees is while they were young seedlings, by ripping the roots out of the ground. The most interesting method mentioned was specific for killing the neem tree: burning millet hulls around the trunk of the tree. The hulls burn slowly, heating the soil deeply to kill the roots. The other favored method for killing neem, was to remove the bark of a living tree and let it dry out and die. Most efforts to kill neem were unsuccessful.

It was hypothesized that there would be a connection between the type and amount of crops are grown and the amount of land, economic class, or education. However, there was no clear correlation. The population of each compound might play a role in this result. If farmers have a high demand on their land for providing food, it would be expected that the staples—groundnuts and millet would be favored over other crops. However, no statistics were kept on compound size.

Farmers were asked to list which trees they thought were best to have in the farm. *Faidherbia albida*, *Prosopis africana*, and *Cordyla africana* were favored (Table 12). Note that neem was not among the responses.

Table 12: Farmer's preferences for good trees to have in their farm fields.

Farmer #	*Acacia nilotica*	*Cordyla africana*	*Faidherbia albida*	*Ficus spp.*	*Fruit trees*	*Gmelina arborea*	*Kehku*	Nitrogen Fixing Trees	*Parkia biglobosa*	*Prosopis africana*	*Pterocarpus erinaceus*	*Sclerocarya birrea*	*Terminalia spp.*	*Ziziphus mauritiana*
1		●	●							●				
2		●	●				●		●		●			
3			●	●						●			●	
4			●							●			●	
5	●		●						●					
6			●											
7		●	●							●				
8		●	●											
9					●									
10			●							●		●	●	●
11			●			●								
12		●							●				●	●
13		●								●	●			
14		●						●						
15							●		●					
Total	**1**	**7**	**10**	**1**	**1**	**1**	**2**	**1**	**4**	**6**	**2**	**1**	**4**	**2**

Table 13: Number of trees found in farms compared to number of farmers stating a preference for that tree.

Species	Total Trees	Farmers Preference
Acacia nilotica	0	1
Acacia tortilis	4	0
Azadirachta indica	**643**	**0**
Bombax costatum	1	0
Borassus aethiopum	2	0
Celtis intergrifolia	2	0
Claotropis procera	6	0
Combretum glutinosum	2	0
Cordyla africana	**11**	**7**
Faidherbia albida	**20**	**10**
Ficus spp.	8	1
Fruit trees	0	1
Gmelina arborea	0	1
Kehku	3	2
Lonchocarpus laxiflorus	1	0
NFT	0	1
Parinari excelsa	1	0
Parkia biglobosa	3	4
Piliostigma reticulatum	2	0
Prosopis africana	**12**	**6**
Pterocarpus erinaceus	3	2
Sclerocarya birrea	8	1
Tamarindus indica	1	0
Terminalia spp.	**21**	**4**
Ziziphus mauritiana	1	2

A strong relationship can be seen, between the tree species farmers preferred and the trees that were found in their farms (Table 13). Notably, *Terminalia spp.*, *Faidherbia albida*, *Prosopis africana*, and *Cordyla africana* were all trees that farmers preferred and were found in the field in large numbers. This shows that despite comments about the negative effects of trees in the farm shading other trees, farmers are protecting the trees that they like. Neem and *Claotropis procera* were the only species that were found in farms in a great number that were not recommended by farmer. One reason why farmers did not mention *Claotropis procera* is that it is considered a bush or weed, which grows to a maximum height of one and a half meters tall (Maydall 1990). Table 14 lists farmer's responses to the question: "What can neem be used for?" In retrospect, it might have been better to ask, "What do you use neem for?", to better compare the actual use of neem in Njawara and Kerr Katim Wolof. Many people knew uses of neem, but rarely were these uses observed in the compound. The three most popular responses in order were medicine, roofing poles, and fencing. However, from observing the roofing on their houses, neem is rarely used for that purpose. Two different medicinal uses were mentioned by the respondents. A small amount of neem leaves can be boiled and the water consumed as a weak tea to reduce the effects of malaria. The other medicinal use of neem is for inducing abortion for unwanted pregnancies. Again, a tea is made from the leaves of the plant, but the concentration is much stronger.

Table 14: Farmer's knowledge of neem use.

Farmer #	Fencing	Firewood	Medicine	Ornamental	Pest Control	Roofing Poles/Posts	Shade	Toothbrush
1	•				•			
2	•	•			•	•		
3				•	•		•	
4			•			•		
5	•		•			•		
6	•		•			•		
7	•							
8			•					•
9			•					
10			•			•		
11			•		•			
12	•					•		
13			•					
14			•			•		
15						•	•	
Total	**6**	**1**	**9**	**1**	**4**	**8**	**2**	**1**

Many farmers mentioned ways of killing neem, but nobody had a reliable method. Many stated that the root system of neem is large. If you cut the tree down, dig up the main root ball, and burn grasses in the stump area, the tree would still resprout from the root fragments (Figure 20). Everyone agreed that neem is difficult to kill.

Figure 20: Neem tree sucker sprouting after a farmer tried to kill the tree by digging up and burning the stump.

Is neem a good development intervention?

Many development efforts in The Gambia have focused on importing technologies and giving gifts to communities in the hopes that they will use them without giving the knowledge and education needed to benefit from them in the long term.

Foreign technologies may not be needed or appropriate for use in a given environment or culture.

Neem was encouraged to give Gambians an alternative fuel source to native species, reducing pressure on The Gambia's remaining forest resources, and meet farmer's firewood needs in areas of fuelwood scarcity during the 1970s fuelwood crisis. However, Gambians do not use it for its intended purpose. It makes decent firewood, with a specific gravity of 0.56 to 0.85, but it is rarely used for firewood because the wood emits a foul smoke when burned (National Academy of Sciences 1980). Not one farmer out of fifteen interviews in Njawara mentioned using neem for fuelwood. For this reason, the plan to encourage neem for fuel was ill conceived. It should be noted however, that it would be more appropriate to interview women rather than men to have a better understanding of species preferences for fuelwood, as they collect and use it. The reason neem adoption was so successful in The Gambia was its ability to grow easily, quickly providing shade in compound areas and roadsides. It has improved the quality of life in many cities, towns, and villages.

In The Gambia, government agencies, foreign aid workers, and farmers have commented on the negative effects of the neem tree. In all three interviews with experts, negative impacts of neem were mentioned. They claim that it reduces soil moisture and nutrients. It is allelopathic, reducing crop production, and out-competes native vegetation.

One farmer commented on how the bitter roots disrupt surrounding trees, making it difficult to establish fruit trees such as the mango tree (*Mangifera indica*)*,* killing them. It is believed that neem prevents other plants from fruiting, because its insecticidal alkaloids discourage pollinator insects when planted close together (All Africa, Inc. 2001). Peace Corps once encouraged the plant, now volunteers are advised not to propagate it. The Gambia Forestry Office has stated "they no longer support the further propagation of neem trees because they are highly invasive and tend to out-compete local species" (Bergner 1998).

Another reason why farmers dislike trees in their farms is that they harbor weaverbirds (Figure 17). The gregarious bird's constant chirping can be annoying, but they are hated because they are pest, consuming millet seed, reducing the farmer's harvest. Children can be seen catching the fledglings and torturing them before they are grilled on charcoal and eaten. Weaverbirds tend to prefer certain tree species for their nests: *Azadirachta indica, Gmelina arborea,* and *Ficus spp.* Often, farmers will cut up the limbs of the tree to rid the area of the birds.

This story might seem a grim tale, documenting the invasion of an exotic species into farms, displacing native vegetation, and disliked and unused by farmers. Maybe it would be best to heed the motto "make do with what you have", because neem is not going away. Neem is a very useful tree. Farmers have only known the tree for fifty years.

What is neem's niche in The Gambia's farming system? How will the management of neem evolve in the farm? Social-cultural beliefs will most certainly play a large role in farmer's decisions in how neem will be incorporated into the farming system, if at all. If farmers feel that neem is a bad tree to have in their farms, then they will continue to try to eliminate it. One example of how cultural beliefs affect tree planting is that Mandinkas believe *Jatropha curcas* brings loneliness to a compound, while the Fulani grow the tree inside the village as a woody barrier to control animals. If it is the case that farmers dislike the tree, then they best try to remove the trees at a young stage, when they can easily be uprooted. *Azadirachta indica* has long lateral roots extending up to fifteen meters. If the main trunk is injured or cut, the roots produce suckers, taking up more of the farm (National Research Council 1992).

Tree planting does not need to occur on farmlands. Interstitial tree planting, planting trees in border locations between farms, roadsides, compounds, waterways, in wastelands offers the benefits of tree products with little lost opportunity (Raintree 1986). This is where Njawara and Kerr Katim Wolof are today: there are many neems found in compounds, along roads, and in waste areas, but rarely are adult neem trees found in the farm.

In western Kenya, farm borders are marked by a relatively useless tree, *Euphorbia tirucali*. This reduces conflicts over who should benefit from the tree's products (Raintree 1986). Neem wildlings could easily be transplanted to farm boundaries, to ensure that land disputes are avoided.

There are two main difficulties in growing trees in dry climates. High evapo-transpiration rates due to the heat, aridity, and wind make seedling survival difficult, often requiring special care. Only in cases where there is a great benefit, will farmers plant trees. Mangos are commonly planted in compounds for this reason. The other difficulty comes from animals browsing seedlings, substantially reducing survival rates, unless protected vigilantly. Neem is not affected by either of these problems. The genotype found in West Africa is not browsed by animals, and the tree can survive in low rainfall areas.

Farmers could begin to make use of this tree in the future. As fewer natural resources are available to farmers and the population increases, they will be forced to manage their resources more intensively. Wood resources are scarcer in Kerr Katim Wolof than Njawara. Njawara has access to tree resources; there is a narrow buffer of forest and mangrove along the river. In Kerr Katim Wolof, farmers are managing neem for poles, because they have no access to their preferred tree species. Most buildings are roofed with either eucalyptus or neem. Neem poles are commoditized in Kerr Katim Wolof, selling for five to ten dalasis per pole (US$0.15 to US$0.30).

Farmers in Njawara might begin managing their neem differently. Wood products are becoming less available. For example, to get Rhun palm, one must travel to the Central River Division. Women have to travel farther to collect white mangrove (*Avicennia germinans*) for firewood, and men are traveling farther in their boats to get red mangrove (*Rhizophora racemosa*) poles. Perhaps a new trend in tree management will occur when these resources become scarce enough for farmers to value neem wood. In other West African countries people are continuing to transplant wildlings and managing neem trees in their farms.

According to recent studies in Burkina Faso, neem trees don't necessarily have to be harmful to crops. Neem is a relatively new tree to the Gambia, and farmers are still learning how to utilize it. In Burkina Faso, neem branches and suckers are trimmed back at the beginning of the rainy season, and left to enrich the soil (Bationo et al. 2004). This illustrates an integrated approach to manage neem in the farm: the crops benefit from the trees (organic matter and nutrients for the soil) and negative effects (shade) are minimized through management.

Although competition between neem and crops for water is a concern, nitrogen is more limiting in many arid areas (Felker et al. 1980 in Raintree 1986). This study has shown that neem trees increase organic matter content of the soil, which increases soil's water holding capacity. Although nitrogen was not tested in soils, neem has been shown to increase nitrogen levels in the topsoil (Radwanski 1969). Even water consumption of neem is very low. A study conducted in Senegal found that *Azadirachta indica* used less water per unit leaf area than the native trees *Acacia aneura*, *Acacia seyal*, and *Acacia nilotica* during three successive days during the wet season (Deans et al. 2004).

Neem might not affect crops as adversely as some farmers believe if different management techniques are used. Tylandet (1996) states that sorghum growing within eight meters of a neem tree has a lower yield, he found that if neem is pruned at the beginning of the cropping season, the yield of sorghum increased within three meters of the tree by 14.8%. If the neem is used to mulch the field three years in a row, it can increase sorghum yield 20% to 40% (Devernay 1994 in Ganaba 1996). This is probably a result of enrichment of the soil with organic matter rich in nutrients.

Mature native trees are dieing regardless of whether neem is killing them or not. As shown in this paper, little regeneration of native vegetation is occurring. For farmers practicing annual cropping with no fallow, alley cropping and other tree intercropping systems are the natural point of departure from cropping monocultures (Raintree 1986). Alley cropping is not an appropriate technique for Gambia, as it tends to compete with crops in areas with low rainfall, however intercropping has been practiced in the region (Nair 1989). *Faidherbia albida* intercropped with millet is a well-known indigenous agroforestry system in northern Senegal (Beets 1990). It increases the productivity of the land by improving the soil, and hence the yields, and provides fodder for animals.

Farmers in Kerr Katim Wolof are beginning to experiment with neem in their farm fields. There, neem fills a niche—providing timber that would otherwise be purchased or harvested from the river over fifteen kilometers away. If their management system proves to be successful, the methods could spread to other areas. This indicates that there is scope for a neem agroforestry system.

Current farmer management of trees in the farm is in the early stages of a progression to an agroforestry system (Raintree 1986). Integration of trees into the farming system will require time to evolve. Farmers are beginning to plant trees for windbreaks and live fencing in Kerr Katim Wolof. In both Kerr Katim Wolof and Njawara, farmers are beginning to protect valued trees in their farm. Neem could be another tree that becomes managed, if it finds its niche in the farm.

Chapter 7: Conclusion

Increasing demands are put on land to provide the means for survival, farmers will need to intensify production by either increasing labor inputs or integrating trees into farms. Trees provide marketable products, reduce dependency on outside sources, and diversify the farm, while adding ecological benefits to the production base (Raintree 1986). Neem could be a component of an evolving agroforestry system that farmers practice in the Baddibu districts.

Neem is being managed for two different purposes: for growing two to three meter poles used in construction, and for small sticks for fencing and furniture. Otherwise, farmers are cutting the trees and burning them in hopes of killing the trees, with limited success. At present, none of the farmers are propagating the tree.

This contrasts with many other localities given in the literature. In Burkina Faso, neem is being actively propagated by farmers. They transplant wildings into the farm and along boundaries (Bationo et al. 2004). In another part of Burkina Faso, one farmer is growing neem around the border of his farm interplanted with *Ziziphus mauritiana*, so that cassava, pepper, and eggplant can be cultivated inside the field (Van Gelder et al. 1995).

Obara (2004) suggested a management system for neem woodlots in Kenya to provide an alternative source of wood for the woodcarving industry. Neem trees generally grow in higher densities on public land than private land. It was hypothesized that because neem has very little value there, it was reduced on private land by clearing and burning, preferring to grow move valuable trees for fruit or wood.

Neem is most commonly known for use as medicine by farmers in Njawara. In *Swahiii* (a tribe in Kenya), the tree is called *mwarobaini,* which refers to the ability of the plant to cure 40 different diseases (Obara 2004).

Farmers explained that they do not like neem in their farm fields. They believe that it is detrimental to crop production, reducing the yields of crops surrounding the trees. Farmers are making efforts to protect certain trees that they feel are beneficial in the farm, including *Faidherbi*a *albida*, *Cordyla africana, Prosopis africana*, and *Terminalia spp*. *Faidherbia albida* is integrated into the farming system in northern Senegal, where farmers are well aware of its beneficial affects on millet yield (Anonymous 1989; Beets 1990).

Increased phosphorous and organic matter content in soils under the crown of neem was revealed from soil tests. This confirms Radwanski (1969), and Radwanski and Wickens (1981), who have also shown improvement of soils under neem.

Neem is a naturalized exotic in The Gambia, reproducing naturally, and appears to be spreading quickly. Neem regeneration is overwhelming areas under the canopy of native species, competing with them for nutrients and soil water, and may play a role in their mortality. Soils are enriched with litter from the canopy of mature trees increasing phosphorous and organic matter content.

For more than two decades, agroforestry literature has warned about the threat of exotic tree species spreading uncontrollably, although many foresters do not see this as problem in degraded, low potential areas (Fonseca et al. 2004). Neem is a prolific seeder, characteristic of invasive species. One tree can produce eight to thirty kilograms of seed per year; each kilogram yields 2000 to 3000 seedlings (Nandal and Bahdur 2004). The fruit ripen at the onset of the rainy season. They then germinate and establish themselves while there is available soil moisture (CAB International 2004). Ganaba (1996) describes this process occurring in Burkina Faso and calls for the control of its expansion. He states that neem is taking up the most fertile locations, under trees, where yields are the greatest. Many other sources mention the prolific nature of neem (Benge 1986; Faneska et al. 2004). Neem is also reported to displace native vegetation, intolerant of other plants (Radwanski and Wickens 1981; Ganaba 1996). This was observed, but not measured in this study.

In Njawara, and from casual observations in Kerr Katim Wolof, I have found that neem is spreading in a way characteristic of an invasive species. They are spread by birds and bats, becoming numerous under native trees. The literature confirms these findings. "[The] trees themselves may become 'weeds.' They spread widely under favorable site conditions, since the seeds are distributed by birds, bats, and baboons. For the same reason, natural regeneration under old trees is often abundant (National Academies Press 1992)." Since farmers in Njawara do not like neem in their field, it can be considered a weed, and because it can reproduce in large quantities, at a considerable distance from the parent plant, it is by definition an invasive plant (Fonseca et al. 2004).

Although neem could be totally eradicated from an area, it could only be completely successful with outside assistance and vigilant effort. The better solution is to remove neem trees as they germinate, in order to stop any further spread of the tree. They can simply be pulled from the ground in its early stages by farmers, while weeding their fields. In time, I expect that farmers, being resourceful people, will find locally available methods for removing unwanted adult neem trees, than the current practice.

Neem is an abundant resource for Gambian farmers. Gambians are just beginning to realize the potential of the tree, for medicine, for pest control in gardens and grain storage. If those benefits are realized, neem could find a place in the farming system.

Gambian gardeners are constantly fighting pests: red spider mites, aphids, caterpillars, thrips, grasshoppers, whiteflies, and nematodes. NARI and the Ministry of Agriculture have been working on integrated pest control techniques that would reduce the dependence on harmful insecticides. It will be difficult to convince farmers to switch to neem controls, because neem does not have an immediate knockdown effect that chemicals do. Research has shown that neem oil is effective for pest control, but collecting seeds and pressing the oil is a laborious and time consuming process. Peace Corps promotes an easier method, spraying plants with water fermented with neem leaf for several days to control pests. Radville Farms, an exporter of beans and okra in The Gambia, have been successfully growing organic produce on their farm for three years. They have been using neem sprays as both a preventative and to treat their organic crops for aphid and mite infestations. There have been fewer pest outbreaks in their organic farm than in their conventional farm. Instructions for how to make the leaf insecticide are listed in Appendix B.

Losses of grain and especially legume seed due to pests are high in The Gambia. Farmers are always looking for more seed for planting at the beginning of the next season. Neem kernel extract can also be used to safely protect groundnut seed and other pulses from weevils, so they can be used in the next growing season (Jenkins 1998). The Peace Corps environmental project in The Gambia should begin promoting the use of neem to protect seed stores, by demonstrating the methods and effectiveness in counterpart trainings.

Neem could be grown as a cash crop—neem seed is a valuable crop. In India, buyers pay US$1,000 to US$2,500 per metric ton of quality kernels (Chin 2004). Kernels are pressed to oil for the production of USDA approved organic natural insecticides (Peaceful Valley Farm Supply 2004). This would take a large amount of investment in infrastructure to get the product to market, and an effort to attract manufacturers or traders willing to operate in The Gambia.

New forestry initiatives need to take place that reflect the needs and attitudes of small farmers, by assessing the situation at the village level. Often initiatives take a top down approach by policy makers in the big city who are not in touch with village life. Perhaps one new initiative should be given more attention is encouraging farmers to protect volunteer wildings in the farm fields. Many farmers in this study were found to be protecting *Faidherbia albida*, *Cordyla africana*, and *Prosopis africana*.

The Ministry of Forestry would do well to avoid the bias against native trees by transferring ownership of native trees in farm fields to the owners of the farms, so that no confusion over ownership occurs. *Prosopis africana* and *Cordyla africana* have many uses. *Cordyla africana* is a valuable wood, used for making the *sabar* (a traditional Wolof drum), canoes, and pounding bowls. The tree produces fruit at the beginning of the rainy season, just as food stocks are running low. *Prosopis africana* is a very strong wood, it makes the best charcoal for brewing tea, and the wood is said to last 100 years. It is used for building fences. Standing trees could represent a substantial savings for a compound. As farming systems evolve in The Gambia, trees including neem, will play a more important role in farm productivity.

Further research should be conducted to ascertain the effects of different management methods of neem on the millet crop. Past research has shown neem will reduce yields of some crops, while improving others. No research has been conducted on the affect of neem on millet or groundnut yield. It may be possible that by trimming neem trees before the rains, allowing leaves to enrich the soil, and minimizing competition for light, that millet might show an improved yield over the open farm. The results of this research could lead to better agroforestry management of neem in the farm.

Gambians are a very intelligent and resourceful people. Surely, farmers will overcome their obstacles to find better management alternatives that increase production of crops and wood products. It will require the intensification of production on farms and an emphasis in soil fertility management, and a willingness to innovate.

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Note: Figure 2.1 and Figure 2.2 from CIA website (http://www.cia.gov/cia/publications/factbook/index.html) are public domain. For all other maps, permission was granted for use. All images are used with permission. Photographs are by the author, unless noted.

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Appendix A: Soil Test Results

Owner	Field (crop)	Tree	Canopy Tree Spp.	Neem Stage	Soil pH (Water)	Soil pH (.01 NaCl2)	EC (mmhos/c)	Bray-1 Avl. P (ppm)	Organic Matter (%)	% Sand	% Silt	% Clay	Soil Texture Class
1	1	0		0	3.8	3.6	0.05	8.5	0.60	70.2	19.4	10.32	sandy loam
1	1	1	Faidherbia albida	4	4.1	3.9	0.05	19.0	1.15	74.2	15.4	10.32	sandy loam
1	1	1	Prosopis africana	4	5.3	5.1	0.06	28.5	2.23	68.2	19.4	12.32	sandy loam
1	2	1	Ficus platyphylla	4	4.4	4.2	0.09	7.5	1.65	76.2	13.4	10.32	sandy loam
1	3	0		0	4.1	4.0	0.14	11.0	2.71	72.2	15.4	12.32	sandy loam
1	3	1	Prosopis africana	0	4.2	4.0	0.06	11.0	1.65	76.2	11.4	12.32	sandy loam
1	3	1	Ficus platyphylla	4	5.5	5.2	0.11	23.5	2.72	76.2	11.4	12.32	sandy loam
1	3	1	Ficus platyphylla	3	6.6	6.4	0.11	11.0	1.38	78.2	11.4	10.32	sandy loam
2	4	0		0	4.6	4.4	0.19	10.0	2.72	80.2	9.4	10.32	sandy loam
2	4	1	Ficus platyphylla	1	6.1	5.9	0.09	10.5	1.02	74.2	13.4	12.32	sandy loam
2	4	1	Cordyla africana	1	6.0	5.9	0.10	5.5	1.56	70.2	16.7	13.04	sandy loam
3	5	0		0	4.3	4.0	0.04	2.5	1.93	80.2	10.7	9.04	loamy sand
3	5	1	Prosopis africana	2	5.6	5.4	0.10	10.0	1.10	72.2	18.7	9.04	sandy loam
3	5	1	Ficus platyphylla	1	5.4	5.1	0.10	5.5	1.43	76.2	12.7	11.04	sandy loam
3	5	1	Ficus platyphylla	2	4.3	4.1	0.06	14.0	1.63	80.2	8.7	11.04	sandy loam
4	6	0		0	5.0	4.9	0.03	2.0	1.13	80.2	10.7	9.04	loamy sand
4	6	1	Terminalia macroptera	2	4.0	3.9	0.04	2.5	0.98	76.2	10.7	13.04	sandy loam
5	6	0		0	6.4	5.2	0.03	2.0	1.11	66.2	22.7	11.04	sandy loam
5	6	1	Cordyla africana	1	6.5	5.9	0.03	2.0	0.86	78.2	8.7	13.04	sandy loam
5	6	1	Cordyla africana	2	6.5	6.2	0.04	2.0	1.22	78.2	10.7	11.04	sandy loam
6	7	0		0	5.4	4.8	0.02	1.5	0.59	72.2	16.0	11.76	sandy loam
6	7	1	Cordyla africana	1	5.9	5.1	0.03	2.0	0.73	76.2	12.0	11.76	sandy loam

Owner	Field (crop)	Tree	Canopy Tree Spp.	Neem Stage	Soil pH (Water)	Soil pH (.01 NaCl2)	EC (mmhos/c)	Bray-1 Avl. P (ppm)	Organic Matter (%)	% Sand	% Silt	% Clay	Soil Texture Class
6	7	1	Ficus platyphylla	1	5.0	4.9	0.02	1.9	0.70	71.5	19.8	8.68	sandy loam
6	7	1	Cordyla africana	2	7.0	5.5	0.04	2.5	0.86	78.2	10.0	11.76	sandy loam
7	8	0		0	5.0	4.2	0.02	2.0	0.99	78.2	10.0	11.76	sandy loam
7	8	1	Faidherbia albida	1	6.5	4.9	0.02	3.5	0.99	78.2	8.0	13.76	sandy loam
8	9	0		0	4.0	3.7	0.02	3.5	0.76	80.2	8.0	11.76	sandy loam
8	9	1	Prosopis africana	2	4.5	4.3	0.02	1.5	0.79	80.2	8.0	11.76	sandy loam
9	10	0		0	4.9	4.5	0.02	2.0	0.85	80.2	8.0	11.76	sandy loam
9	10	1	Ficus platyphylla	1	4.5	4.9	0.02	2.0	0.58	78.2	10.0	11.76	sandy loam
9	10	1	Azadirachta indica	9	7.1	6.5	0.02	5.0	0.70	74.2	15.4	10.32	sandy loam
9	10	1	Azadirachta indica	1	5.4	5.0	0.02	2.0	1.13	80.2	8.0	11.76	sandy loam
10	11	0		0	5.1	4.1	0.02	1.5	1.12	80.2	11.4	8.32	loamy sand
10	11	1	Ficus platyphylla	1	7.3	7.0	0.03	19.0	0.91	78.2	9.4	12.32	sandy loam
10	11	1	Terminalia albida	1	5.1	4.7	0.03	1.5	1.15	72.2	15.4	12.32	sandy loam
10	11	1	Ficus platyphylla	1	7.0	6.2	0.03	10.0	0.80	80.2	9.4	10.32	sandy loam
10	11	1	Azadirachta indica	0	5.4	5.0	0.03	2.5	1.23	78.2	13.4	8.32	sandy loam
11	12	0		0	5.6	4.0	0.03	2.0	1.82	76.2	11.4	12.32	sandy loam
11	12	1	Ficus platyphylla	1	6.5	6.0	0.04	5.0	1.18	80.2	13.4	6.32	loamy sand
12	13	0		0	3.9	3.5	0.02	1.5	0.89	78.2	11.4	10.32	sandy loam
12	13	1	Parkia biglobosa	2	4.6	3.5	0.02	2.0	0.83	72.2	15.4	12.32	sandy loam
13	14	0		0	5.2	4.9	0.03	2.0	1.02	69.5	19.8	10.68	sandy loam
13	14	1	Prosopis africana	1	3.7	3.5	0.02	2.0	0.68	71.5	15.8	12.68	sandy loam
13	14	1	Azadirachta indica	9	4.5	4.0	0.02	1.5	1.45	79.5	11.8	8.68	loamy sand
14	15	0		0	4.8	4.5	0.02	2.0	1.05	75.5	13.8	10.68	sandy loam
14	15	1	Parinari excelsa	1	4.6	4.0	0.02	5.0	1.32	69.5	21.8	8.68	sandy loam
14	15	1	Cordyla africana	1	5.2	4.9	0.02	2.0	0.78	73.5	13.8	12.68	sandy loam

Owner	Field (crop)	Tree	Canopy Tree Spp.	Neem Stage	Soil pH (Water)	Soil pH (.01 NaCl2)	EC (mmhos/c)	Bray-1 Avl. P (ppm)	Organic Matter (%)	% Sand	% Silt	% Clay	Soil Texture Class
15	16	0		0	4.3	4.0	0.02	2.0	1.43	69.5	23.8	6.68	sandy loam
15	16	1	Prosopis africana	1	4.2	3.5	0.02	2.0	0.78	73.5	15.8	10.68	sandy loam
			Average		**6.2**	**5.7**	**0.05**	**5.7**	**1.20**	**75.7**	**13.3**	**10.9**	**sandy loam**

Appendix B: Method for Processing Neem as a Natural Insecticide.

1. Collect a kilogram of neem leaves (about three large handfuls).
2. (Optional) Dry the leaves in the shade and pound the leaves to a powder.
3. Place the leaves in a 15-liter bucket of water with a tablespoon of laundry soap.
4. Keep the bucket in a shaded place (sunlight breaks down azadirachtin, the active chemical).
5. When the water becomes a dark greenish-yellow color, the solution is ready to use.
6. It can be applied by either a broom, by flicking the solution onto the leaves, or preferably, by using a backpack sprayer.
7. The solution must be reapplied every three to four days, or after rainfall.

Leaves can also be mixed with stored products such as groundnut or millet seed to inhibit insect infestation and microbial growth.