Parkia biglobosa: CHANGES IN RESOURCE ALLOCATION IN KANDIGA, GHANA

BY

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The thesis: "*Parkia biglobosa*: Changes in Resource Allocation in Kandiga, Ghana" is hereby approved in partial fulfillment of the requirements for the Degree of MASTER OF SCIENCE IN FORESTRY

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PREFACE

This study was done between September1999 and December 2001, during my service with Peace Corps in Kandiga, Upper East Region, Ghana. Prior to enrolling at Michigan Technological University in the Master's International Program I worked for several years in the biotech pharmaceutical industry. My studies in Biology at San Francisco State University were the foundation for my career in the biotech industry. During my undergraduate years, my interests were in natural history and manifested itself with several years of work at the San Francisco Zoo.

I have had many wonderful opportunities to travel and visit many exotic and foreign destinations. My time in Peace Corps and in Ghana has not only been a reaffirmation of my interests in different countries and their history, but a brand new experience of immersing myself in a different culture.

I can recall when I was inspired to study the interaction between people and trees. After two months of service at my site, I attended a special workshop offered by Peace Corps. It was a study on effective community entry activities being developed by an RPCV from Senegal. Developing these methods were part of her fulfilling the requirements for a Master's degree. One of the activities I participated in and modified was the market survey. I adapted that community entry method by specifically looking for products from trees. This thesis is a result from that first step and venture into the market.

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ACKNOWLEDGEMENTS

I would like to thank my advisor, Dr. Blair Orr for his tireless support. In June 1998 I had applied for Peace Corps when I became aware of the Master's International Program. My decision to come to MTU and pursue my Master's degree through the Loret Miller Ruppe Peace Corps program was based initially on the effort he showed when I was inquiring about the program. The last four years have been challenging and satisfying and I'd like to thank Dr. Orr for the constant and consistent energy and support I received both here at MTU and overseas in Ghana. I would also like to thank the members of my graduate committee: Dana Richter, Pat Martin, and Curtis Tompkins.

I would like to thank Peace Corps Ghana, especially Aba Sey, APCD of Forestry and Environment. She was always smiling and encouraging me and also recognizing my efforts. I would like to thank Vincent Djarbeng, Agroforestry Specialist, and Anthony Mainoo, CCFI Coordinator, of ADRA for their positive attitudes and their excellent examples of working with farmers in Ghana. I would like to thank my friends in Ghana, Arne and Jan Vanderburg, Jeanine Ewert, and all my Peace Corps colleagues who helped me maintain a positive attitude even when things were difficult.

I would like to recognize the warmth and spirit of the people of Kandiga. They offered me a home for my two years in Ghana. I feel I learned much more from them and hope I was able to help in a small way by being in Kandiga.

I would like to thank Husky TKD. They are a great club that welcomed me when I first came to Houghton and were here with open arms when I returned. They also supported me overseas and TKD provided an entry to the community and people of Bolgatanga, the regional capital 30 km away from my site.

Finally, I would like to thank my friends and family who have supported me throughout. They are all wonderful, encouraging, and understanding people who I greatly appreciate. Thank you.

Chapter 1 Introduction

In September 1999, I arrived in Ghana to begin my two-year Peace Corps assignment working in the environmental sector. I was assigned to work with a countrywide program called the Collaborative Community Forestry Initiative (CCFI) (Heist 2000). This program follows the paradigm resulting from a conference on natural resources in Kenya. The basic outline of the program was to insure food security, provide technical assistance to farmers, and to introduce agroforestry and tree planting in order to improve the standard of living for rural farmers. The collaborative partners for this program were: Adventist Development and Relief Agency (ADRA) which provided the funding, Ghana's Ministry of Food and Agriculture (MoFA) and the Forestry Commission which provided technical assistance, and Peace Corps which provided volunteers to manage the tree nurseries established in the communities. The program was established in 31 different communities in six of the ten administrative regions in Ghana. I was assigned to Kandiga, a community in the Upper East Region in northern Ghana.

Kandiga is a widely spread out rural community with smaller sub communities based on clans. Most of the people in Kandiga are subsistence farmers who rely on the crops produced during the one rainy season a year to provide for their families. In 1994, the CCFI program was introduced to this community. The sub communities of Sirigu, Mirigu, Kumbusingo, Longo, and Azeadoma were chosen and twenty-four farmers from each community were accepted into the program. Also in 1994 the first Peace Corps volunteer was assigned to Kandiga to establish a tree seedling nursery, an integral part of

the CCFI program. The nursery provided the tree seedlings and extension advice for the farmers to plant trees on their farms. In most of sub Saharan Africa, the threat of desertification and land erosion is directly related to the rapid depletion of local native trees used by the increasing population for fuelwood and building. In November 1999, I arrived in Kandiga as the fourth and final volunteer to serve in that community.

I spent the first six months working at the nursery to fully experience all of the nursery activities. I also spent the early part of my assignment meeting my neighbors and members of the community. I observed many different non-timber uses for many of the local trees. Curious children came to my house offering unfamiliar fruits for me to eat. I would ask them to take me to the trees where they had gathered these fruits. Sitting under the shade of a massive mango tree I would see children strip and alter the mango leaves in such a way to produce a pinwheel that would spin furiously in the dusty wind of the Harmattan season. My next-door neighbor was boiling a cauldron full of empty pod husks to make "sour water", mixed into the mud in order to strengthen and waterproof the plaster on his house (Figure 1). Strolling through the market, I would see unfamiliar seedpods, dried bark, and many different products derived or harvested from trees. I was very curious about these non–timber forest products and wanted to look at the cultural uses, an ethnobotanical approach for studying several local trees. Ethnobotany is defined as observing and recording indigenous knowledge and folk culture relationships between humans and plants (Martin, 1995). However, with the limited time of my assignment and the seasonality of many tree products I chose to focus on one species of tree, *Parkia biglobosa.*

Figure 1 – Plastering house with mud mixed with 'sour water'

P. biglobosa has great importance to the people of Kandiga. There are many obvious uses including human food, traditional medicines, glaze for ceramic pots, animal fodder, firewood, and charcoal production. Less apparent benefits include fixing nitrogen in the soil, checking soil erosion, and providing shade. This thesis will focus on the local uses of *P. biglobosa* with particular attention to the local production of *dawadawa*, a fermented food made from the seeds. I chose to investigate and assess how local people perceived the value and benefits of *P. biglobosa*. But, I had to consider the local value of the tree and if that perceived value changed with the relatively recent introduction of industrially manufactured bouillon cubes or a soybean version of *dawadawa*.

Initially, I assumed that the presence of a manufactured bouillon cube or soybean version would replace the existing home manufactured product. In turn, the replacement products would divert precious cash for a food item that had little cost if home produced; lessen opportunities for income generation at the village level, and decrease the value

local farmers had previously placed on the tree. Understanding the local perception of *P. biglobosa* as a resource is vital in creating a sustainable resource management plan.

This thesis provides a description of *P. biglobosa* and the non-timber forest products (NTFP) obtained from it. Chapter 2 will provide statistics on Ghana. Information on the history, politics and economy will offer a background and context for the study. A more specific portrayal of the physical environment, farming system, and land tenure system is discussed in Chapter 3. The methods I used for research are explained and covered in Chapter 4. Chapter 5 is an overview of different aspects of *P. biglobosa*. Botanical features, the traditional uses, the process of producing *dawadawa*, fermentation aspects, and limits on natural regeneration of *P. biglobosa* are discussed. The presence of soybeans and potential uses are discussed in Chapter 6. The results and discussions are covered as well as recommendations of management practices to conserve in Chapter 7. The final chapter offers a summary of the research and conclusion that *P. biglobosa* is highly valued and worth conserving as a positive response to the degradation of resources in this region of Africa.

Chapter 2 Background

History

There is evidence of human habitation in Ghana dating back at least 10,000 years. However, the people of Ghana today can claim their ancestry to immigrants who came from the north and east of present day Ghana. These early immigrants established distinct and separate states by the end of the sixteenth century. The most well known state is the Ashanti Empire, located in central forests of Ghana. The Ashanti Empire gained their wealth through monopolizing gold mining and trade. In the north of Ghana, the Mole-Dagbane states of Gonja, Mamprusi, Dagomba, and Mossi states of Yatenga and Wagadugu, were among the earliest kingdoms to dominate in pre-colonial Ghana. Although many states were establishing themselves, a number of peoples lived outside of these loosely organized states and were primarily agriculturalists, living in societies based on kinship ties and ruled by the heads of their clans (Library of Congress 2002).

Europeans were lured to this region of Africa for gold and slaves. The first Europeans to arrive were the French who sailed to the coast in the fourteenth century and established a post at Elmina. The Portuguese built the first coastal fort at Elmina by the late fifteenth century. Other Europeans soon followed including Danish and Swedish traders as well as the British who came for the gold trade, hence the name "Gold Coast" (Naylor 2000).

The need for labor in the rapidly developing plantations in the Americas resulted in the trans-Atlantic slave trade that soon became more lucrative and profitable than gold trading. Between the years of 1701 and 1810, an estimated 6.3 million slaves were

shipped from West Africa to the Americas. At the peak of the slave trade, 5000 slaves a year were shipped from the Gold Coast alone (Library of Congress 2002).

In the seventeenth century, Christian missionaries arrived. The missionaries brought European religion, agricultural innovation, and education, though primarily to the southern part of Ghana. This access to education and advantages near the coast contributed to the present day disparity between the northern and southern regions of the country. By the nineteenth century, Britain was the most important European power in the Gold Coast and in 1876 established the Gold Coast Colony (Naylor 2000).

Political History

In 1947, the 'Big Six' founded the United Gold Coast Convention (UGCC). The founders, popularly known as 'the Big Six', were: Dr. J.B. Danquah, Mr. Obetsibi-Lamptey, Edward Akuffo-Addo, Ako Adjei, William Ofori Atta, and Dr. Kwame Nkrumah. The goal of the UGCC was self-government. In 1956, Prime Minister Nkrumah and the UGCC passed a motion calling for independence that was approved by the British Parliament. The Gold Coast Colony was renamed the Republic of Ghana when it gained its independence on March 6, 1957, the first independent nation in sub-Saharan Africa.

In 1966, a military coup usurped Nkrumah from his seat and Ghana was under military rule until 1977. During this time, world oil prices soared, cocoa prices fell and Ghana's economy was suffering 300 percent inflation. In 1979, Lieutenant J.J. Rawlings, representing the Armed Forces Revolutionary Council (AFRC), declared a revolution and executed heads and associates of the previous military government. Rawlings formed a

government known as the Provisional National Defence Council (PNDC). This was the eighth government since the fall of Nkrumah fifteen years earlier (Naylor 2000). J.J. Rawlings continued to serve as head of state for over twenty years. A new constitution, restoring multiparty politics, was approved in 1992. J.J. Rawlings was elected president both in the 1992 and 1996 elections. He was limited to two terms as president under the constitution and in the 2000 elections John Agyekum Kufuor representing the New Patriotic Party was elected president (CIA World Factbook 2002).

Economy

At the time of independence, Ghana's national accounts were substantial and the economy was strong from a boom in cocoa and mineral exports. Nkrumah envisioned a modern industrial Ghana. He began an aggressive modernization movement in the 1960s by nationalizing foreign owned businesses, building factories, and made attempts to improve agriculture through collectives and mechanization. One successful venture during Nkrumah's term as president was the building of Akosambo dam, completed in 1964. Akosambo dam created the world's largest artificial lake as well as the first large-scale hydroelectric venture that could provide all of Ghana with electricity**.** However, other ventures were not as successful.

The push for modernization in fact produced rampant corruption and an economic crisis. Political motivation instead of sound economic planning used up precious capital without viable production, causing many enterprises to fail. One of these failed attempts is a meat-processing factory built in the Upper East Region near Bolgatanga. The local suppliers of livestock, individual farmers and small cooperatives, could not meet the

required targets for the meat processing plant to operate as a profitable business. Another example of the government's failed attempts at modernization is a tomato-processing factory built near Bolgatanga. The local farmers could not produce large enough quantities of tomatoes necessary for this processing factory to operate at full capacity. Both factories today stand idle and in poor condition.

Collective farms relied upon heavily subsidized inputs from the government. Tractors, agricultural inputs such as fertilizers and improved seed often were promised but not delivered. Due to poor management and widespread corruption, the vision of high yields and self-sufficient agriculture were met with extremely low production (Naylor 2000). Within a short time, Ghana suffered large debts, inflation was high, and corruption was endemic. Though Ghana experienced the highest GNP on the continent before the economic crisis in the 1970s, military takeovers and corruption crippled Ghana's economy. Today, the economy is rebounding only through stringent economic recovery programs and large subsidies from foreign aid (World Bank 2002).

From 1961-1966 Ghana was 83 percent self-sufficient for food. But by 1982, this percentage dropped down to 23 percent. Farming is still the primary occupation of Ghanaians although the rate of self-sufficiency is still low. The domestic economy primarily revolves around subsistence farming, which accounts for 36% of the GDP and employs 60% of the population. The current economic situation in Ghana has an uncertain future. The estimated external debt in 1999 was over $7 billion and international monetary aid totaled $477.3 million in 1995. Ghana's economy is a casualty of the sharp decline in foreign exchange tied to its two main exports of cocoa and gold. (CIA World Factbook 2002, World Bank 2002).

Geography

Ghana is situated in West Africa between the latitudes of 4°44' and 11°11' North and longitudes 3° 15' West and 1° 12' East (Figure 2 and 3). Ghana occupies a total of 238,540 square kilometers, roughly the size of Oregon. Ghana shares its borders with three countries, 668 km with Cote d'Ivoire to the west, 548 km with Burkina Faso to the north, and 877 km with Togo to the east. The coastline of Ghana stretches for 539 km along the Gulf of Guinea. Half of the country lies less than 152 meters (500 ft.) above sea level, and the highest point is Mount Afadjato at 883 meters (2,900 ft.). The coastline is predominantly tropical sandy beaches and inland of that are the drier coastal plains. The south central area of the country is a tropical rain forest belt where most of the country's cocoa, minerals, and timber are found. Grasslands and Guinea and Sudan savanna predominate in the northern part of the country. In 1964, the Akosambo dam was built on the White Volta River that created Lake Volta, the world's largest artificial lake (Library of Congress 2002).

The population of Ghana is estimated at 19,894,014 with an equal ratio of males to females. The life expectancy is estimated at 57 years. Education and literacy rates are averaged for the country and one must take into account the south has much higher literacy rates than the north. The literacy for age 15 and above rate is 65% of the total population, 76% for males and 53.5% for females. Ghana is a diverse country as one looks at the differences in languages, ethnicity, and religious beliefs. English is the official language, however over 79 languages are spoken in Ghana including Akan,

Figure 2 – Map of Africa (http://www.lib.utexas.edu)

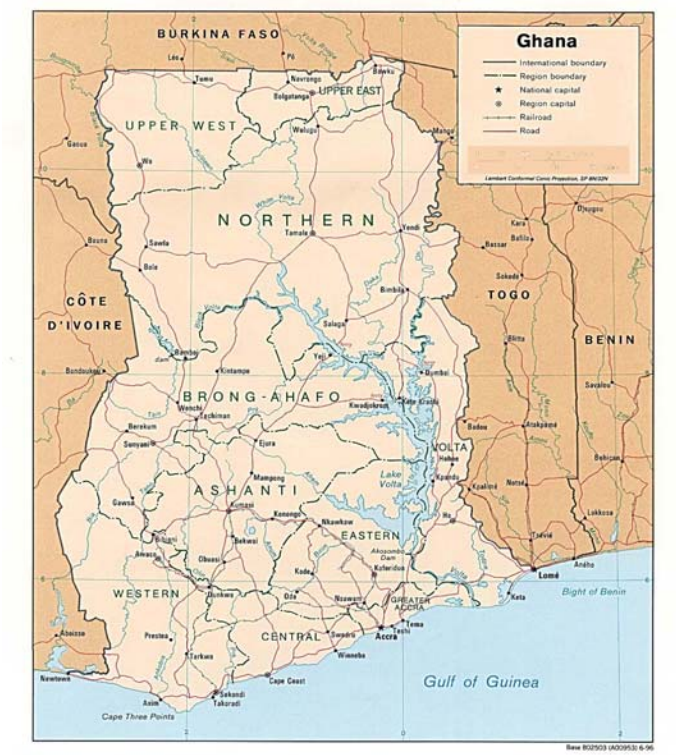

Figure 3 – Map of Ghana (http://www.lib.utexas.edu)

Moshi-Dagomba, Ewe, and Ga. The ethnic groups in Ghana are black Africans comprised of the major tribes: Akan 44%, Moshi-Dagomba 16%, Ewe 13%, and Ga 8%. Religion is somewhat localized with a greater proportion of Muslims in the north, but averages across the country are traditional/indigenous beliefs 38%, Muslim 30%, Christian 24%, and other 8%. Ghana is divided into 10 administrative regions with the most densely populated being the Greater Accra region. The least densely populated regions are the Upper West and Upper East regions (Figure 4) (CIA World Factbook 2002).

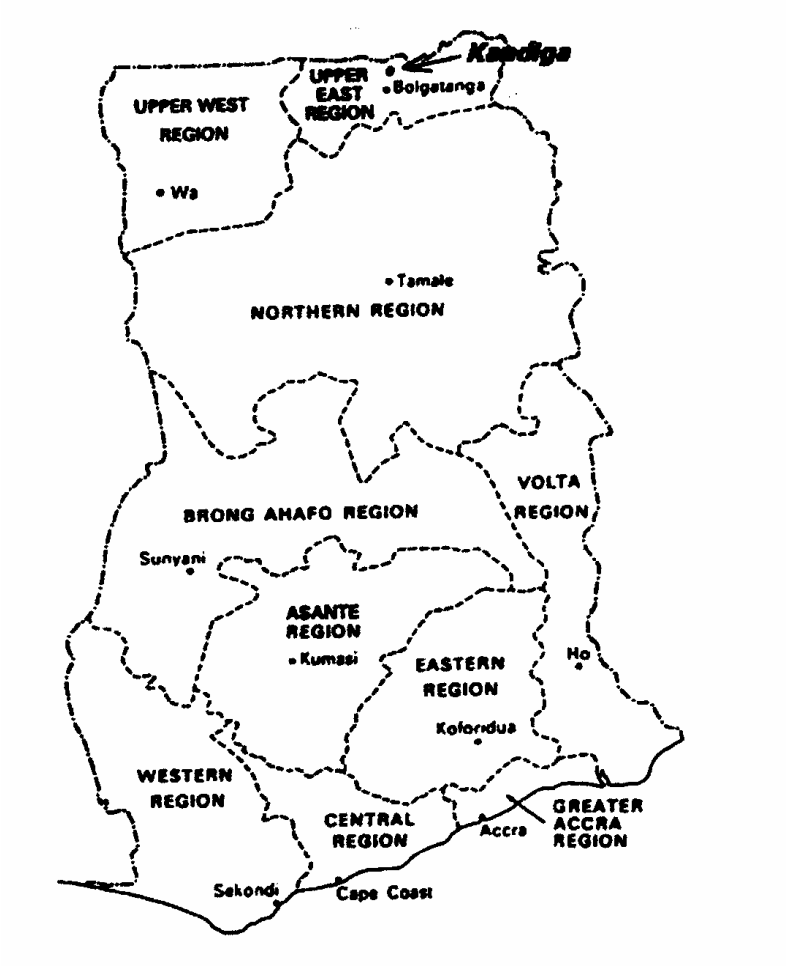

Figure 4 - Administrative Regions in Ghana
(http://www.lib.utexas.edu)

Kandiga, Upper East Region

My Peace Corps assignment was in the rural village of Kandiga, located in the Kassena-Nankana District within the Upper East Region (Figure 4). Kandiga is situated between the district capital of Navrongo that lies 20 km northwest and Bolgatanga, the regional capital that is 30 km to the southeast. The population of the village is approximately 6000, widely spread out on clan or familial homes on or near their small farms. This region is considered Guniea savanna. Guinea savanna is characterized by low rainfall that occurs between May and October. Shea trees, acacia, and baobab are the dominant tree species with tall grasses across the savanna. Most of the land has been converted for the cultivation of millet, groundnuts, sorghum, and rice. The remainder of land is for grazing livestock: cows, goats, and sheep.

The local economy is based on subsistence farming and some small secondary income businesses. Many of these small secondary businesses trade goods. The women in Kandiga are the cornerstone of the labor force in the village economy. Birmingham *et al.* (1966) analyzed the census data and reported the percentage of labor each gender contributed within the adult population of Ghana. His analysis showed that male labor and participation was low compared to female labor. In Ghana, the female level of economic activity is well above average among fifty-six countries examined by Birmingham *et al* (1966). Only two countries had lower levels of male participation. The large proportion of women at work can be attributed to the great enterprise and self-reliance of Ghanaian women exemplified by their domination of the retail and wholesale trading (Clark 1994).

Despite the modernization attempts from the government of the newly independent Ghana, many regions especially the Upper West and Upper East regions of the country are still far behind the southern regions in Ghana. Remnants of the big modernization push are still apparent and dot the landscape. A large tomato processing plant is sitting idle and in disrepair just outside Bolgatanga. A large corrugated zinc barn that at one time housed tractors and the heavily subsidized fertilizers that were sold to the farmers at a greatly discounted price sits abandoned in the center of Kandiga (Figure 5).

Figure 5 – Abandoned zinc barn once used for subsidized inputs in Kandiga

These relics are a reminder of the failed attempts of the government to aid the local economy. Churches, missions, and non-government organizations (NGOs) provide funding and auxiliary support to the village. These organizations provided large water reservoirs, borehole pumps, a health clinic, schools, and supplemental food aid. In spite of the difficult living conditions villagers have found ways to generate additional income to their households.

Chapter 3 Study Area

This section will describe in greater detail the physical environment, the farming systems, land tenure system and resource management of the study area. The physical environment encompasses the soil, climate, and rainfall patterns. Description of the farming systems includes land use and sources of household income. Description of land tenure involves the ownership of the land and who has access to the land and its products.

Physical Environment

The village of Kandiga is positioned at 10° N and 0° W at an altitude of 193 meters. Kandiga located in the Kassena-Nankana district, in the Upper East Region of Ghana. The soils in this area are underlain by two geological systems. The Voltaian system consists of sedimentary rocks of shale and sandstone. The other underlying geological system consists of granite as the parent material.

The major soils include Savannah Ochrosols, classified as Alfisols, Ultisols, and Inceptisols. Most of these soils are shallow soils overlying ironpans. These soils are generally low in organic matter, cation exchange capacity, and fertility (Quansah 1990). Organic matter in the soil contributes to the cation exchange capacity, regulates soil temperatures, and enables soil organisms like earthworms to be active. Generally, as organic matter decomposes, it adds nutrients to the soil. The soils in this area are deficient in nutrients, especially phosphorous and nitrogen. Crop production yields are reduced as result of the low concentrations of these nutrients. The average phosphorous contents of these soils are 80-150 ppm, compared to temperate soils that average 1500-

3000ppm (Ker 1999). Nitrogen content is also low, the main source coming from biological nitrogen fixation by vegetation from the atmosphere. *Parkia biglobosa*, *Faidherbia albiza*, and groundnuts, are examples of native leguminous trees and plants in this area that fix nitrogen. Historically, land use in this area was a traditional shifting cultivation fallow system. This system allowed areas to lay fallow after two or three seasons of cultivation and natural vegetation would then regenerate. Vegetative cover reduces the damage from erosion. However, with increasing human and livestock population, these shallow soils are continually cultivated and browsed leaving the soil bare and highly susceptible to erosion from rain and wind without adequate protection provided by trees and vegetative cover.

There are two distinct seasons in this region, the rainy season and dry season. The rainy season extends from the months of April through October while the dry season extends from the months of October through March. During the height of the dry season, from December through February, the desiccating Harmattan winds blows sand and silt down from the Sahara until March, when the temperatures rise upwards to 49° Celsius. The rains are intense throughout the rainy season. Tropical rains on average have six to ten times more erosive power than temperate rains (Ker 1999). Rates of rainfall intensity are variable but have been measured at 200 mm/h for brief time intervals. The seasonal distribution of the kinetic energy load, that is the intensity of the rain averaged over the season, results in 27-33% of the energy load occurring between April and June. These early rains in the season can cause substantial erosion since the soil is bare of vegetation (Quansah 1990). Estimates of soil loss are high in the area and with high erosion the result is declining soil productivity.

Within Ghana, there are several ecological zones. Kandiga lies within overlapping ecological zones, the Guinea savanna and Sudan savanna (Figure 6). The Guinea savanna stretches across the southern Senegal, Gambia, Guinea, through southern Mali, Burkina Faso, through northern Côte d'Ivoire, Ghana, Togo, Benin, central Nigeria, Chad, Central African Republic, southern Sudan, most of Uganda, and Western Kenya.

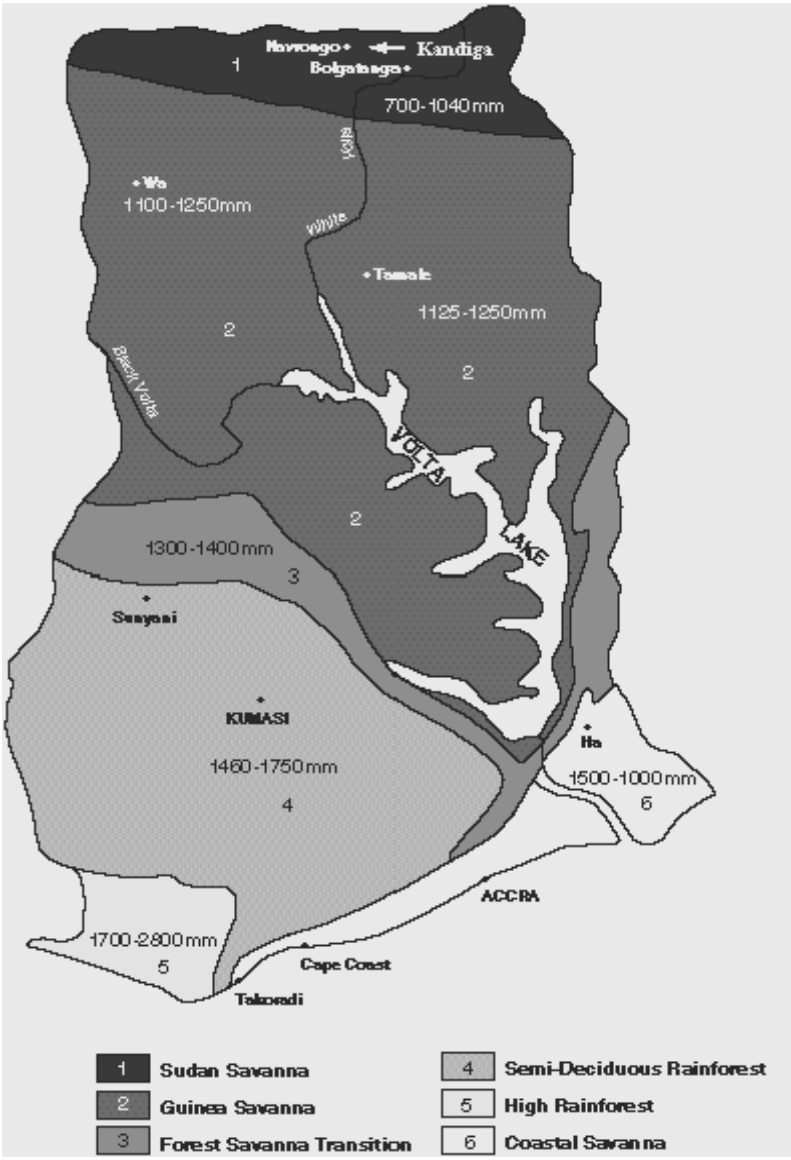

Figure 6 – Ecological Zones in Ghana (source Timballa 1994)

The Sudan savanna stretches from central Senegal, central Mali, southern Burkina Faso and Niger, northern Nigeria, and central Chad, Sudan, Ethiopia, northeast Uganda and central Tanzania. Table 1 describes the typical rainfall, length of growing season, the predominant vegetation, and common crops found for these zones.

Table 1 - Description of Ecological zones (source Ker 1999)

Ecological Zone	Rainfall (mm)	Growing Season (days)	Vegetation (Trees and grasses)	Agricultural Crops
Guinea savanna	900-1200	140-190	*Vittelaria paradoxa, Parkia biglobosa, Adasonia digitata, Afzelia Africana, Isoberlina spp., Andropogon gayanus, Hyparrhenia spp.,Pennisetum spp.*	Early millet, late millet, sorghum, rice, maize, groundnut
Sudan savanna	600-900	90-140	*Faidherbia albida, Hyphaene thebiaca, Parkia spp., Cenchrus ciliaris, Eragrostis trula, Pennisetum pedicallatum*	Sorghum, millet, maize, cowpeas, groundnuts, cotton

Farming Systems

The traditional farming system is shifting cultivation. Resources were effectively managed in an area of low soil fertility and limited external outputs by leaving land fallow. Increasing population pressures have supplanted this type of farming system. In Kandiga, many factors influence the type of farming system and its success. External factors such as location of roads and markets, access to improved seeds, fertilizers and internal factors such as available farm size, inherent soil fertility, labor force are all determinants of a favorable farming system. Critical aspects of the success of the farming system in this area are the soil fertility, risks involved (uncertain rainfall, crop and animal diseases, credit) and availability of labor (Ker 1999).

Viehe (2000) identified three major farming systems in the Upper East Region of Ghana. The types identified consisted of pure arable, pure livestock, and mixed systems. An example of pure arable land use is a cash crop farm producing cotton. A pure livestock system involves land use devoted to intensive cattle production. Quansah (1990) reported that overstocking of cattle was common throughout the Upper East Region and Upper West Region. In the Bolgatanga and Navrongo Districts, cattle population density was 103 per 100 hectares, dramatically exceeding the estimated carrying capacity of one cow for 10 to 20 hectares. However, the most common and widespread farming system is this area is the compound farming system. This system is a mixed system of field crops and livestock: poultry, goats, sheep, and some cattle or donkeys.

The compound house is comprised of related families, for example a father and mother, their sons and the sons' wives and children. In a typical compound house in

Kandiga, three or four related families may share a common yard, an area surrounded by a low mud wall, with a secure gate that serves as a pen for the livestock. The animals roost or are herded in for the night to prevent theft and the compound serves as a manure collection site. Often, a cone shaped mud silo with a thatched roof is also standing in the yard. Millet, sorghum, groundnuts and other farm produce are stored in this silo throughout the dry season (Figure 7). Adjoining the yard will be entrances to each family's house.

Figure 7 – Typical compound house in Kandiga

A single-family house is comprised of an outdoor patio surrounded by a low wall that prevents larger livestock like goats and sheep and cattle from entering the human habitat. The majority of activity occurs on this patio, a tamped earthen floor that can be plastered with mud plaster or a mud/cement mixture depending on the family's wealth.

Food preparation, cooking, eating, socializing and sleeping take place on the patio. Two or three rooms that are constructed of mud bricks surround the patio. One room is typically a storeroom for the family's effects; clothing, sleeping mats, bicycles, and tools. During the rainy season, the family often sleeps in this room. The roof is usually flat, supported by wood pole rafters, plastered with mud. Stairs built of mud brick or a notched log acts as a ladder accessing the flat roof. The flat roof is useful for drying cereals, grain, groundnuts, and also serves as a sleeping platform in the hot dry season.

A second room is a small doorless room that is used for cooking, particularly during the rainy season. Bathing is usually done in the home off the patio, in a walled space providing some privacy. The common behavior for personal hygiene is typically referred to as free ranging, that is relieving of bodily functions away from the house in the fields. Depending on the family's wealth, the house can have additional rooms or the presence of sturdier construction materials such as cement bricks or corrugated zinc roofing.

Immediately surrounding the house are small plots of land divided among the compound families for permanent cultivation. Bush fallow or land rotation is practiced on plots farther from the compound house. The plots immediately surrounding the compound house are intercropped with sorghum, millet, and groundnuts. Other crops like rice and soybeans are planted in the plots farther from the house, sometimes referred to as bush farms. The livestock can contribute to the farming system by supplying animal traction for plowing and their manure is used for soil enrichment.

The men, women, and children of the compound house provide the labor for the farms. If a farmer has access to credit or currency, he can hire day labor or hire animals

to plow his land. In Kandiga, there were certain members of the community more educated and able to earn salaries: schoolteachers, agricultural extensionists working for the Ministry of Food and Agriculture, and health workers. Other individuals generated income by hairdressing, tailoring, and trading goods. However, all these community members were still actively involved in farming. Most farming is labor intensive relying on manual labor. Everyone works during the farming season. Children are excused from school and farmers are in their fields before sunrise and after sunset. Farmers spend long hours hoeing, sowing seeds, and removing the grasses and weeds competing with the crops for the precious rain and soil. Children spend their time pegging goats, herding sheep, herding cows and preventing them from eating the newly emerging crops. As the crops mature, harvesting is also intensive difficult manual labor. Farmers gather and harvest the heads of millet and sorghum, bundle the stalks, pulling up the groundnuts plants, then removing the groundnuts from the roots. Groundnuts are harvested by pulling the entire plant from the ground when the soil is still soft from the rain. If the rains have stopped and the crop is still in the ground, women carry headpans of water to the fields in order to soften the soil enough to extract the groundnuts.

Food security is an indisputable problem for these subsistence farmers. Many risks are related to this farming system. These farmers rely on the one rainy season to produce adequate food to sustain them and their families throughout the year. Farmers must consider the proper sowing time of the seed. Rains early in the season are inconsistent and unpredictable. If a farmer sows his seeds too early, he may risk losing all his seed if the next rains do not arrive and all the newly germinated seeds dry up and die. Farmers suffer from droughts ranging from a single year to severe droughts lasting

many years that plagued Sub Saharan Africa in the 1960s and 1970s (Nicholson 1978). Farmers attempt to survive these droughts by selling livestock, one of their few forms of stored wealth, to buy food.

Another imminent threat to these farmers may be trade liberalization, the removal or reduction of barriers to international trade. Madeley (2000) suggested that the World Trade Organization's Agreement on Agriculture signed in 1994 would impact developing countries by intensifying rural poverty and destroying smallholder livelihoods. Small-scale farmers in Ghana who sell produce to obtain cash cannot compete with cheaper food imports and dumped surplus food. The increase in commercial food imports is substantiated by the USDA overview of U.S. Ghana Agricultural Trade and Transportation. Retail food sales in 1999 were estimated at $1.2 billion, 32% of which represented high-value food imports. The report continues by suggesting a potential for increased sales of U.S. food and agricultural products to Ghana (Olowolayemo 2000).

This traditional system of farming required few external inputs to be productive. Decreased soil fertility, increased population pressure, and lower yields of farm produce have increased the need for a cash income to buy additional food and fertilizers. Cash is also necessary to buy goods like soap, kerosene, tools, buckets, hoes and cooking pots. Farmers in this area can generate additional income through dry season gardens. Near rivers or wells, farmers laboriously plant and water tomatoes and tobacco. However, this further depletes the soil and contributes to soil erosion along riverbanks. Women producing home manufactured products such as *pito* beer from sorghum, *dawadawa* from *Parkia biglobosa* and shea butter from *Vittelaria paradoxa* generate additional income.

Land Tenure

Land tenure is a complex and evolving issue today in Ghana and West Africa. Land tenure can be defined as a bundle of rights associated with a parcel of land, held by an individual or a group. A specific definition given by the United Nation's Food and Agricultural Organization (FAO 2001) for West Africa states, "land tenure refers to a collection of rights, only some of which are held at any one time by a particular individual or social unit". These range from the state to individuals who may have tenures derived secondarily from other individuals (such as a sharecropper who has his tenure rights from someone who has leased the land from yet a third person). These rights co-exist; frequently different individuals or groups hold different tenures to the same piece of land but using it at different times or in different ways. For example, one group may own rights to the harvest from the shea trees, another group may pasture their animals, while yet another group will have gleaning rights to the wood fall from the same piece of land (FAO 1995). In Ghana, the land tenure system is an overlap between customary land tenure systems and government structures.

The administration and management of land in Ghana is mired under the bureaucracy of several public institutions; Ghana's Ministry of Land Commissions, Metropolitan and District Assemblies, and the Office of the Administrator of Stool Lands. These public institutions administer the land for infrastructure purposes such as roads, schools, and clinics in collaboration with the customary land system administered by the chief (Kasanga and Kotey 2001). An example of the overlap between customary land tenure and government bureaucracy was a secondary project I undertook erecting a three-classroom cement block building to the existing primary school. I had to acquire

permission not only from Kandiga's chief, but also acquired cooperation with both the Kassena-Nankani District Assembly and the District Office of the Ghana Education Service (GES) located 20 km away in Navrongo. A family had tenure rights to farm the land allocated for the school but the chief suspended those rights in preference to building the school.

Another example of the customary land tenure system involved acquiring the land for the Kandiga CCFI Tree Nursery. The landholder gave the nursery the land for the benefit of the community. Numerous capital improvements were made to the land such as wells established, wire fencing enclosing the plot, toolshed built, and an irrigation channel built leading from the reservoir to the nursery. An agreement signed by the landholder, chief, community committee, and ADRA (who provided funds) stated the nursery belonged to the community and if the nursery operation failed, the land and attached effects would remain with the community. Legal documents such as land title, private ownership, and registration are rare in northern Ghana but increasing as access to land is decreasing.

In Kandiga, and rural areas of northern Ghana, the landholders are individuals, families, and the *tendamba* (the pioneer settler and his descendants). Another definition of *tendamba* or *Tengan-sob* by the Dagaaba tribe in northern Ghana is the one who 'posesses the hoe', the spiritual caretaker of all the land resources, and holds land in trust for the whole community (Bakang and Garforth 1998). The *tendamba* traditionally allocated the rights to land. Colonial government introduced 'chieftancy' to organize the northern regions in Ghana. The chief acts as liaison and spokesman for the people to the government. The traditional and customary functions of allocating rights to land by the

tendamba are rapidly being replaced, superseded by the power of chiefs (Kasanga & Kotey 2001).

Lands are usually inherited through the father in Ghana. An exception is the Akan ethnic group who practice matrilineal inheritance. In many parts of southern Ghana, timber rights, mining rights, farmlands, housing tracts and related land markets are flourishing. However, in less developed northern Ghana, land sales are informal or non-existent and the customary land tenure system prevails. Farmland is usually divided between male family members within each clan. Women are encouraged to help the men farm the land. A woman is only given farmland when no male member of the group wants to use it, usually land with the poorest fertility. Outside the clan, land is often given as gifts, or the rights are loaned until the family needs the land back. (Bakang and Garforth 1998). A case study by Kranjac-Berisavljevic *et al.* (1999) of the village of Dunglaagberuk in East Mamprusi district found that the various means of land acquisition were inheritance, purchase, hire, loan, inheritance and hire (Table 2).

Table 2 - Means of Acquiring Land (by Kranjac-Berisavljevic *et al*. 1999)

Land Acquisition	Frequency	Percentage
Inheritance	174	82.9
Purchase	6	2.8
Hire	10	4.8
Loan	4	1.9
Inheritance + hire	16	7.6
TOTAL	210	100

The community shares access to resources such as water, grazing land, and bush game. However, a landholder determines and limits the access to resources such as fruit trees and fuelwood. In the case of economic trees such as *Parkia biglobosa*, the

landholder must grant permission for collection of the fruits, or other products from the tree. Access to land and the rights to the land are becoming more complex with the rising population and increasing degradation of the natural resources.

Under the customary land tenure system, women have little access to secure lands or rights. Divorced women or widows must abandon land belonging to their husbands, despite the amount of labor she has invested in farming the land. This custom discourages women from acquiring land or farming commercial crops, for the products and labor they invest in a piece of land can be easily taken back by the male of the household. Driven by the poor economy and need for cash, the male labor force is moving to towns and cities for employment. Men leave the village farms for much of the year, leaving the farming to women. However, the men still retain the rights and decision making for the land (Leonard and Toulmin 2000).

Resource Management

The customary land tenure system is often blamed for the degradation of the land, declining resources, soil infertility and erosion, and deforestation. The attitude of the farmers exploiting resources without taking responsibility for managing those resources harkens back to the essay, 'Tragedy of the Commons' (Hardin 1968). Hardin uses the impact of overgrazing as a primary argument in his article. He states that a herdsman concludes that the only sensible course for him is to add another animal to his herd, and then another. The tragedy lies in that each man is locked into a system that compels him to increase his herd without limit – in a world that is limited. This example reflects a simplified explanation of the condition of resource management in Ghana.

Water, grazing land, and bush game are shared resources within a community in northern Ghana. These communal resources are shared, only managed and limited when an individual exploits a resource beyond reasonable amounts. For example, a borehole providing water is situated near a group of households. Everyone within the village has access to the water, however, if an individual from a distant household filled several 55 gallon drums with water to use in molding bricks for his house, he would have to pay or his access would be cut off. He has limited rights because this individual did not provide labor to establish or maintain the borehole. The community itself acts to control and manage resources when overexploited by one individual.

Ghana's government has mandated policies to address the management of resources. Government policy recommends families have no more than four children. Fewer children would decelerate population growth and encourage families to provide better care to fewer children. Another government policy bans bush burning. Radio

announcements and newspaper articles publicize these policies; however, the government is ineffective in enforcing these policies. Farmers who do follow these policies usually have strong leadership and commitment from the chief and elders in the community who understand the benefits and are effective in promoting these methods. The government has stated these policies but little effort or resources are used to implement and enforce them.

Farmers do practice different methods of resource management but economic pressures increasingly force farmers to abandon some of these methods. Farmers historically and traditionally leave economic trees standing in their fields. Despite the long-term benefits, a farmer may chop down the trees to increase his arable land anticipating higher yields, or immediately sell the wood for cash.

Farmers can reduce risk and achieve greater productivity and manage limited resources through mixed cropping. Groundnuts fix nitrogen and improve the soil and when planted with millet or maize the crop yields increase. Customary practices such as leaving millet stalks in the field after harvest are now often forsaken. The crop residue when left in the field prevented erosion and returned organic matter to the soil. However, the fields are now often bare because households now collect and use the millet stalks for cooking fuel while selling firewood for cash (Wheat 2000). Increasing competition for resources and decreasing land productivity demands that farmers adopt more sustainable farming practices. The local resources will soon disappear without a collaborative and cooperative management plan developed by local communities and help from government.

Chapter 4 Methods

The approach I used to study *P. biglobosa* could be classified as an ethnobotanical investigation. My interests and focus of study evolved as my 27-month service in northern Ghana progressed. I began as a cultural and linguistic outsider, and as I progressed in my language skills and assimilation into the village society, my cultural and local knowledge increased. Casual observations and information gathered during my first year in Kandiga were the basis for concentrating on local trees and how people use them, or as Martin (1995) defines ethnobotany as the study of interactions between people and plants.

My interests for this study concentrated on the traditional and economic values of one specific tree, *P. biglobosa*. I sought to assess the local perception of this tree. I employed several research methods including participant observation, informal interviews, formal interviews, group interviews and simulations. These methods are not independent and exclusive of each other. I used these methods concurrently and throughout the study. The information I gathered from observations and informal interviews progressively narrowed my focus to *dawadawa* production. However I did not abandon these methods as I carried out formal interviews and simulations. The following descriptions are details of the research methods I used.

Participant Observation

My personal observations were a major source for the data I collected. I lived in Kandiga over a span of two years. I was the fourth and final Peace Corps volunteer in Kandiga, and villagers were accustomed to *solemia*, the Nankani word for white man,

living among them. The longer I lived there, the more I became a member of the community. I would visit homes and neighbors, but many of my observations came from market days. African market days are not only for commerce, but largely for social interactions. The compound farms and widespread community limits communication and social interactions between neighbors and friends. Market days can be considered large social events that allow all members of the community to gather and exchange greetings, local gossip, information, and news. I took advantage of the scheduled social convergence of market days for collecting data.

Market days in Kandiga rotated every third day. Generally, I would spend my mornings working at the nursery and walk or ride my bicycle 500 meters to the market. Market days were an opportunity for me to observe and conduct informal interviews with many members of the community. I would often take my meals at my village mother's chop bar, where she would sell *tuo zaafi* (millet porridge), rice balls, and vegetable soup. While sitting at her chop bar, I would greet and meet other villagers and we would sit and carry on casual conversations and I conducted informal interviews. My observations often took place here, as her chop bar was situated at one of the paths leading into the market. I could see what products were being brought to market, which members of the community were selling goods, and ask my village mother for further information on unusual and interesting items that I was unfamiliar with. I also shopped for my own needs, and became a well-known face in the market.

I carried out a market survey for one year, noting the prices of the *P. biglobosa* products and soybeans. Being a woman researcher aided my acceptance in the market since women are the brokers and buyers for soybeans, *dawadawa*, and products of *P.*

biglobosa. It is common for potential buyers to ask the price, inspect the produce, and continue through the market without raising suspicion. I used this technique when gathering the information on the prices and availability. I would then go home and transcribe in detail the results of my survey. I conducted this in the local language. Devereux (1993) states 'learning the local language is a data collection exercise in its own right'. One learns the fundamental basics to social interaction so important to Ghana. From these observations, I began to conceive an outline for further study that included informal interviews, formal interviews, group interviews, and simulations.

Informal interviews

An informal or unstructured interview involved an informant and myself speaking on general topics. In Ghana, one always begins any conversation with a prolonged dialogue asking after each other's respective family members, work, and personal condition. Sensitivity and respect are key to conducting an open dialogue (Devereux 1993). General topics would include the weather, politics, and local news. My Peace Corps job assignment managing the community tree nursery presented an opportunity to bring in the topic of trees. I wanted to learn and investigate which trees were important and why they were important to the local community. I wanted to ascertain personal preferences for trees, which trees individuals considered valuable, and how much effort individuals spent on conserving those trees. I gathered information across a broad range of local trees and their uses. During these informal interviews, I frequently would initiate questions or narrow the conversation specifically to *dua* (Nankani for *P. biglobosa*) and

dawadawa. Often this informal interview would progress and develop into a formal interview.

Formal interviews

My job as researcher was to develop a framework for the topic of interest. In this method, the informant and researcher are both aware of the interview process. A set of fixed questions is presented to several informants (Alexiades 1996). In the formal interviews, my questions specifically addressed various aspects concerning *P. biglobosa*. I asked about the traditional uses of *P. biglobosa*, detailed descriptions of *dawadawa* preparation, preferences for traditional *dawadawa* or soybean *dawadawa*, medicinal preparations, illnesses treated, who has access to trees, and exact cost of products from *P. biglobosa*.

I utilized different techniques of questioning. One technique is free listing (Alexiades 1996). I would ask informants to name all the uses for *dua* and its products. Another technique is direct questioning. When I sought specific and unequivocal answers I would ask a 'yes' or 'no' question. "Do you eat *dawadawa*?" or " Do you take medicine made from *dua* tree?". After the response, I would employ another technique, probing questions. Types of probes can control or direct the responses. Silence or pausing after a response can be a probe for the informant to further expand on his response with little control exerted by the researcher (Alexiades 1996). I could elicit more detailed responses and probe deeper with questions such as "Is there anything else?" or "Can you give me more examples?" or "How is the medicine prepared?".

I occasionally asked a Kandiga CCFI nursery worker who I worked with to act as liaison or translator during these formal interviews. My language fluency limited my full understanding and I relied on my colleagues to interpret for me. I also asked my village family to help me with translating and interpreting information. Occasionally, I would record the interviews on a micro cassette recorder and ask my village family to translate the tape, and I would transcribe the answers into my notes.

Group Interviews

A group interview process was helpful for soliciting information that often may not be extracted from a one on one interview (Alexiades 1996). Individuals within the group or the grouping itself, act as catalysts, often drawing out novel responses. I conducted group interviews with CCFI nursery workers and Peace Corps Volunteers at two In-Service Training (IST) and the CCFI Annual Review Workshop. One IST took place at Saltpond, Central Region, Ghana, from May 8-12, 2000. Another IST took place in Tamale, Northern Region, Ghana, from March 15-17, 2001. The CCFI 2001 Annual Review Workshop took place at Bunso Cocoa College, Eastern Region from August 20-24, 2001.

An example of a group interview was one I conducted at the CCFI Annual Workshop with nursery workers from nurseries in northern Ghana. The opening question simply was "Tell me everything you know about *dawadawa* and the tree". A lot of information that I had already collected or observed would be mentioned. I would then try and facilitate the interview leading to more specific questions. My next question would be "Have you taken soybean dawadawa?". A follow up question would be

"Which do you prefer the real *dawadawa* or the soybean version?" and "Why do you prefer one to the other?". A response by one group member often could inspire another to elaborate on the response. A limit or cautionary note to this method is the group setting may inhibit the responses of certain individuals. For example, a small number of women within a large group of men could feel intimidated and not answer or respond to questions posed by the interviewer. The nursery workers and foremen attending these workshops are members of their own communities but also have received training and education about tree planting, agroforestry, and conservation. They have a high level of self-confidence when speaking about trees. Their responses offered knowledgeable information from different communities in northern Ghana. I sought to gather information from sources outside my community and compare, contrast, and evaluate those findings with the information gathered from Kandiga.

Key Informants

The key informants I selected were members of the community who were trustworthy, competent, and reliable. I relied on these key informants principally for information and to a lesser extent, as assistants in gathering information, as translators, and liaisons. I also asked these key informants for their guidance when interpreting the information I gathered. I could ask them if a statement was true or if the person I interviewed was truthful. My key informants were members of my village family, Kandiga CCFI nursery workers, teachers, headmasters, assembly persons, and my close neighbors.

As a researcher I had to recognize the possibility that people may be untruthful in their responses. During Peace Corps Training, we (Peace Corps Trainees and Volunteers) were often advised that Ghanaians wanted be helpful, friendly, and did not want to appear ignorant, especially to a foreigner. When asked a question, a Ghanaian may respond enthusiastically and positively, in spite of not knowing the answer. A typical image is of a Peace Corps Volunteer, who after asking directions to a bus stop, would be led aimlessly around for an hour by a helpful but uninformed Ghanaian. One's reputation often had priority over truthfulness.

A group not fully represented was the larger landholders in the community. Often, they left the village and lived in the larger towns. I did not directly interview the few large landholders and ask who could have access and at what cost to their land and *P. biglobosa* trees. That information was indirectly assessed by my discussions with the key informants.

Simulation

This technique is used to get participants to reenact activities out of context for the researcher (Alexiades 1996). I employed this method primarily for observing the preparation of *dawadawa*. The women I asked were older, trusted, respected women in the community. Two of the women served on the primary school PTA and all three were members of the local church. Their motivation for assisting me was so that I could bring back this process to my family and home. I reciprocated by showing them how to prepare soymilk and prepare American pancakes.

The information I gathered in Ghana between September 1999 and December 2001 has been used in writing this thesis. I reviewed, evaluated, and analyzed that data and complemented it with information and supporting data gathered from books, journal articles, and information from the Internet.

Chapter 5 *Parkia biglobosa*

Botany

History

In 1757, Michel Adanson first recorded *Parkia biglobosa* during his collecting trips to Senegal and the Gambia. Although Adanson did not name the tree, in 1763 Nicolas Jacquin formally published the valid binomial name of *Mimosa biglobosa*. It is interesting to note that Jacquin's description and plant material came from tree specimens in the West Indies. The trees were presumably introduced from West Africa during the transatlantic slave trade. Palisot de Beauvois, a botanist who traveled both the West Indies and West Africa, realized the link and described the species as *Inga biglobosa*. He published his discovery in 1816.

Robert Brown in 1826 suggested renaming and reclassifying these plant materials under the same genus, *Parkia*, to commemorate Mungo Park. Park was a Scottish surgeon who explored western Africa in the 1790s following the course of Niger River. Park had mentioned these trees by the local name *nitta*, in his 'Travels in the Interior Districts of Africa' published in 1799. In 1842, Bentham included Asian forms into the genus *Parkia*. Historical literature regarding *P. biglobosa* can be confusing with overlapping descriptions and names describing one species. Currently the described species within the genus *Parkia* number twenty-four; ten species occur in tropical South America, ten species in tropical Asia, and four species in Africa (Hall *et al*., 1997).

Parkia biglobosa (Jacq.) Benth belongs in the family Leguminosae and the subfamily Mimosoideae (Hopkins 1983). Some major synonyms for *P. biglobosa* are: *P. africana* R. Br., *P. intermedia* Oliver, *P. oliveri* J.F. Macbr., *P. clappertoniana* Keay.

Common names are African Locust Bean, fern leaf, arbre à farine, monkey cutlass tree, two-ball nitta-tree. In French West Africa it is commonly known as *néré, netto*, *ulele*, *sé-ou*, and *ouli* (Booth, 1988). In Kandiga, the tree is called *dua*. *P. biglobosa* is a perennial, deciduous tree reaching 7 – 20 m in height. The crown or canopy is large and wide spreading with low branches on a stout bole (Figure 8).

Figure 8 – *Parkia biglobosa* tree in Mole National Park, Ghana

Inflorescence and Flowers

The distinctive large bright red globes or inflorescence of P. *biglobosa* are seen blooming from December through February. The inflorescence or capitulum is composed of up to 2500 individual flowers arranged around a spherical bud. The capitulum measures 45 – 70 mm long and 35 – 60 mm in diameter. The mature capitulum is divided into two distinct parts, a large apical ball and a constricted basal portion attached to a strong flexible peduncle (Figure 9). The apical ball is composed of elongated hermaphroditic, fertile flowers. As the capitulum is pendant, the basal portion is uppermost and composed of modified male and neuter flowers. Several of these basal flowers secrete nectar while the remaining flowers are staminodial, that is male flowers with stamens bearing pollen. The nectar secreting flowers form a cylinder at the basal portion of the capitulum. The fertile flowers are approximately 15 mm long, with anthers measuring 1.0 – 1.5 mm long and the staminodial flowers measure approximately 6-7 mm. (Hopkins, 1983)

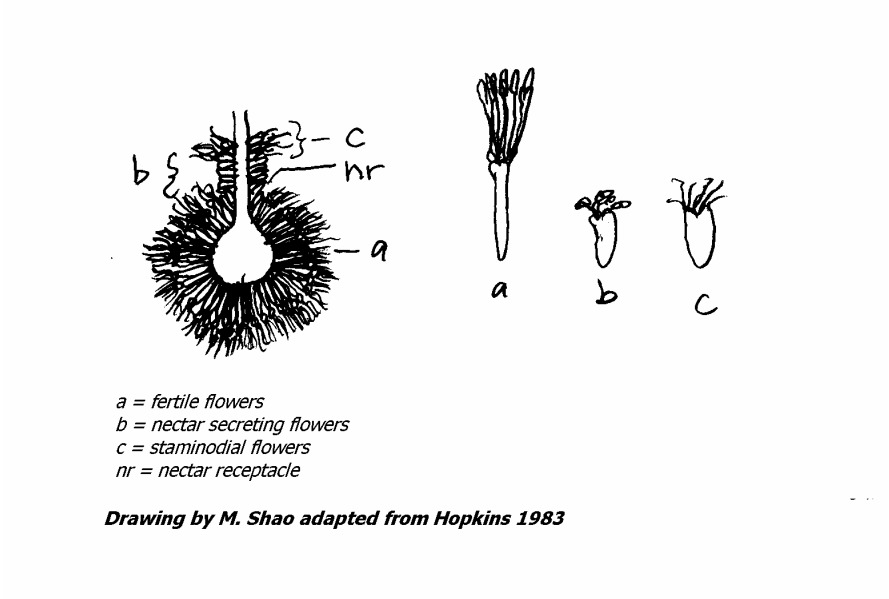

Figure 9 - Shape and structure of capitulum of *P. biglobosa*

The compound inflorescence is a raceme bearing approximately ten capitula. The capitula are arranged on alternate peduncles. This raceme is woody and leafless, measuring 30 cm in length and arranged at the edges of the broad canopy. The tree has dropped most or all of the leaves during flowering. The flushing of leaves comes as the fruit begins to develop between February and April. The compound leaves are divided up to seventeen pairs of pinnae. The leaflets measure 8 – 30 mm in length and 2 – 8 mm in width. 13 – 60 pairs of leaflets are arranged subopposite on the pinnae (Figure 10) (Hopkins 1983).

Figure 10 – *P. biglobosa* capitula and leaves

Pollination

Bats are the primary pollinators of *P. biglobosa*. Hopkins (1983) identified and observed two species of bats that visited *P. biglobosa* trees and fed from the flowers. A larger species (forearm length 105-135 mm), *Eidolon helvum* arrived in the late afternoon and early evening, embracing the capitulum while feeding on the nectar. *Micropteropus pusillus* (forearm length 48 –54 mm) only appeared after dark, flying to and feeding on several capitula.

Individual trees can flower for approximately a month, however each capitulum or inflorescence blooms for one night. The initiation of anthesis, the time and expansion of flower, begins around 1400 and by 1800 the flowers are fully opened. They remain open throughout the night. The anthers mature and the flowers produce a strong floral scent. Nectar production begins and accumulates in the basal depression. Bees and moths have been observed feeding on *P. biglobosa*, however bats are the apparent and active pollinators. *P. biglobosa* possess several characteristics such as easily accessible flowers, nocturnal anthesis, and high nectar and pollen production typical of other bat-pollinated species (Pettersson and Knudsen 2001).

Fruit

The fruit or seedpod is the most widely used and economically important part of the tree. *P. biglobosa* first fruits after eight to ten years. Typically 20 to 25 pods arise from a single capitulum (Booth 1988). The pods when young are green, fleshy, and pliable, and are sometimes eaten by humans after roasting the pods over embers. In March 2001, on a visit to Mole National Game Park in the Northern Region of Ghana, I

observed several baboons in the park feeding on the green pods. The baboons scramble up the tree and bring down the pods to the ground to eat. Throughout West Africa, *Parkia biglobosa* pods are favored foods of chimpanzees, baboons, and other primates (Hopkins 1983).

As the fruits mature they darken to a red-brown or brown color and the hulls of the pods become hardened, smooth, and woody. The length of the pod ranges between 12-35 cm and the width is between 15-25 mm. The pod is sub-cylindrical and compressed laterally in shape. Each pod contains 5 – 20 seeds, embedded in the spongy, yellow endocarp (Hall *et al.* 1997). The spongy endocarp is called *dobulong* in Nankani, and *dozim* in Nigeria. The pulp contains up to 60% carbohydrates, 10-24% of which is sucrose, and 291 mg of Vitamin C per 100 g of *dawadawa* (Campbell-Platt 1980). The pulp is at first white turning to bright yellow as the pods mature. The pulp is a beneficial food source in the middle of the dry season and is used throughout West Africa.

Seed characteristics

P. biglobosa seeds number 5 - 20 per pod. The individual brown, smooth seeds are oval, 0.9 –1.5 cm long by 0.8 – 1.1 cm wide and weigh 0.25 grams each. Each seed consists of 30% testa and 70% green cotyledons. The seeds constitute 22% of the fruit, while the pod case is 42% and the pulp is 36% (Campbell-Platt 1980). The thick seed coat protects the seed for the natural conditions of the savanna; extreme heat, low moisture, drought, and digestive juices of ruminants and primates (Tybirk 1991).

The hard seed coat or testa prevents seed germination. Germination of the seed occurs after the seed coat becomes permeable. Natural germination can occur from

prolonged contact with water, chewing or ruminating by animals mechanically scarifying the seed coat, contact with digestive juices, and fire can break the seed coat. To propagate seedlings, the seed coat can be pretreated in various ways to encourage germination. Soaking seeds in hot water, treating seeds for up to 15 minutes with sulphuric, hydrochloric, or nitric acid, and mechanical scarification all produced good germination rates, up to 80% (Hall *et al* 1997).

Seed Dispersal, Vegetative Propagation, and Nursery Seedlings

Seed dispersal is primarily accomplished through larger ruminants and primates. Antelopes, cattle, sheep, and goats are attracted to the nutritious pulp and feed on the pods. The seeds are then digested and dispersed. Baboons, monkeys, and chimpanzees also feed on the fruit and act as agents of dispersal. The feeding by primates can be more selective and seeds are often spat out rather than passed through the gut (Campbell-Platt 1980, Hopkins 1983).

Parkia biglobosa trees readily coppice after cutting. Shoots and root suckers arise from a stump. Mature trees cut back to 50 cm above the ground, produce new shoots after one week. *P. biglobosa* is often used as a fodder source; branches are cut and fed to livestock. The tree's coppicing ability can continually produce biomass with a cutting interval of sixteen to twenty four weeks without reduction in leaf nutritional value. Roots arising from stem cuttings are undependable and not a reliable means of vegetative propagation (Hall *et al* 1997).

Focus on *P. biglobosa* as a desirable species for rehabilitating arid savanna lands has produced interest in effective nursery seedling propagation. Awodola (1995) studied

the effect of moisture and nitrogen application on the growth of *P. biglobosa* seedlings and found the supply of nitrogen had little effect. Moisture applied at regular four-day intervals significantly increased shoot weight and leaf area. In northern Ghana, many of CCFI (Collaborative Community Forestry Initiative) nurseries, including Kandiga CCFI nursery, are producing seedlings by soaking the seeds before sowing and watering every two to three days.

Root Characteristics

Tree establishment in the semi-arid, sub-humid zone of Africa, relies on rapid and extensive root development with the short rainy season. Tomlinson *et al* (1997) investigated the pattern of root distribution for *P. biglobosa* in Burkina Faso. The results showed the roots were distributed over a wide area, at least ten meters from the trunk, with an average crown radius of seven meters, the area exploited by roots are twice that of the crown. The highest density of roots occurred at a depth of ten to twenty centimeters. The results showed that *P. biglobosa*'s root distribution is complementary and non-competitive with traditional local crops.

Distribution

P. biglobosa has a wide distribution ranging across the Sudan and Guinea savanna ecological zones. The range extends from the western coast of Africa in Senegal across to Sudan (Figure 11). *P. biglobosa* is found in nineteen African countries: Senegal, The Gambia, Guinea Bissau, Guinea, Sierra Leone, Mali, Côte d'Ivoire, Burkina Faso, Ghana, Togo, Benin, Niger, Nigeria, Cameroon, Chad, Central African Republic, Zaire, Sudan,

and Uganda (Hall *et al* 1997). In Ghana, *P. biglobosa* is found only in the North, and its distribution conforms to common environmental factors throughout its range. *P. biglobosa* is found at elevations lower than 1000 meters. The distribution of *P. biglobosa* occurs where rainfall averages 800 mm to 1500 mm and a drought or dry season of four months or more occurs.

Parkia biglobosa

Figure 11 - Distribution of *P. Biglobosa* (adapted from Hall *et al* 1997)

Traditional Uses for Parkia biglobosa

Trees and their products are critically important for rural communities and villages such as Kandiga. The traditional uses for *P. biglobosa* can be defined as non-timber forest products (NTFP), which includes wood energy (fuelwood and charcoal) and all other tangible products other than timber (Chandrasekharan 1993). Non-timber forest products derived from *P. biglobosa* are food, medicine, glazes, animal fodder, soil amendments, charcoal, and firewood.

The most significant product from *P. biglobosa* is food. The food products collected from *P. biglobosa* are especially important due to the seasonality of fruit maturation and food availability. In February or March, young green whole pods are roasted and eaten by men. In March and April, the beginning of 'hunger season' when other foods are becoming scarce, mature pods are collected for food. The seeds are used in preparation of *dawadawa*, a protein and fat rich food. A study by Mertz *et al* (2001) surveyed families in Burkina Faso on vegetable consumption and seasonality and found that in two villages, *dawadawa* was consumed in 78% and 85% of all meals. *Dobulong*, the yellow starchy pulp that surrounds the seed, is an important food supplement rich in Vitamin C and carbohydrates (Figure 12). The dried powder is often mixed with water to produce a drink called *dozim* by the Dagbani tribe and *bololo* in Hausa (Hall *et al* 1997).

Children in Kandiga often go foraging and gather food. Children gather and eat the marble-sized dark green sweet and acrid fruit of ebony trees, *taama* the custardy sweet fruit yielding a pecan sized seed (used to produce shea butter) from shea trees, and the pods from *P. biglobosa* freckling their faces with the starchy sweet yellow powder.

Figure 12 – Pulp from *P. biglobosa* known locally as *dobulong*

Medicines derived from *P. biglobosa* are of value to a rural community that cannot afford or have access to "modern medicine". The importance of the tree and its products as medicine perhaps is the origin for its name. The name of the tree and food product, *dawadawa* is from Hausa, the lingua franca of West Africa, spoken by over fifty million in this part of the continent. Hausa borrowed a great number of words from Arabic, and greatly influenced its vocabulary (Salloum 2001). In Swahili, a language also Arabic in origin, *dawa* is defined as medicament, anything supplied by a doctor, including charms and talisman used by native medicine men and *Dawa ya miti-shamba* is herbal medicine, made from leaves, bark, roots or trees (Swahili-English Dictionary 1939). In my interviews, I asked for uses for *P. biglobosa* other than food and the foremost use is for medicine. To relieve diarrhea, the bark is boiled to make a tea. For

infections, wounds, and fever the bark is boiled and applied topically. Several authors have reported on the medicinal uses and treatments summarized in Table 3 (Hall *et al* 1997, Booth 1988, Abbiw 1990)

Table 3 - Medicinal Uses from *P. biglobosa*

Source material	Preparation	Medicinal use
Bark	Gum extract	Toothache Diarrhea Ear complaints Mouthwash
	Macerated in bath	Leprosy, skin infections, sores, ulcers Bronchitis, pneumonia Colic
	Decoction	Schistosomiasis Rheumatism Circumsion wounds, general wounds
Leaves	Lotion preparation	Sore eyes Burns
	Crushed	Hemmorhoids Toothache Bronchitis
Flowers	Grilled and macerated Infusion	Hypertension Lumbago
Flower bud		Leprosy prophylactic
Pulp		Diuretic, purgative fever
Seeds	Pounded with salt Fermented Decoction	Tension Mouth ulcers Skin infections Wasp and bee stings
Roots	Decoction	Diarrhea, dysentery Eye infections Guinea worm

Decoctions, concentrating an extract by boiling, are used to impart water resiliency to floors, walls, and ceramic pots. *Dooro* is the Nankani name for the husk emptied of the seeds and pulp. My neighbor, Mr. Avaala, boiling a large pot of husks, first introduced me to *dooro*. This 'sour water' produced from steeping and boiling the husks is mixed with mud to produce a plaster to paint the walls of his house (Figure 13).

This plaster is also used to paint tamped earthen floors. The tannins present in the husk act to bind the soil by their polymeric nature, and render the surface impervious to water. In Burkina Faso, Karaboro and Gouin potters splash their pots with a vegetal gum solution made from the pods and husks which acts as a sealant and creates a dark, mottled surface (Cookery 2000). The tannins in the bark and husks of the pods of *P. biglobosa* are also used for dyeing and curing leather (Campbell-Platt 1980). The bark contains 12-14% tannin while the husk contains 27-44% (Hall *et al* 1997). The resulting bright red-brown color of leather is characteristic to the Upper East Region of Ghana.

Figure 13 – Traditional house in Kandiga with colored plaster made with 'sour water'

Throughout the dry season, the green leaves of *P. biglobosa* remain on the tree, a valuable source of animal fodder. Farmers will trim the lower branches of the tree and feed them to their livestock. Sabitti and Cobbina (1992) investigated *P. biglobosa* and

compared the nutritional value to other savannah species trees and found the leaves had a high amount of crude protein and high-energy value, key criteria for good quality fodder. A study by Adeloye *et al* (1993) investigated the feed value of *P. filicoidea* leaves with cassava peels which also fit the criteria for good quality fodder for goats.

P. biglobosa's broad umbrella shaped canopy and retention of the leaves through the dry season offers shade in a hot and harsh climate. The livestock escape the heat by standing in the shade of *P. biglobosa*. Cattle and goats urinate and defecate under the trees enriching the soil. Leaf fall also contributes by adding organic matter to the soil beneath the tree. Farmers in the Gambia gather the leaves for use as fertilizers. In Burkina Faso, Mossi, Gourounsi, Gourmantché, Loi and Sénoufo tribes use the testa, by-products from *dawadawa* production, as fertilizers in their fields (Hall *et al* 1997)

P. biglobosa is used for charcoal production and firewood. Although the fruits and seeds are economically important, *P. biglobosa* is used for the immediate conversion of charcoal and firewood into cash. Funerals in Ghanaian culture are important and significant occasions to honor the deceased. Clan members and guests are invited to funerals to drink *pito* and eat several types of cooked food; *koosi* a bean flour doughnut fried in shea butter, 'light soup', a chicken based peppery soup and rice balls. I attended over a dozen funerals and the number of guests could reach two hundred people or more. Brewing *pito*, a fermented drink made from sorghum, and cooking food for two hundred people consumes a significant amount of firewood and charcoal. From interviews I conducted at the 2001 CCFI Annual Workshop, funerals were the foremost reason given for the decline in population of *P. biglobosa*.

Other non-timber forest products (NTFPs) derived from *P. biglobosa* are fish poisons, a source of fiber, soap making, and indigo dyeing (Campbell-Platt 1980). In small, low flow rate rivers or streams, a small section can be dammed and crushed pods are added to the water. The stunned fish are harvested and with no adverse affects to humans consuming the fish. The strong fibers in the pod are used to attach arrowheads to the shaft, weaving nets for fish, strings for musical instruments, and basket weaving. The woodash resulting from burning *P. biglobosa* is used both for soap making and for dyeing the traditional indigo cloth (Hall *et al* 1997).

Process of Producing Dawadawa

The greatest economic value derived from *Parkia biglobosa* is the fermented product of *dawadawa* made from the seeds. This section will describe the local process of producing *dawadawa*. The seeds can be obtained from trees that are present on family owned farmland. In April and May, the fruits are fully mature and women with long sticks harvest the seedpods with a crook at the end to pull down the pods. Small, agile children also climb the trees, harvesting the seedpods. The outer shells or husks of the pods are now brown, smooth, and woody, each pod containing 10-18 seeds encased in a yellow, sweet, farinaceous endocarp. Locally this is known as *dobulong* or *dozim*. To separate the seeds from the sticky endocarp, the husks are removed and the seeds and pulp are deposited into a wooden mortar. The pulp is pounded with a large pestle until the seeds are separated from the endocarp. The endocarp is set aside and eaten as is, or

used as flour to make into porridge. The seeds are laid out to dry in the sun for a day. They can be used immediately or stored for future use.

The seeds are now selected for use in *dawadawa* preparation. The first step requires sorting the seeds and removing small stones or small unusable seeds. The seeds are then placed in a large aluminum pot with sufficient water for boiling. Plenty of wood is gathered or purchased to keep the fire burning for twelve to fourteen hours (Figure 14). Exclusively, women produce *dawadawa*. Local beliefs prohibit women who are having their monthly menses to engage in this three-day process. The belief is that the menstruating women may impart some essence that may somehow foul or spoil the product. This holds true for other lengthy processes done by women in Kandiga. The

Figure 14 – Chopping wood for fire in *dawadawa* preparation

process of making *pito* takes three days to complete. It is also considered taboo for a menstruating woman to make *pito*.

Once the fire is lit, and the seeds begin to boil, embers or wood from this fire must not be taken to light other fires. It is common to use embers or a burning stick from an existing fire to light a tobacco pipe or light a kerosene lantern. Matches are somewhat expensive and are used sparingly. However, with the long boiling time of the seeds, the belief is the fire may extinguish or the batch will not be boiled thoroughly because the woman was not adequately tending the fire. The seeds are boiled, adding water as necessary to keep the seeds covered.

This lengthy boiling is necessary to soften and separate the hard seed coat or testa from the cotyledons. After the initial boiling, the seeds are drained and the water is now poured off. The seeds are transferred to a large hollowed out log that is fashioned into a mortar. During the process, whenever the seeds are transferred any distance, a sprig of a local herb called *nuha nua* and a red chili pepper is placed on top (Figure 15). The belief is that spirits and ghosts will want to partake of the seeds or *dawadawa* and spoil the batch. Ghosts and spirits dislike the hot peppers and *nuha nua* and therefore will not disturb the seeds. Other local herbs used as talisman to ward off spirits are *kashisago mo* and *ko yenkaa*. Campbell-Platt (1980) observed that a piece of charcoal was placed on top to prevent witches from eating the beans.

The seeds are now placed in the mortar with wood ash. The wood ash acts as an abrasive to help remove the testa from the cotyledons. After several minutes of pounding

Figure 15 – *Nuha nua* and pepper placed on *dawadawa* to ward of spirits

with a pestle, the seeds are collected and laid out in a single layer to dry in the sun (Figure 16 and 17). After drying, the seeds are poured from one calabash to another at arm's length to winnow away the testa.

Figure 16 – Pounding seeds with wood ash

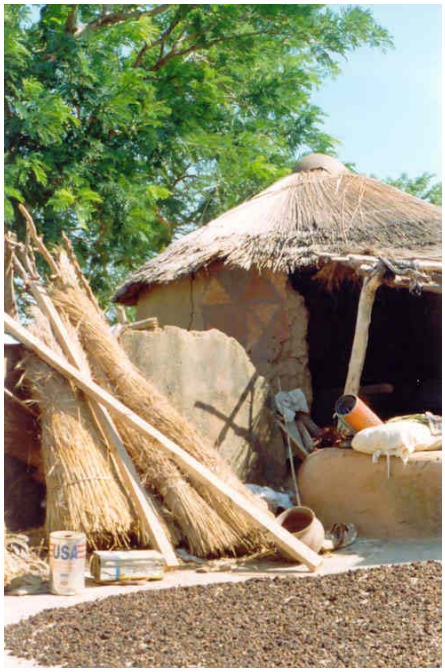

Figure 17 – Drying seeds in sun

The boiled cotyledons are brought to the borehole pump and washed several times. This is an extremely tedious task using copious amounts of water. The washings remove the wood ash and testa leaving the clean cotyledons. The exposed cotyledons are now boiled an additional one to two hours to further soften the cotyledons. The seeds are drained again then packed into a nylon or jute bag. The cotyledons are packed tightly in the bag, with a sprig of *nuha nua*, placed in a basket, and weighted down with large stones to press out any excess water. The bacteria, *Bacillus subtilis*, is a naturally occurring microbe that attaches to the softened cotyledons and begins the fermentation process. The cotyledons are left for three full days, 72 hours, until the *dawadawa* has fully fermented. Figure 18 describes in a flow chart the entire process. In Nigeria, a shorter fermentation time of 24 hours produces *iru* (Odunfa 1985).

The fermentation period is now stopped. The temperature and pH of the *dawadawa* has increased over the three days. The jute bag is opened and the *dawadawa* is deemed ready by taste and its pungent sweetly rancid aroma. The post fermentation *dawadawa* can now be further processed in various ways depending on regional or personal preferences. In the Gambia, the fermented beans are used or sold directly as loose individual beans called *netetou* (Campbell-Platt 1980). One method is to simply form the fermented cotyledons into various sized balls that are then left to air dry. The drying yields a brown or black product that is a result of polyphenol oxidation. In some regions of West Africa, salt or wood ash is added as a preservative before the *dawadawa* is formed into balls. The proper salt concentration of 5% weight to 95% *dawadawa* inhibits both the growth of *Bacillus subtilis* and its proteolytic activity (Odunfa 1985). A popular

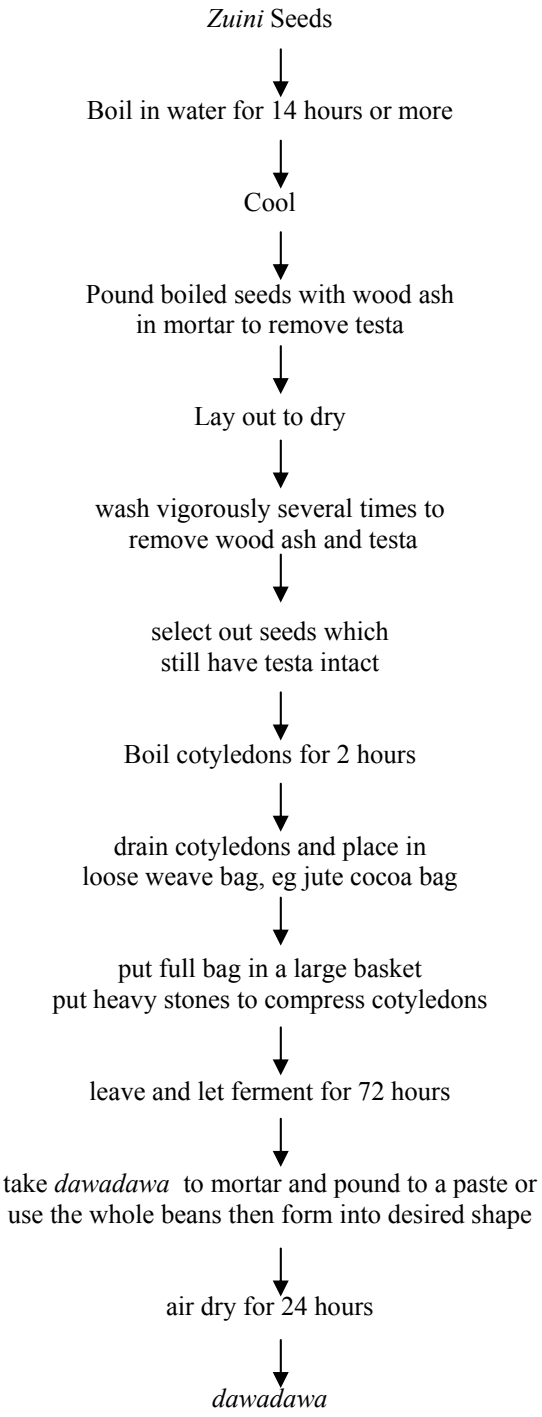

Figure 18 - Flow chart of *dawadawa* processing steps

local method is to pound the *dawadawa* into a smooth paste and form the paste into balls or cigar shapes (Figure 19 and 20). A more recent processing method is to add fermented soybeans as filler, increasing the volume, diluting but not losing the preferred taste of the traditional *dawadawa*.

Figure 19 – Forming balls of *dawadawa*

Figure 20 – *Dawadawa* balls left out to dry

The process of producing soybean *dawadawa* is similar with only one critical and major difference. The first major step of boiling the seeds of *P. biglobosa* for fourteen hours is changed to only one hour of boiling of the soybeans. The composition of *P. biglobosa* seed is 30% testa and 70% cotyledons (Campbell-Platt 1980) compared to soybean which is10% testa and 90% cotyledons (Wolf 1971). The soybeans have a thin seed coat; the bran is easily removed after only one hour of boiling. An alternate method of removing the bran is to dry roast or fry the soybeans, imparting a golden brown color to the soybeans, then the beans are pounded to remove the bran (Odunfa 1986). The sequence of steps then follows the traditional method. I observed Mary Nso, Perpetua Nso, and Roberta Abonsponsu produce both the traditional and soybean versions of *dawadawa*.

The traditional *dawadawa* is greatly preferred for taste over the soybean version. Every person I interviewed for this study preferred the traditional. I believe this is due to the recent introduction of soybeans and slow adoption or acceptance of new foods. Konlani *et al* (1999) states that *tonou* in Togo is now prepared from soybean. However, those interviewed would only use the soybean version because it was a cheaper substitute or because the traditional dawadawa was not available.

One of the major advantages, perhaps a critical advantage in the future, is the shorter boiling period of the soybeans. The traditional *dawadawa* takes an enormous amount of fuel wood to boil the *P. biglobosa* seeds for fourteen hours when compared to the one or two hours necessary to boil the soybeans. Fuel wood is a precious commodity in all of West Africa and a major factor driving deforestation in northern Ghana. A familiar sound throughout the bush is the rhythmic thud of a cutlass chipping away at low

branches or downed trees, the sound of women collecting firewood. September and October are months in the latter part of the rainy season and most women are on their farms, weeding, harvesting, and tending their crops. There is little time for women to gather wood. Many meals in the households during these months would be simple, perhaps only roasting some heads of millet over a small fire or eating groundnuts. The traditional boiling pots of porridge or rice are uncommon during these months because of the time allocated to farming and the limited firewood resource.

In Kandiga, the *dawadawa* is usually sold in the market by young children, mainly girls, and women. One woman in Kandiga I interviewed was the equivalent of a wholesaler (Figure 21). She did not want to sit in the market herself, so she would make a large batch, sell it a reduced price to girls or women willing to spend time at the market, and they, in turn would sell it at slightly marked up price for a tiny profit.

Figure 21 – *Dawadawa* wholesaler

Based on my interview with the wholesaler, and under ideal conditions, I calculated the following potential profits. She had purchased the 5 bowls (approximately 10 quarts) of seeds from the market for 4000 Ghanaian cedis each for a total of 20,000 cedis (equivalent to US $2.90). After processing the *dawadawa* she formed them into cigar shaped logs, 4 cm by 10 cm. She sold 6 for 500 cedis ($ 0.07). The children would sell in the market one log for a 100 cedis ($0.015). A market seller could realize a profit of 1000 cedis ($ 0.14) if she traded 60 logs. The wholesaler produced 300 *dawadawa* logs from her initial 5 bowls of seeds. If she sold all units, she would have 25,000 cedis, a profit of 5000 cedis ($0.71).

Microbiology and Fermentation of Dawadawa

Fermentation is a process where any group of living organisms, such as yeasts, molds or certain bacteria act upon a substrate such as glucose, carbohydrates, or proteins by enzymatic activity. Many familiar foods and beverages are fermented: yogurt, cheese, sauerkraut, beer, wine, and soy sauce. Often the fermentation not only imparts a pleasing taste, but can also increase the nutritional value of a food and act as a preservative. In African countries cereals account for as much as 77% of total caloric consumption and contribute substantially to dietary protein intake. A majority of traditional foods consumed in Africa are processed by natural fermentation (Haard *et al* 1999). Many common foods in Ghana are fermented. *Kenkey*, a rich carbohydrate staple, is a fermented product of maize (*Zea mays*). *Pito*, a local beer, is a popular beverage made from sorghum (*Sorghum bicolor*). *Banku* is a fermented cereal product made from

cassava (*Manihot esculenta*) and maize (*Zea mays*). *Gari*, a carbohydrate sold in polythene bags to which one can just add water and eat, is roasted and flaked from fermented cassava (Campbell-Platt 1980).

Dawadawa is used as flavoring but also adds protein to a protein-poor diet. Kwashiorkor is a syndrome characterized by a swollen belly. This swelling or ascites is excess fluid pooling in the abdominal cavity resulting from a protein poor diet. The name was derived from the Kwa language of Ghana. Kwashiorkor, is the evil spirit which infects the first child when the second child is born. This condition arises when the second child is weaned from the protein rich breast milk to a protein poor plant-derived diet (United States Library of Medicine 2002).

Dawadawa is used as a protein additive to most stews and soups, the main meals in West Africa (see Appendix). In Togo, the Cabrais tribes of northern Togo used

Table 4 – Average daily consumption of *dawadawa* (source Hall *et al*. 1997)

Region	Ethnic Group/Religion	Consumption (g person^{-1} day^{-1})
Eastern Nigeria	Ibo	1
Northern Nigeria	Hausa	1-7
Ghana	-	2
Burkina Faso	Mossi	3
Togo	Kabyé	4
Parakou, Benin	-	5
Kodowari, Benin	Anii/Muslim	7-10
Western Nigeria	Yoruba	10
Northern Nigeria	Christian	14
Northern Nigeria	Muslim	17

dawadawa in 90% of their meals while the Mobas further north, used *dawadawa* 60 days out of 100 (Table 4). In the Northern region of Ghana, ten percent of all meals contained

dawadawa (Campbell-Platt 1980). In northern Nigeria, *dawadawa* constituted 1.4% of the daily calorie intake and 5% of the total protein intake (Odunfa 1985).

There are many names for the fermented product of West African locust beans. Widely used in many countries in West Africa, this fermented product also has different names. In Togo, this food is known as *tonou* and slightly altered with the addition of groundnuts or made from soybean (Konlani *et al.* 1999). Yoruba tribes in southwestern Nigeria call it *iru* and the fermentation time is 24 to 36 hours (Antai *et al.* 1986, Konlani *et al.* 1999). In French-speaking African countries the names *soumbala* or *soumbara* are used (Campbell-Platt 1980). In my village, Kandiga, the name in the local language is *koligo*. In Hausa, a language spoken throughout West Africa, the term *dawadawa* is used to describe the black balls of fermented beans fermented for 72 hours (Antai *et al* 1986, Ikenebomeh 1984). In kiosks and stores, the processed and manufactured products sold as bouillon cubes are printed with the Hausa name of *dawadawa*. The basic fermentation process and the microorganisms associated with them are fundamentally the same.

Many fermented foods and beverages are based on carbohydrate utilization, acting on starchy foods or foods high in sugar. The major constituents of the raw seeds of *P. biglobosa* and of soybeans are proteins, lipids or fats, and carbohydrates. Konlani *et al* (1999) found that soybeans contained 45% protein, 31% carbohydrates, and 17% lipids and the seeds of *P. biglobosa* contained 34% protein, 35% carbohydrates, and 19% lipids. The microorganisms responsible for the fermentation must be capable of utilizing these three constituents.

Microorganisms associated with the fermentation of *dawadawa* have been identified in several published studies (Antai and Ibrahim 1986, Ikenebomeh *et al* 1986,

Konlani *et al* 1999, Odunfa 1985). In the household or cottage industry preparation of *dawadawa*, the techniques employed are simple and non-sterile materials are used. Fermentation relies on natural inocula under uncontrolled fermentation conditions. This uncontrolled fermentation can lead to inconsistent products and shorter shelf life (Latunde-Dada 1997). In industrial manufacturing, the process is more closely monitored and controlled with direct inoculation with isolated and purified microorganisms. Longer shelf life is an advantage of the commercial product.

The studies of Antai (1986) and Odunfa (1985) found several microorganisms associated with *dawadawa* but the most abundant and the major agent of fermentation after 72 hours of fermentation was *Bacillus subtilis*. These bacteria have also been identified as the agent for the fermentation of soybean into Japanese *natto*. Other microorganisms present after fermentation were *Leuconostoc mesenteroides* and *Staphylococcus spp.*. Antai and Ibrahim (1986) and Konlani *et al* (1999) results found the fermentation process to produce dawadawa is exothermic, that is heat is produced during fermentation, and pH also increases during the fermentation (Table 5)

Table 5 - Physical and microbial changes during fermentation of *P. biglobosa* beans (Konlani *et al* 1999)

Time (hour)	Moisture Content (%)	Temperature (°C)	pH	MicroFlore (1 g sample)
0	40	25	6.5	25
24	45	30	7.0	1.1×10^3
48	52	40	7.5	1.2×10^4
72	65	45	8.0	1.5×10^5

The result of fermentation increases the digestibility and nutritional value of *P. biglobosa.* Ibrahim and Antai (1986) followed and analyzed the protein, lipid, and carbohydrate content throughout the fermentation process of the seeds of *P. filicoidea*, a closely related species. The results showed an increase in free fatty acid content, an increase in proteins, and decrease in carbohydrates (Table 5). The most significant biochemical change is the protein hydrolysis that is similar to the Japanese fermentations producing *miso*, *natto*, soy sauce, *tempeh*, and Nigerian *ogi*.

Table 6 - Chemical analysis of fermented *P. filicoidea* (source Ibrahim and Antai 1986)

Test	Day 0	Day 1	Day 2	Day 3
Crude lipid (%)	19.9 ± 0.3	21.5 ± 0.1	18.7 ± 0.2	15.4 ± 0.3
Crude protein (%)	23.4 ± 0.3	24.4 ± 0.7	26.5 ± 0.5	33.3 ± 0.6
Carbohydrate (%)	41.7 ± 0.9	39.4 ± 0.5	36.9 ± 0.6	33.5 ± 0.6
Soluble sugars (%)	28.3 ± 0.7	23.6 ± 0.2	15.4 ± 0.7	14.9 ± 0.8
Free fatty acid (%)	3.3 ± 0.4	5.5 ± 0.2	9.8 ± 0.3	15.1 ± 0.4

The fermentation liberates soluble amino acids, namely glutamic acid. The salt of this amino acid, monosodium glutamate is used widely as an additive to enhance flavor (Odunfa 1985). *Dawadawa* is also an important source of Vitamin B. Vitamin B in the form of riboflavin is generally deficient in the African diet and *dawadawa* contained the highest riboflavin content, 0.80mg per 100 g, when compared to 33 common plant foods (Campbell-Platt, 1980). At the end of the fermentation, a strong ammonia smell is present which is a common end product and characteristic of proteinase activity (Odunfa 1985, Campbell-Platt 1980). This unique and distinct smell associated with *dawadawa* leads one's nose through the market to the *dawadawa* vendors.

Industrial manufacturing of *dawadawa* offers an alternative to the cottage-industry product. Royco, a subsidiary of Unilever Brothers, markets a bouillon cube in Ghana (Figure 22). In Nigeria, Cadbury successfully produced *dawadawa* on an industrial scale. Modern processing is done under controlled conditions of pH, temperature, oxygen, aeration, and isolated microbes of *Bacillus subtilis*, the same microorganism responsible for traditional alkaline fermentation of locust beans. Cadbury Nigeria was able to attractively package and market dawadawa to the urban and more sophisticated housewives (Latunde-Dada 1997).

The fermentation of the seeds of *P. biglobosa* converts an indigestible seed into a flavorful and nutritious food. The process of removing the hard seed coat and softening the cotyledons lend the beans to be edible, but the additional fermentation imparts benefits in increasing nutritional value, digestibility, and flavor. It is a locally available food, rich in protein and fat, desirable for a West African diet that is characteristically poor in balanced nutrition and calories.

Figure 22 – Royco (top), traditional (left), and soybean (right) *dawadawa*

Natural Regeneration of Parkia biglobosa

Northern Ghana, as in most of sub Saharan Africa, is suffering from deforestation. Ghana's major exports are gold, cocoa, and timber (Library of Congress 2002)). Trees from the rain forest belt in Ghana are rapidly being depleted to meet export demands. The need for foreign exchange has outweighed conservation measures to protect trees and forests. Only recently, in 1994, the Ministry of Lands and the Forestry Commission adopted the Forest and Wildlife Policy to create conditions suitable for sustainable forest resource management throughout Ghana (Kotey *et al* 1998).

In northern Ghana, the number of trees is being depleted by the heightened demand resulting from increasing population pressure. An article written in August 29, 2001, Ghana's Daily Graphic noted findings from the Environmental Protection Agency. The article reported the alarming rate that charcoal producers were destroying economic trees like shea and *dawadawa* trees. A survey in 40 communities in the Upper West Region revealed that 80% of the charcoal produced is from shea trees and the remaining 20% produced from *dawadawa* trees. The Bolgatanga – Navrongo road which I often used going into town from Kandiga was lined with mahogany trees. It was obvious to me after two years that the many of major branches had been chopped off for wood or charcoal and several trees were destroyed (Figure 23). The switch to economic trees like shea and *dawadawa* occurred once common traditional charcoal sources like mahagony, *Acacia spp*, and *Pterocarpus* trees were harvested (Kyei-Boateng 2001).

Figure 23 – Mahogany tree destroyed on Bolgatanga - Navrongo Road

Culturally, trees have been protected in sacred groves, a forest patch that is a remnant of original forest that the local community perceives as sacred. Their traditional belief is that ancestral spirits reside in the sacred grove and protect the community. These sacred groves are also valuable as reservoirs of biodiversity in an area where natural resources are rapidly being depleted (Miller *et al* 1999). Lykke (2000) investigated the local perceptions of trees and determined which species should be considered top priorities for conservation. *P. biglobosa* was mentioned as a highly preferred fruit bearing tree and conserved in farmlands and forests. Unfortunately, the majority of informants named *P. biglobosa* as particularly declining in numbers. Other trees protected in farm fields and of economic importance are *Vitellaria paradoxa* and *Pterocarpus erinaceus*.

Tree planting and afforestation in Africa are not widely practiced. In response to world markets and demands, certain trees have been planted or managed as cash crops in Ghana, primarily cocoa trees in the south as well as oil palms (Bergert 2000). However, planting of trees especially in northern Ghana is a recent idea more aggressively introduced in the last two decades. Tree planting activity in northern Ghana exists, although mainly done by foreigners and expatriates who have access to large tracts of land. The Sirigu mission 12 kms away from Kandiga has a large mature mango orchard that was planted by the Catholic missionaries in the 1950s.

Individual farmers resist tree planting on their small landholdings for several reasons. A major constraint for the farmer is land. As the population has increased, the land each farmer can farm has decreased, and farmers are not willing to forfeit agricultural land for planting trees. Another reason is local superstition and fear. Several people I interviewed stated that many villagers believe that if a man plants a tree he will die when it begins bearing fruit. Gender roles also discourage tree planting. In northern Ghana, men are the managers of the land and do not value the direct benefit of tree planting for maintaining the household. Traditionally, women do the majority of wood gathering for household use. As women progressively travel farther distances to gather wood they are thwarted from planting trees. Married women do not have rights to the land since it is not their original home. As a result the population of local trees is diminishing.

Parkia biglobosa is one of the trees protected in farmer's fields and near households. When preparing fields for farming, *P. biglobosa* trees are left untouched because of their economic and cultural importance, However, as mentioned above, their

numbers are threatened as natural resources are depleted and people are suffering from their poor economic situation. Currently, farmers do not actively plant *P. biglobosa* trees, therefore regeneration must be carried out by natural means. Livestock, fire, and humans are all factors that limit the success of natural regeneration.

The Upper East Region supports a large percentage, as much as 30% of Ghana's livestock: cattle, sheep, and goats. Livestock are maintained is this region since tsetse flies are absent. A main constraint to cattle production in south central Ghana is the prevalance of trypanosomosis disease transmitted by the tsetse fly (Hendrickx *et al* 1999). Consequently, more and more farmers in the Upper East region are relying on raising livestock as a means of increasing their wealth (Figure 24). For example, one of

Figure 24 – Sheep and cattle herded by village boys

the CCFI nursery workers resigned from our nursery to exclusively trade livestock from northern Ghana to Kumasi and Accra in the south. Livestock have a great impact on limited local resources. During the farming season, especially at the beginning in June

and the first rains, livestock are tied, pegged, or herded by small children to prevent them from eating the young, emerging crops. After the rainy season, the livestock are left to freely graze and browse for whatever food they can find. Any small tree seedlings that naturally regenerated are potential fodder for the free-ranging livestock. Working as an agroforestry extensionist in Kandiga, I observed any tree seedlings left unprotected by thorn fences, mud walls, or bricks, were invariably eaten by livestock. Tybirk (1991) observed that livestock and ruminants are the most common agent of seed dispersal for *P. biglobosa*, however, the effect of free grazing by livestock can be deleterious to naturally regenerated seedlings of *P. biglobosa*.

Fires are an integral component of the farming system in northern Ghana. Farmers use fires for various reasons. Honey gatherers use smoke and fire to drive away bees and often set the snag or hollow tree on fire. Others will set fire to encroaching brush to discourage snakes. Hunters will set fires to tall grasses to flush out grasscutter, rats, and other small game meat. Historically, farmers would rotate their farmlands, allowing heavily farmed land to lay fallow, slashing and burning a new section in

Figure 25 – Bush burning land to clear for agriculture

preparation for the next season's crops (Figure 25). Fire is still used in this way; however, the farmland is now repeatedly used, not allowed to lay fallow. In turn the soil cannot regain certain nutrients or fertility from incorporating organic material, namely nitrogen and sulphur when brush is burned away. Fires are deliberately set under *dawadawa* trees to promote fruiting. The cumulative effect of these fires is that West Africa, between the Sahara and the Gulf of Guinea has the highest proportion of annual fire in the world (Pyne 1999).

Humans play an important role in the decline of natural regeneration of *P. biglobosa*. The greatest impact is the intensive harvesting of the mature pods for production of *dawadawa*. During March and April the local markets are flooded with *zuini* (*P. biglobosa* seeds), *dobulong* (yellow starchy endocarp), and *dooro* (empty husks). The women harvest the pods for home use, although the pods are sold to convert this resource into much needed cash. March and April are months in the middle of dry season, and the beginning of the "hunger season". Most of the stored household grains have been used and cash is necessary to purchase food. Women entrepreneurs, especially from the larger towns of Bolgatanga and Navrongo, take advantage by buying up all the products from the local markets with their cash assets. These women bring the seeds into Bolgatanga or Navrongo and sell them at a profit, or sell the *P. biglobosa* seeds to buyers for the industrial manufacturers, especially Royco (a Unilever Brothers subsidiary). These enterprising women will also come back to the village markets later in the year and sell seeds at a higher price to the local *dawadawa* producers who do not have access to transportation. Consequently, the requirement for cash has directly depleted the soil's seed bank.

Chapter 6 Soybeans

History of Soybeans

The cultivation and domestication of soybeans (*Glycine max* (L.) Merrill) dates back over 3000 years to China. It was considered one of the five sacred grains along with barley, wheat, millet, and rice during the Chou Dynasty (1134-246 BC). Many foods popular in Asia are derived from soybeans; tofu, *natto*, *tempeh*, *miso*, and soy sauce (Fallon and Enig, 2000). Engelbert Kaempfer, a German botanist who lived in Japan for several years, introduced soybeans to Europe in the 1690s. By 1790, soybeans were growing in the Royal Botanical Gardens of Kew in England. However, the plant was more a curiosity than an agricultural crop. European climates and soils were not suited for extensive soybean cultivation (Lager 1945).

Introduced to America in the late 1800s and early 1900s, soybeans were used for hay and feed. Extensive cultivation in the U.S. began in the 1920s when soybean processing became an established industry producing oil and meal (Wolf 1971). Soybeans are second only to corn in production value in the U.S.. Soybean oil comprises 74% of the oils used in edible oil production while the by-product of soy meal comprises 75% of protein fed to livestock and poultry. (USDA 1990). The U.S. is the largest producer of soybeans, providing 50% of the world's supply. The total value of soybeans exported from the U.S. in 2001 equaled $5.4 billion dollars (BICO Reports 2002).

Many authors praise the soybean as the miracle crop. Books published in the United States in the 1940s titled "Soybeans, Gold from the Soil" and "The Useful Soybean" including chapters titled 'Agriculture's Cinderella' and 'Our Wonder Crop' are

evidence of the admiration. Soybeans' significance in the U.S. and the global market depends largely on industrial manufacturing and large-scale livestock production, while a minor role as a human food source. West African countries are looking to soybeans as 'the miracle crop' to alleviate malnutrition and poverty. Nutritionally, soy protein is cheaper than meat and soybeans contain 35% protein and 20% fat by weight. Large areas of Africa possess suitable conditions of acceptable daylight hours and rainfall to support soybean cultivation (Figure 26)(FAO 1997). Another advantage of soybeans are they are not native to Africa, and therefore less prone to pest and diseases.

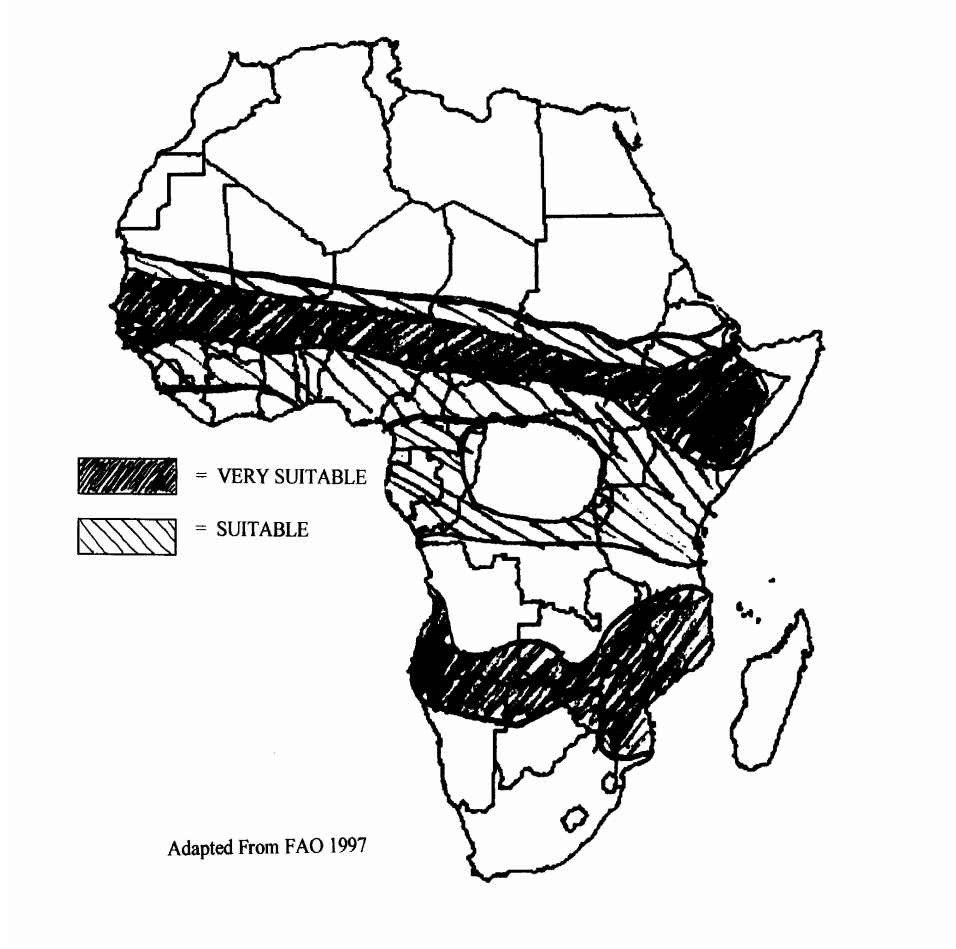

Figure 26 - Areas of Africa suitable for rain-fed production of soybean (FAO 1997)

Colonials and missionaries in the 1940s first introduced soybeans to Nigeria and Ghana. In 1987, the International Institute of Tropical Agriculture (IITA) supported with funds from the International Development Centre (IDRC) aggressively introduced soybeans into Nigeria. In 1985, Nigeria only produced 28 metric tons and in 1995, production increased to 200,000 metric tons (Dashiell 1998). In the last 20 years, several agencies within Ghana have advocated soybean cultivation. Ghana's Ministry of Food and Agriculture (MoFA), Adventist Development and Relief Agency (ADRA), Catholic Relief Services (CRS), and other NGOs have been educating, promoting, and assisting farmers in the cultivation and use of soybeans (Figure 27)

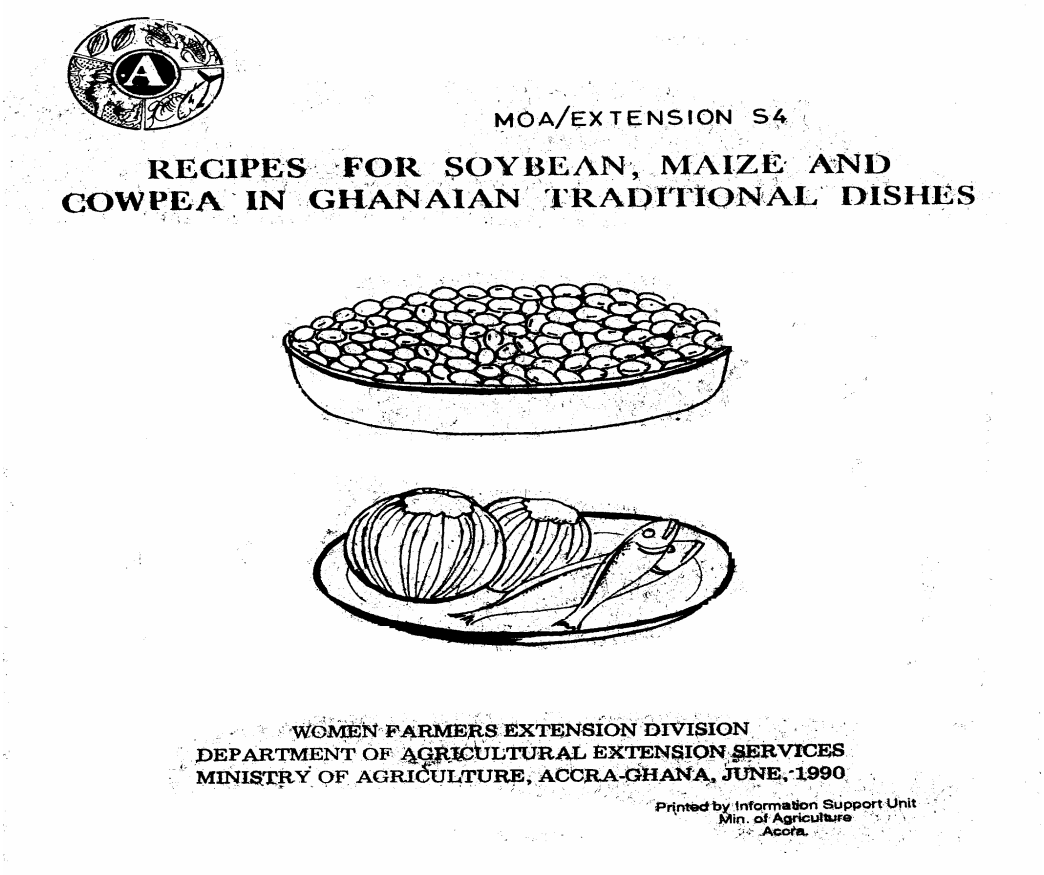

Figure 27 - Cover of MoFA Soybean Extension Cookbook (Women's Farmers Extension Services 1990)

The presence of soybeans in Kandiga, both in the market and in the fields is on the increase (Figure 28). I worked directly with ADRA (Adventist Development and Relief Agency) farmers promoting agroforestry. Those chosen by ADRA were low-resource farmers who needed assistance attaining self-sufficiency. One of the expectations from ADRA for the farmers was to cultivate soybeans. Farmers were given soybean seed on credit and the assurance that ADRA would buy the harvest in lieu of cash for payments on farmer's loans. I observed that non-ADRA farmers would also plant soybeans in their fields. One example was a widow, a neighbor of mine who farmed a small plot of soybeans from seed given to her from an ADRA farmer. The crop yields could vary with rainfall and proper spacing and cultivation methods. The greatest obstacle to the success of soybeans in Kandiga was that approximately half of the ADRA farmers would sell the seed for cash immediately, instead of planting it on their farms.

Figure 28 – Soybean plant

Chapter 7 Results and Discussion

In discussing the results, I must first acknowledge when I began the study I had a bias against replacements, soybean or commercial, to traditional *dawadawa*. I believed that a traditional method using local resources would be favorable and beneficial for the local economy. For sustainability, a locally produced food product is preferable to a commercial product. I found traditional processing used a great deal of wood to produce *dawadawa*. In fact, the net loss of local resources may be greater maintaining the traditional *dawadawa* processing over the adoption of the soybean substitute. The following section will discuss the results from the market surveys and observations of soybeans as a resource for *dawadawa* preparation.

Soybeans in Kandiga Market

During my research on *P. biglobosa*, I discovered a Ghanian manufacturer, Royco, produced bouillon soup cubes flavored with *dawadawa* selling in the market. I contemplated what effect the manufactured substitute would have on locally produced *dawadawa*. My hypothesis was that traditional *dawadawa* would eventually be replaced by the manufactured substitute.

Deforestation, degradation, and low productivity threaten the semi-arid region of Africa (Awodola 1995, Bakang and Garforth 1998, Kranjac-Berisavljevic 1999). I assumed if the population of *P. biglobosa* continues to decrease with no active management, the non-timber forest products would soon become unavailable. As a result, local women would lose income from their cottage industry of *dawadawa*

preparation, and be forced to buy a manufactured product. I soon discovered the bouillon cubes were not the main competition to traditional *dawadawa* but *dawadawa* produced with soybeans.

I began recording the cost of soybeans and *zuini* (*P. biglobosa* seeds) in January 2001. *Zuini* were most abundant and cheapest in April and May when the fruits were ripe. Most products like rice, groundnuts, shea nuts are sold by the bowl. Each product has a corresponding bowl size. For the *zuini* and soybeans, the bowl measures approximately 2 quarts. An adept market woman can increase the amount of seeds by her expertise of filling and piling the seeds. By encircling and cupping the rim of the bowl using her arm, she can get more seeds than a less accomplished buyer.

In Kandiga market the cost and supply of *zuini* fluctuated throughout the year (Figure 29). In September, October, and November, the height of farming season, I was not able to find *zuini* available at market. In April and May, most women in Kandiga sell

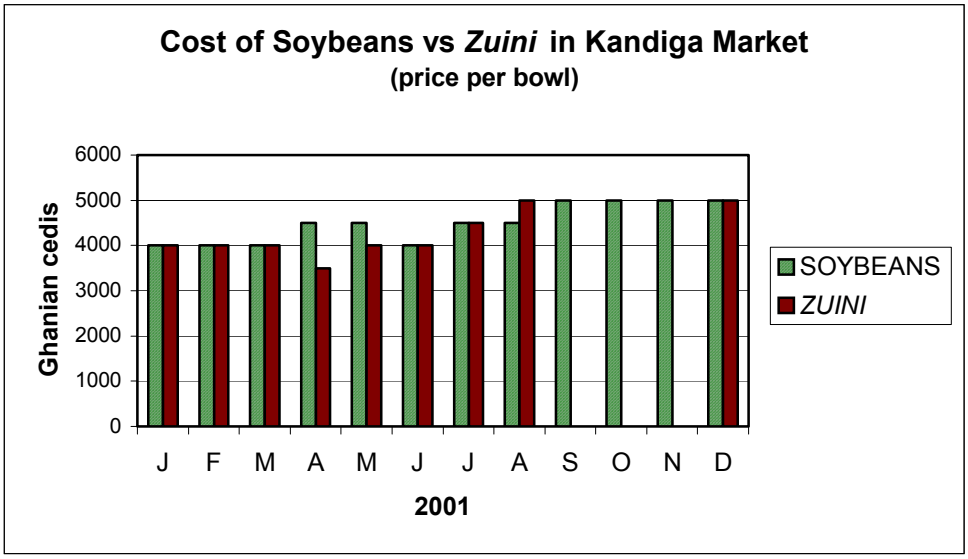

Figure 29 - Cost of Soybean and *Zuini* for 2001

the *zuini* when the market is brimming over with *P.biglobosa* products. The prices may be low, but converting the products to cash immediately helps the local women survive the remainder of the dry season. Through my interviews, I found two related reasons affecting the local supply of *zuini*. *Zuini* is a cash commodity, and trade depends upon demand in northern Ghana. Firewood is rarely collected during the farming season and traditional *dawadawa* is not prepared in Kandiga during this time.

Traders with cash assets from the larger towns of Bolgatanga and Navrongo buy up groundnuts, *zuini*, and other grains and store them for sale later in the year when prices have increased. *Zuini* are traded in this same way. Women traders buy up the low-cost *zuini* from local village markets and can either store the seeds or sell them immediately. I could buy *zuini* sold by traders in Bolgatanga and Navrongo market year round. However, it was not always available at Kandiga market. The women traders who store the seeds will bring *zuini* to Kandiga market after several months and sell it at a higher price. A measuring bowl of *zuini* bought in April for 3500 cedis (US $0.50) would sell for 5000 cedis ($0.71) in December, a profit of 1500 cedis ($ 0.21). A trader could bring the *zuini* to Tamale and sell the seeds to the Royco manufacturer, a subsidiary of Unilever Brothers. Tamale lies approximately 170 km southeast from Kandiga and is the regional capital of the Northern region. The Northern region also has many *P. biglobosa* trees; two villages on the Bolgatanga-Tamale road are named Dawadawa 1 and Dawadawa 2.

Zuini and traditional *dawadawa* were not available for September, October, and November. I asked several women why this was the case and the explanation was the lack of firewood. The traditional *dawadawa* process requires vast amounts of wood to

boil the *zuini* for fourteen hours or more. Women's labor is concentrated on weeding, farming, and harvesting during the months of September, October, and November leaving little time for collecting firewood. However, soybeans and soybean *dawadawa* were available throughout the year. The soybeans only require enough wood to boil the seeds for two hours to prepare soy *dawadawa*. Seasonality, the time when resources are available, has a major effect on the production of *dawadawa*. Latunde-Dada (1997) studying fermented foods and cottage industries in Nigeria found the locust bean seasonality caused the production bottleneck. *P. biglobosa* trees are not managed in large orchards. The supply of seeds depends on scattered individually owned trees that only produce once a year and therefore are an unreliable source of seeds for industry. He suggested soybeans could be substituted and scaled-up to larger industrial manufacturing.

Adoption of soybeans in Nigeria

Adoption of new crops and foods are dependent on relevant knowledge, the amount of risk involved, and the potential benefits. A few innovative farmers in Kandiga were testing introduced varieties of groundnuts anticipating increased benefits and profits. I observed a few varieties of groundnuts different from the main variety, which had small seeds and a pale pink testa. One variety had a maroon red testa referred to as 'Nigerian', quite large and robust seed. In another variety the testa had a red and white marbled pattern that people referred to as the 'agric' variety.

A study by Shannon and Kalala (1994) examined production and utilization of soybeans to determine if adoption of this crop would take place in Sub-Saharan Africa. Approximately 50% of the farmers ranked soybean first or second in importance of local

legumes. This study took place in Nigeria and Zaire in 1987. The researchers found that soybean production and utilization had increased from the previous three years. Shannon and Kalala concluded that low-resource farmers were readily adopting the crop and modifying the soybean for traditional uses.

A case study for adoption and social impact of soybean in Nigeria's southern Guinea Savanna can be a model or template for northern Ghana. Sanginga *et al* (1999) surveyed 203 households in Benue State to determine the level of adoption of soybean using social impact assessment (SIA). The results showed soybean adoption rates rose from 9% of farmers in 1989 to 75% in 1997. The high adoption rates are attributed to improved material welfare, household income generation, and human capital development. This study also showed that soybeans were an acceptable substitute in traditional foods. Virtually all the farmers used soybean *dawadawa*, 90% used soybean *akpupa*, a steamed bean flour cake, and 60% used soybean *akwese*, fried bean cakes. Innovative soybean utilization, such as soymilk, and a local 'tofu' were moderately adopted at 25% utilization.

"Onions Are My Husband" is a common phrase used by Ghanaian market women and used as a title for a book describing women traders in Ghana by Gracia Clark (1994). This phrase encapsulates the income, benefits, and relative security that trading goods offers in Ghana. Nigerian women are now calling "Soybeans are my second husband" because it helps to pay school fees and medical bills (Future Harvest 2001). I can only approximate the effect of the introduction of soybean cultivation to Kandiga and Ghana. Interviewing MoFA agents, the best estimates are in the 1980s. During this study, I

found that soybeans were an acceptable substitute and during part of the year, an appropriate replacement for traditional *zuini* and *dawadawa*.

Recommendations

Natural resource degradation in the semi-arid regions of Africa is of alarming concern for many researchers. Numerous studies have investigated the declining productivity of agricultural crops, escalating erosion, and depletion of soil fertility. In the 1960s, modernization of farming methods and revolutionary ways of increasing productivity through expensive external inputs such as fertilizers, mechanization with tractors, improved seed, or introduction of cash crops were introduced to deal with these issues. The revolutionary methods of modernization have not succeeded (Keatinge *et al* 2001). Intensive agricultural practices in the savanna regions of West Africa failed because little attention was given to local economies and traditional conservation methods. Many studies (Kranjac-Berisavljevic *et al.* 1999, Bakang and Garforth 1998, Viehe 2000, Lykke 2000) strongly recommend and advocate that active participation and the incorporation of existing socioeconomic realities from the stakeholders is necessary for sustainable conservation practices to be successful in northern Ghana and savanna regions of West Africa. This study investigated *P. biglobosa* as a resource against the socioeconomic background of Kandiga

P. biglobosa is named specifically in several studies as an important and beneficial native tree species and should be targeted for conservation and tree planting plans for the savanna woodlands and Sahel region of Africa (Sabitti and Cobbina 1992,

ICRAF 2000, Bakang and Garforth 1998). *P. biglobosa* is considered a natural renewable resource that can support sustainable rural development. However, the conservation of *P. biglobosa* depends on increased and dedicated efforts by the local farmers. People choose to adopt conservation measures or agroforestry practices either for economic gain or to solve specific environmental concerns on their land. For successful sustainable resource management local people must feel empowered and confident that they can play a role in conserving and improving their access to available resources. The following are recommendations of management methods for *P. biglobosa*.

One recommendation is to actively cultivate *P. biglobosa* as a 'cash crop'. Oil palm, rubber cashew, cocoa, and coffee are examples of products once derived from wild sources, which are now cultivated at lower costs, provide a reliable supply, and improved quality (Chandrasekharan 1993). In Mali, the OAPF (Industrial Plantation Project of Malian Forest Service) is assessing the performance of native species for use in managed plantations. In conjunction with plantations, formal scientific research to identify and develop genetically superior trees which are higher producing could increase non-timber forest products (NTFP) yields of native species such as *Vitellaria paradoxa* and *P. biglobosa* (Gakou *et al* 1994). A management plan for cultivating *P. biglobosa* should also include fast growing non-native species. Cultivating *P. biglobosa* as a cash crop could generate income while planting fast-growing non-native species could alleviate the fuelwood crisis.

The local home processing of traditional *dawadawa* demands a great deal of firewood, an already limited and rapidly disappearing resource. Selling the *zuini* seeds to

a large manufacturer could provide income to local farmers. The manufacturer has easier access to alternative fuel sources and would be able to produce *dawadawa* on a larger scale and at lower costs. In addition, by encouraging the use of soybean as an alternate source for preparing *dawadawa*, the local demand for firewood would be decreased.

One of the main constraints to industry in Ghana, such as tomato processing or cashew processing, is the insufficient supply of raw material sources to operate at full capacity. The demand for *dawadawa* is growing within Ghana. Attitudes of people in southern Ghana to *dawadawa* are changing. Traditionally only used in northern Ghana, the demand for and availability of commercial *dawadawa* is increasing in southern Ghana. Markets and kiosks are selling the *dawadawa* cubes while radio and television commercials are advertising the *dawadawa* bouillon cubes.

NGOs and other development agencies must continue farmer education and increase efforts promoting the benefits of agroforestry, which is the practice of integrating trees with crops. Agroforestry requires and encourages farmers to actively manage resources by planting and protecting the trees among crops. During this study, I accompanied the Kandiga CCFI nursery extensionist as he spoke with several farmers. We wanted to educate them on the advantages and benefits of agroforestry. Planting trees would increase the supply of firewood, provide windbreaks preventing soil erosion, and provide income, especially if fruit trees were planted among their farms. When I arrived at Kandiga CCFI nursery, most of the tree species were non- native. At first I met resistance when I suggested producing local seedlings such as shea tree (*Vitellaria paradoxa*) and *dua* (*P. biglobosa*). The nursery produced a small number of local seedlings the second year of my assignment, and we were pleased that farmers bought

them. These farmers recognized, based on their own observations, the benefits experienced by the early adopters and members of the community who first planted trees.

An indirect method for conserving *P. biglobosa* is to discourage bush burning. Bush burning can damage and destroy young naturally regenerated seedlings of *P. biglobosa.* A study by Aalangdon *et al.* 1999 in northern Ghana studied farmer's attitudes towards bush burning. The study showed results of crop yields of maize on

Table 7 - Advantages and disadvantages of non-burning (source Aalangdong *et al* 1999)

Village	Advantages	Disadvantages
Goziire (Upper West Region)	-regrowth of natural vegetation, especially trees and grasses -improved yields of shea and dawadawa trees -reducing erosion, improve crop yields -retention of livestock nearby because forage is available	-fewer dead trees for women to collect as firewood -proliferation of pests such as rodents and insects which destroy crops
Zagsilaari (Northern Region)	-improvement of soil fertility -reduction in soil erosion -increased crop yields and food security for family	-inaccessibility, limited mobility and visibility, -bushes become hideouts for thieves

burnt and non-burnt fields. The results showed the yields were doubled in the non-burnt fields. Furthermore, the longer a field is not burnt the yields improve. When presented the results, farmers were keen on non-burning and it strengthened their acceptance for other methods of clearing their fields (Table 7).

Although local farmers have little control or input to government policy, perhaps the role of government can improve the conservation of resources, especially for northern Ghana. A resolution may be government, creating, implementing, and enforcing beneficial collaborative policies taking into account the local stakeholders. Ghana's

government acknowledges the disproportionate economic advantages and access to resources across the country. Prior to the 1999 National Land Policy, Ghana had never formalized or implemented a land policy. The aims and objectives of the Land Policy are "the judicious use of the nation's land and all its natural resources by all sections of the Ghanaian society in support of various socio-economic activities undertaken in accordance with sustainable resource management and maintaining viable ecosystems" (Kasanga and Kotey 2001).

In summary, I recognized the survival of *P. biglobosa* as a resource is not threatened by the presence of soybeans. The danger of overexploitation and depleting a resource often comes from a dismal economic situation and poverty. The social impact assessment study in Nigeria (Sanginga *et al* 1999) showed that farmers who adopted soybean cultivation improved their material wealth. Diversifying their methods of generating income, farmers will be capable of managing their resources, instead of depleting them. Soybeans present a viable substitute to *P. biglobosa* in several ways. Soybeans are available throughout the year. The difference in cost relative to *zuini* is negligible. Soybeans are equally nutritious and beneficial supplement to the local diet. Adopting soybeans as a crop can improve farmers' level of affluence and material wealth.

Generating income and improving material wealth alone cannot ensure the survival of *P. biglobosa*. Continued education and outreach programs are critical for encouraging sustainable resource management and conservation practices. Enforcing policies against bush burning by local government improve crop yields but may also promote natural regeneration of trees. Promoting agroforestry practices that benefit the farmers and their lands are important. Farmers can derive income from fruit trees or

fuelwood trees planted on their land. Farmers can cultivate and manage *P. biglobosa* and sell the *zuini* as a cash crop to the larger commercial manufacturers of *dawadawa*. Planting trees and shrubs reduce wind and rain erosion of the soil. An integrated system of reducing demands on depleting resources and improving beneficial farming practices will be the solution for preserving *P. biglobosa*.

Chapter 8 Conclusions

The study of ethnobotany can have two goals or perspectives for a researcher. One goal is discovering new natural products of commercial value for the benefit of the developed world. The second goal is studying the local knowledge and the value local people associate with plants. Using this knowledge, one seeks possible conservation measures or local resource management strategies to protect this resource (Martin 1995). In this study, I concentrated on the second goal. I wanted to document and understand the economic and social value of *P. biglobosa* and non-timber forest products derived from the tree and their importance to the people of Kandiga.

The results of this study show that *P. biglobosa* has many diverse uses and is considered an extremely valuable resource in Kandiga. The main and primary use is as a food source. Mature seedpods produce dark brown smooth seeds known locally as *zuini*, which provide the raw material for producing *dawadawa*, a fermented and favored condiment used in soups and stews. *Dawadawa* provides a desirable protein and fat source for the nutrient poor diet. The seeds which are gathered by women and children, also provide household income sold as seeds or when prepared as *dawadawa*. The starchy yellow endocarp or pulp that surrounds the seeds is an important source of carbohydrates and energy source, especially during the hunger season when other food is scarce.

P. biglobosa is a precious and convenient resource for producing traditional medicines. People in Kandiga cannot afford expensive western medicines, and various parts of the tree are macerated, crushed, ground, and boiled to create tonics and ointments to treat many different ailments. Diarrhea, dysentery, eye infection, wounds, and leprosy

are some of the illness that are treated from the bark, flowers, seeds, husks, and leaves of *P. biglobosa*. The chemicals in the pods also act as fish poison. Another notable use is the empty pod husks. The husks are boiled and the red mucilage extracted and the liquid solution is used to treat pottery, mud walls, and floors. The husks contain a large amount of tannins. Tannins derived from the bark are used locally for tanning leather and dyeing cloth.

P. biglobosa presence on farmlands and around households improves and enhances the local environment. Wind and rain erosion are especially severe in Kandiga and contribute to the loss of topsoil. The trees provide windbreaks and vegetative cover that reduces soil erosion. The broad and widely spread canopy provides considerable shade in the hot dry environment. The roots of *P. biglobosa* readily fix nitrogen, while the leaf fall adds organic matter thereby enriching the poor local soils. The improved soil and shade create better growing conditions under the tree that are compatible with local crops. The tree's ability to coppice allows lower branches to be cut and used as fodder for livestock. The leaves are rich in protein and energy providing a good source of feed for the large proportion of livestock in Kandiga. Goats, sheep, and cattle often forage and assemble under the shade of the tree, urinating and defecating, thereby enriching the soil beneath the tree.

I initially focused on local *dawadawa* preparation and its financial benefit to local producers, compared to the cash expense and cost required to purchase a commercially manufactured bouillon cube product of *dawadawa*. I assumed that spending cash for a commercial product was deleterious to the already financially strapped household accounts. The commercial product had little consequence on household expenses

compared to the traditional *dawadawa*. I discovered a more significant challenger to traditional *dawadawa*, the soybean version. Soybeans, soybean *dawadaw*a, and commercial bouillon *dawadawa* cubes were consistently available in the market year round whereas traditional *dawadawa* was not available throughout the year.

Seasonality was a limiting factor for *P. biglobosa* products. An overabundance of *P. biglobosa* products was available in April and May during fruit maturation and local harvest of the seedpods. The supply diminished the remainder of the year while in certain months, *zuini* and *dawadawa* were completely unavailable. Traditional *dawadawa* preparation is more costly and demanding of resources than soybean preparation, either in time used for collecting wood or money spent to buy wood. Long hours are required to remove the hard seed coat compared with the thin testa of the soybeans. Collectively, people preferred the traditional *dawadawa* even though traditional version was not available throughout the year.

Soybean *dawadawa* is equally nutritious compared the traditional *dawadawa*. Both versions are rich in fat, amino acids, and an important supplement to the local diet. *Dawadawa* is used extensively throughout West Africa with studies reporting consumption of *dawadawa* constituting up to ten percent of the main meals. The difference in the cost of seeds was negligible between *zuini* and soybeans. Although the introduction of soybeans was relatively recent in Kandiga, an extensive study of increased soybean cultivation and rapid adoption of utilization in Nigeria by Sanginga *et al* (1999) may predict the acceptance and adoption of soybeans in northern Ghana. The adoption rates in Nigeria rose from 9% of farmers in 1989 to 75% in 1997. Soybeans

may replace *P. biglobosa* seeds as raw material for *dawadawa*. However, soybeans cannot replace all the benefits obtained from *P. biglobosa*.

My conclusion is that people still regard *P. biglobosa* as an important natural local resource. Only under dire economic circumstances are farmers compelled to destroy the trees. Some farmers believe that cutting the tree is taboo and violates traditional religion. The considerable benefits from the tree may be the foundation for this belief. *P. biglobosa* usually is protected on farmlands, though the present deteriorating economic situation and poverty force some farmers to sacrifice the tree for charcoal or firewood. The immediate and somewhat desperate needs outweigh the long term and diverse value of trees and *P. biglobosa* as a resource. Nevertheless, the people of Kandiga still regard *P. biglobosa* as a valuable resource. The tree provides financial benefits, and the many diverse uses and traditional regard still have enormous value. The solution is not only to discourage destruction of the trees but also to encourage active management practices that farmers can employ without large monetary cost.

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Maps:

Map of Africa and Ghana
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Free Blank outline map of Africa
http://geography.about.com/library/blank/blxafrica.htm

APPENDIX

GHANIAN RECIPES USING *DAWADAWA*

SOY DAWADAWA (Women Farmers Extension Division 1990)

Ingredients
Soybeans
Corn flour or Wood Ash

Method
1. Clean and wash soybeans to remove dust and dirt
2. Blanch (i.e. boil) for 20 – 25 minutes
3. Wash with cold water and dehull (i.e. remove the coat)
4. Separate hulls and boil for 2 – 3 hours
5. Strain and allow to cool
6. Spread plantain leaves or any non-toxic leaves inside a basket
7. Sprinkle a little corn flour on leaves in basket
8. Put a layer of soy of about 3 cm into the basket and sprinkle with a little corn flour on top
9. Add another layer of soybeans and sprinkle corn flour on top until the soy is finished
10. Cover with leaves and allow to ferment for 3 days
11. Dry for some few hours to become fairly dry
12. Pound and make into balls
13. Dry and store
14. Use in seasoning soups and stews

YAAKIKALLI KASIM *(Apapransa Wasala)*

Ingredients
One margarine tin of millet flour
2 medium onions
smoked fish
¼ bottle groundnut oil
4 medium tomatoes
1 ½ margarine tins water
1 ball dawadawa

Method
1. Make gravy with all ingredients except millet flour
2. Add enough water and bring to boil
3. Stir in flour with stirring stick
4. Keep stirring till a fine paste results
5. If product is thick, add fetched gravy and stir to desired thickness

TUO ZAAFI

Ingredients
2 margarine tins millet flour
water

Method
1. Put enough water on fire and bring to boil
2. Make porridge with 1/3 total flour
3. Allow to cook for 15 minutes while stirring
4. Divide porridge into two
5. Stir in remaining flour in half of porridge on fire
6. Stir until smooth
7. Add remaining half of porridge and stir gradually until cooked and smooth
8. Dish out in serving bowls
9. Serve with ayoyo or groundnut or vegetable soup

AYOYO SOUP

Ingredients
2 bunches of ayoyo or kontumbre (cocoa yam leaves)
1 large onion
dry peppers
4 large tomatoes
1 kilo fish/meat
1 tablespoonful ground saltpeter
pinch of dawadawa
salt to taste

Method
1. Cut meat into desirable pieces
2. Add chopped onions, salt to meat and steam
3. Add water and ground tomatoes, dawadawa
4. Pick and wash ayoyo
5. Chop ayoyo into small pieces, boil with saltpeter in a little water and stir until tender
6. Reduce heat then simmer until soup is cooked 10-15 minutes
7. Serve