Coconut Palm on the Coastline of Western and Central regions of Ghana

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Abstract:

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The coconut palm (*Cocos nucifera* L.) is the most well known of the palms. It has a pantropical distribution but is largely constrained to coastal locations. The pantropical spread of the coconut palm is heavily influenced by humans. Coconut were taken on trading vessels as a source of fresh water and food supply and were planted at destinations along trade routes. At a local level coconut spread was aided by humans because of the plethora of uses for every part of the palm. The coconut palm reached West Africa, and Ghana, about 500 years ago.

The Republic of Ghana was the first sub-Saharan country independent of European rule and has enjoyed a relatively peaceful and stable state without armed conflict. The primary economic sectors of Ghana are mining, timber, agriculture, and tourism. Over 40% of the population is engaged in agriculture. Along the coast coconuts contribute a significant portion to peoples livelihoods.

Coconuts in Ghana had a modest distribution until World War I when markets stimulated the establishment of coconut plantations. In 1932 a lethal yellowing disease, locally known as Cape Saint Paul wilt disease (CSPWD), was introduced to Ghana. CSPWD has since been slowly spreading and devastating the coconut palm population. The breeding of hybrid variety coconuts to obtain resistance to CSPWD has seen some success. Use of hybrids for plantings, however, has been slow. Local people mostly find the hybrids advantageous, but say they are difficult to obtain and expensive. Future recommendations include alteration of current programs and to include more educational information for farmers.

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Chapter One: The Coconut Palm (*Cocos nucifera* L.)

Introduction

The coconut palm (*Cocos nucifera* L.) is the most well known member of the palm family (Last 2001). It is the only species recognized in the genus *Cocos* (Chan and Elevitch 2006). It is in the family Arecaceae (palm family), sub family Cocoideae, Genus *Cocos*, and species *nucifera* (Chan and Elevitch 2006). In many cultures around the world the local name for the coconut palm translates to "tree of life", "tree of heaven", or other such names bcause of the numerous uses and products derived from the coconut palm (Chan and Elevitch 2006; Last 2001; Ghana Ministry of Food and Agriculture (A) 2011; Frater 2004). *C. nucifera* is found throughout the tropics, with different varieties in different locations (Chan and Elevitch 2006; Ghana Ministry of Food and Agriculture (B) 2011; Gunn et al. 2011; Noel et al. 2007; Quaicoe et al. 2009). In the southern parts of Ghana, coconut palms of the 'West African Tall' variety (Quaicoe et al. 2009) are common (Ghana Ministry of Food and Agriculture (A and B) 2011; Noel 2007; Quaicoe 2009; Okorley and Haizel 2004). Here, I will discuss coconut palm morphology, the country Ghana, the role of coconuts in Ghana, and uses of the coconut palm (Appendix 1).

Description

Coconut palm varieties

The two main classifications of varieties are the 'Tall' and the 'Dwarf'. 'Tall' varieties, the more common to the two, are named mostly for their geographical location and sometimes the morphology of the fruit. The fruit of the coconut is spherical to oblong in shape, at least 850 g (1.9 lbs), and occur in bunches on the palm. 'Dwarf' varieties are also named for their location

and the color of the immature fruit. The ‘Dwarf” variety, generally, are shorter in stature, have a thinner stem, fruit earlier, and have smaller fruits than the ‘tall’ varieties (Chan and Elevitch 2006). The descriptions listed below encompass both varieties.

Fronds

The crown of the coconut palm consists of its fronds, flowers, and fruits, and is usually between 8-9 m (26-30ft) in diameter with fronds evenly distributed around the stem. Fronds of the coconut palm are pinnate, with a primary rachis. The rachis has 200-250 lanceolate leaflets on each of the two horizontal planes. Leaflets on either side of the rachis grow in the same orientation to the rachis. The leaflets on the fronds of a coconut palm younger than one year of age do not separate. Leaflets are 1.5-5 cm (.6-2 in) wide, 50-150 cm (20-60 in) long, and have a rigid central vein. The petiole, leaflet-less area at the base of the frond, is about a quarter of the frond length. The petiole continues to widen from the rachis to the base providing a secure, broad attachment to the stem of the palm. Individual fronds emerge one at a time from the growing tip of the palm, initially growing straight up, and reaching a length of 4.5-5.5 m (15-18 ft). As a frond ages, it tips to one side of the palm, gradually dropping farther from its vertical starting point, and eventually hangs vertically, assuming the frond does not fall off first. Depending on the variety, fronds are usually green to bronze in color, fading to yellow and then brown as they age and drop off. When a frond detaches from the stem, it leaves a smooth surface. A frond is retained for 2.5 years. A healthy palm produces 12-22 fronds each year and retains 30-45 fronds on the palm at a time (Chan and Elevitch 2006).

Flowers

A coconut palm takes 3-7 years to flower (Chan and Elevitch 2006; Last 2001; Melendez-Ramirez et al. 2004; Okorley and Haizel 2004), but some varieties, usually 'Dwarfs', fruit as fast as 3 years (Chan and Elevitch 2006; Melendez-Ramirez et al. 2004; Okorley and Haizel 2004). In ideal conditions, a healthy palm produces a new inflorescence, or spadix, with each new frond. A healthy palm is capable of producing 40-60 coconuts per spadix; the average is 50-80 coconuts per year (Chan and Elevitch 2006; Last 2001; Okorley and Haizel 2004). The spadix develops in a woody sheath that splits open and peals back when the spadix is mature. There are 40-60 spikelets on the spadix, with 0-3 female flowers at the base, and several hundred male flowers above the female flowers. Only one female flower develops into a mature fruit (Chan and Elevitch 2006). The male and female flowers mature at different times, encouraging cross pollination; however, self-pollination is possible (Chan and Elevitch 2006) and does not cause problems (Last 2001). Pollination is accomplished by wind and insects; the latter is more important (Melendez-Ramirez et al. 2004). Conditions for spadix development occur years before it emerges, and adverse growth conditions will show in the mature spadix 1-2.5 years later (Chan and Elevitch 2006; Last 2001).

Coconut

The coconut palm name was derived from the description of its fruit by early Spanish explorers. The three indentations, or "eyes", of the hairy coconut resembled a "monkey face", coco, and nucifera referred to the "nut-bearing" property of the palm (Ghana Ministry of Food and Agriculture (A) 2011). The coconut consists of a thin hard skin (*exocarp*) covering a thick fibrous layer known as the husk (*mesocarp*) attached to the outside of a hard shell (*endocarp*).

Inside the shell is a white kernel (*endosperm* when immature, *copra* when mature). The kernel surrounds a vacuole that is filled with water when immature, but the water is replaced by an empty space as the fruit ages (Chan and Elevitch 2006; Last 2001; Okorley and Haizel 2004; Rachel et al. 2010). This empty space is crucial to the coconut's ability to be dispersed by the ocean; the empty vacuole helps the nut to float (Last 2001).

The coconut size, shape, husk thickness, and color of a coconut depend on the variety (Last 2001). A coconut can be light or heavy, 850-3700 g (1.9-8.1 lbs), and can be elongated or spherical (Chan and Elevitch 2006). Figure 1 shows the variation of coconuts. The coconut water is nutrient rich, almost perfectly isotonic, and aseptic enough to be used as an IV fluid (Frater 2004; Ghana Ministry of Food and Agriculture (A) 2011). The kernel of the coconut, known for its high-oil content, is rich in saturated fatty acids (Frater 2004; Last 2001; Ghana Ministry of Food and Agriculture (A) 2011). Saturated fatty acids are normally considered non-nutritious; however, evidence points to the contrary for fatty acids derived from the coconut (Rachel et al. 2010). In fact, coconut oil is traditionally used medicinally for many illnesses. Some Pacific Islanders view coconut oil as the cure for all illness (Ghana Ministry of Food and Agriculture (A) 2011). The amount and quality of oil in the kernel, however, varies among the variety and age of the coconut (Rachel 2010).

Figure 1: Morphological differences between coconut fruiting body types (Bourdeix et al., 2005).

Figure 2: Severely damaged coconut stem. Location: Sanzule, Western Region, Ghana, West Africa. (photo taken by Ben Ross Caulum)

Stem

Capable of obtaining heights of 40 meters (130 ft), the stem's primary purpose is to keep the palm in the light (Chan and Elevitch 2006; Last 2001). The coconut palm is a monocotyledonous plant; it does not have thickening circumferential rings or secondary thickening. Instead, the coconut palm reaches maximum diameter early in life and maintains an almost uniform size stem with efficient vascular bundles scattered evenly throughout the stem, giving it a homogeneous cross section. This makes the stem strong yet flexible and capable of sustaining massive amounts of damage while maintaining its function and sustaining the palm (Last 2001). An example of this is shown in Figure 2, where a coconut stem was reduced to

approximately one third its diameter, had a partially broken trunk early in its life, but has continued growing a healthy crown.

Roots

There is no tap root for the coconut palm, but rather a fibrous network of adventitious roots (Chan and Elevitch 2006; Last 2001; Meerow and Broschat 1993). The individual roots are approximately 1 cm (0.39in) in diameter, spreading mostly horizontally from the stem base. The majority of the roots are in the top 1.5 m (5ft) of the soil but can reach depths of 5 m (16 ft). The roots grow laterally about 6 m (20 ft) from the stem, but can reach as far as 30 m (100 ft) in ideal conditions (Chan and Elevitch 2006). The roots usually do not branch (Chan and Elevitch 2006) but when cut, branched 50 percent of the time, regardless of the length of the remaining root (Meerow and Broschat 1993). The adventitious nature of the roots is evidence of evolution in stormy regions. Broken roots are quickly replaced. A leaning palm that was not completely uprooted can grow new roots and recover within a year (Last 2001). This characteristic of palms, in general, makes it possible to transplant palms, regardless of size or age. Digging around the palm the appropriate distance from the stem, leaves a root ball of sufficient size attached to the palm. This allows the palm to survive and establish a new rooting system after it has been transplanted (Meerow and Broschat 1993). Figure 3 shows an exposed root ball by the ocean and the resulting lean of the coconut palms.

Figure 3: Exposed root ball and resulting lean of the coconut palm. Location: Near Butre, Western Region, Ghana, West Africa. (photo taken by Ben Ross Caulum)

Environmental Requirements

Coconut palms have the best competitive advantage on sandy shorelines. Their ability to grow in infertile and saline soil, tolerate short inundations of the roots in salt water, and thrive in a wide range of pH environment gives coconut palms this advantage. Coconut palms are naturally found on course sandy soil, but their ideal growth medium is well-drained fertile loam or clay soils. Tolerable pH ranges from 4.5-8 but the ideal range is 5.5-7. The well-drained soil is necessary because of the high-level of required precipitation. The level of precipitation required is not less than 1000 mm (40 in), but preferably 1500-2500 mm (60-100 in). Ideally, the precipitation is evenly distributed throughout the year (Chan and Elevitch 2006; Last 2001). A supply of ground water by seepage from upslope or a reachable water table could mitigate a lack of rainfall (Last 2001). Inadequate water supply is not well-tolerated and results in faster dropping of fronds, death of emerging fronds, premature fruit drop, and poor fruit crop in later years (Chan and Elevitch 2006; Last 2001; Prado et al. 2001). Poorly draining soils receiving the sufficient rain quantities could become water-logged; two weeks of water-logged soil kills

coconut palms (Chan and Elevitch 2006). Along with high precipitation requirements, coconut palms also require plentiful sunlight and a humid environment; 60 percent humidity is optimal (Chan and Elevitch 2006). Coconuts can grow in shade but nut production is adversely affected (Chan and Elevitch 2006; Last 2001). Temperature requirements of the coconut palm are as follows: mean annual between 21-30 °C (70-86 °F), mean max of hottest month 28-37 °C (81-99 °F), mean minimum of coldest month 4-12 °C (39-54 °F), and coldest tolerated temperature of 0 °C (32 °F) (Chan and Elevitch 2006; Last 2001). Freezing will kill seedlings and young palms and prolonged exposure will kill older palms (Chan and Elevitch 2006). Coconuts grow in elevations ranging between 0-600 m (0-1970 ft); however, 600 m is only obtainable near the equator. The optimal latitudinal range is approximately 23° north and south of the equator and is pantropical. Coconuts can only be found on the coast at sea level at the north and south extremes of this range. Although coconut groves can be found outside of the tropics, in near sub-tropic regions, they are rare (Chan and Elevitch 2006; Last 2001).

Origins, Natural Distribution, and Global Dispersal

Coconut distribution is pantropical and its range is delineated by coastlines and the Tropic of Cancer and Tropic of Capricorn. The origins of the coconut palm, based on genetic analysis and origination of 'Dwarf' cultivars, are in Southeast Asia and the islands around the seas surrounding Indonesia and Malaysia (Chan and Elevitch 2006; Gunn et al. 2011; Last 2001; Perera et al. 2003). From its origin, it naturally spread west to the east coast of Africa and east among the tropical islands of the Pacific (Last 2001). The coconut would not have reached the west coast of Africa without human aid because of its inability to survive the duration of travel and southern climactic conditions that fall outside the coconut temperature tolerance. In addition,

the coconut would not be able to compete in a trans-continental spread. Humans aided the spread of the coconut from West Africa to the Caribbean (Gunn et al. 2011; Last 2001). Initial introduction of the coconut to Panama was most likely accomplished by pre-Columbian Austronesian seafarers. Europeans introduced different varieties later (Gunn et al 2011). The eastward expansion was aided by humans bringing other varieties from the west coast of the New World to the Caribbean side of the continent (Gunn et al. 2011; Last 2001). Thus, completing the coconut's pan tropic expansion.

Human aid in the distribution of the coconut may or may not have been an intentional act (Last 2001). Early Polynesians would have used the coconut as a source of fresh water or food (Chan and Elevitch 2006; Gunn et al. 2011; Last 2001). An immature coconut can contain as much as two liters of water and keep fresh for a few days. The mature nuts may contain as much as 700 ml of water and has an edible kernel inside. If the mature nut sprouted into a seedling, the kernel inside would still be edible, or if it was a surplus at the end of the journey, it could be planted at the destination (Last 2001). Eurasians followed in suit years later, approximately 500 years ago (Last 2001). It was European trade vessels carrying coconuts for supplies that completed the coconut's spread around the world. First, Europeans introduced coconuts to West Africa, then from West Africa to the Caribbean and the rest of the Atlantic American tropics. Figure 4 displays a map from Last (2001), delineating the area of origin and natural distribution and global range. This map is super-imposed on a map from Gunn et al. (2011) showing the coconut varieties in different locations and the different trade routes that influenced the spread.

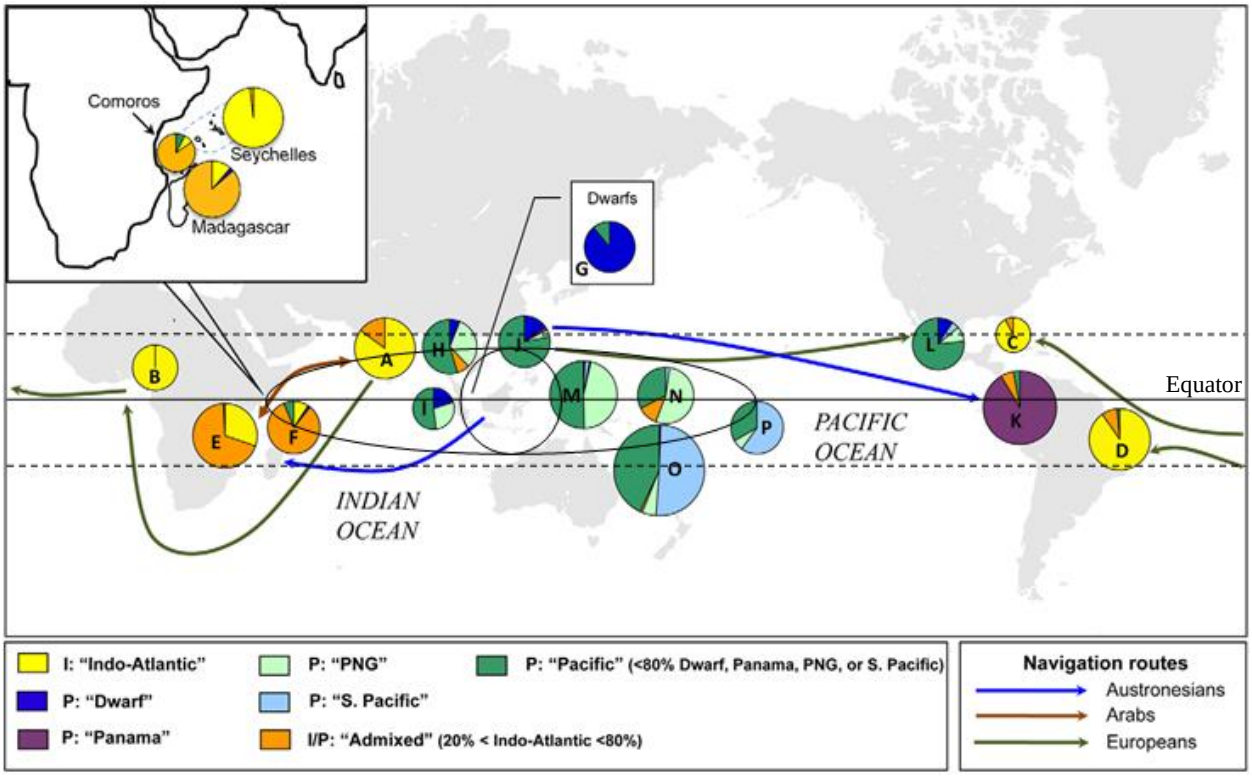

Figure 4: Distribution and spread pattern by trade routes of coconut. The circle represents the origin, location of domestication, of coconut palms. The ellipse is the natural distribution, and the current distribution is delineated by the parallel lines aproximating the Tropic of Cancer, in the north, and Tropic of Capricorn, in the south (Last 2001). The pie charts represent the varieties present at the locations with the arrows showing how trade routes influenced coconut spread (Gunn et al. 2011).

Coconuts in Ghana

With its pantropical distribution coconuts have become integrated into many cultures around the world. Before discussing the role of coconuts in any location first the location itself must be examined. The next chapter will delve into the country of Ghana, followed by chapter three examining the history of coconuts in Ghana and cultures there that the coconut is a part of.

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Chapter Two: Ghana

Overview

The Republic of Ghana, commonly known as Ghana or "The Gold Coast", is an English speaking democratic nation located in West Africa. Ghana gained independence from British rule in 1957, making it the first sub-Saharan country independent of European rule. After independence, a parliamentary government was in place, followed by alternating military and civilian governments until 1993 when the Fourth Republic came to power. The constitution of 1992, implemented by the Fourth Republic, divided powers among President, Parliament, Cabinet, Council of State, and Judiciary and made it so the government is selected by a general election. Despite the changes in types of government, Ghana has enjoyed a relatively peaceful and stable state without armed conflicts since independence (Berry 1995).

Accra, the capital city of Ghana, is located in the south of the country on the coast, at 5° 33' 15" N, 0° 11' 30" W. Ghana borders Cote d'Ivoire to the west, Burkina Faso to the north and northwest, and Togo to the east (US Department of State Geographer 2012). Total land area of Ghana is about 238,533 km^2 (92,100 mi^2), roughly the size of Oregon, and is divided into ten regions: Western, Central, Greater Accra, Volta, Eastern, Ashanti, Brong-Ahafo, Northern, North Western, and North Eastern, shown in Figure 5 (Berry 1995).

Ghana's primary economic sectors are mining, timber, agriculture, and tourism (Americas Forum on Trade and Sustainable Development 2006; Konadu-Agyemang and Adanu 2003; Osei-Bonsu et al. 2002). Oil does not currently play a major role in Ghana's economy; however, oil has been discovered in the territory and will be extracted. Oil has the potential to become a primary contributor to Ghana's economy (Van Gyampo 2011). Mining sector outputs are mostly gold, but manganese, bauxite, and diamonds also contribute (AFTSD 2006; Berry

1995; Environmental Protection Agency 2011; Hilson and Banchirigah 2009). High value timber species have been exported in large quantities; however, the overall sector is starting to experience problems with general deforestation and the decreasing numbers of high value species due to overharvest (AFTSD 2006, Attah et al. 2010; Berry 1995; Cashore et al. 2006; Environmental Protection Agency 2011; Konadu-Agyemang and Adanu 2003). The influence of the agricultural sector comes mostly from cocoa export. Coconut export used to contribute significantly before its downfall from the Cape Saint Paul Wilt Disease (AFTSD 2006; Berry 1995; Environmental Protection Agency 2011; Konadu-Agyemang and Adanu 2003; Osei-Bonsu et al. 2002; Quaicoe et al. 2009). Ghana's tourist industry is almost exclusively ecotourism, with some cultural tourism centered on the slave trade. Main attractions include Lake Volta, Lake Bosomtwe, Mole National Park, Wechaiu Hippo Sanctuary, Kakum National Park, Nzulezo Stilt village, Cape Coast and Elmina slave castles (AFTSD 2006; Berry 1995; Environmental Protection Agency 2011).

Ghana has six main ecological zones: rain forest, deciduous and semi-deciduous forest, forest-savannah transition, guinea savannah, Sudan savannah, and coastal savannah (AFTSD 2006, Environmental Protection Agency 2011). The rainforest is in the southwest corner of Ghana, coastal savannah is in the southeast to south-central, and the deciduous and semi-deciduous forest is on the southwest to south-central coast and north of the rainforest and coastal savannah. As shown in Figure 6, the Transition zone, Guinea Savannah and Sudan Savannah, are present in territories across the country progressing north (Environmental Protection Agency 2011).

Figure 5: Map of Ghana depicting bordering countries, the ten regions, and regional capitals (Berry 1995).

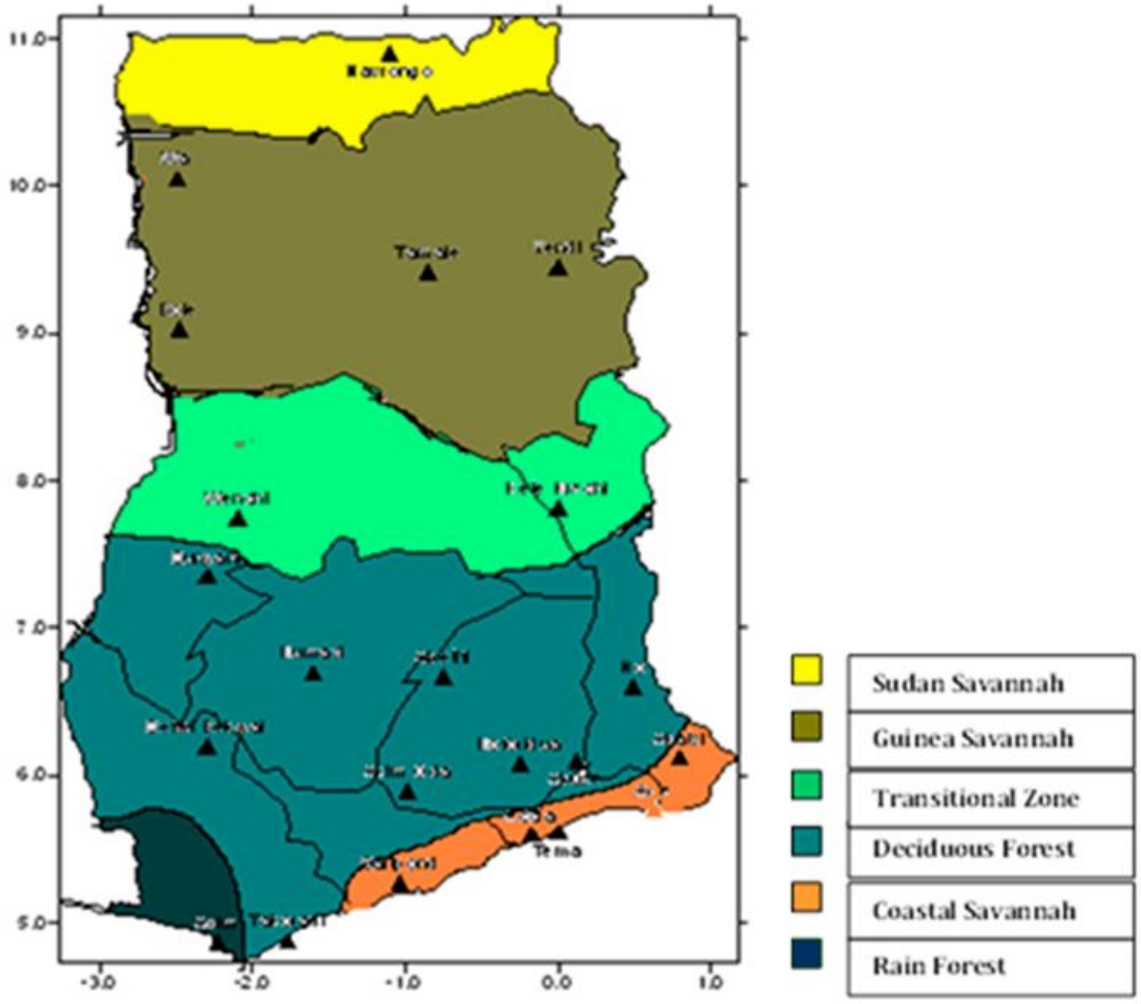

Figure 6: Six main ecological zones of Ghana. Triangles represent locations that climate change scenarios were developed (Environmental Protection Agency 2011).

Demographics

Population size and density

Ghana had a population of 24,658,823 according to the 2010 census (2012). The region with the highest population was Ashanti (4,780,280; 19.4 percent), followed by Greater Accra (4,010,054; 16.3 percent). The least populated areas were the Upper-West (population 702,110; 2.8 percent) and Upper-East territories (population 1,046,545; 4.2 percent) (Appendix 2:

Additional Tables and Figures). The population growth, from the previous decade, was 30.4 percent, with the largest growth rate, of 3.1 percent, in the Central and Greater Accra regions. This puts the population density of Ghana at 103 persons per square kilometer. Greater Accra was the most densely populated at 1,236 people per square kilometer, followed by Central Region at 224 people per square kilometer. The most sparsely populated region was Northern Ghana with 35 people per square kilometer. A count of 5,467,136 households in Ghana makes the average household size 4.4 persons. (Ghana Statistical Survey 2012)

Sex, Age, and Urban vs. Rural

In Ghana the male:female ratio in Ghana was approximately 95.2:100 in 2010, showing a slight decrease in the male population from 97.9:100 in 2000. Of the population of people 12+ years of age, 42.9% of the population was married. A graph of age distribution in Ghana resembles an inverse function graph, highly skewed towards the youngest populations (Appendix 2: Additional Tables and Figures). This shape is affected by high fertility rate and elongating life expectancy (Ghana Statistical Survey 2012). The current life expectancy is 58 years (Environmental Protection Agency 2011). Populations are also shifting towards more urban areas in Ghana. In 2000, the urban population constituted 43.8 percent. Now 50.9 percent of the population live in urban settings. Greater Accra region leads this statistic with 90.5 percent of the region's population living in urban settings. The Upper-West region, with 16.3 percent, represents the lowest percentage of urban population (Appendix 2: Additional Tables and Figures) (Ghana Statistical Services 2012).

Ethnicity, Religion, Literacy and Education

The four largest ethnic groups in Ghana are Akan (47.5 percent), Mole Dagbani (16.6 percent), Ewe (13.9 percent), and Ga-Dangme (7.4 percent). Religions affiliations include various Christian faiths (71.25 percent), Islam (17.6 percent), traditional religion (5.2 percent), other religions (.08 percent), and no religious affiliation (5.3 percent). The majority of Ghanaians (74.1 percent) are literate in a language. Approximately 67.1 percent of the population is able to read and write English, while 53.7 percent of the population is able to read and write in at least one Ghanaian language. About 76.6 percent of the population has attended school; 39.5 percent of the educated population is currently attending school. Of those who have schooling, 53.7 percent have completed primary or junior high school, while only 12.1 percent have graduated high school (Ghana Statistical Services 2012).

Occupation Sectors and Agriculture

Of the total population, 15 years or older, 71.5 percent are economically active: employed or looking for employment. Of the four largest occupations for persons 15+ years, agriculture, forestry, and fishery workers make up the largest demographic (41.3 percent), followed by service and sales workers (21.2 percent), crafts and trades (15.2 percent) and elementary occupations (6.0 percent). Elementary occupations are those that require the use of some kind of hand tool and some physical effort, for example, shoe shiner or street washer of car windows (International Labor Organization 2004). Of all households in Ghana, 45.8 percent have an economically active individual engaged in agriculture, forestry or fishery. Most agriculture is crop farming (95.1 percent), followed by livestock rearing (40.5 percent), tree growing (1.1 percent), and fish farming (0.2 percent) (Ghana Statistical Services 2012).

Western and Central Regions Demographics

Population Size and Density

The land area of the Western and Central regions are 23,921 and 9,826 square kilometers, respectively. Population sizes are 2,376,021 and 2,201,863 respectively translating to population densities at 99.3 people per square kilometer in the Western region, and 224.1 people per square kilometer in the Central region. From 2000-2010, population growth rate in the Western region was approximately 2.0 percent, the third lowest rate experienced of the ten regions. The Central and Greater Accra region's growth rate was 3.1 percent during this time period—the largest growth rates in the country. Housing count in the Western and Central regions were 553,635 and 526,764, respectively. The average household sizes were 4.2 and 4.0 persons per household, respectively (Ghana Statistical Services 2012).

Sex, Age, and Urban vs. Rural

In the Western region, the male:female ratio is almost equal, 99.98:100; the Central region ratio is closer to the national average at 95.38:100. Marriage rate in the Western region is 40.99 percent and Central region is 40.87 percent. Both percentages are slightly below the national average. The age distribution in both Western and Central regions follow a similar inverse function-like graph as the nation's age distribution. The amount of people living in urban environments of the Western (42.4 percent) and Central (47.1 percent) are slightly below the national average, but much closer to the average than the extremes—Greater Accra (90.5 percent) and Upper West (16.3 percent) (Ghana Statistical Services 2012).

Ethnicity, Religion, Literacy, and Education

Western and Central both have a large Akan population, 78.2 percent and 81.7 percent respectively. The Western region's next three largest ethnic groups are Mole-Dagbani (8.6 percent), Ewe (6.2 percent), and Ga-Dangme (3.1 percent). The Central region has a different mix of dominant ethnicities; the three largest are: Ewe (6.2 percent), Guan (5.3 percent), and Ga-Dangme (2.5 percent). Religions in the Western and Central regions are predominately Christian and similar to the national averages: Christianity (82.2 percent and 83.2 percent, respectively), Islam (9.4 percent; 8.7 percent), traditional religion (0.8 percent; 0.6 percent), other religion (1 percent; 0.9 percent), and no religious affiliation (6.7 percent; 6.6 percent). The number of literate people in the Western (76.4 percent) and Central (78.2 percent) regions is higher than the national average. English literates constitute 70.9 percent of Western population and 71.9 percent of Central populations. Ghanaian language literates constitute 52.3 percent of the Western region and 55.2 percent of the Central region. School attendance in the Western and Central regions is higher than the national average: 79.3 percent (41 percent currently attending), and 80.9 percent (43.1 percent currently attending), respectively. Of the populations, 45.7 percent and 47.7 percent claim only primary or junior high as highest level completed, while 7.7 percent and 7.1 percent have completed high school (Ghana Statistical Services 2012).

Occupation Sectors and Agriculture

Approximately 70.4 percent of the Western region population age 15+ are economically active, while 70 percent of the Central region population age 15+ are economically active. The three largest employment sectors in nation are the same in both Western and Central regions: agriculture (46.8 percent and 42 percent, respectively), service and sales workers (17.3 percent;

20.5 percent), and crafts and trades (13.2 percent; 17.2 percent). Elementary occupations which constitute 5.3 percent in Western and 5.4 percent in Central, are surpassed in the Western region by plant and machine operators and assemblers (7.4 percent) and professionals (5.5 percent) in the Central region. Crop farming, livestock rearing, tree growing, and fish farming, in Western region are 96.2 percent, 29.2 percent, 0.5 percent, and 0.4 percent, respectively, and in Central region are 94.1 percent, 34.9 percent, 1.7 percent, and 0.2 percent, respectively (Ghana Statistical Services 2012).

Forestry, Agriculture and Poverty

Ghana, like many developing countries, has a history of deforestation and still struggles to sustain forest territories (Codjoe and Dzanku 2009; Kufuor 2004; Hill and Curran 2003). In the early 1900s, Ghana's forests coved 8.2 million hectares of land. This number has been reduced to 1.6 million hectares (Kufuor 2004). Policies like the Timber Resource Management Act and establishment of reserves have been enacted to stop or reverse deforestation. These policies have had various effects, mostly minimal or none, especially in areas where locals were not supportive (Codjoe and Dzanku 2009; Danielsen et al. 2008; Kufuor 2004; Rudel et al. 2009). Pressure on forests come from agriculture, logging, wood harvesting for fuel wood, animal husbandry, and urban expansion (Aabeyir et al. 2011; Attua and Fisher 2011; Campbell (B) 2009, 2005; Codjoe and Dzaknu 2009; Danielsen et al. 2008; Kufuor 2004;. Rudel et al. 2009; Norris et al. 2010).

One attempt at controlling deforestation includes requiring forest certifications to increase the standard of what constitutes a well-managed forests. However, proving a forest is well-managed is difficult for small level operations, and small landholders are common in Ghana

(Cashore et al. 2006; Environmental Protection Agency 2011). The need for a chain of custody is also a hindrance. Without a chain of custody to provide proof of timber origin, the timber cannot be certified as sustainable, and company awareness of this issue is minimal (Attah et al. 2010). Forest certification, however, does not adequately address the issue of deforestation because any timber that is certified is sold abroad, but everything else, certified or non-certified, legal harvest or illegal harvest, can be sold on local markets.

Another attempt at reducing deforestation is the establishment of reserves or protected areas. These reserves can aim at conserving biodiversity, a unique landscape feature, and specific species (Thompson et al. 2011; Ntiamoa-Baidu 2008). These reserves can benefit local people in many ways: increased rates of pollination of crops, more abundant natural pest control, greater yields, and healthier agricultural and argoforestry systems (Thompson et al. 2011). The reserves, however, will not be successful unless local people realize these benefits (Thompson et al. 2011; Ntiamoa-Baidu 2008). For this reason, Abrams et al. (2009) illuminates the need for integrating policy of a top-down approach with a grass roots approach. Examples of such approaches and suggestions ensure such successes. Ntiamoa-Baidu (2008), Barre et al. (2009), Campbell (A) (2005), and Awuah-Nyamekye (2009) all delve into traditional sacred groves, taboos, religious, and cultural perspectives about conservation. Some of which have had a successful integration between tradition view and policy for conservation (Ntiamoa-Baidu 2008), while others give examples where the two may be misaligned (Campbell (A) 2005).

Agriculture could arguably be the biggest pressure on forests, especially in the short-term (Codjoe and Dzanku 2009). Growing populations necessitating more food, desertification of current agriculture lands, and an impoverished populations contribute to the destruction of forest land for agriculture (Agbeja et al. 2011; Phalan et al. 2011; Codjoe and Dzanku 2009). The

agricultural crop exerting the largest pressure in Southern and Southwestern Ghana is cocoa (Asase et al. 2009; Osei-Bonsu et al. 2002). Cocoa is one of Ghana's largest export cash crops (Asase et al. 2009; AFTSD 2006; Berry 1995; Environmental Protection Agency 2011; Konadu-Agyemang and Adanu 2003; Osei-Bonsu et al. 2002). It grows best in areas normally identified as biodiversity hotspots (Asase et al. 2009). Attempts such as improving agricultural practices, agro-forestry practices, and farming within already forested areas are used to reduce the pressure exerted by agriculture. Locals are starting to grow cocoa under existing canopy or intercrop the plant with various tree species (Asase et al. 2009; Osei-Bonsu et al. 2002), like the coconut palm (Osei-Bonsu et al. 2002).

Poverty rates in Ghana are high (Ghana Statistical Services 2008) and with 45.8 percent of Ghana already engaged in agriculture (Ghana Statistical Services 2012) the knowledge necessary for a person to clear land and start a farm is accessible. In some cases, this would be preferable over other work where the hours and pay are not enough to sustain a family (Bardasi and Wodon 2010). An example from Cape Coast is the stone chip industry, where long hours of work, in bad conditions are compounded by the family responsibilities, and an uncertainty in the market (Lund et al. 2008). Cape Coast, however, is trying to find other ways out of poverty, such as using its past history to attract tourism (Agyei-Mensah 2006). Other locations, without this option, are turning to new industries, or revamping and reviving old industries (Fielmua and Bandie 2011).

Coastal geography and climate of Western and Central regions

The coastal geography of the Western and Central regions alternates between (1) sandy beaches, up to 30 meters (100 feet) wide, with villages, town, cities; vegetation for agriculture,

forested, or mashes; or (2) rocky beaches with the similar adjacent land uses. Land beyond the rocky beaches tend to have steper and higher hills, rising up to 30 meters (100 feet) above sea level, while land-rise behind sandy beaches is more gradual (US Department of State Geographer 2012). The coast west of Axim, starting at Kikam, is only sandy beach. From Kikam to the Western and Central region border, the coast is rocky, composed of short stretches of sandy beach separated by rocky beaches or points. East of the Western and Central region border, the stretches of sandy beaches become longer, but are still interrupted by rocky beaches or points (US Department of State Geographer 2012). Along the coast, river mouths appear at fairly regular intervals as a result of the runoff of the high levels of precipitation (Asian-Pacific Network on Integrated Plant Nutrient Management 2004). Figure 7 is map of Southern Ghana, delineating watersheds and major rivers.

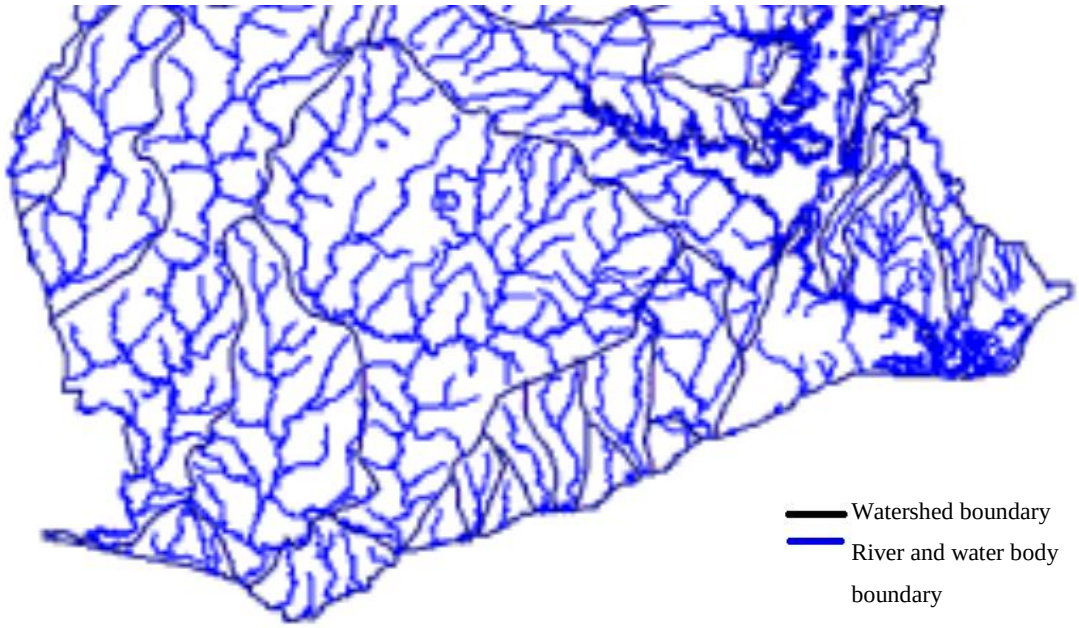

Figure 7: Southern Ghana river, water-body, and watershed boundary (Asian-Pacific Network on Integrated Plant Nutrient Management 2004).

Rainfall in Ghana is highest in the Southwest region. This region receives up to 2200 mm (87 in) of annual rain fall, with decreasing amounts progressing north and north east (Asian-Pacific Network on Integrated Plant Nutrient Management 2004). Figure 8 is a map of rainfall patterns in Ghana. Following the rainfall pattern is also a shift in ecological zones: (1) from rainforests west of Cape Three Points, (2) to deciduous forest, from Cape Three Points to the boarder of Western and Central regions, and (3) from coastal savannah to east of the Western and Central region border (Environmental Protection Agency 2011). Annual temperature along the Ghanaian coast, from the east border of Central region to the west border, is homogeneous with an average annual temperature between 26-27 °C (79-81 °F) (Asian-Pacific Network on Integrated Plant Nutrient Management 2004).

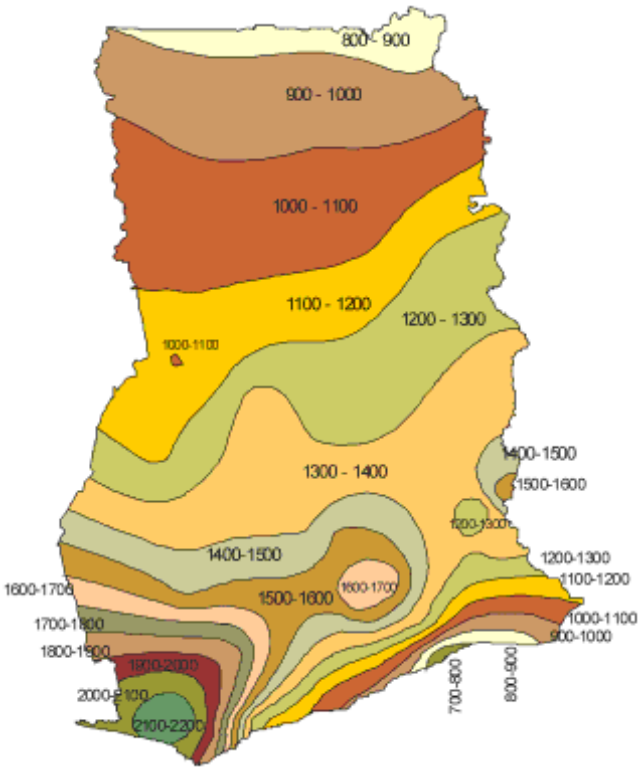

Figure 8: Annual precipitation (mm) in Ghana (Asian-Pacific Network on Integrated Plant Nutrient Management 2004).

Coastal and Climate Change

Climate change will have a variety of effects on the coast of Ghana. The predicted rise in temperature will not adversely affect the coconut palms, as the rise is still within the normal range for coconut palms (Chan and Elevitch 2006; Forbes 2008; Last 2001). A shift in rain pattern, especially in the coastal savannah of the Central region, could have an adverse effect if the amount of precipitation dropped below 1000 mm (40 in) a year, the amount the coconut needs without supplementary water sources (Chan and Elevitch 2006; Environmental Protection Agency 2011; Last 2001). Over the last decade, farmers have noted increasing temperatures and shifts in rain patterns (Kemausuor et al. 2011). Currently, the combination of shoreline recession and sea level rise poses one of the largest problems. The Ghanaian shoreline is in a state of flux. The coast is slowly receding as it is washed away by the waves, especially during violent storms or extreme high tides. The current rate of erosion is 1.13m/yr (Addo et al. 2008). The photos in Figure 3 show how the changes in land level on the coast and the areas protected by vegetation have been able to slow the erosion process. The drop in land elevation where the vegetation is not present is clearly visible. A rise in sea level would speed up the process, enabling the sea to reach progressively farther inland during high tides and violent storms (Addo et al. 2008; Addo et al. 2011; Boateng 2012).

Conclusion

The "Gold Coast" is the closest country to 0° N 0° W, and has a diverse range of ecological zone that gradually shift from north to south through the country. The ethnicities of Ghana also change with a latitudinal shift; however, the coast has a large majority of the Akan ethnicity. The majority of the population in Ghana is Christian. Most Muslims inhabit the

northern regions. The population of Ghana is shifting towards a more urban population. The country has currently passed the 50 percent mark of the population living in urban settings. Deforestation is a problem in Ghana; with pressure coming from logging, agriculture and housing, and the general high level of poverty. The coastline is in a constant state of flux due to land eroding into the sea every year. Climate change and a rise in sea level contribute to an increased rate of erosion.

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Chapter Three: Coconuts in Ghana

Distribution

Environmental conditions in Ghana are highly conducive to the growth of coconut palms. Coconuts can be found along the entire coast, though they are less common in the driest parts of the coastal savannah. If the coconuts had been left to spread on their own, the coast would be the only place they would be found. But humans have aided the dispersal so much that coconuts can be found at any location that meets the silvicultural requirements in Ghana (Anyane 1963). In Ghana, this has effectually extended the range of coconuts north to approximately 8° N latitude, with a thinning gradient of the density of the coconuts as you move north in the distribution. The Western region has climatic conditions best suited to the coconut; thus, groves can be found throughout the region. The density of coconut decreases moving north and east. At the extremes of the range, only solitary coconut palms are found—perhaps one per village (Anyane 1963; Campbell 2006; Ghana Ministry of Food and Agriculture (A) 2011).

History: until 1950

The introduction of the coconut palm to Ghana occurred about 500 years ago, within 50 years of 1499, when the Portuguese brought the coconut to the Atlantic coast of Africa (Last 2001). The coconut palm was important along the coastal region due to the contribution to trade routes, but was not immediately of commercial importance. After World War I, however, large communal coconut plantations were established along the coast, in Ghana, with stimulation for the markets coming from by both African and European interests (Anyane 1963). By the end of 1936, there were at least 5,693.4 hectares (14,076 acres) of coconut plantations located in southern Volta as well as the Eastern, Central, and Western regions, totaling over 1.3 million

individual coconut palms. In the 1940's, there was a substantial reduction in export because the Cape Saint Paul Wilt Disease (CSPWD) was causing a significant number of deaths in the southern Volta region (Anyane 1963). After World War II, the demand and increased price for coconut stimulated more plantings of coconut palms, especially in the Western region (Anyane 1963), where the CSPWD was not yet present (Danyo 2011). In 1950, the Agricultural Produce Marketing Board assumed responsibility for overseas marketing of coconut copra, the mature kernel, and consequently played an important role in the expansion of the industry (Anyane 1963).

Cape Saint Paul Wilt Disease

Cape Saint Paul Wilt Disease (CSPWD) is one of the global Lethal Yellowing Type Diseases (LYTD) specific to West Africa (Mpunami et al. 1999). LYTD are associated with the phytoplasma, phloem-restricted mollicutes, of the coconut that is spread primarily through insect vectors. It is also spread via vegetative propagation (Nipah et al. 2007). LYTD are characterized by an initial incubation stage where it is not observable, followed by browning then yellowing of fronds that then drop off, and premature fruit drop and dropping of inflorescence. Eventually, the entire crown will fall off, leaving the trunk with a power pole appearance (Dery et al. 2008; Danyo 2011; Mpunami et al. 1999; Nipah et al. 2007; Nkansah-Poku et al. 2009; Noel et al. 2007; Quaicoe et al. 2009). Figure 9 shows photos of a grove of coconuts that have CSPWD outside the village of Sanzule, Western region.

CSPWD first appeared in Ghana in 1932 at Cape Saint Paul in the Volta region. This is also where the name for the disease was derived. The spread was slow but devastating, mostly destroying the coconut industry in the Volta region by 1950 (Anyane 1963; Danyo 2011;

Quaicoe et al. 2009). Many plantations sustained a 100 percent mortality of coconut palms as the disease spread (Danyo 2011). In 1964, CSPWD was found at Cape Three Points, in the Western region, and after approximately 5 years, it began spreading quickly east and north, with a much slower westward expansion (Danyo 2011; Nkansah-Poku et al. 2009). CSPWD reached the middle of the central region by 1983. Beginning in 2008, there were reports of the disease reaching the Eastern Region (Danyo 2011).

Figure 9: Grove of coconut palms with CSPWD mortality leaving power pole appearance and a single palm with advanced CSPWD symptoms. Location: outside of Sanzule, Western Region, Ghana, West Africa. (photo taken by Ben Ross Caulum)

Danyo (2011) estimated that 4.2 percent of the population, or 1.01 million Ghanaians, depend on the coconut as their source of income. The value lost to CSPWD was calculated based on the price of a single coconut estimated to have an income value of GHC 0.30 (0.30 Ghana cedi, or 30 pesewa; with the December 2010 exchange rate at GHC 1.4: USD 1). This estimate also assumes 48 coconuts per palm per year and 160 palms per hectare. With these numbers, Danyo (2011) calculated the income from coconuts per year to be GHC 2,304.00 per hectare of coconut palms. If there are approximately 462,000 coconut farmers cultivating one hectare of coconut palms, a 50 percent loss of the palms would result in lost annual incomes

totaling GHC 532,224,000. This estimate is only from the coconut fruit. This does not include loss of income from supplementary items that come from other possible uses of the living coconut palm (Appendix 1: Uses of the Coconut Palm from Central and Western regions of Ghana).

Over the years, the Ghanaian Department of Agriculture, along with others, have tried to develop methods to deal with CSPWD. There is no cure, the exact vectors of spread are not all known, and resistance is still minimal. Currently, resistant varieties and hybrids are showing the most promise for combating CSPWD (Dery et al. 2008; Danyo 2011; Nipah et al. 2007; Nkansah-Poku et al. 2009; Quaicoe et al. 2009). Trials in Ghana to find resistant varieties started as early as 1956. In 1981, hybrid breading and testing started (Quaicoe et al. 2009). There have been at least 27 different varieties and hybrids tested for resistance (Quaicoe et al. 2009). The tested varieties include the following: 'Andaman Tall' (ADOT), 'Catigan Green Dwarf' (CATD), 'Cameroon Red Dwarf' (CRD), 'Equatorial Guinean Green Dwarf' (aka Brazilian Green Dwarf, EGD), 'Laccadive Tall' (LCT), 'Malayan Red Dwarf' (MRD), 'Malayan Yellow Dwarf' (MYD), 'Malayan Tall' (MLT), 'Panama Tall' (PNT), 'Rennell Island Tall' (RIT), 'Sri Lanka Green Dwarf' (SGD), 'Tacunan Green Dwarf' (TACD), 'Tagnanan Tall' (TAGT), 'Tahiti Tall' (aka Polynesian Tall, TAT), 'Vanuatu Tall' (VTT), and the local variety 'West African Tall' (WAT) (Dery et al. 2008).

Hybrid Breading in Ghana

Breeding of hybrid varieties of coconut palms is done for two reasons. The first objective was to make a variety with a higher resistance to CSPWD. This was done by taking two varieties, cross breading them, and then using the resultant hybrids in a disease resistance trial

plantings. The second purpose of hybrids is to obtain disease resistance while preserving desirable characteristics of a non-resistant variety (Danyo 2011; Last 2001; Quaicoe et al. 2009). The first trials to use hybrids were done in 1981 and 1983, with 17 different hybrids planted (Quaicoe et al. 2009). The results of the 1981 and 1983 trials identified four varieties with some level of resistance and less than 50 percent infection rate; however, no hybrids showed complete resistance to CSPWD (Quaicoe et al. 2009). This trial was built upon by later trials.

A cross of MYD x VTT is a heavily used hybrid for replanting to help prevent a total collapse of the coconut industry (Ghana Ministry of Food and Agriculture (B) 2011; Quaicoe et al. 2009). The 1981 and 1983 trials showed a low susceptibility to the disease (Quaicoe et al. 2009). Furthermore, Dery et al. (2008) 2006 plots showed a 66.7 percent infection rate. This seemingly high rate of infection occurred in one of the most disease resistant strains and was the best hybrid tested by Dery et al. (2008). It performed well in multiple locations, and it is recommended for planting in areas far ahead of the disease front. This hybrid was used for a massive coconut planting during the 2011 World Food Day in Ghana in the Nzema East municipal (Ghana Ministry of Food and Agriculture (B) 2011; Ghana Ministry of Food and Agriculture (C) 2011). In 1995, the highly resistant SGD was crossed with the resistant VTT. The resulting hybrid has been under screening at Agona junction (near Cape Three Points) and there has yet to be an incidence of CSPWD to occur in this hybrid (Quaicoe et al. 2009). While Dery et al. (2008) and Quaicoe et al. (2009) did not have data for a SGD x VTT hybrid screening exposure to CSPWD, both expect a high resistance and infection rate under 37 percent and recommend use of this hybrid for planting in all locations. There are now seed gardens capable of producing enough SGD x VTT hybrids to plant 200-300 ha each year (Quaicoe et al. 2009). This type is now being distributed to farmers in Ghana. Different varieties, hybrid or pure, are

able to cross pollinate, in a natural setting (Enaberue et al. 2006); therefore, locals hope that the resistant strains will continue to breed with each other and the local varieties to build resistance in future wild type generations.

Uses and products of the Coconut Palm

The tree of life, as the coconut palm is sometimes called, earned its name because the multitude of uses for the palm. Indonesians say there is a use for the coconut tree for every day of the year (Chan and Elevitch 2006). Along the coastline of Western and Central regions of Ghana there are over 100 individual uses for the coconut palm. Appendix 1 offers a comprehensive list of these uses, products, and instructions for coconut production. This list was compiled, by myself, from 97 interviews of 216 individuals and combined with observations from 68 villages along the coast of Western and Central regions of Ghana.

The most commonly known uses of the coconut are from the nut: drinking water from both immature and mature nut, eating of the kernel, oil from the copra, and use of copra as a confectionary (Anyane 1963; Bhatia and Smith 2008; Chan and Elevitch 2006; Frater 2004; Hawes 1987; Last 2001). But there are several other uses from the fruit as well. Rope, doormats, and carpets can be made, as well as fabrics from the fibers of the coconut husk. In Kerala, India there is a large industry centered on products using coir (term used to refer to fibers derived from the husk) (Bhatia and Smith 2008). The shells are used in decoration, jewelry, as cups and ladles, and other items. Below is a list of some of the categories that the coconut tree is used in.

Fuel

Every part of the coconut tree can be used as fuel for cooking and other purposes. The trunk, however, would not be used until the palm is senescent and stops producing (Last 2001; Appendix 1: Uses of the Coconut Palm from Central and Western regions of Ghana). The fruits, specifically the husks and shells, as well as the protective sheath and spadix, can also be burned along with the fronds. The regular shedding of the fronds and fruiting bodies provides a constant supply of fuel for cooking, smoking, and warmth (Chan and Elevitch 2006; Appendix 1: Uses of the Coconut Palm from Central and Western regions of Ghana). There are additional benefits to using the coconuts. Oduor-Odote et al. (2010) found that using coconut as the fuel for smoking marine and freshwater catfish not only provided a good appearance and taste but also improved the length of time the fish can be stored without insect or mould attacks.

Soil stabilization

Alive or dead the coconut is used to stabilize soil. The dense roots of the living coconut hold soil in place in locations other plants cannot, like on the sandy coastline (Chan and Elevitch 2006; Appendix 1: Uses of the Coconut Palm from Central and Western regions of Ghana). A stem laid on its side, perpendicular to a slope, stabilizes and prevents erosion. The stems are also used to make planters or hold soil around a local spot or bar. Figure 10 shows a retaining wall made entirely out of coconut stems. The husks of coconut are used as a filler, like a mulch, or to help repair and prevent erosion in areas of high traffic. In areas of erosion, the husk would be pounded into an existing waterway erosion area or in road potholes, and covered with soil and is then compacted. In some locations, a stem with husk piled on the uphill side is used as an

effective back fill (Appendix 1: Uses of the Coconut Palm from Central and Western regions of Ghana).

Figure 10: Coconut retaining wall, and live palms used for shade. The structures used coconut stems as the posts and the rachis from the frond, and the fronds woven together, to construct the walls. Location: outside of Gomwa Nyanyano, Central region, Ghana, West Africa. (photo taken by Ben Ross Caulum)

Structures

Both the stem and the fronds can be used in a variety of ways for the building of structures. The rachis of the frond can be used to build walls and fencing. The rachis with the leaflets attached can be woven into mats that can be used for walls, fencing, or shade (Figure 10). If the leaflets are removed from the fronds, as a strip, they can be used to make thatching for roofs (Figure 10). The stems can be used as pillars for house frames or cut into boards and used as timber for the construction of trusses, bridges, patios and furniture (Figure 11). An entire house can be built by cutting the coconut stem into different sizes and using fronds (Appendix 1: Uses of the Coconut Palm from Central and Western regions of Ghana). On small Pacific

islands, where wood is scarce or non-existent, the coconut palm is of critical importance (Chan and Elevitch 2006).

Figure 11: Coconut stems used as pillars and cut into timbers for the construction of a raised patio. Location: Outside of Atuabo, Western region, Ghana, West Africa (photo taken by Ben Ross Caulum)

Food Production

The coconut provides sustenance both from the water in the coconut and the edible kernel. The sap of the coconut can also be turned into palm wine, an alcoholic beverage, though this is the less popular variety in Ghana (Appendix 1: Uses of the Coconut Palm from Central and Western regions of Ghana). Other than producing fruit, the coconut also provides shade in pastoral systems (Figure 12), and the leaflets and copra remnants, left over from oil production, are good fodder. The copra can also be used as a bait to attract fish into traps that are made from the fronds (Chan and Elevitch 2006; Appendix 1: Uses of the Coconut Palm from Central and Western regions of Ghana). On several Pacific islands, the rachis from the fronds are turned into fishing poles (Frater 2004). In an agricultural intercropping system, coconut palms are also a good shade tree for crops (Osei-Bonsu et al. 2002). The preservation of food, as mentioned

earlier, is helped by smoking fish with coconut (Oduor-Odote et al. 2010), and extracts from the leaflets of the coconut palm were found to aid in the protection of grain from stored product pests (Rani et al. 2011).

Figure 12: Coconut palms providing shade for fenced in cattle. Location: Near Twinen, Western region, Ghana, West Africa (photo taken by Ben Ross Caulum)

Figure 13: Coconut palm being used as anchor while villagers pull in fishing nets and a coconut stem showing wear from repeated use as boat mooring and fish net anchor. Location: Anlo village, Western region, Ghana, West Africa. (photo taken by Ben Ross Caulum)

Coastal Uses of Live Palms

Along the sandy coastline where most trees are unable to grow, the coconut provides many functions, like the previously mentioned erosion control by the rooting system. Groves of coconut palms act as wind breaks for villages and their crops, preventing damage to the village and crops and wind erosion (Chan and Elevitch 2006; Frater 2004; Appendix 1: Uses of the Coconut Palm from Central and Western regions of Ghana). The palms also provide a secure anchor to hold fishing nets or as a boat mooring (Figure 13). Fishermen also greatly appreciate the shade that the coconut palm provides while they repair nets, sort fish, or take a mid day break (Appendix 1: Uses of the Coconut Palm from Central and Western regions of Ghana).

Medicinal and Health

In traditional Ghanaian culture, most parts of the coconut palm have medicinal use. The majority of the palm teas are made and used for curing malaria, fevers, toothaches, constipation, asthma, and influenza. Some interesting practices include using the coconut roots to treat erectile dysfunction, the bark as an anti-inflammatory, the fronds to treat jaundice, charcoal from the shell to filter water, and eating the copra to cure rheumatism. Most of these are not backed by scientific research; however, some uses are backed by science, e.g. the use of coconut for smoking fish or leaf extracts used on grains (Rani et al. 2011) to prevent the spoiling of food (Oduor-Odote et al. 2010). Other scientifically backed uses include coconut endosperm as an aphrodisiac (Wani et al. 2011), the antibacterial properties of the roots and bark (Sivakumar et al. 2011) as a dermatological ointment (Ajose 2007), and of shell carbon to filter water (Afrane and Achaw 2007).

Perception of Local People

Cape Saint Paul Wilt Disease

The majority of Ghanaians interviewed knew of CSPWD in coconut palms. This fact is consistent with the study by Okorley and Haizel (2002), where 95 percent of farmers in the Western region knew of CSPWD. Additionally, 91.5 percent of farmers in the Okorley and Haizel (2002) study were able to accurately describe what CSPWD symptoms looked like. There was, however, an occasional interviewee who blamed the death of the coconut palms on off-shore oil drilling. They also believed that while the oil killed the coconuts, the palms had protected the inland areas from being ruined. Of those aware of CSPWD, some blamed the government for not doing enough to stop the spread, while Okorley and Haizel (2002) found that 37 percent of farmers learned of the disease through the Ghana Ministry of Food and Agriculture.

Hybrids

Findings by Okorley and Haizel (2002) confirmed the observations of local knowledge concerning hybrid varieties. Eighty five percent of the population surveyed in Okorley and Haizel (2002) knew about the existence of hybrids and, for the most part, found them to be advantageous. The faster fruiting time and a higher fruit yield made most hybrids economically preferable (93.2% percent in Okorley and Haizel (2002)). There were, however, comments about a lower oil quality from certain hybrids (Okorley and Haizel 2002). Specifically, palms with yellow coconuts were cited. When asked about coconut palms bearing yellow coconuts, the interviewees could not tell if they were hybrids or not. There was also mention about less potency for medicinal uses from hybrids. This may be a result of personal feeling or hearsay from others (Okorley and Haizel 2002), similar to a placebo effect.

Okorley and Haizel (2002) found the participants frequently complained about the difficulty of obtaining the hybrids and of the cost of seedlings and transportation. To continue planting local variety coconuts, locals need not use, for alternate means, a coconut off a palm to allow it to sprout, and then plant it in the desired location. To obtain hybrids, the seedling must first be bought from a reputable location so the farmer knows it is a "pure" hybrid (Okorley and Haizel 2002), and then brought back to the village or farm. If the fruits that are eventually produced by the bought hybrid are not from a "pure" hybrid, more seedlings must be bought. Because of these costs, most villages only plant hybrids around or close to the village and surround them with protective fencing (Figure 14), which incurs additional costs. As concluded by Okorley and Haizel (2002), these issues may be the biggest reason that hybrids are not used more extensively to aid the recovery of the industry.

Figure 14: Hybrid coconut seedlings next to town with protective enclosures. Location: Atuabo, Western region, Ghana, West Africa. (photo taken by Ben Ross Caulum)

Loss of a Tree and the Change of a Culture

The growing of coconut trees is considered part of the traditional agriculture of municipalities of southern Ghana (Ghana Ministry of Food and Agriculture (C) 2011) even

though the coconut did not arrive in Ghana until Europeans introduced it approximately 500 years ago (Last 2001). The 500-year presence of the coconut palm and its multitude of uses made it a naturalized part of the environment, and it became as culturally significant tree, especially along the coast where it naturally grew. In some coastal villages, where the coconut was the only available source of woody building materials, the importance of the palm in daily life was even more pronounced. With the loss of the coconut palm, land use was converted to alternate agriculture; thus, this resulted in an obvious lack of use traditional building materials in villages. This is apparent when villages west of the disease front, i.e. Atuabo, are compared to those in disease hot spots, like Cape Three Points (Danyo 2011; Nkansah-Poku et al. 2009). What is unknown, however, is if the move away from coconuts as an important daily used plant is due primarily to the loss of the palm or influence of western societies. Locations that have been most devastated by the CSPWD are also much closer to large cities, or between them, while locations that still have a healthy coconut population are often less accessible due to longer travel time or ill maintained roads. The use of parts of the palm by children to make a variety of toys is also observed in the villages with less western influence or a high presence of coconut palms (Figure 15). It appears that a loss of the palms not only can result in a loss of part of a culture, but in some locations, like small Pacific islands, the death of the entire culture (Chan and Elevitch 2006). In Ghana, the question remains: 'Did the loss of the coconut palm alter the coastal cultures?'

Figure 15: Children using the coconut frond to make a bracelet or watch, spectacles, and a pin wheel (left to right). Location: Ketakor, Western region, Ghana, West Africa. (photo taken by Ben Ross Caulum)

Future Recommendations

In Ghana, literature on the coconut palm is lacking. This excludes literature on the Cape Saint Paul Wilt Disease. Further research should be done with regards to the traditional uses of the coconut palm and ability of different varieties and hybrids to match the versatile uses of the natural variety. Due to the combination of local dislike for the MYD variety and the equal and lower resistance shown in trials, compared to SGD x VTT and MRD hybrid, it is recommended that use of the MYD and related hybrids should cease and be replaced with other alternatives.

To help address the problem of accessibility to "pure" hybrids, the existing Ghana Ministry of Food and Agriculture programs should have a few alterations made. The easiest and most cost efficient way would be through extension agents that are already in field. If the extension agents can teach farmers how to artificially pollinate the hybrid palms they already have, or teach while a farmer purchases seedlings, then the farmer can use a couple of hybrids to produce "pure" hybrid offspring for future propagation. This will enable a farmer to replant with

only hybrids and sell coconut seedlings to the rest of the village, eliminating transportation costs, after the initial investment. In this way, the most remote locations would only require one input of hybrids to make multiple stock improvement plantings possible.

Conclusion

The coconut was introduced to Ghana by European trade routes where it thrived and where its spread was greatly aided by humans. Foreigners promoted the growth of the coconut industry with an end effect of more and more established plantations. Introduction of the a lethal yellowing disease, now known as Cape Saint Paul Wilt Disease (CSPWD), at Cape Saint Paul in 1932, and the subsequent introduction at Cape Three Points in 1964, greatly contributed to the decline of coconut export. Attempts to find cures and resistance to the disease started in 1956, via screening trials and later hybrid varieties. Hybrid varieties are perceived as advantageous by locals because of the resistance, and faster fruiting times; however, accessibility to hybrid seedlings and cost have proved to be a hindrance for locals.

The multitude of uses of the coconut palm made it culturally significant especially along the coast. The coconut could provide almost anything that was needed for daily living. The loss of the coconut has been filled by other forest and agricultural products, as well as "western" alternatives. Revival of coconut groves with preferred hybrid varieties would not only help to restore cultural aspects but also return some people's means of livelihood.

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Appendix 1

This Appendix was written by the author as an instruction booklet after extensive field research and interviews for use in Peace Corps, Ghana. The research focuses on four areas covering approximately 43.4 km (27 mi) of coastline and interviews with 1-8 people in every village along the coast, including those only accessible by foot or after river crossings. A total of 97 interviews were conducted with 216 individuals from 68 villages. The first range of land surveyed begins in the western region in the village of Twinen, about 48.3 km (30 mi) east of Ghana's western coastal border and continues east to the village of Kikam. The next range surveyed began in Prince's Town and covered 40.2 km (25 mi) of coast to the town of Adjuah, in the Western region. The third went from the town of Komenda, in Central region, east 35.4 km (22mi) to the town of Biriwa, or Sameranum. The area farthest east covered the 51.5 km (32 mi) encompassing the town of Apam to Kokrobitey, on the east side of the Greater Accra and Central border.

Uses of the Coconut Palm (*Cocos nucifera*)

From Western and Central Region coast lines of Ghana, West Africa

By: Ben Ross Caulum

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Fresh Fruit

The fruiting body of the Coconut palm is used differently at different stages of fruit development. “Fresh fruit” defines the period when the fruit is still green. Fresh fruit is usually found on the palm, but at times, fresh fruit may be found on the ground. Often, the palm sheds fresh coconuts because of an infection in the coconut. When on the ground, fresh coconuts dry out much quicker than on the palm; thus, are then no longer useable in the same capacities.

To harvest the fresh coconut from a palm, the easiest method is to twist the nut, like unscrewing a light bulb. Coconuts are very heavy; therefore, the stem is designed to bear a significant increase in downward pull. Due to the size of the coconut and difficulties faced while climbing a coconut palm, use of a blade is not recommended. There is little room for freely swinging or sawing with a blade, and the fibrous stem is difficult to cut through. The twisting of a coconut is very easy and requires no more than six full turns before the coconut falls off.

Part: Water.

Uses: **Drinking**: The water of the coconut is almost perfectly isotonic, equal in ratio to the salt, fats, and sugars to the human body. It is also sterile and can be drunk straight out of the coconut.

Cooking: Used in place of drinking water gives a slight coconut flavor to food, e.g., coconut flavored rice.

Medicinally: *Warning: these are listings of ailments that the drinking of coconut water helps, based on oral tradition of coastal society in Ghana. The following listed medical uses are* ***not backed by scientific research****. The author recommends that coconut water be used medicinally as a hydration solution, used in the same capacity as a rehydration packet from a first aid kit.*

- Diarrhea
- Fever, Malaria
- Urination troubles or system flush
- Stomach or heart problems
- Measles
- Rheumatism

Extraction: The fresh coconut is easily opened with a medium sized blade. The blade should be a machete, or large knife with a minimum recommended weight of 10 ounces, and at least 13 cm (5 in) of a sharp cutting edge. Recommended machete length should not exceed 46 cm (18 in). Be sure the blade is not too large or cumbersome and make sure you are familiar with the handling of the tool before attempting to open a coconut. **Use the blade to cut off pieces of the husk a little at a time. Each cut should be done swiftly is a single slicing motion.** Do not try to saw through. This is most easily done if the coconut is resting on a surface upon which it will not easily slip and will not damage your blade. More experienced people can hold the coconut freely in the air while cutting off top pieces. This however requires more skill and confidence to not cut though and strike the fingers on the backside or the thumb in front. **Start by cutting off a top section then work around the edges of previous cuts. The shell of the coconut will appear a quarter to halfway through the husk.** When the coconut is fresh, the shell is soft and easy to cut through. If one of the slices hits the shell without going through, the shell will crack and water will begin to leak, this is not cause for concern, continue cutting. **When the shell is exposed, hit it with the sharp edge of your blade, then turn the coconut and cut again so the cuts form a ring. The shell section should pop out or be easily pried open.** If the coconut is very young, the water is now accessible; however, if the coconut is picked later, the thickened meat inside will need to be removed as well. This can be done with the tip of your blade, knife, or finger.

Part: Meat.

Uses: **Eat.**

Extraction: If you desire to use the water as well, follow the steps to extract the water first. Then, proceed with the meat extraction. If you do not care for the water then just begin with the meat extraction but water will come out anyway. **Cut the coconut in half or into thirds.** These proportions are easiest to obtain and handle, base the number of cuts on coconut size. A smaller blade will have more difficulty handling this task. **Once the coconut is open, use a blade, spoon, or fingers to remove meat.**

The easiest way is to use the thumb, soft side against the shell, and push into the meat. The meat should pop off the shell in sections if done properly.

Part: Whole coconut.

Uses: **Sale**: In Ghana, the sale of whole coconuts off the palm is widely done as a means of livelihood. The coconuts are cut down to the shell so that when purchased, the shell can be quickly removed and the buyer can drink the water. The coconut is then handed back and opened the rest of the way so the buyer may also eat the meat.

Part: Stem insert: This is the area where the stem that connects the coconut to the palm, inserts into the husk. It is characterized by an area with a decrease in fibrous material.

Uses: **Medicinally**: *Warning: these are listings of ailments that the use of coconut husk stem insert helps, based on oral tradition of coastal society in Ghana. The following listed medical uses are* ***not backed by scientific research****. The author does not recommend using the coconut to cure ailments and recommends seeking medical attention instead.*

- Tooth aches: (1) Place the stem insert in mouth, (2) masticate, and (3) place over tooth ache and hold there for 10-20 minutes.
- Stomach pains: (1) Boil coconut meat into a tea, (2) add salt, and (3) drink.

Extraction: After removing the coconut from the palm, use a blade to remove the area surrounding the stem insert, or top of the husk, approximately half an inch down from the surface. Remove excess fibrous material until the less fibrous part remains.

Dry Fruit

The dry coconut fruit is brown in color and weighs less than a fresh fruit, due to the loss of water weight from the inside of the coconut and the husk. The dry coconut is occasionally found on the palm but, most frequently, will have already dropped off the palm before becoming completely dry.

The dry fruit has three distinct, usable parts. The most used, in terms of income generation and dietary supplementation, is the copra, or dry meat of the coconut. After copra, the husk is the most used in the household and to generate income. The hardened internal shell is the third part.

Part: Copra: This part of the coconut is found inside of the dry coconut, attached to the inside of the hard shell, white in color, and approximately 1.25 cm (½ in) thick.

Extraction: If the copra is all that is desired, the easiest way to obtain it is to **take a medium sized blade and cut longitudinally into the coconut. Two cuts, on opposite sides, should cut the coconut in half, or three cuts placed equally apart can cut it into thirds.** The first attempt usually will not open the coconut. Continue to cut the coconut in the same locations, trying to pry it open each time before removing the blade. **Once the coconut is open, use the blade, a spoon, or your fingers to pry up pieces of the copra.** The copra should pop free from the shell with relative ease.

Use: Consumption: Eat the copra alone or mixed in the following ways:

- Fried maize with ground or grated copra
- Soup with ground copra
- Chocolate with ground, chopped, or grated copra
- Rice with ground, chopped, or grated copra
- Gari with ground copra
- Ice cream with ground or grated copra

Use: **Medicinally:** *Warning: these are listings of ailments that the consumption of coconut copra helps, based on oral tradition of coastal society in Ghana. The following listed medical uses are* ***not backed by scientific research****. The author does not recommend using the coconut to cure ailments and recommends seeking medical attention instead.*

- Rheumatism.
- Purgative.

Produce: **Oil:** The Malaysian Yellow Dwarf (MYD) and hybrids of this coconut variety are not used in the production of oil in Ghana. Interviewees stated that it is either poor in quality, or no good at all.

Extraction: 1. Dry copra.

2. **Grind copra.**
3. **Put grinds in cloth sack.** It must be a tight sturdy weave, e.g., flour sack.
4. **Squeeze out water into a barrel—**this should be done with a mechanized press, i.e., manual screw press.
5. **Mix remains with a little salt water, then re-squeeze all water out.**
6. **Let extract sit for approximately 24 hours.**
7. A film will form on the surface that looks like condensed milk. **Remove film into separate container.**
8. **Fry surface film to separate out the oil** that can then be poured into another container.
9. A little water can be added to what remains of the film after the first frying, and can be refried to extract more oil.

Uses: Cooking: Coconut oil is used instead of palm oil or vegetable oil.

Sale: It used to be a major Ghanaian export before the Cape St. Paul Wilt Disease decimated much of Ghana's coconut region, killing 90 percent of coconuts it reached.

Soap: Used for cleaning of both the body and cloths.

Recipe: This is a very basic recipe; many variations exist.

1. **Mix 3 cups of water with 350 grams of lye**. Mix slowly and carefully, mixture will become very hot.
2. **Let solution cool for at least 1 hour.**
3. **Slowly mix 1.5 liters of coconut oil with lye solution.**
4. **Pour mixture into cooling pan.**
5. **Leave until hardened**. This usually takes 1 -2 days.
6. Cut into desired sizes.

By-Products: (1) Solid remains of copra after oil has been pressed out in steps 4 and 5.

(2) Remaining surface film after step 9.

Uses: Both by-products are frequently used as animal fodder in either a pure form or mixed with other fodders. The remaining solid copra after step 4 is also frequently used for various types of consumption; however, if put through a second squeeze it is only used as animal fodder.

Produce: **Kube Cake:** Kube is the Twi and Fanti word meaning coconut. Kube Cake is produced and sold in markets as a type of candy or treat. Some people are able to produce and sell enough to make a living.

Recipe: The following recipe is based largely on an amalgamation from several recipes that the author was taught.

1. **Chop or pound copra.**
2. **Put sugar in a pot on stove until the sugar turns to liquid**. Use ratio of 1 cup of sugar:1 cup of chopped or pounded copra.
3. **Add chopped or pounded copra.**
4. **Pour onto flat surface.**
5. **Shape and cut immediately.**
6. **Let cool before eating.**

Produce: **Toffee:** Toffee is produced and sold in markets as a type of candy or treat. Some people are able to produce and sell enough to make a living.

Recipe: The following recipe is based largely on a single recipe, but is also an amalgamation from several others recipes that the author was taught.

1. **Grind or grate copra into cloth flour sack.**
2. **Add a tsp. of water.**
3. **Squeeze and extract all fluid until mixture is** milky white.
4. **Put coconut water in a pot on the fire with sugar and salt** (use 5 coconuts, 3 cups of sugar, and 3 pinches of salt).
5. **Stir continuously until it turns light brown.**
6. **Add enough milk** to make the mixture thick.
7. **Add one tsp. small bit of lime.**
   Optional: add ginger.
8. **Pour into a wooden tray.**
9. **Stir until the oil comes out.**
10. **Remove oil.**
11. **Shape into desired form.**
12. **Cut with scissors.**

Produce: **Coconut biscuit:** Coconut biscuit is produced and sold in markets as a type of treat or snack.

Recipe: The following recipe is based largely on an amalgamation from several recipes that the author was taught.

1. **Grate copra.**
2. **Mix 1 cup flour, 1 cup copra, 1/3 cup sugar, 1 tsp. salt, and enough water to make a sticky mixture of all ingredients**
3. **Fry mixture.**
4. **Remove when golden brown.**
5. **Let cool before eating.**

Produce: **Animal Fodder**: Goat, pig, sheep, cattle, fish.

Method: **1.** Grind copra.

2. Feed to animals pure or in mixture with other fodder ingredients.

Note: The ground copra can be used after oil has been removed. The nutritional value, however, will be slightly reduced, and will have less of a fattening effect than pre-oil production copra.

Use: **Fishing bait:** The mixing of ground or grated copra with oil, fat, lard, or other binding agent to produce a solid mass to draw fish or crustaceans into a trap.

Use: **Grass cutter deterrent:** Spreading of waste product copra, after oil extraction, around a farm helps to keep the grass cutter out. Note: *This was not confirmed by a second party during any interviews*.

Grass Cutter: large rat-like rodent, body over a foot long, with a tail about a foot long

Part: **Husk**: Fibrous outer covering of a coconut. When fresh, it is green in color on the outside and yellow and white on the inside (except for the Malaysian Yellow dwarf and hybrids of it, which are more yellow in color). When dry, the husk turns brown in color, inside and out.

Removal: If the coconut is fresh it can be opened, but it will have to dry before the husk can be used.

A. Use a medium size blade to cut longitudinally into the husk until the shell. Make second cut several inches over. Grab either end and pull the husk away from the shell. Repeat.

B. Hold of the coconut as firmly as possible. Slam it against a palm or other sturdy surface at a slightly glancing angle. Repeat until husk is forced lose. Grab a hold of the lose husk and pull it away from the rest of the coconut. Repeat.

Use: **Fire:** The dry coconut husk can be used to fuel a fire for, but not limited to; cooking, craft making, and smoking fish. The preferred use is for smoking fish.

Use: **Scrub Brush:** The dry coconut husk can be used as a scrub brush without any work needed. Often, Ghanaians will pound the husk to shape it and make the first uses a little less abrasive.

Use: **Filler or fertilizer:** Used to fill water pathways to fix erosion, pot holes, or planters.

Produce: **Cordage or rope:** The most common use for the coconut husk.

Directions: The following directions are based largely on an amalgamation from several interviewees. Tensile strength is not known.

1. **Pound husk to loosen fibers.**
2. **While pounding, pull off the loose fibers.**
3. **Once a sufficient pile of fibers is obtained, take a bundle of fibers, half the thickness you desire for the rope, and roll it between your hands so they twist around each other.**
4. **Add fibers to the end so they overlap with old ones and roll between your hands.** This way you can continue to lengthen the rope.
5. After approximately 9 inches is made, **make a second one.**
6. **Twist the two strands around each other.**
    a. **Twist both strands, individually, counter clockwise.**
    b. **Then twist them around one another clockwise.**
    The individual twisting of both strands should make them want to twist around each other. It should not be forced and the twist should not be fought.
7. **Continue lengthening each individual strand as directed in step 4 until desired rope length is achieved.**

Note: It is recommended that a bundle not exceed 3/8 inch in thickness. If a thick rope is desired three bundles may be used, but this is more difficult to manage; thus, it is recommended that a person first gain experience with two bundles.

1. **To make a rope thicker than one inch in diameter, first make two, or three, smaller ropes.**
2. **Twist the ropes clockwise, individually.**
3. **Complete step two while twisting ropes around each other, counter-clockwise.**

Produce: **Doormat or Carpet:** The doormat is the second most commonly known use for the coconut husk.

Directions: A. This is the first and most common method used to make a doormat from the husks. Directions for a carpet are the same but on a much larger scale.

Thickness of the doormat and carpet are determined by the thickness of the ropes used.

1. **Make many small ropes.**
2. **Lay them in pairs, side by side.**
3. **Tie one end of each pair together using an overhand knot.**
   Steps 2 and 3 can be combined by making the ropes twice as long and folding them in half.
4. **Lay all of the pairs next to each other, on a flat surface,** with all the knots on the same side.
5. **Take the left of each pair and cross it over the right of the pair next to it.**
6. **Cross the left piece back under the same right piece it just passed over.**
7. **Take the right of each pair and cross it over its left partner.**
8. **Cross the right piece back under the same left piece it passed over.**
9. **Repeat steps 5-8 until the ends are reached.**
10. **Tie the ends together with an overhand knot.**

B. This method can be accomplished with just one very long piece of rope, but is usually done with multiple pieces. This method will also produce a higher quality, thicker, and longer lasting product. It also uses twice as much material.

1. **Produce enough ropes to cover the desired area when you lay them next to each other.**
2. **Pair them off and tie the ends together with an overhand knot.**
3. **Lay all of the pairs next to each other, on a flat surface**, with all the knots on the same side.
4. **Tie the loose end of all the left side ropes with the loose end of the right side rope from the pair next to it.**
5. **Produce a rope of same thickness but** long enough so it can be folded to cover the same desired area.
6. **Tie the long rope to an outside edge rope,** right next to the knot.
7. **Go under the next rope.**
8. **Go over the following rope.**

9. **Repeat steps 6 and 7 until you reach the end.**
10. **a. If you went under the last rope, restart the process, going in the other direction, by going over the last rope and under the next.**
    b. If you went over the last rope, restart the process, going in the other direction, by going under the last rope and over the next.
11. **Continue with steps 6-9 until desired doormat or carpet size is achieved.**
12. **Tie off all lose ends.**

Note: This can be done with one piece of rope by snaking it back and forth throughout steps 1-3, and then skipping straight to step 6. Managing the rope length and estimating the appropriate amount needed is very difficult. It is recommended that weavers first gain experience using many smaller ropes for smaller size projects.

Secondary Uses: 1. Chair Cover: Small cover on a wooden seat.

2. Car interior: A large enough "carpet" can be cut and sewn, like a piece of fabric.

3. Wallet: Fine ropes used in the second style can be sewn together to make a wallet.

4. Sandals: A very thick bottom made from second style, with ropes for straps.

Part: Shell: Harder protective covering to which the meat is adhered to on the inside and the husk is attached to on the outside. When the coconut is fresh and green, the shell is soft and easy to cut through with a medium sized blade. After the coconut dries, the shell hardens and becomes very difficult to cut. A knife would be unable to cut through the coconut shell; a saw is needed. The shell, however, becomes more brittle and a hard hit will crack it, or even break it into several pieces. An undamaged extracted shell is round in shape, brown in color, usually has three "seams", and three "eyeholes" on the top of the shell, which are softer than the rest of the shell. The shell can be polished to a near mirror finish.

Extraction: The shell of a fresh coconut is not used for anything; only the hard shell from the dried coconut is used.

Use a medium size blade to cut longitudinally into the husk, all the way to the shell. If an intact shell is desired, be sure not to cut to deep or hard, or the shell will crack. You can also use a small knife, less than 10 cm (4 in) in length, and drag it through the husk in the same direction to make the cut, thus, reducing risk to the shell. **Make a second cut several inches away from the first cut. Grab either end and pull the husk away from the shell. Repeat until the entire husk is removed. Open the shell and remove all copra from the inside.** If you want the shell to be as whole as possible, can poke out the "eyes" in the top of the coconut where the shell is softest. Through those holes, smaller tools can be inserted to scrape out the copra. This is a painstakingly longer way of removal and should only be used when a whole coconut shell is desired.

Use: Crafts: The shell of a coconut has a multitude of uses whether it is whole or in pieces. Some of the crafts listed below are used in everyday life, while others are targeting a tourist market.

- **Cup/ladle**: This can be as simple as a half coconut shell, used to ladle soup in the kitchen, or as elaborate as a more decorative style design, sold in tourist shops. The complexity can include the addition of a bottom, from the other half of the coconut, to make it chalice like. These more complex cups usually also involve work with clay, or an epoxy or binding agent, to make the shell stand on its own or hold multiple pieces together.

- **Jewelry**: Pieces or a whole shell can be shaped and polished for the use in jewelry making. This includes, but is not limited to, necklaces, earrings, and rings.
- **Decoration**: Used to decorate walls, floors, or to produce a desired atmosphere.
- **Bag/wallet**: Parts or a whole shell can be cut and have a zipper, or strings, attached to make a small flat wallet or bag. To attach the zipper, many small holes need to be drilled to pass a thread through, so the cloth can be sewn to the shell.
- **Ashtray**: A simple use of the coconut shell requiring little to no work. Partial shells can be used to make ash trays of varying complexity.
- **Lamp**: A whole shell with just one eyehole poked out. The shell is modified to stand on its own, filled with kerosene and equipped with a wick.
- **Bank:** A whole, entirely intact shell, with only two "eyeholes" poked out, with a a small cut made between the two "eyes" just large enough for coins and folded bills to be pushed in. When the bank is full or the money inside needs to be taken out, the shell is smashed open.
- **Funnel**: If the shell can be extracted with the top half intact, it can be used as a funnel. The shell should be cut in half and have one of the "eyeholes" poked out of the top.

Produce: **Mosquito coil:** The shell is ground, mixed with a little water and oil, then pressed into shape. This is done on a much larger scale and with more complex recipes by private industries. Locals, for the most part, only sell the shells to these companies.

Use: **Sell:** Supplementing household income can come from the sale of the coconut shell. Private companies that can processes the shell and make a new product are the primary buyers of coconut shells.

Use: **Fire:** The shell can be burned for cooking or smoking fires. Typically, if this is the use, it is not removed from the husk.

Use: **Charcoal:** The shell can be turned into charcoal and used for cooking or smoking fires, or water purification.

Use: **Gun powder:** The shell was, at one point in time, used as an ingredient in gunpowder. The production was done by larger companies, not individual households. The individual would sell the coconut shells to the companies.

Other parts of the fruiting structure

When a coconut palm fruits, it must first have a place for the coconuts to grow. It starts out with the stem and all potential coconuts inside a protective sheathing. As they mature, the sheath opens and peals back. Revealed, at first, this looks like nothing more than a small tree branch. Eventually the coconuts grow, ripen, and fall off or are pulled off. The stem and the sheathing are also used in Ghana.

Part: Protective sheathing: This is connected to the base of the fruiting stem. When the coconuts are visible, this will appear as a hard, black, banana shaped piece of the palm that looks ready to fall off.

Harvesting: Grab close to the base and pull it off, if it has not already fallen off.

Use: **Toy canoe**: Children like to play with it in the water and pretend it is a toy canoe, or boat.

Part: Fruiting Stem: This is the structure that the coconuts grow on in groups.

Harvesting: After all of the coconuts have been removed, **cut the stem off the palm** at the base**.**

Use: **Paintbrush:** One end of the stem is beaten and crushed against rocks or other hard surfaces until it is adequately frayed. It can then be used as a paintbrush.

Fronds

The fronds of the coconut palm are pinnate, 4.5-5.5 m (15-20 feet) long, and comprised of a primary spine and rachis, whose base attaches to the palm. Off the rachis are leaflets, each with a rigid medial vein, 50-150 cm (20-60 in) long. The fronds are green in color, fading to brown and black when dead, before dropping off the palm. Occasionally, the fronds will also fade to a sickly yellow color. In Ghana, this is often a sign of Lethal Yellowing Disease (LYD), or Cape St. Paul Wilt. Both fresh and dried fronds are used in Ghana.

Part: Ribs.

Make: **Broom:** Made from the dried medial veins. **Remove leaflets from rachis. Then, peel leafy part of leaflets off the rigid medial veins. Finally, bundle and tie veins together.** The size of broom varies depending on the number of veins used.

Use: **Sweeping**: Can have a stick attached for long handle broom; however, this usually not the case.

Use: **Shoo away flying insects and children**. Used in a swatting motion.

Part: Whole frond.

Use: **Fire:** Smoking fish or cooking food.

Make: **Simple woven mats:** Made from the middle 2-4 m (6-13 feet) of the frond.

Directions: 1. Cut off the end and base of frond to make the middle the desired length, to use the part with the longest leaflets.

2. **Lay two frond segments parallel and even** with the leaflets pointing the same way. The length of the leaflets determine the distance between the two frond rachis. The leaflets from one frond should overlap the second where the leaflets are between 6-12 mm (1/4-1/2 inch) thick. When weaving starts, the leaflets should have both soft, fleshy parts coming off the medial vein, pressed together.

3. **Take the leaflets of both fronds.** Designate one as "frond one" and the other as "frond two"**. At the half way point between "frond one" and "frond two", put the first leaflet of "frond one" under the first leaflet of "frond two".**
4. **Then, put the first leaflet of "frond two" under the second leaflet of "frond one".**
5. **Put leaflet two of "frond one" under leaflet two of "frond two".**
6. **Put leaflet two of "frond two" under leaflet three of "frond one".**
7. **Repeat steps 5-6 progressively, down the fronds until all leaflets are completed.** The whole frond does not need to be done right away if the leaflets being worked with on the next steps have already passed through steps 5 and 6.
8. Start where the first leaflet of "frond one" ends, overlapping the rachis of "frond two". **Take a leaflet of "frond two" and pass the end of the first leaflet from "frond one" over it and under the rachis.**
9. **Take the corresponding leaflets of "frond one" and pass the end of the first leaflet of "frond two" over it and under the rachis.**
10. **Take the next leaflet of "frond two" and pass the end of the next leaflet of "frond one" over it and under the rachis.**
11. **Take the next leaflets of "frond one" and pass the end of the next leaflets of "frond two" over it and under the rachis.**
12. **Repeat steps 10-11 until entire frond is finished.**
13. **Repeat steps 1-12, using the outside,** unused portion of the **already completed segment until a desired width is achieved.**

Note: A more complex version would be altered in steps 3-6. The revised step 3 instructs the reader to continue by going over leaflet 2 and under leaflet 3, continuing in pattern until reaching the rachis. Steps 4-6 would end similarly. The directions would then end at step 7.

Use: **Fencing:** The rachis' can have a lower potion buried, giving the necessary support to the fence. The two unused ends can also be woven together to make a closed-off, circular fence.

Use: **Shade/Roofing:** Used to give simple shade from the sun, or in layers and in combination with other materials to make a roof to withstand rain.

Use: **Walls:** Used for the walls of a kitchen or summer hut. Also used to cover the outside of clay walls to protect them from wind and rain erosion.

Use: **Smoking/Drying rack:** Used for smoking fish or drying coco, cassava chips, palm nuts, etc.

Use: **Sleeping mat/Door mat:** Not often used for these purposes because the rachis is bulky.

Part: Rachis

Isolating: Strip off all leaflets and separate from ends so rachis lays flat.

Make: **Roofing support:** Fill the gaps between the horizontal support beams that connect vertical supports.

Make: **Wall covering fence:** Place side-by-side, alternating thick end up and thick end down. Place two pieces horizontal in height. Tie remaining pieces perpendicular to the initial two pieces. Tie these remaining pieces parallel to each other.

Make: **Rope.**

Directions:

1. **Pull off thin, small, long strips of the fibers.**
2. **Gather two or three small bundles of the fibers.**
3. **Twist the bundles counter-clockwise, around themselves.**
4. **Twist the bundles clockwise, around each other.**
5. **Continue adding fibers to the end of the bundles,** with the ends overlapping, until desired length is produced.

Make: Drinking horn.

Directions:

1. **Cut off base of rachis.**
2. **Hollow out base.**
3. **Use hollowed base to hold beverages.**

Part: Leaflets.

Use: Animal Fodder: Eaten by goats and sheep.

Make: Roofing.

Production:

1. **Starting at the tip of the frond, cut into the rachis, 2 mm from the edge, all the way through it.**
2. **Pull the piece with the leaflets away from the rachis. Do this while using a blade to help separate the strip connecting the leaflets from the rachis, until all the connected leaflets are separated from the rachis.** Now, there should be a thin strip of fiber connecting all the leaflets to each other, approximately two meters in length.
3. **Repeat on other side.**
4. **Continue with more fronds until adequate number of leaflet strips are made.**
5. To cover roof, **start at the bottom of the roof.**
6. **Place one leaflet strip horizontally across the bottom of the roof supports, so the leaflets are pointed in the down flow direction, and the leaflets have their "V" shape open upwards.** Each point where the strip passes over a support should be secured to the support with a rope or nail.
7. **Place a second leaflet strip on top of the previous leaflet strip. The leaflets should "V" in the same orientation, connected by one point at the bottom of the leaflets.** Be sure that the individual leaflets do not perfectly overlap between strip one and two. Each point where the

strip passes over a support should be secured to the support with a rope or nail.

8. **Repeat step 7 until entire roof is covered.**

Note: A denser concentration, thus, more rain protection, can be achieved by laying a second layer of leaflet strips on top of the first layer.

1. The first leaflet strip of **layer two should be placed on top to leaflet strip one and two of layer one**, on top of the leaflets of strip two, but under the leaflets of strip three of layer one.
2. **Each point where the strip passes over a support should be secured to the support with a rope or nail.**
3. **Continue in same pattern until roof is finished.**

Make: Tea/Drinks.

Uses: Medicinally: *Warning: these listings of ailments that the drinking of coconut leaflets tea helps are based on **oral tradition** of coastal society in Ghana. The following listed medical uses are **not backed by scientific research**. The author does not recommend use of coconut leaflets to cure ailments and recommends seeking medical attention instead.*

1. Fever.
2. Jaundice.
3. Poor vision.

Uses: Mixed with bitters or alcohol.

Make: Fan: Author was unable to obtain adequate directions about fan production.

Part: Rachis and leaflets.

Make: Basket.

Directions:

1. **Pull off wide, thin, long strips of fibers from the rachis.**
2. **Take three pieces,** called "spokes", **and arrange them in a pin wheel or asterisk shape with 6 spokes.**
3. **Add a seventh spoke and tie them together in the middle**; the seventh spoke should only be connected on one end, and is half the length of the other strips.
4. **Use a leaflet and secure its end around one of the spokes next to the middle.**
5. **Proceed in a circle going over the next spoke and under the following spoke.**
6. **When the leaflet approaches its end, start another with the ends of the old and new piece overlapping.**
7. **Continue in this fashion, moving in a circle that gets larger with each turn.**
8. After adequate size is made for the base, **bend all the spokes in an 80-90 degree angle.**
9. **Continue weaving with the leaflets until basket is desired depth.**
10. **Fold spokes over, tuck ends into weave, and cut off excess.**
11. **Fold leaflet back on itself, tuck into weave, and cut off excess.**

Trunk

The trunk of the coconut palm is roughly 9-12 inches in diameter with very little taper from bottom to top. This makes the use of the trunk suitable for wood purposes because of the uniform size throughout the species and individual trunks. The wood, however, is used more often than coconut trunk due to wood availability, rather than choice. The coconut does not grow large in diameter, so it cannot be used for obtaining large pieces. There are harder, more rot resistant palm species.

Use: Timber: There are two primary ways of using the coconut palm for timber. The trunk can be cut into flat boards, or the whole trunk can be used and cut to length.

Make: Boards: The trunk can be cut up many different ways to make many different sizes. The most common way is to **split the trunk in half, and split the halves**. **Cut off the points to make 4 boards. Cut off the smaller part of the point from the remainder of the points that were just cut off and make four additional, smaller boards and four small triangular pieces.** Figure 1 shows the cuts as dotted lines through the solid line of the trunk. The different pieces have been numbered and lettered.

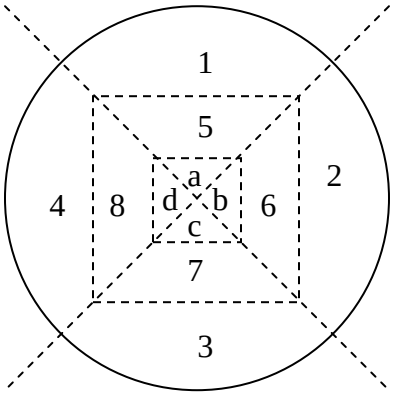

Figure 1: Cutting a coconut trunk to make 8 boards and 4 triangular pieces (transverse view).

Whole log: Another use for timber is to leave the trunk round and cut it to the desired length.

Products: Listed, are some of the products derived from the timbers. The part used for the different products will be listed as "log", indicating to use the entire piece, or the number or letters of the wood cuts in Figure 1.

- **Support pillars:** log: Used in the construction of homes and summer huts.
- **Roof supports:** 1-8: Stretch between weight bearing posts to bear the weight of the roof.
- **Roof supports:** 5-8, a-d: Stretch between the primary weight bearing beams to which a thatch roof is secured.
- **Rooftop:** 1-8: Cut short and used like wood shingles.
- **Erosion control:** log: Placed parallel to the contour of a slope to help prevent or stop erosion. Sometimes placed in water drainage channels to slow water flow.
- **Border delineation:** log: Used to mark out the border of a chop bar or vendors area. Will sometimes have sand or soil added to the inside area to raise the elevation.
- **Planter:** log, 1-8: Hold in sand or soil to elevate the area and offer protection to plant.
- **Seat/Bench:** log: Lay an entire log on its side to serve as a seat.
- **Furniture:** 1-8, a-d: Use pieces to make furniture including but not limited to tables, chairs, or couches.
- **House sides:** 1-8: Use as floor boards, walls, or doors.
- **Fence:** log, 1-8, a-d: Use All parts to make various quality fences.
- **Bridges:** log, 1-8, a-d: Use all parts are for different stages of the bridge construction. Amounts of each vary on bridge type, size, and design.
- **Ladder:** log, 1-8, a-d: Cut notches out of the log to make a single beam ladder. Additionally, more complex ladders may be built using the other pieces.
- **Gutter:** log: Cut and hollow out a log into a U shape to create a gutter on a roof or to redirect water flow elsewhere.
- **Doormat:** 1-8, a-d: Secure parts together in different ways to make different types of doormats.

Use: Fire: The trunk of the palm can be used as fuel wood and to make charcoal. Largely used for cooking food and smoking fish or meat.

Use: Fertilizer: When downed trunks begin to rot, the inside starts to decompose fastest. The rotting substance is used sometimes as an additional fertilizer.

Use: Medicinally: *Warning: these are listings of ailments that coconut bark (phylum) helps, based on **oral tradition** of coastal society in Ghana. The following listed medical uses are **not backed by scientific research**. The author does not recommend use to cure ailments and recommends seeking medical attention instead.*

- **Anti-inflammatory:** Chew on the bark, or make a tea out of it.
- **Fever reduction:** Chew on the bark, or make a tea out of it.
- **Tooth ache:** 1. Make tea using salt water 2. Hold mixture in mouth over painful area, but do not swallow 3. Spit out mixture and repeat three times a day.
- **Body pains:** Chew on the bark, or make a tea out of it.
- **Heart Problems:** Chew on the bark, or make a tea out of it.
- **Constipation/enema:** Grind and mix with charcoal and a ¼ cup of water.

Use: Palm Wine:

A. Stem has a hole cut open in top section of the trunk.
B. After a few weeks, a fire is lit in the hole to start the flow of sap.
C. Fermented sap is collected and sold as palm wine**.**

Roots

The roots of a coconut palm are different from those of most palms. It does not have lateral roots or a taproot. Instead, the coconut palm has a fibrous root system. The roots are approximately 1 centimeter (0.39 in.) in diameter and can extend more than 10 meters. They are brown in color on the outside and white to light butter yellow on the inside.

Harvest: Dig up roots and cut roots out of the ground.

Uses: Medicinally: *Warning: these are listings of ailments that coconut root helps, based on **oral tradition** of coastal society in Ghana. The following listed medical uses are **not backed by scientific research**. The author does not recommend the use of coconut root to cure ailments and recommends seeking medical attention instead.*

- **Erectile Dysfunction:** This is the most well-known and common use for the coconut root. Taken by eating (cooked or as butter), drinking a coconut root tea, or adding a root to an alcoholic beverage.
- **Tooth Ache:** Make a salt tea with the root and hold it in mouth over toothache.
- **Stomach pain:** Make a tea.
- **Malaria:** Make a tea.
- **Fever:** Make a tea.
- **Hemorrhoid treatment:** Make coconut root butter, using just the roots, and rub butter on affected area.
- **Anti-inflammatory soap:** Add ground coconut root to a fresh batch of soap. Use the soap as a topical anti-inflammatory.
- **Asthma:** Make a tea.
- **Influenza:** Make a tea.
- **Joint pain:** Make a tea, or, rub coconut root butter, using just roots, on aching joints as a topical reliever.

Uses: Eat: **1.** Shave the root **2.** Fry root **3.** Add a teaspoon of lime juice **4.** Serve with other foods.

Uses: Make Butter: **1.** Shave the root **2.** Grind root into fine paste **3.** Continue adding more roots until desired amount of root butter is obtained. Note that mixture may also be combined with dairy butter.

Use: Fire: According to interviewees, the roots of a coconut palm burn unusually well, with an unusually high heat and long burn time.

Live, standing coconut palm

The coconut palm, as a whole, has additional value and uses. It does not necessarily need to be cut down.

Uses: **Erosion control:** The rooting system of a coconut palm can be over 10 meters in radius, 20 meter diameter, and is comprised of hundreds to thousands of one centimeter (0.39 in.) thick fibrous roots. This creates a very good source to hold soil in place and slow erosion. In addition, the decomposing dead fronds add top soil, and increase the water holding capacity of the soil.

Atmosphere: A scenic beach view is often characterized by the presence of coconut palms. Hotels and other tourist locations often plant coconut palms to increase the perceived aesthetic beauty of a location.

Shade: Used by locals and tourists alike to help escape from the hot sun.

Windbreak: A row or two of coconut palms can reduce the wind speed through an area. This is especially useful during stormy seasons to help protect houses, crops, and topsoil. A well-planted windbreak can help to reverse wind erosion in areas.

Boat mooring/Fish net anchor: Fishermen will often tie their boats and nets to coconut palms near the water. When pulling the nets in, a coconut palm is often used to supply a friction lock to prevent the net from being pulled back out.

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Meerow, A. W. and Broschat, T. K., 1993. Transplanting Palms. *University of Florida extension, Institute of Food and Agricultural Sciences*. 1-7

Appendix 2:

Additional Tables and Figures

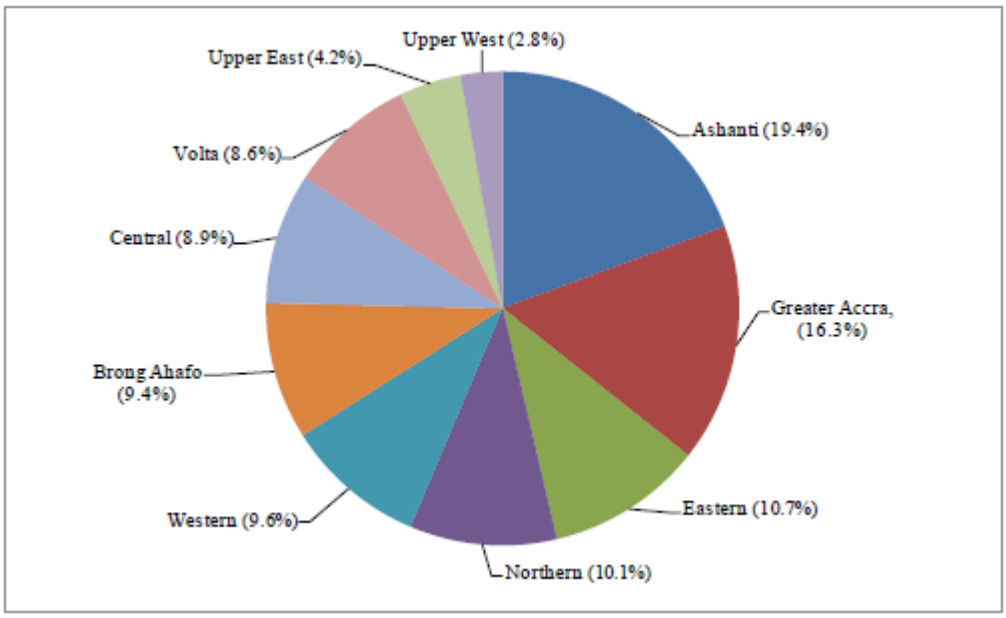

Figure 16: Population distribution of Ghana by region (Ghana Statistical Services, 2012).

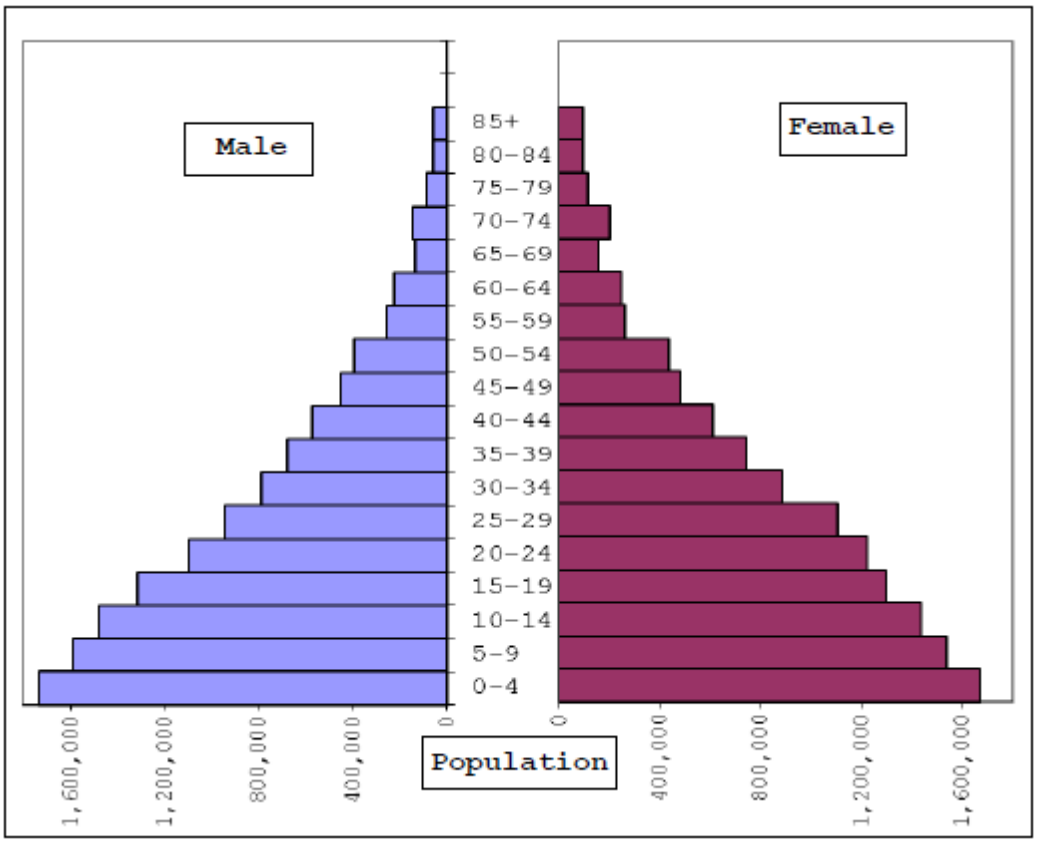

Figure 17:Age distribution in Ghana, by sex (Ghana Statistical Services, 2012).

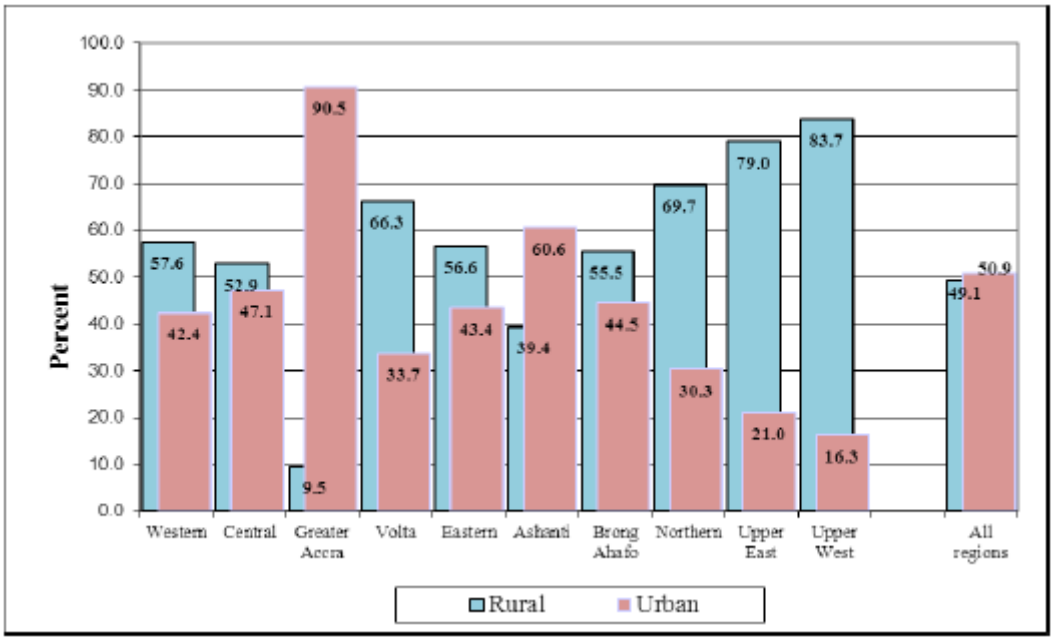

Figure 18: Rural and urban distribution of Ghana's population, by region (Ghana Statistical Services, 2012).