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DEPARTMENT OF HORTICULTURE

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EVALUATION OF SOME INDIGENOUS TREES FOR URBAN LANDSCAPE DESIGN:

A CASE STUDY OF THE KUMASI METROPOLIS IN THE ASHANTI REGION OF GHANA

NYANSAPƆ WↃSANE NO BADWENMA

BY

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MARCH, 2010

EVALUATION OF SOME INDIGENOUS TREES FOR URBAN LANDSCAPE DESIGN:
A CASE STUDY OF KUMASI METROPOLIS IN THE ASHANTI REGION OF GHANA

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A THESIS SUBMITTED TO THE SCHOOL OF RESEARCH AND GRADUATE STUDIES,

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BY

SAM SARKODIE MENSAH

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DECLARATION

I hereby declare that except for reference to other people's work which have been duly acknowledged, this write-up submitted to the School of Research and Graduate Studies, Kwame Nkrumah University of Science and Technology, Kumasi is the result of my own investigation and has not been presented for any degree elsewhere.

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DEDICATION

This thesis is specially dedicated to my wife Mrs. Georgina Sarkodie Mensah and the Department of Horticulture, Kwame Nkrumah University of Science and Technology, Kumasi, my academic birth place.

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ABSTRACT

Trees found in the local environment can be classified by their uses, water requirements, families and even origin. In terms of origin, there are basically indigenous and exotic species. Indigenous trees as those that arrived at their present environmental setting by natural means, for example water, animal, wind dispersal, without assistance of man. On the other hand, exotic trees are those that people brought from a place. Endemic trees, which are subsets of indigenous trees, are they are those that evolved in a certain location and are found only there. In practice, exotic and indigenous trees are planted in landscapes, but the indigenous, in general, are most appropriated for local environments, as compared to the exotics, because they have the advantage of being climatically suited and live in some degree of equilibrium with pest organisms such as insects and fungi.

Exotic trees such as *Cassia siamea* (Siamese Cassia), *Acacia auriculiformis* and *Polyalthia longifolia* (Weeping Willow) dominate the Ghanaian urban landscape. Looking at their form, colour and rate of growth, these plants from South East Asia, are high ornamental performance trees. Some of them are rightfully located, while others are not. Ghana has indigenous trees that are believed to comparatively measure to the standard of these exotic ornamental trees, but no conscious attempt has been made to select them for landscape applications as it has been the case with evaluation of indigenous trees for timber. This study sought to systematically select some indigenous trees of Ghana to fit into the urban setting by using Kumasi as the case study area. The methodology consisted of a baseline study of tree species populations in a purposively selected neighbourhood to establish the extent of dominance posed by exotic trees. Tree selection criteria were set for various urban landscape areas namely: street, residential, reserved, parklands and campuses. A database of the indigenous and exotic trees was prepared and sieved through the criteria to pick candidate trees for the various urban landscapes. Factors that were used to build the criteria were form, height, wood density, vegetation zone, conservation status, growth rate, stem base type and leaf fall behaviour.

The results were that some indigenous trees were selected for specific urban landscape areas in the Kumasi metropolis. For example, *Spathodea campanulata* and *Ekebergia capensis* were selected as potential trees for street use. Among the exotic trees captured

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from the baseline studies, some were found to be mislocated, even as others were accepted and retained for their present use. For example, *Cassis siamea* was rejected as nature reserve tree on the basis of conservation status, but retained as street and parkland tree,whilst *Cedrella odorata* was outrightly not accepted for any use because of its low wood density. Recommendations for the use of indigenous trees for landscape applications were made, for instance collection of data on young trees (similar to what is done for mature trees) to enable their use in comparatively short – lived projects such as strreets. Another vital recommendation set aside reserved lands for the preservation of threatened tree species. In addition, topics needing further research were presented, for example, shrubs that mature into small trees have to be investigated to fill tight street locations under utility lines. Further work on the selected trees concerning how they are going to adapt to urban conditions was also suggested. Lastly, additional work was proposed to test the atmospheric carbon dioxide reduction capacity of the selected tress for the purpose of reducing global warming.

CHAPTER ONE

1.0 INTRODUCTION

1.1 INTRODUCTION

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Trees are a familiar sight to most people, even in large cities, however a few people pause to consider how they became established, managed and the benefits they bestow on man. In reality people often take them for granted (Tree Council, 2007). The Tree Council (2007), also pointed out that choosing planting sites, selecting the trees and ensuring their survival are critical to the health of an urban tree population, as without trees the population will eventually decline. Among the most important conservation and amenity reasons for planting trees, in urban areas for example, are to improve landscape amenity, screen buildings, provide shelter in open areas, diversify wildlife habitats and to stabilise easily eroded soils (Tree Council, 2007).

Different sites constitute the urban environment, and may have different tree needs. The Tree Council (2007) gave categories of urban sites as roundabouts, traffic islands, housing estates, parks and open spaces, school grounds, nature reserves, hospital and industrial estates. Similarly, The World Forestry Centre (WFC) and Morgan (1993), in their Technical Guide to Urban and Community Forestry, gave a similar account by dividing urban landscape into four broad land use categories namely, natural reserves, parklands and campuses, residential property and streets and fragmented spaces.

Trees are found everywhere, either in urban or rural environments, and they can be indigenous or exotic. Trees such as *Casuarina equisetifolia* (Whistling Pine) and *Azadirachta indica* (Neem) have been listed by Abbiw (1995) as exotic trees, but because of some admirable characteristics, such as shape and colour, they have been introduced into other countries such as Ghana. Indigenous trees, as compared to exotic species are more ecologically adaptable, socially and culturally acceptable and though selecting indigenous plants to fit local landscape uses is a sound idea, it is a task that needs much effort, (WFC and Morgan, 1993). One of the most important aspects of urban forestry, they said, is selecting trees, and that thousands of indigenous trees are available but a few people know all of them and therefore stressed that finding the best species required research.

1.2 STATEMENT OF PROBLEM

Exotic trees, as a matter of fact, constitute a greater portion of amenity trees in Ghana (Abbiw, 1995). However, it is interesting to note that indigenous trees of Ghana may have comparatively desired characteristics but have not been thoroughly researched into for selection. Most of the indigenous tree selection or domestication in the tropics have been in the direction of agro forestry (Simons and Leakey, 2004: Moore, 2003; Hines and Eckman, 1993).

Exotic trees, which are indigenous trees elsewhere, dominate the Ghanaian urban environment while our local trees remain in the bush. Some of these introductions were made from pre –independence times (before 1957), resulting in introduced trees such as *Cassia siamea* (Siamese Cassia from Malaysia), *Polyalthia longifolia* (Weeping willow from India), and *Azadirachta indica* (Neem tree) from India. For instance, over fifty percent of trees in Kumasi (from homes, streets, parks and nature reserves) is made up of *Cassia siamea*, and in Accra, it is the Neem tree. The urban populace and commercial nurseries will continue using these trees as far as they are found useful. In addition, no attempt has been made to evaluate the landscape potential of indigenous trees of Ghana, as the foresters have done on wood properties for commercial timber production, (Oteng – Amoako 2006). Shamefully, local landscape designer and urban foresters have no choice but rely on these exotics for their projects. For example, a riverine conservation area (planted in 2003) from The Kumasi Officers' Mess to the Golden Tulip Hotel is generally planted to *Cassia siamea*. Such a cover will definitely attract less wildlife because it is foreign to the natural environment and it is a mono-culture. Furthermore, many of urban tree planting locations are not appropriate, in that spreading trees with aggressive roots are planted as streets trees and narrow-crown trees planted as park shade trees.

Though evaluation of landscape potential of the indigenous trees have not been carried out, attempts have been made by some organizations PROTA (2008); and individual foresters and botanists (Hawthorne and Gyakari, 2006; Oteng – Amoako, 2006; Quashie_Sam, et. al., 2004; Dokosi, 1998; Abbiw 1995; and Burkhill, 1995) to generally categorize local trees into various landscape uses, for example, shade, avenue, hedge and decorative purposes from ethno-botanical methods such as observation and user preferences. Though the works were impressive, they lacked the evaluation element (physical, ecological and growth characteristics) which enables one to select a tree to fit a particular part of the urban landscape. This is what this research seeks to fulfil.

1.3 MAIN AND SPECIFIC OBJECTIVES

The main objective of this study is to systematically select indigenous trees of Ghana for urban landscape design by:

a. Listing the identified indigenous trees of Ghana and documenting their special uses, value, physical characteristics, ecological needs and growth habits.

b. Categorizing the Ghanaian urban scene into specific landscape areas and setting criteria which would help in the selection of trees for them.

1.4 QUESTIONS TO BE ANSWERERED

a. What are the current exotic and indigenous tree populations and uses in Kumasi?

b. If the indigenous tree population is found to be on the low side, what indigenous trees have the potential to be evaluated, selected and added to the exotic stock for landscape applications in Ghana?

c. How would the evaluation process be carried out?

d. Where could the selected trees be planted in the urban environment?

e. Can the selected indigenous trees match up with the exotic species?

1.5 DEFINITION OF TERMS

a. Indigenous tree is one that was present in a defined area prior to European settlement. They were established by natural means (water, animal, wind dispersal) without assistance of man. The word indigenous is used interchangeably with native.

b. Endemic trees, a subset of indigenous trees, are those that evolve in a certain location and are found only there.

c. Exotic trees are those that people brought from one place to another. They are species of plants not naturally occurring, either presently or historically, in any ecosystem.

d. Urban is a non rural settlement, physically structured by roads and streets, residential and industrial sites, reserved sites, parks and campuses. Kumasi, for instance which is urban, is the second largest city in Ghana, located inland in the Ashanti Region of the country.

E Landscape design is the imaginative arrangement of landscape elements, such as trees, shrubs, grasses, pavement, structures or artefacts, water, wall and fences, to satisfy a useful purpose(s) such as a calm and beautiful streetscape, campuses designed to facilitate learning.

1.6 SCOPE

The scope covered the location of a study area, collection of indigenous tree species and their evaluation and selection for use in specific urban landscape sites.

Kumasi was chosen as the city for a case study for familiarity and effective data collection. In terms of physical development, Kumasi ranks second to Accra, the capital city of Ghana.

In the species collection, the study considered indigenous trees of Ghana that have been listed by PROTA (2009), Hawthorne and Gyakari (2006), Oteng-Amoako (2006), Abbiw (1995), and Burkhill (1990, 1991, 1995) to have amenity landscape uses and belonging to the semi-deciduous forest of Ghana in which Kumasi lies. .

Selection from the tree specie list was carried out by passing them through three main criteria, namely design, site and maintenance. The sub-criteria factors were

Physical (under design): form, height, wood density.

Ecological (under site): vegetation zone, conservation status.

Growth (under maintenance): growth rate, stem base, leaf fall.

Issues concerning pests and diseases, tolerance (drought, fire, pollutants) symbolic, medicinal uses and others were not considered. Reserve sites, parkland and campuses, residential property and streets were the urban landscape sites or classifications considered to receive the selected trees.

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1.7 JUSTIFICATION FOR THE STUDY.

Naturally, indigenous trees adapt better than exotic ones for climatic and edaphic reasons, and since these exotics are indigenous to some regions it would be prudent searching from within to domesticate the indigenous trees to add up to the exotic population and hence increase the range of choices. In so doing, biodiversity would be conserved and familiar habitats for urban wildlife would also be created. Streets and parks have most often been planted with inappropriate exotic trees, for instance, street trees with life threatening weak branches and aggressive roots that lift pavement.

Furthermore, Ghana cannot rely on exotic plants on a continuous basis because of cumbersome phyto-sanitary procedures, high cost of importation and uncertainties involved in the establishment of the plant material.

The Plant Resources of Tropical Africa, PROTA, (2008); Hawthorne and Gyakari, (2006). Oteng – Amoako, (2006); Abbiw, (1995); Burkhill, (1991, 1993, 1995) have laboured listing indigenous trees for landscaping but their basis of selection has been on observed and preferred uses from indigenous communities. What this study seeks to do would move Ghana a level up from the ethnobotanical basis of tree selection to critical evaluation and selection of trees to fit specific urban landscape areas such as streets, parks and reserved areas. Ghanaians would then have the joy and confidence of using scientifically evaluated indigenous trees.

The United States of America, Canada, some European nations and Australia have attempted and succeeded in developing tree selection criteria to get appropriate tree species for specific urban landscape uses, such as for home, street, industrial area and parks, through urban forestry development programmes, (Moore, 2008; Davies *et. al.* 2004 and Tree Council, 2007) which Ghana in its current position can also work on. The result of the study would reveal local trees with local and export potentials to broaden the commercial opportunities of local nurserymen. It would also generate interest in landscape research in the area of indigenous plants.

There are drawbacks which the country would face if the study is not carried out. Urban wildlife diversity would be narrowed. New towns and cities, such as Dodowa and Bui will be built and are likely to be planted with exotic trees and indigenous trees from ethnobotanical references thereby repeating old problems. Urban renewal schemes, expanding cities and towns would also at risk, because it will be the same variety of foreign trees with little or no social, symbolic and ecological attachment to people and wildlife of Ghana.

Landscape research interest in local plants would continue to be on the low side. We would continue to waste scarce foreign exchange in importing foreign plants into the country, and at the same time, local commercial nurseries will lack the opportunity to expand.

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1.8 RESOURCES AVAILABLE FOR THE RESEARCH

Resources available were Teaching and Research staff of the Department of Horticulture, KNUST, Faculty of Renewable Natural Resources (KNUST), Forest Research Institute of Ghana (FORIG). Additionally, library facilities in these institutions were used. The internet, another source global data, was also intensively used.

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CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 INTRODUCTIION

The literature for this study has been reviewed beginning from the use of indigenous trees and their capacity to be used as landscape materials, domestication of indigenous trees which comprises exploration and compilation of a potential list and finally evaluating and selecting candidate trees, for use, based on set criteria. The criteria have been grouped into general and location specific uses, for example street, residential and parkland.

2.2 INDIGENOUS TREES

Indigenous trees as those that arrived by natural means, for example by water, animal, wind dispersal, without assistance of man. Endemic trees, subset of indigenous trees, are those that evolve in a certain location and are found only there. On the other hand, exotic trees are those that people brought to a place. Use of indigenous trees promote biodiversity and creation of wildlife corridors while reinforcing a sense of place for attachment to nature. According to Kuhns (2009), indigenous plants in general, are most appropriate for local environments, as compared to the exotics, because they have the advantage of being climatically suited and live in some degree of equilibrium with pest organisms such as insects and fungi. The root of the usage of indigenous plants is in the renewed global interest in environment that has come about over the last several years. For example, plant-people (horticulturist, botanists, foresters, etc) in educational institutions, nurseries, garden centres, and horticultural societies are also advocating the use of locally-adapted indigenous plants. This idea was upheld by Florida Department of Transportation (1998) in its plant material selection for highway landscaping.

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Apart from these advantages, it is interesting to know that debate about the use of indigenous or exotic trees in landscape applications still goes on. Moore (2003) wrote, passions and emotions run high when choices have to be made about selection for prominent public open spaces and streetscapes. Davies *et al*. (2004) also wrote that whilst the use of indigenous species may be the most appropriate for local environmental conditions, the growing conditions within the urban environment are often very different, because of disturbed soil profiles, compaction, altered drainage patterns and paved surfaces. This seemingly difficult urban environmental difficulties were also echoed by Moore (2003) that it has been difficult to justify the choice of indigenous species for difficult urban situations because there is relatively little scientific information about their likely performance. The Australian indigenous plants are known to be ecologically responsive but how they would perform against horticultural criteria in adverse urban environments was unknown. Clearly there is a broad pallet of indigenous species from which to choose, but research work on their horticulture and arboriculture in an urban context must underpin the choice. To buttress his point, Moore (2003) continued that, many of the indigenous plantings of species as Blue Gums (*Eucalyptus globulus*), Paper

Barks (*Melaleuca sp*.), Grevilleas (*Grevillea robusta*) and even Bottle Brushes (*Callistemon sp.*) that were undertaken in the 1970s in Australia had failed consequently tainting the reputation of indigenous trees for urban use.

Similarly, the U.K. Tree Council (2007) revealed that less than one third of 30 indigenous trees or so, have been proven to fare well in the inhospitable conditions provided by urban environments such as compacted and arid soils, atmospheric pollution and hot microclimates and therefore advised that when considering trees for urban sites one should look towards the huge range of non-indigenous trees as well. Moore (2003), again indicated that some adaptations have to be done to accept indigenous trees, into the urban environment, since they have evolved for thousands of years and have adapted to environmental regimes of floods, fires, droughts, wind, soil conditions and pests and diseases in the wild; he further argued that it is the responsibility of professional plant managers to identify these adaptations, understand their implications and use them in the selection and maintenance of indigenous trees in the urban environment.

Moore (2003), also listed some of the adaptations that Australian indigenous trees have to meet in the urban area as, flooding tolerance, capacities to withstand lengthy periods of water logging and high tolerance to grazing and especially from insect infestation. The rest were protective bark, capacity to cope with nutrient deficient soils and high levels of stomatal control and water regulation.

He stated however, that many of the adaptations that Australian indigenous tree species possess or are assumed to have, do not necessarily benefit their growth and persistence in urban environment.

In Ghana, indigenous trees have not been "scientifically" selected and adaptations tested, but attempts have been made by organizations such as PROTA, (2008) and individuals such as Hawthorne and Gyakari (2006), Oteng – Amoako (2006) and others to compile indigenous tree uses from ethno-botanic sources to have landscape applications such as specimen, avenue, shade and fruit (see appendix 1).

There is sufficient research and knowledge available now to indicate future directions in tree selections and breeding after the compilation of indigenous species. The selection approach according to Roshetko and Verbist (2000) and others including World Forestry Centre (WFC) and Morgan (1993) is that, the indigenous trees themselves would have to be scientifically assembled and evaluated. This is, in fact, a tree domestication process.

2.3 TREE DOMESTICATION PROCESS

Domestication is simply, the adaptation of an animal or plant through breeding in captivity to a life intimately associated with and advantageous to humans (Britanica Concise Encyclopedia, 2008). There are many definitions of this term and references point to the same description or meaning as the process whereby a population of animals or plants become accustomed to human provision and control for a wide range of reasons, for example with respect to plants, to enjoy as ornamentals (Britanica Concise Encyclopedia, 2008).

Domestication of trees for ornamental purposes can be carried out from wild trees, timber trees or other used trees outside the sphere of landscape development. It is not a one activity but chain of them, and according to Roshetko and Verbist (2002), tree domestication includes a range of many activities, namely exploration and collection of natural populations, evaluation and selection of suitable species, developing propagation techniques, multiplication and dissemination of germplasm. The other activities, they continued, are development of management techniques, utilization and tree-product market, and lastly, development and dissemination of relevant technical information.

The domestication process can best be described as an iterative continuum of closely related activities (Fig. 2.1).

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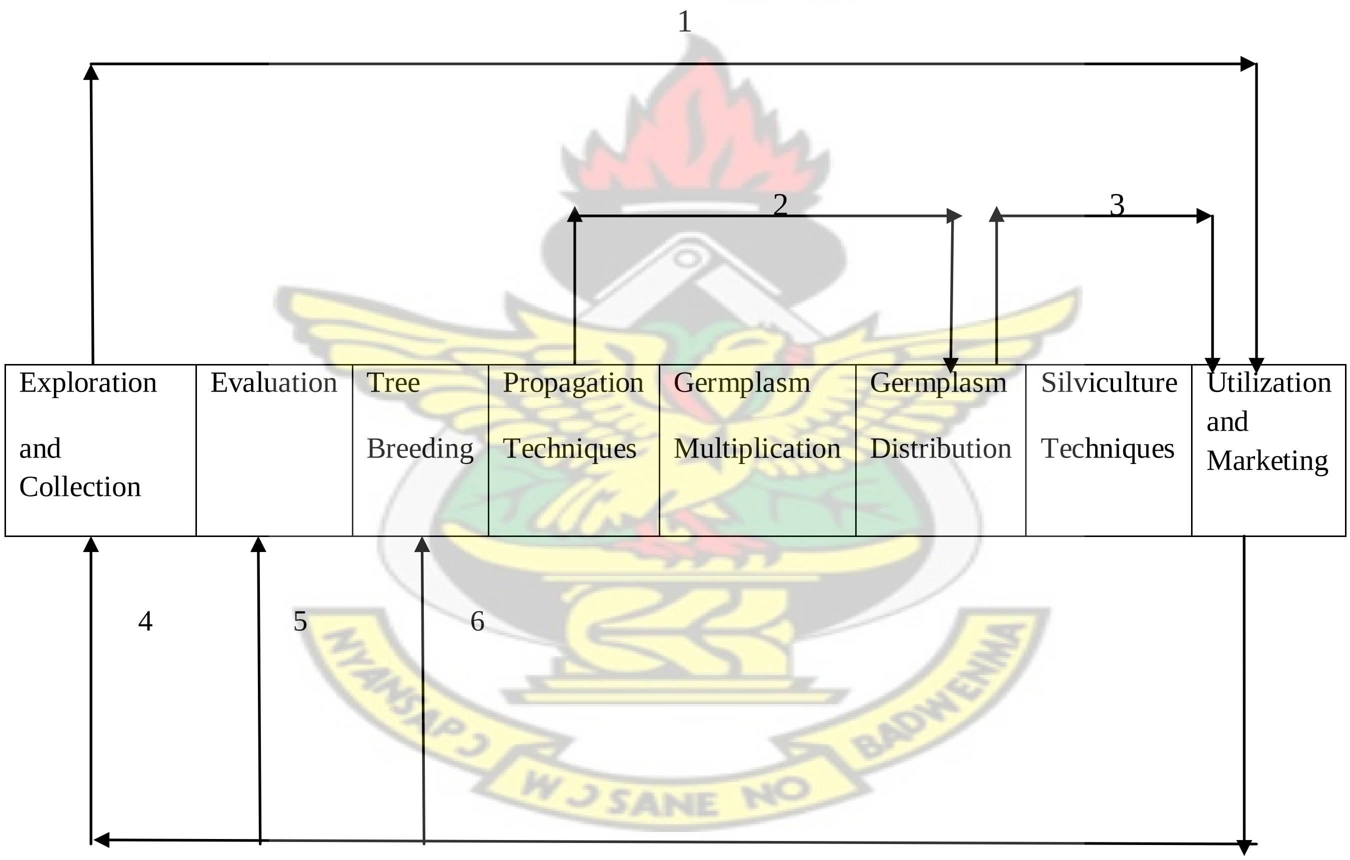

Figure 2.1 Tree Domestication Continuum

Source : Roshetko and Verbist (2000)

The activities within the domestication continuum, according to Roshetko and Verbist (2000) represent a general progression from the wild to generally transformed state.

However, the domestication of any given species will not necessarily follow a sequential flow from, left to right, they pointed out. Thus, some steps (activities) in the continuum may be by-passed during the domestication process and similarly progress may flow back to earlier steps in the continuum as interest in or the value of a species develops further. Other related definitions of domestication include work done by Akinnifesi *et al.*(2002) in domesticating priority Miombo indigenous fruit trees as a promising livelihood for small-holder farmers in South Africa. In their approach, tree domestication was defined in four basic steps:

1. Identification of priority species by communities and other users
2. Participatory selection of superior trees and naming them in situ
3. Propagation and cultivation of trees as fruit orchards and
4. Dissemination and adoption.

Lastly, on the part of Akinnifesi *et al.* (2007) who used a farm community driven called participatory domestication approach, the steps involved;

1. Selection of priority indigenous fruit tree species based on farmers' preferences and market orientation.
2. Identification of superior or elite trees based on established criteria by users, marketers and market preference through tagging and naming of the trees.
3. Development and application of efficient vegetative propagation and nursery management techniques for producing quality propagules for on-farm dissemination.
4. Integration of improved germplasm into farming systems; and

5. Post-harvest handling, processing and marketing research of fresh and processed products from domesticated species.

To begin with the process of domestication as Roshetko and Verbist (2002) wrote, tree exploration and collection of natural populations need to be considered first.

2.3.1. Exploration and collection of natural populations

In their approach, the World Forestry Centre (WFC) and Morgan (1993) suggested that exploring indigenous trees for selection should begin with an extensive list of trees which would be sifted to get rid of unwanted materials. This is done by passing them through three levels sieves namely site, design and maintenance considerations.

Indigenous trees of Ghana are numerous and have been collected and described by many sources as Plant Resources of Tropical Africa (PROTA, 2008), Oteng-Amoako, (2006), Burkhill, (1995) and Abbiw, (1995). Examples of the trees are *Afzelia africana* (Papao), *Albizia adianthifolia* (Pampena), *Albizia ferruginea* (Awiemfo-samena), *Albizia zygia* (Okoro), *and Allanblackia floribunda* (Sonkyi). Some occur in many agro-ecological zones (wide ecological amplitude) while others are located in a few (narrow ecological amplitude).

Having explored and collected natural populations from the indigenous plants according to Roshetko and Verbist (2000), the next domesticating activity is evaluation and selection of suitable species. This selection approach is carried in stages, first generally selecting significant or superior tree and secondly selecting trees from the superior tree list to meet specific uses in the urban landscape for example street, residential, reserve and parkland. Even, within the specific selection, as WFC and Morgan(1993), came up with, the trees would be sieved by the site conditions they are to meet, design consideration and maintenance requirements they should satisfy for their chosen location in the urban landscape. These sieves are embodied in a criteria set for the process.

2.3.2 Evaluation and Selection of Suitable Species

Evaluation and selection activities as found from literature, have generally been carried out by private firms, research units and Departments such as Forestry and Public Works. There has been attempts to be general in the selection whilst others have been specific setting performance criteria to select trees for specific uses in the urban environment. All these attempts have most often been on the physical and ecological characteristics of form, height, wood density, conservation status, rate of growth and leaf fall behaviour. How the selected tree would respond to the site selected for it hinges on another level of assessment called adaptation to withstand pest and disease, drought, flooding, compact soils and air pollutants (Moore,2003).

2.3.2.1 General Selection

The general selection approach involves making lose and non-specific considerations to assemble potential species as pre-selection exercise (Moore, 2003). This looked at characteristics used in early tree selection and breeding programmes (Table 2.1).

Table 2.1 General aspects for selecting trees.

CHARACTERISTIC	ASPECT FOR SELECTION
Inherent Characteristics	Growth habit and size
	Leaves , flowers, fruit and bark
Rate of Growth	Fast growing
	Slow growing
Wood Strength	Capacity to withstand wind and storm events
Rooting	Root architecture
	Likelihood of root damage to hard landscape
Environmental Adaptations	Climatic adaptations
	Edaphic adaptations
	Water relations – drought, water logging
Pest/Disease Resistance	Selection for pest resistance
	Selection for disease resistance
Stress Resistance	Tolerance of winds and storm events
	Tolerance of pollutants
Longevity	Longer life spans under urban conditions

Source: Moore (2003)

In a related selection activity in agroforestry of indigenous multipurpose trees of Tanzania, Hines & Eckman (1993), used species selection questionnaire data, in villages and markets with seasonal calendar. In the Species Data uestionnaire the Name (Latin, common and local) Species Status (indigenous, introduced), Distribution (local, widespread, threatened) Dendrology (striking characteristics), Technical Feasibility (site's climate, soil resistance to fire, drought, pest and diseases) and Methods of Propagation were considered.

For the villages the community's tree preferences were investigated by looking at predominant trees planted at home, pasture, woodlot, road, fallow land, forests and boundaries. It probed the planters of the trees, for example the respondent, parents, grand parents and even gender balance. The market survey looked at the species, its product, season, and prices; the seasonal calendar compared harvest to the seasons and seasonal market prices.

2.3.3.2 Specific Selection

There are two similar approaches here in the specific tree selection. The first has to do with the urban landscape area itself where the tree is being assigned to. The area for example, street, residential, or reserved land, has its own setting and requirements which have to be satisfied (WFC and Morgan, 1993).

The other approach is the sieving , which WFC and Morgan (1993), stressed that potential trees pass through site, design and maintenance considerations (called the sieves) for selection and use in a particular area.

(a) **Selecting trees by the landscape area setting and requirements.** The urban landscape can be divided into four broad land use categories: streets, residential property, reserved areas, parklands and campuses (WFC and Morgan, 1993). These categories are based primarily on activities that take place in them and the mood created by those activities.

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(i) **Streets** have the greatest variety from the streets of the urban core to wide open areas around suburban streets (WFC and Morgan, 1993). Between these extremes are streets and boulevards in residential, industrial or commercial areas. Fragmented open space also fall under this and they include parking lot islands and narrow planting strips around parking lots or next to buildings (WFC and Morgan, 1993). Fragmented areas and streets, in fact, fall into the same category, because plant selection criteria and environmental conditions are similar. In these areas, available space is restricted and the land is divided into small pieces. Urban rooftop gardens where plants must be grown in containers offers an extreme example (WFC and Morgan,1993). They advised, when selecting plants for this spatially restricted spaces one must remember that it is essentially a symbolic forest and also the most visible part of the urban forest, and the largest part in public ownership. Rather than designing a natural forest, the urban street tree manager chooses plants that will bear the burden of this symbolism under the most stressful of the urban environments (WFC and Morgan, 1993).

In addition to the above, others go a little further in street master plans to pin-point particular requirements, for example in the Culver City Street Tree Master Plan (Culver City Council,2002). The Council approved the Street Tree Master Plan (STMP), which designated tree species for public street parkways and medians in the City. The intent in the STMP was to foster coherent and sustainable tree plantings, through the use of drought-tolerant species, that have low maintenance needs. The tree species in the STMP were those with the fewest faults that typically caused negative impacts to the community. The trees are expected to have long lives and retain their attractiveness into their maturity. The trees were also reasonably free of insect infestation, and typically had less aggressive and invasive deep-root systems in order to reduce the potential for negatively impacting sewer lines, sidewalks, curb and gutters, and streets (Culver City Council,2002).

(ii) **Residential Property** comprises a very large portion of most urban environments. In these areas small parcels are typically under the private ownership of different people. Several issues grow out of this pattern of ownership .
Buildings divide the open space into small, tight fragments. The visual character and the level of maintenance vary dramatically from properties with a relatively "natural" appearance to those that are manicured and open (WFC and Morgan,1993). The intensity of uses include passive visual appreciation, active recreation and even storage of personal possessions. There may not be a

consistent pattern of open space. In some cases, buildings and paved surfaces occupy most of a lot, while on others, they cover only a small portion of the total area(WFC and Morgan,1993). Because of the diversity found in residential areas, they suggested that, planting guidelines should be general rather than specific.

Among the diverse uses of ornamental trees are specimen, screen and boundary trees and shade trees which can be explained.

Specimen tree is a tree placed so people can gain the greatest enjoyment for the colour, texture, scent, or other pleasures it provides (Anon,2009). The definition of a specimen tree varies. Some consider especially old trees as specimen trees, others believe that trees with exceptional beauty are the ones that stand out as specimen trees (Anon,2009) and still others will only consider trees that have reached a certain height (Anon,2009). Trees used as screen, hedge, windbreak, sound barrier, snow or border demarcation are collectively called working trees (Anon,2009). These trees are especially selected for their fast growth rates. Their forms, sizes and canopy densities are critical to the barrier performance. The screen tree blocks visual access or intrusion, while the boundary tree, in the home environment, has to neatly demarcate property lines (Anon,2009). In addition to being evergreen and fast growing, screen and boundary trees need not have spreading canopies and roots because of the restricted border line spaces they may occupy in order not to generate controversy with a neighbour (Anon,2009)

In British garden law, a tree or shrub belongs to the owner of the land on which it grows even if its branches or roots go over or under adjoining land. This includes the branches and the fruit of any tree or shrub. This even applies to windfall apples etc. The Theft Act 1968 makes it a criminal offence to take wild flowers, fruit and foliage from any plant if it is sold for commercial gain (Anon, 2009). However, falling leaves and fruit still belong to the owner of the tree or shrub, the law does not require the owner to come and sweep up the leaves or pick up the fruit. Having said that if falling leaves block a gutter, which results in water damage, the owner of the tree could be sued for damage, (Anon, 2009).

A shade tree is one planted or valued chiefly for its shade from sunlight It is any tree grown specifically for its shade (Rodekohr and Harris, 1990). This term, they said, usually applies to large trees with spreading canopies. Shade trees are effective in reducing the energy used in cooling homes (Rodekohr and Harris, 1990). Any tree can make an impact on a landscape but a large shade tree can be truly dramatic. In addition to their beauty, Rodekohr and Harris (1990) continued that shade trees have practical benefits as well. They reduce heating and cooling costs both indoors and out by reducing electricity usage energy costs could be reduced by 25 percent. They drop summer temperatures under their canopies by up to 10 degrees, reduce heat reflected from paved areas, attract and sustain wildlife, convert carbon dioxide to oxygen and attract and sustain wildlife (Rodekohr and Harris,1990) They ended by noting that growth rate need not to be slow so that the grower or homeowners can enjoy the benefits in their lifetime.

Rodekohr and Harris (1990) in selecting shade tree used the table below to capture data including width of spread and growth rate.

Table 2.2 Factors considered in selecting shade trees

Common Name	Botanic Name	Height (m)	Width (m)	Form	Growth Rate	Use in landscape
Red Maple	*Acer rubnum*	12-18	7-15	Upright to round	Medium to fast	Specimen, street
Sugar Maple	*Acer sacchanum*	12-21	15-18	Upright to oval	Slow to medium	Specimen, street, residential
River Birch	*Buitia nigra*	9-15	9-15	Upright oval, round	Medium to fast	Specimen, residential
European White Birch	*Betula pendula*	7-12	3-5	Oval, graceful pendulous	Medium	Good for narrow spaces, specimen

Source: Rodekohr and Harris (1990)

On the local scene in Ghana, such requirements for shade trees in the above table for example, quick growing and round form apply, giving Plate 2.1 in KNUST as an example.

Plate 2.1 Quick growing, round, indigenous *Milletia thonningii* shade tree on KNUST Campus in Kumasi, Ghana

(iii) **Reserved areas** are relatively protected and undisturbed. The typical urban resident also considers them to be "natural," because of their size and location. These areas tend to occupy land considered unbuildable due to poor accessibility, rugged topography, poor soil, or inappropriate hydrology. They are frequently linear, such as ravines, stream corridors and steep slopes. Other types of natural areas in this category may include: "greenbelts," flood plains, wetlands, ponds, waste areas, abandoned land and "buffer zones" around undesirable land uses, such as land fills WFC and Morgan (1993).

The creation of protected forest area may fulfill two main motivations, which are to protect key sites such as valleys, green belts, ravines, for the conservation of rare or threatened species and habitats and to restore the state of naturalness typical of unspoilt woodlands (WFC and Morgan, 1993). Ravines, as one of the protected sites, are an important feature in the landscape, providing spectacular views and corridors of wildlife habitat. They convey and provide storage of storm water and they serve many important ecological functions. The Ravine By-law protects trees and the ravine landform. The trees offer habitat and protection against erosion (WFC and Morgan,1993)

WFC and Morgan (1993) noted vegetation on ravine slopes are critical for preventing surface erosion of soil. Changes to grade and removal of vegetation on slopes or at the base of slopes may undermine slope stability. Vegetation in ravines provides habitat food sources and safe corridors for wildlife, particularly migratory birds. They ended by saying that well-vegetated ravines contribute to reducing storm flows whereas loss of vegetation or changes in grade can alter the pathways and volumes of storm water to the ravine, which may result in increased erosion and or flooding.

Activities occurring in reserve areas range from casual recreation to no activity at all. Increasingly, these areas are seen as valuable components of the urban environment, because of their aesthetic qualities, their symbolic value as reminders of the natural environment and their value as critical natural habitat. (WFC and Morgan, 1993) Coherent management policies for these types of areas have rarely been developed. They typically receive little or no maintenance, and are left to their own devices. They have almost always been disturbed by human activities at some point in their history and in most cases, these areas are in some stage of plant succession with various tree forms and strata.

To select trees for these areas, WFC and Morgan (1993) recommended indigenous trees that enhance or maintain the feeling of a "natural" environment to preserve an "uncontrolled" appearance. This naturalness, Bruquart (2009), in his selection criteria for protected forest areas, defined as unspoilt woodlands characterized by a lot of rare and threatened species.

Plate 2.2 Less diverse collection of *Cassia siamea* and *Acacia auriculiformis* put together as reserve vegetation.

(iv) **Parklands and campuses** include traditional parks that host recreational activities, community open space in planned residential developments, freeway interchanges, as well as business and industrial areas with a campus-like atmosphere (WFC and Morgan,1993). These developments are normally large, with a high percentage of open space to paved or built-up areas. They typically contain large lawns and clearly defined beds of flowers or shrubs. Trees are planted as individuals, groves or small woodlands. Although they usually receive relatively high levels of maintenance, some people consider their character to be "natural" (WFC and Morgan,1993). They ended by saying this feeling may grow from traditional landscape maintenance techniques and "naturalistic" plant arrangements (WFC and Morgan,1993).

These areas are intensively used. Even as a campus of industrial or commercial buildings, the landscape may simply be an area viewed by workers and visitors- but rarely entered. If it is only looking out an office window, these people are using the outdoor areas and benefitting from the presence of well-maintained trees and lawns. So, observation represents a high level of "use" (WFC and Morgan,1993). Attitudes toward these areas may be changing, prompting a change of management as measures are sometimes taken to reduce maintenance costs, encourage wildlife habitat or allow for a wider variety of uses to occur within these campus areas (WFC and Morgan,1993). The long term implications of these trends must be considered when trees are selected because cost of maintenance relate to low leaf fall, less root and buttress aggression and dense wood.

Plate 2.3 A parkland of low maintenance *Milletia thonningii and Cassia siamea* on KNUST campus environment.

Plate 2.4 A parkland of low maintenance *Azardirachta indica, Acacia auriculiformis Milletia thonningii* in Kumasi Royal Golf Course, Danyame.

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(b) Selecting trees by the use of strict sieve criteria.

Tree selection is among the most challenging activities of urban landscape practitioners. Thousands of species are available, but few people know all of them. Furthermore, objective information on long-term maintenance requirements and other potential problems is not readily available (WFC and Morgan, 1993). Although it may be tempting to choose species that appear frequently in the landscape, popularity should not determine suitability for urban use. In deed, many desirable trees that require minimal maintenance seldom find their way into the urban landscape and may not be even available from nurseries (WFC and Morgan, 1993). . As such, finding the best trees species they pointed out, requires research. Some research activities have been made and selection considerations, though varied but similar have been used.

(i) **site considerations** for selecting plants are embodied in the ecology of the site which is considered important to many tree selection workers. The ecology involves site-tree relationships in which the site influences tree growth and performance and vice-versa. Site considerations of interest to urban landscape are the site's agro-ecological zone (vegetation zone), soil moisture, volume and nutrient status (WFC and Morgan, 1993). Others, they continued, are soil improvement ability of the tree, its conservation status and wildlife influence. The rest include flower smell and season, ecological indicators, tolerance levels.

- **Vegetation zones :** All plants belong to vegetation zones which can be described as ecological units characterized by factors such as climate (mainly rainfall, temperature) soil(texture, pH and moisture), and landform (valley, plain, steep slopes). Critical among these is rainfall,

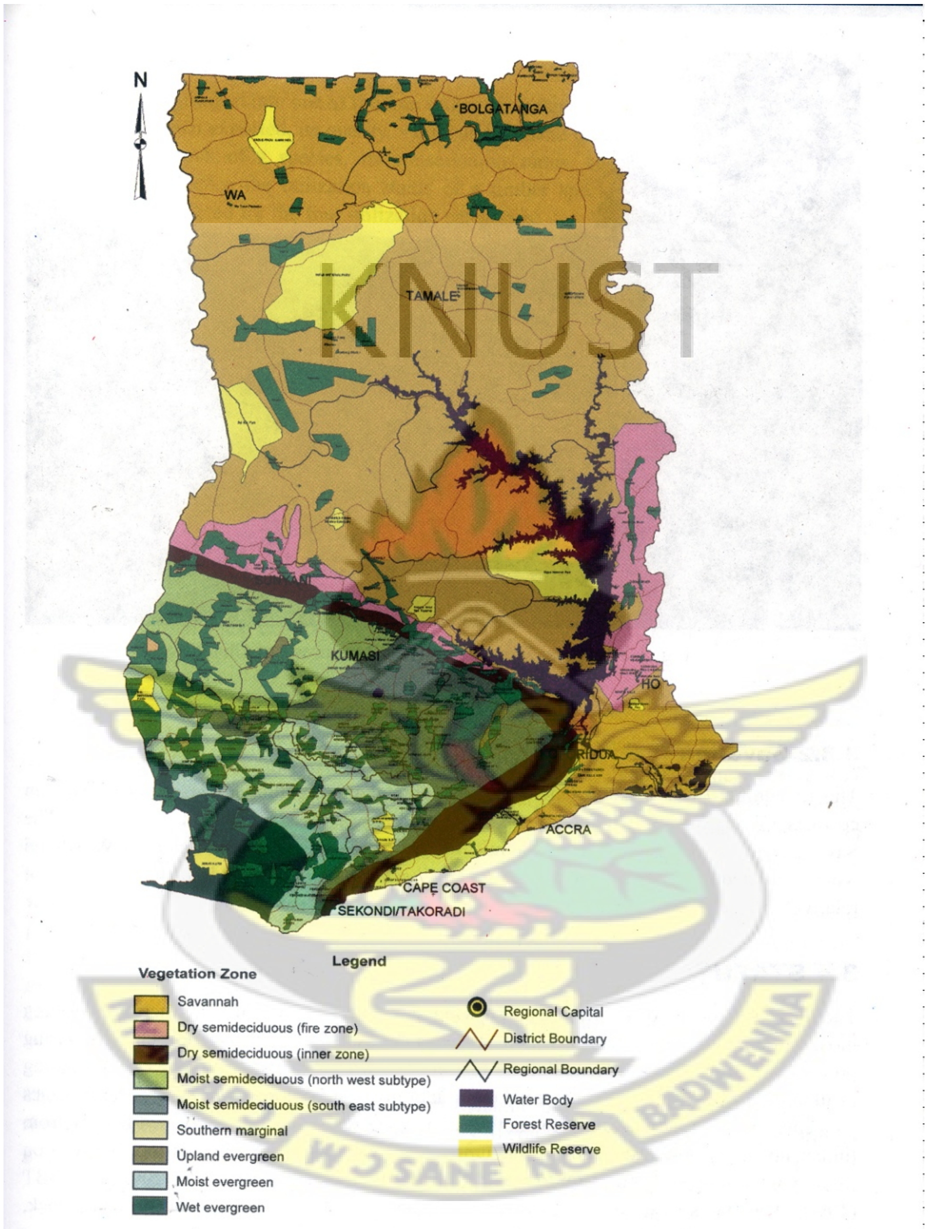

Figure 2.2 Vegetation Map of Ghana showing the distribution of species in the two major forest types of Evergreen and Semi-deciduous forests, and in the Savanna Woodland of Ghana.

(source: Cartographic Unit, Forestry Commission, Ghana (Oteng-Amoako, 2006) which has demarcated Ghana into rainforest and savanna vegetation zones, (Oteng-Amoako, 2006). Ghana has two main vegetation types: Tropical High Forest and Savanna. The High Forest originally accounted for about a third or 8 million hectares of the land area of 23.85 million hectares; the Transition Zone is about 1.1 million hectares and 14.7 million hectares for the Savanna. The following description on Tropical High Forest of Ghana includes the Transition Zone, and is based on Hall and Swaine (Oteng-Amoako, 2006).

Some trees are found only in a particular vegetation zone, eg. *Cynometra ananta* (Ananta) in the evergreen forest of Ghana; while others thrive in so many of them and are described as having wide ecological amplitude for example, *Voacanga Africana* (Voacanga), and *Calenchoba gilgiana* (Asratoa) are found from the evergreen, semi-deciduous and savanna zones of Ghana (PROTA, 2008). Cities by their nature have multiple ecological zones, some dry, wet, humid, and in such situations plant selection favours those species which have wide ecological amplitude.

- **Tropical rain forest** consists of the evergreen forest in the South-West corner of Ghana with annual precipitation of not less than 1750 mm and covers about 30 % of the original forest land (Fig. 2.2). This forest is characterized by predominantly evergreen trees growing on acidic leached oxysol soil. The evergreen forest is floristically very rich, contains few valuable evergreen timber trees usually with heights between 35 and 50 m, and are relatively shorter than trees of Moist Semi-deciduous forest. This forest is further subdivided into Wet and Moist Evergreen forests (Fig.2.1).

The Wet Evergreen at the extreme south-western part of Ghana with annual precipitation of over 2000 mm covers 8.1 % of the original forest land. It is surrounded by the Moist Evergreen which covers 21.9 % of the forest land with annual precipitation between 1750 and 2000 mm. The remaining 70 % of the original forest land is Semi-deciduous forest, characterized by ochrosols soils with annual precipitation range of 1250 to 1750 mm (Oteng-Amoako, 2006).

- **Semi - deciduous forest** as fully explained by Oteng-Amoako (2006) here contains many deciduous tall timber trees of economic importance, and is further subdivided into Moist and Dry Semi-deciduous forests. The Moist Semi-deciduous forest which surrounds the Moist Evergreen forest, covers about 43.4 % of the forest area with precipitation range from 1500 to 1750 mm. This is further divided into South-East and North-West subtypes and has the highest frequency of premium and commercial timber species usually with tree heights exceeding 50 m (Figure 2.2). The Dry Semi-deciduous forest, which covers about 26.4 % of forest land with annual precipitation range from 1200 to 1500 mm, extends over wider range of environmental conditions with tallest timber trees between 30 and 45 m in height. It forms a peripheral band around the Moist Semi-deciduous forest, and is adjacent in the north to the Savanna Woodland. This forest type is also subdivided into the Fire zone of the North-West and the Inner zone of South-East. Other minor forest types exist, but they contain very few economic trees.

- **Savanna** The remaining 75 % of total land area with annual precipitation of less than 1200 mm consists of Savanna Woodland to the south and Low Grass Savanna to the north. The Savanna zone has virtually no economic timber trees, except in the Savanna Woodland where isolated economic timber trees like *Khaya senegalensis* and *Anogeissus* spp. of relatively short heights are found. Indigenous communities in the various vegetation zones of Ghana have for centuries selected and used the indigenous trees for landscape purposes and writers, foresters and botanist in Ghana have been able to compile them in books and other storage media from these ethno-botanical sources (Oteng-Amoako, 2006)..

- **Conservation status** issue arises when populations of species begin to dwindle to a point where the species existence become threatened. In Ghana, according to Hawthorne (1993), tree populations are being reduced by fire, farming and notoriously by commercial timber extraction. Oteng-Amoako (2006) also cited commercial timber production as the greatest threat to biodiversity of tree species in Ghana. Hawthorne and Abu-Juam (1995) concluded in their book that timber extraction has destroyed part of the reserve and off-reserve forests such that 40 to 50% of the reserve forest is considered to be "mostly degraded" while about 25 to 30% has no forest at all. Timber growing stock is affected by forest depletion and Oteng-Amoako (2006) estimated the cost of forest depletion to be nearly 323 million US dollars a year including loss of economic timber species. To forestall the problem of forest destruction, control" creaming" of economic timber species, and conserve biodiversity of the remaining timber species the Convention on International Trade in Endangered Species (CITES) Oteng-Amoako 2006) evaluated 255 timber species worldwide and tagged 13 of them in Ghana.

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Similar to global attempts to control global warming, there are measures to conserve species that are being lost by,

i) conservation status tagging

ii) limited logging

iii) protected reserve area (forest reserve, nature reserve, selected reserve site in the city, national park).

- **Conservation Status Tagging** is a system of classification to assign a conservation designation to a tree species either under threat or not. The International Union of Conservation of Nature (IUCN), Star Classification and Convention on International Trade in Endangered Species (CITES) have well-known classification systems on threatened species.

  According to Hawthorne (1993) various categories of conservation priorities have been designated in different contexts, but the most widely adopted is that of International Union of Conservation of Nature (IUCN) Red data book (Table 2.3).

Table 2.3 IUCN Conservation Status Rating.

1) Extinct: No longer known to exist in the wild after repeated searches of known and other likely localities. 2) Endangered: Taxa in danger of extinction under current circumstances, including taxa whose numbers or habitats have been reduced to a level judged to be critical. 3) Vulnerable: Taxa that could move into the endangered level soon under current circumstances, including over-exploited species and abundant species with adverse factors throughout their range. 4) Rare: Small world populations, but not 1) – 3), and restricted to geographic areas or habitats, or thinly scattered over a more extensive range. Rare species are not seriously under threat from their current circumstances. Such species are endangered or vulnerable. 5) Indeterminate: one of above categories, but poorly known. 6) Insufficiently known: suspected to be one of categories 1)- 4) above, but little known. This category includes species whose taxonomy is not well-defined. 7) Out of danger. Taxa previously in one of above categories, but now adequately protected 20,000 individuals is a guide to the population size below which a species is rare.

Source: Hawthorne (1993)

Oteng-Amoako (2006) quoted the IUCN Red List of Threatened Species in a another way and explained as follows.

Critically Endangered (CE): Threatened species which face extremely high risk of extinction or are critically endangered in the wild in the near future.

Endangered (E): Threatened species which are not critically endangered, but face very high risk of extinction in the wild soon. The species in the group are recommended for complete ban on exploitation to avoid their eminent extinction. Two indigenous species, *Pericopsis elata* and *Tieghemella heckelli,* belong to this category.

Vulnerable (V): Threatened species that are not endangered, but are facing a high risk of extinction in the wild in the medium–term future. They are recommended for strict exploitation controls to avoid overexploitation and ensure their future sustainability. Oteng-Amoako (2006) identified twenty four species as vulnerable, two of which are *Afzelia africana* and *Anopsis klaineana*

Lower Risk Near Threatened (LRNT): Species are not threatened, but are close to be qualified as vulnerable. They are recommended for some form of exploitation controls to avoid overhauling which could lead to vulnerable status. Twenty two have been identified by Oteng-Amoako (2006) and examples are *Albizia adianthifolia* and *Tetrapleura tetraptera.*

Lower Risk Least Concern (LRNT): species are not in any way threatened. Exploitation of the species is recommended with no restriction other than the normal sustainable harvesting practice. Examples are *Irvingea gabonense and Parkia bicolor.*

In another approach too, Hawthorne and Abu-Juam (1995) used a “star” conservation grouping to rank plants including over 600 tree species in Ghana’s forest. Their rating was based on local and global distribution as well as on ecological, commercial social and taxonomic considerations.

The star ratings are Black, Gold, Red, Blue, and Green in order of decreasing conservation priority (Hawthorne, 1993). Green star species are of no particular conservation concern. In addition fairly common or widespread species that would otherwise be allocated but which are heavily exploited or show exceptional economic potential in Ghana are listed as Reddish star (i.e. Scarlet, Red, and Pink) species. Where exploited species have an otherwise high conservation rating they are allocated Black or gold stars as appropriate (Hawthorne, 1993).

The primary factor used in the classification is rarity. A judgement is made based on rarity of the plant in Ghana and rarity internationally. Only species rare on both scales can score Black star, although rarity on either scale can contribute to a Gold or Blue star. Hawthorne (1993) listed the star rated species and some of which are *Cola umbratili* (Black Star), *Mansonia altissima* and *Mammea africana* (Pink star), Afzelia Africana and *Lovoa trichiliodes* (Red star), *Garcinia cola* and *Milicia excels* (Scarlet star)

(ii) Design considerations

Design considerations of trees relate to mainly physical characteristics such as fruiting, leaf and root habits but prominent among them are those that manifest in size, form (shape) colour and texture. Relf (2008) listed design characteristics as aesthetics, fruiting habit, shade, form and tree form accommodating traffic. Saebo *et al.*. (2003) supported the above with considerations of form and aesthetic factors.

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Similarly, but on a higher side, Thompson and Turner (2008), Seattle Department of Transport (SDOT) (2008) and the Tree Council of UK (2007) categorized design characteristics into leaf, fruit and flower characteristics and tree characteristics such as maximum height, longevity, growth rate, tree shape, functional form, branch strength and litter type. In Thompson and Turner (2008)'s submission tree, shape examples were given as columnar, conical, oval, rounded and umbrella. WFC and Morgan, (1993) in their technical guide to urban and community forestry dwelt on the crown form as the determining factor in urban tree selection, which they broke down as oval round, columnar, pyramidal and vase as shown in Figure 2.3. They stressed some tree shapes are more suitable than others for particular sites' for example fastigate for narrow street side planting. .

In summary, design considerations in tree selection are physical qualities which WFC and Morgan (1993) listed as form, size, height, colour and canopy density among others. Of the five physical qualities, form is the strongest design element and must be considered in any well-designed planting, Grey and Deneke (1986).

- **Form** is described by the shape or the physical configuration of the canopy of a tree. A tree's form is created by its outline, branch and twig structure and habit of growth. Form is such a prominent characteristic of many species that a tree can be identified from its form often from several blocks away. Physical representation of the forms are shown in figures 2.3 and 2.4 below where oval, pyramidal, conical, fastigate are upright and narrow, whilst the columnar strictly upright and the rest of round, vase and irregular have a wide spreading character (New York State Department of Transportation, 1999 and Hannebaum,1994)

Figure 2.3 Typical Tree Forms - 1

Source : Hannebaum (1994)

In the urban landscape, WFC and Morgan (1993), found out that some trees are more suitable than others for particular sites. For the streetscape the most suitable forms as Grey and Deneke (1986), discovered included round, oval, oval, columnar, fastigate and irregular as compared to pyramidal and weeping. Pyramidal or weeping forms, they pointed out, are seldom suitable in streetside applications since they occupy spaces often needed for vehicular and pedestrian movement..

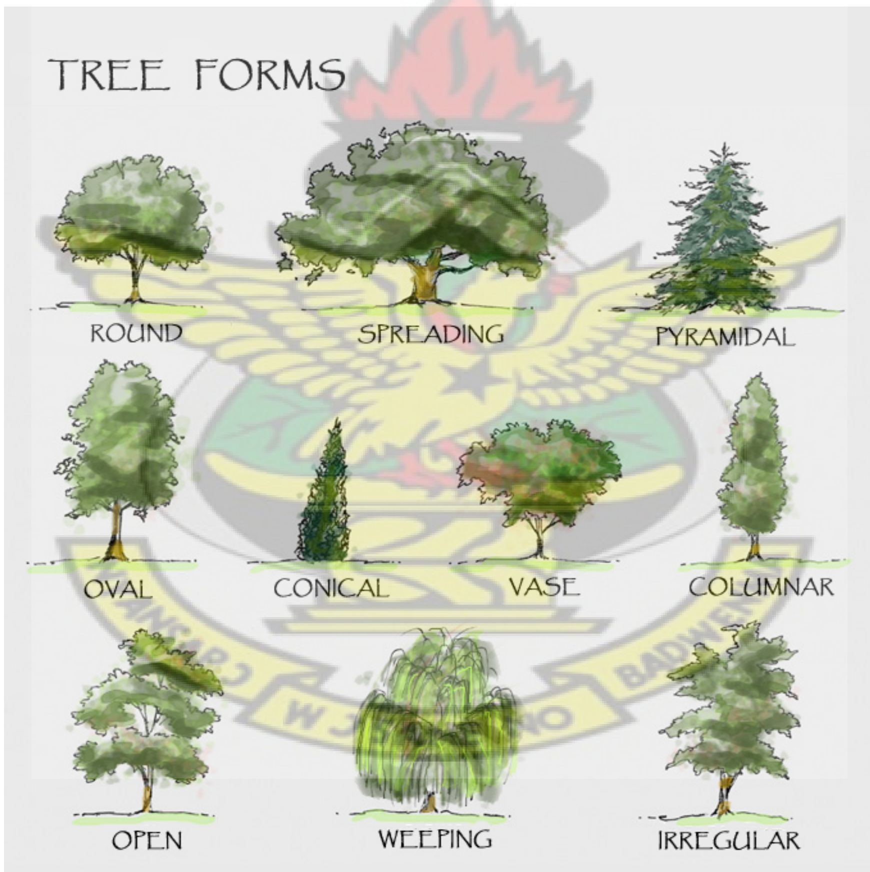

Figure 2.4 Typical Tree Forms - 2

Source: New York State Department of Transportation (1999)

Columnar trees usually have tightly ascending or descending branches with narrow branch angles and short branches. Trees with this shape are valued for their narrow width that enables them to be planted in tight spaces where there is not enough room for a spreading structure (WFC and Morgan1993).

Spaces and physical elements that trees relate with include buildings, walls, utility, lines and trees and it is important to consider these space-physical element relationships when choosing trees based on their form at maturity.

A round tree with a horizontal branching structure, for example, demands a greater distance between adjacent trees or buildings, if it is to attain a natural form and require minimal pruning. (WFC and Morgan 1993).

On the streetscape crowns could interfere adjacent buildings, overhead utility lines and views. Critically speaking, some trees are suitable than others for streetscape as they influence safe stringing of overhead utility lines. Among the tree forms WFC and Morgan (1993) selected on this note are oval and vase shaped trees for street planting on the basis that vase shaped trees grow up and out and arch over streets and sidewalks to form a shady canopy, while maintaining visual clearance and vehicular access. Oval trees they continued, do not interfere too much with vehicular traffic but their lofty heights may make them unsuitable for planting under power lines.

In fact, it was noted in the City of Sydney Street Tree Master Plan 200 (CSSTMP200) by Davies, *et al.* (2004) that of all the factors that limit the benefits trees contribute to the streetscape is the conflict between overhead power cables and tree canopies. As a solution, it was strongly recommended in the CSSTMP200 that small trees could be used instead. It was however pointed out that this could be viable for narrow streets, but for wide streets these small trees are inevitably not of scale and thus present a poor outcome.

If planting is not expected to be under or over utility lines, larger and higher trees could be planted with a minimum distance of six metres (20ft) off the line Davies, *et al.* (2004).

In their tree selection and site design, WFC and Morgan (1993), found out that in most cases natural areas are in some stage of plant succession as wild plants and animals re-establish themselves; they argued that for these areas selection should be directed towards indigenous trees that enhance the feeling of a natural environment by preserving an uncontrolled appearance calling for all tree height levels.

- **Height** as a design element is akin to size, which is probably next in importance to form but it is the most missed element in planting, especially in streetside landscape. The layperson will frequently select a tree on the basis of how well he likes a certain species and give little regard to how large it will grow. Thus it is common to see trees growing into overhead utilities, breaking sidewalks and kerbs, obscuring views, creating traffic hazards and growing out of scale with respect to their surroundings (Grey and Deneke, 1986).

  Size and height seem inseparable as they influence each other. Wrong location or an oversized selection can call for periodic tree pruning. In their Garden Notes #632, the Colorado State University Extension, (Whitling, *et al.* 2006) singled out size as a primary consideration in tree selection and planting under utility lines as the utility has the right-of-way. On the other hand, the Tree Council (2007) went on further to point out that the ideal is to plant a tree that will be able to grow to full maturity with little or no surgery as pruning cuts are potentially harmful exposing trees living tissue to decay.

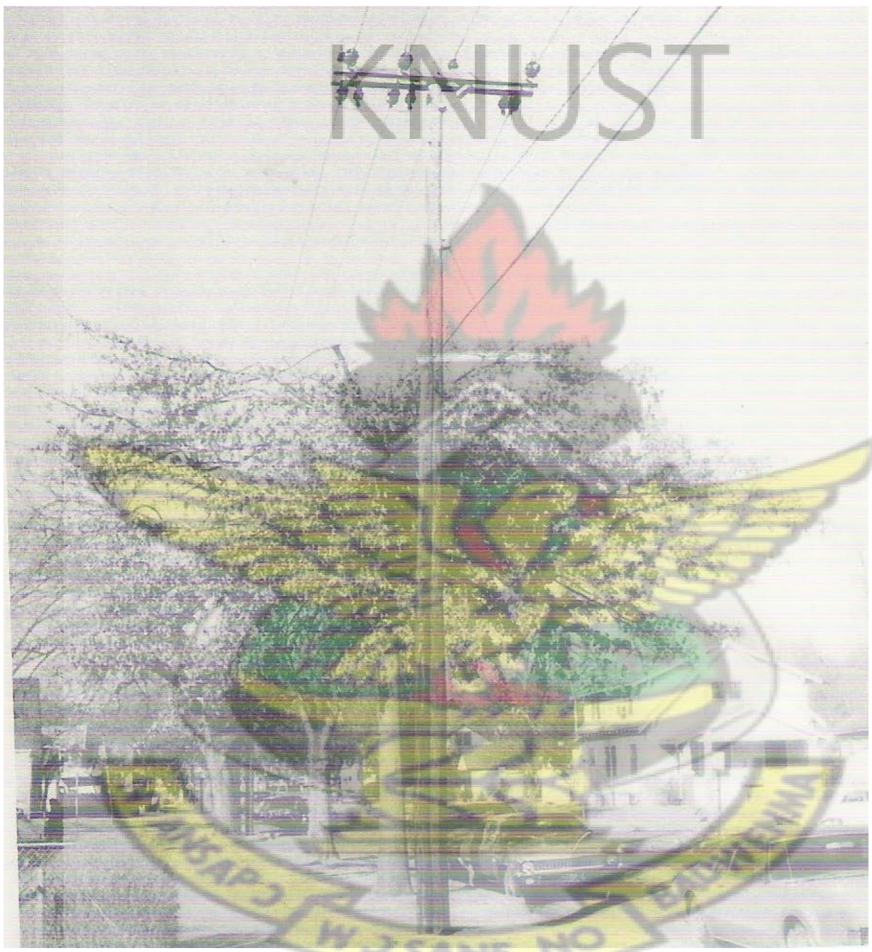

Plate 2.5 Tree height – overhead utility conflict.

Source : Grey and Deneke (1986)

For the purpose of design, they continued, trees can be grouped into three size categories: small, medium, and large. They observed that lately, street design approaches have changed as utilities both above and below ground are more numerous, drives and sidewalks occur frequently, all resulting in reduced space for trees. Consequently, large growing trees seldom have a place along the street today. Even medium trees grow too large for some situations. Small and medium growing trees should therefore comprise the basic landscape in most modern street corridors.

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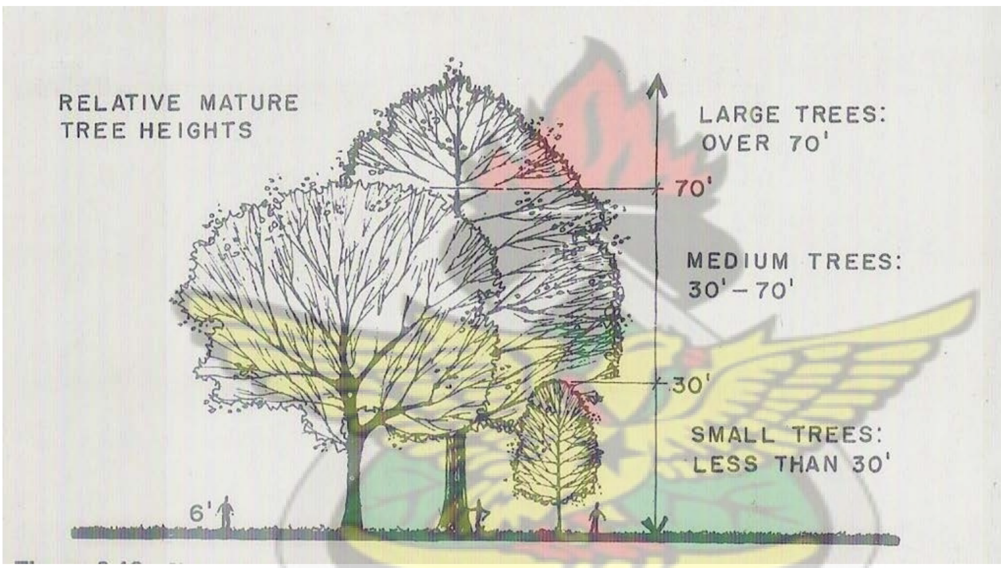

Figure 2.6 Height / Size Categories of Mature Trees for Design Purposes.

Source : Grey and Deneke (1986)

According to Jauron's (1996) classification small trees should be under 25 ft. (6.5m) in height at maturity, medium tree 25 feet-50 feet (6.5m – 15m) and large trees over 50 feet (15m). Based on the above, Jauron (1996), pointed out that knowledge of the mature height and spread of trees and shrubs can prevent many landscape problems. He continued that, the mature height and spread of trees and shrubs will vary somewhat due to soil conditions and other factors, however, knowledge of their approximate mature size can prevent overcrowding, interference with overhead utility wires, obstruction of vehicular and pedestrian traffic, and other problems. To avoid the tree-overhead line conflict, the Planning and Design Services of City (2007) of Louisville¸ Kentucky in its tree canopy and open spaces implementation standards (2007), stipulated a minimum location of 20 feet (6m) away from any overhead wire for medium-sized trees .

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(iii) maintenance

Trees as living entities need to be maintained for good health and performance. The roots, branches leaves and flowers all need to be maintained but the focus depends on the use or purpose of planting and budget. As WFC and Morgan (1993), pointed out maintenance will be required of all trees species but some will require far more than others. Areas of concern on tree maintenance include leaf fall, stem base and roots, wood density and growth rate.

- **Leaf Fall** Leaves would naturally fall from trees, unnoticed in evergreen broad leaf species, slightly seen in the semi deciduous and glaring in the deciduous (Oteng-Amoako, 2009). Species with fleshy fruits or leaves that become mucilaginous on decomposition must be avoided for selection in paved areas to prevent slipping and waste collection. City centres environment are traversed by busy arterial roads are subject to phytochemical pollution produced by exhaust system and as such tree selected for these areas need to be able to tolerate these vehicle emissions. The ability to tolerate resides in the leaves ability to absorb the pollutants and fall with them (Davies, *et al.* 2004).

Deciduous trees are generally considerably more tolerant than evergreen species due to the duration with which different species retain their leaves. The longer the life of a leaf the greater the likelihood that the threshold levels for pollutant damage will be exceeded, thus making evergreen trees undesirable for street use in the temperate regions (Davies, *et al.* (2004). Notwithstanding, in the tropics where summer conditions are always the case, evergreen and semi-deciduous trees constitute a better choice over the deciduous because of their shade provision and not too obvious leaf fall behavior (Davies, *et al.* (2004).

Critically speaking, deciduous trees are a maintenance nuisance because of the complete leaf fall, but since the evergreen (broad leaf) and semi-deciduous also shed considerably well they constitute a better choice.

When used as specimen, all three forms of leaf fall namely, evergreen, semi-deciduous and deciduous present themselves in various forms of beauty. As screen tree the canopy must have leaves to block the view in question and in a parkland – campus situation, where passive viewing is an activity (WFC and Morgan, 1993) , different types of leaf fall offer a variety of visual interest.

Plate 2.6 Evergreen indigenous *Cola gigantea* sheds leaves ‘quietly’

Plate 2.7 Semi – deciduous indigenous *Spathodea campanulata*

Plate 2.8 Deciduous, indigenous *Bombax buonopozense*

- Stem Bases and Roots. Stem base is the physical manifestation, at the tree's stem base, of the roots which are underground. They are twin or continuous anatomical features, buttress above-ground and root below-ground (Oteng-Amoako (2006). Buttresses tend to be above ground exteriors of the root, but form part of the stem base. Trees normally have tap root and lateral roots. Types and behaviour of roots and buttresses are shown in Examples of buttresses are wandering, high, low and slightly buttressed (Plates 2.9 – 2.13).

Root and buttress give stability to the tree structure but they spread chasing the canopy. As a result spreading canopy forms, for example, round, umbrella, irregular and vase tend to pose root and buttress problems to nearby landscape elements. The lateral roots spread away from the trees just as the buttress does, but interest in them arises when they spread and affect landscape features such as pavement, drains, pipelines, kerbs and walls to raise maintenance cost. There are harmless buttress-free stem bases, as in *Khaya senegalensis* (fig. 2.9) but there are spreading underground roots too as in *Pithecellobium saman* (fig,2.10) that have the potential of developing into wandering buttress later.

Plate 2.9 Non-buttressed stem base of *Khaya senegalensis*, a common street tree in the city of Accra, Ghana.

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Plate 2.10 *Pithecellobium saman* has underground spreading roots destructive to pavement and walls.

Plate 2.11 Slightly buttressed stem bases are harmless.

Plate 2.12 Wandering buttresses spread and destroy landscape elements.

Plate 2.13 High buttresses also spread and destroy landscape elements and need not be close to them.

Cities have long faced the problem of roots breaking sidewalks. Many people have searched for 'deep-rooted' species, however, the depth of rooting is more of a function of site conditions than an inherent characteristics of a species (WFC and Morgan, 1993).

Actually, most species are regarded as having shallow roots at maturity and besides, tap-rooted species possess their vertically oriented roots for a short period of their lives. For that matter, to reduce the importance of sidewalk damage as a criterion, WFC and Morgan (1993) in their tree selection and site design research, advised for the use of appropriately sized trees for a given space.

On the part of Davies *et al.* (2004) in the City of Sydney Street Tree Master Plan 200, the potential of species to cause pavement damage should be used as a guide for future tree location. Similarly, Whitling, *et al.* (2006), considered potential damage to landscape (sidewalks, gutters, etc) below-ground utilities as useful selection criterion.

It was suggested in the CSSTMP200 by Davies *et al.* (2004) that, although, no guarantees can be given that any particular street trees species will not interact with kerbs and pavements uplift should be avoided. It was recommended in the plan though, to investigate the use of alternative indigenous foot path materials and design to minimize tree root and bitumen interaction having in mind that tree roots can grow up to three times the diameter of the canopy (Davies *et al.*, 2004).

Above all, if careful planning is undertaken, root and buttress conflicts and differing views would be minimised. In so doing, Pauleit (2003), identified key requirements, in the Municipal Engineer journal for urban tree planting, and advised that there is a need for close collaboration between civil engineers and landscape architects from a very early stage to integrate tree plantings into the design of pavement in order to maximize their benefits and avoid potential conflicts with traffic and utilities.

- **Wood Density** is the weight per unit volume at a given moisture content, usually at 15%. (Oteng-Amoako, 2006). It is one the most important diagnostic physical features and directly correlated with modulus of elasticity (MoE), another expression of wood strength or limb shear (Oteng-Amoako, 2006). Limb loss occurs on an occasional basis for most trees due to wind induced mechanical breakage. Trees that are renowned for having brittle branches and regular branch drop are described as soft, weak and brittle and must be avoided for use as street trees. Davies, *et al.*. (2004). Problematic trees having brittle or weak structures shall be prohibited for parking lots.

  Oteng-Amoako (2006) in his book on 100 Tropical African Timber Trees from Ghana, classified wood density ranges with corresponding tree species (Table 2.4).

Table 2.4 Wood density classification

Wood density classification		Name of sample tree
Ordinal	Interval (g/cm^3)	Scientific name
Low (soft, brittle, weak)	0.25 – 0.50	*Bombax buonopozense*
Moderate (fairly hard)	0.50 – 0.75	*Copaifera salikounda*
High (hard)	O.75 – 1.00	*Afzelia Africana*
very high (very hard)	Above 1.00	*Erythrophyllum suaveolens*

Source : Oteng-Amoako (2006).

- **Growth Rate** can be slow, moderate or fast. The desire for a particular growth rate can be related to an intended use or an informed decision. Homeowners often desire fast-growing trees. However, fast-growing species are typically more prone to insects, diseases, and internal decay. Fast-growing species typically have a shorter life span (Whitling, *et al*. 2006).

  Not every tree or every planting situation lasts for hundreds of years. Being dynamic, cities have spaces, such as streets, that are available for relatively short periods, making them suitable for short-lived trees or those that begin exhibiting undesirable traits as they mature (WFC and Morgan 1993) for example *Acacia auriculiformis* (Plate 2.14) an exotic specie and *Poiniciana regia* an indigenous tree. Slow and moderate growth rate trees have uses that fit them, for example *Lignum vitae* (life plant) makes a good specimen tree for decades in gardens.

Plate 2.14 Quick growing, young, *Acacia auriculiformis* planted as street tree, but will exhibit undesirable traits such as low wood density as it matures.

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CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Introduction

Tree selection methods that have been used for selection include scoring charts, criteria building and questionnaire approaches. The World Forestry Centre (WFC) and Morgan (1993), suggested that in finding the best species the researcher begins with an extensive list of trees and sift out unwanted material until only the right choice remains by passing them through three levels sieves namely site, design and maintenance considerations. The scoring method used by the City of South Perth Significant Tree Register (Anon,2002) to select trees was based on their size, uses, scarcity, and wildlife value Similarly, Hines and Eckman (1993), identified key requirements for tree selection by using four methods namely, species data questionnaire, village level questionnaire, market survey and seasonal calendar. The species data questionnaire included criteria that required the tree species to be currently used by local people, and among others, have end uses that have no substitute.

For this study, five-point methodology, beginning with objectives, followed by data collection and analysis, discussion of results, summary and conclusion, and recommendations was adopted.

3.2 DATA COLLECTION

3.2.1 First Objective

a) The first objective was to list some identified indigenous trees of Ghana noted for various landscape uses and document their physical characteristics, ecological needs, growth habits.

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b) Data needed

The data needed were from primary and secondary sources.

i) some indigenous landscape trees of Ghana identified by PROTA (2008), Oteng – Amoako, (2006), Abbiw (1995), Burkhill (1991, 1994, 1995) to have amenity landscape uses.

ii) baseline study on the identification including origin, location, population and uses of exotic and indigenous trees in purposively sampled neighbourhood of Danyame in Kumasi, which had all the urban landscape sites within it.

iii) characteristics and ecology of the indigenous and exotic trees: (secondary data).

physical qualities(form, height, wood density),

ecology (vegetation zone of Ghana, conservation status)

growth habits (growth rate, stem base type (root damage potential), leaf fall (litter type).

iv) photographs of the indigenous and exotic trees.(primary and secondary)

c) Where data were located

The data were located in the libraries of Kwame Nkrumah University of Science and Technology, Forestry Research Institute of Ghana, on the internet and in the Kumasi city.

d) How the data were collected and analyzed.

(i) **Baseline data** : The baseline study on the identification including origin, location, population and uses of exotic and indigenous trees in purposively sampled neighbourhood in Kumasi were captured (Table 3.1).

Table 3.1 Format for collecting baseline data on exotic and indigenous tree in Danyame, Kumasi.

DANYAME - KUMASI TREE INDIGENOUS-EXOTIC COUNT									
NAMES				Origin	Number count in landscape Areas				Total
No	Scientific	Common	local	Exotic/ indigenous	Street	Residential	Parkland	Reserved	Species count
1									
2									
Total count									

Total count of trees was carried out for the trees to determine their level of use.

(ii) Composite Tree Database of Kumasi

The Danyame tree list was added to indigenous landscape trees of Ghana identified to have amenity landscape uses and were presented in Table 3.2.

Table 3.2 Composite Tree List.

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No	Names		
	Scientific	Common	Local
1			
2			
3			
4			

(iii) Tree Database of Physical and Ecological characteristics

Using the Composite Tree List, the corresponding physical and ecological characteristics and growth habits of the indigenous and exotic trees were extracted from PROTA 2008, Oteng-Amoako 2006, Burkill (1991, 1994, 1995) and other internet sources to create Tables 3.3 – 3.5

Table 3.3 Format for collecting data on the physical qualities of the trees on the Composite Tree List.

No	Names			Physical Qualities		
	Scientific	Common	Local	Form	Height (m)	Wood Density
1						
2						

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Tree forms considered were round, fastigate, vase (including flat and umbrella), pyramid conical, columnar and irregular. Height was in metres and wood density, the wind damage protection factor, was graded very low, low, medium, high and very high.

Table 3.4 Format for collecting data on the ecological factors of the trees on the Composite Tree List.

No	Names			Ecology	
	Scientific	Common	Local	Veg. Zone	Cons. Status
1					
2					

Possible entries for vegetation zone ranged from evergreen only; evergreen and semi-deciduous; evergreen, semi-deciduous and savanna combined; semi-deciduous only; semi-deciduous and savana, moist semi-deciduous only. Conservation status was either threatened or not threatened

Table 3.5 Format for collecting data on the growth habits of the trees on the Composite Tree List.

No	Names			Growth habits		
	Scientific	Common	Local	Growth rate	Stem base-root type	Leaf fall
1						
2						

Entries for growth rate were quick and slow. Stem base types were no buttress, buttressed, slight buttressed , stilt and taproot, whilst leaf fall possibilities were evergreen, evergreen and semi-deciduous, semi-deciduous, deciduous, evergreen and deciduous.

Tables 3.3 – 3.5 were combined and named Complete Composite Tree List as shown in Table 3.6 was coded and stored in SPSS format.

Table 3.6 Complete Composite Tree List.

No	Scientific name	Form	Ht (m)	W_dens	V-zone	Conserv. status	Growth Rate	Stem base	Leaf fall
1	*Acacia auriculifurnis*								
2	*Acacia farnesiana*								
3	*Acacia nilotica*								

From Table 3.6 trees were sorted against their vegetation zone (V-zone) and those that belonged to the semi-deciduous forest (Kumasi zone) were retained.

Data entered on form, height, wood density(W_dens), conservation status, growth rate, stem base and leaf fall behaviour were held waiting for criteria selection in objective two.

e) Interpretation of analysed data

The Danyame Indigenous-exotic tree count format in Table 3.1 was performed to establish their extent of use and level of dominance of indigenous and exotic trees in Kumasi to establish the basis for researching into the indigenous tree.

After the vegetation zone sorting, the resulting list was taken as trees that are ecologically fit to survive in the semi deciduous forest vegetation zone of Ghana in which Kumasi lies. The resulting data were called Tree Database of Kumasi.

Table 3.7 Tree Database of Kumasi.

No	Scientific name	Form	Ht (m)	W_dens	Conserv. status	Growth rate	Stem base	Leaf fall
1	*Acacia auriculifurnis****							
2	*Acacia farnesiana*							
3	*Acacia nilotica*							

*** exotic

Live photographs of both indigenous and exotic trees were taken to show their physical features, for example, form, height, stem base and leaf fall behaviour.

3.2.2 Second Objective

a) The second objective was to categorize the Ghanaian urban scene into specific landscape areas and select indigenous trees to meet their needs.

b. Data Needed

(i) Data needed were the tree characteristics to meet needs of the following areas that constitute the urban landscape;

- streets
- residential property (home landscapes)
- reserved areas (green belts, wastelands, reserved open spaces, stream corridors)
- parklands and campuses (traditional parks, industrial sites, educational sites)

(ii) The Tree Database of Kumasi from objective one.

(iii) Literature on domestication of indigenous trees, and evaluation and selection of trees for urban landscape applications.

c) Where data were located.

The data on the nature and tree needs of urban landscape and domestication process were located in the libraries of Kwame Nkrumah University of Science and Technology, Forestry Research Institute of

Ghana and on the internet in the form of text, tables and pictures. The Tree Database of Kumasi were taken from objective one.

d.) **How the data were collected and analyzed.**

The tree characteristics needed for the categories of urban landscape were captured as secondary data in text and pictures.

Literature on domestication (including selection processes) of indigenous trees for urban landscape applications were secured in text, table and pictures.

e) Interpretation of analyzed data.

Tree selection criteria were developed from the literature on domestication and tree needs of the various urban landscape areas to:

(i) Select suitable indigenous trees for the landscape areas.

(ii) Verify the fitness of location or use of existing exotic trees in Kumasi.

All tree selection criteria for streets, residential property, reserved areas parklands and campuses were set and fed into SPSS Software .The selection criteria were sieves from WFC and Morgan (1993) named as design, site and maintenance considerations. Factors under design considerations were form, height, wood density; those for site considerations were vegetation zone and conservation status; and under maintenance were growth rate, stem base- root type, leaf fall

Selection Criteria Tables.3.8 – 3. contain all criteria to help select trees both indigenous and exotic and get them their rightful place in the urban landscape. Each column in the tables contains criteria from the sieves named as design, site and maintenance considerations. As part of the analysis and interpretation, the Tree Database of Kumasi from objective one was passed through the criteria of sieves, using the SPSS software to sort trees for streets, residences, reserved areas, parkland and campuses.

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Tree Selection Criteria for Streets

General selection criteria were set basically to select trees for all street classifications. Conditions to meet maintenance sieve were evergreen and semi deciduous leaf fall but not complete shedding; for design sieve, moderate to very high wood density to prevent accidental limb shear and under maintenance sieve, moderate to high growth rate for tree to reach appreciable height before the next street expansion project. Trees that would be selected after this sieving would be a general collection for all streets. The further sieving would be carried out for specific street locations.

Table   3.8 Tree Selection Criteria for streets

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General selection	Tree Selection for specific street location classifications			
	1	2	3	4
Basic criteria for all streets	location close to street and under utility lines	location close to street but without overhead utility	location away from street and but under	location away from street and not under overhead utility lines.

	.(up to 6m from street edge)	Lines. (up to 6m from street edge)	overhead utility lines(over6m from street edge)	(over 6m from street edge)
Leaf-fall Evergreen - Semi deciduous	Form columnar, conical, fastigate, oval,	Form columnar, conical, fastigate, oval	Form columnar, conical, fastigate, oval, pyramid, vase	Form all forms allowed. columnar, conical, fastigate, oval, pyramid, round, vase irregular
Wood density: moderate to very high	Height 8m. or less but fastigate trees exempted	Height unrestricted but should conform to scale of surrounding landscape.	Height 8m or less but fastigate trees exempted	Height : all. select to on - site scale
Growth rate Moderate to high	Stem base Non buttress, slightly buttressed	Stem base Non buttress, slightly buttressed	Stem base All types: non- buttressed, slightly buttressed, buttressed	Stem base: all types: non- buttressed, slightly buttressed, buttressed

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Tree Selection Criteria for Residential Property

Because of the diversity found in residential areas, planting guidelines should be general rather than specific (WFC and Morgan, 1993). On the contrary, in Ghana, general considerations cannot meet specific requirements for residential uses such as shade, boundary, and specimen because these uses require different tree characteristic needs. For example, shade trees spread and cannot fit into residential boundaries which most often are narrow

Table 3.9 Tree Selection Criteria for Residential Property

Specific Residential Property selection for:		
Shade trees	Boundary trees	Specimen trees
1. Form: round, vase, umbrella, irregular	1. Form: columnar, conical, oval, . fastigate, pyramidal	1. Form: all forms
2. Height: up to 15m (small to medium size)	2 .Height: to scale	2. Height: up to 15m (small to medium size)
3. Wood density: medium to very high	3. Wood density: medium to very high	3. Wood density: medium to very high
4. Leaf fall: evergreen semi-deciduous	4. Leaf fall: evergreen semi-deciduous	4. leaf fall: evergreen semi deciduous deciduous
5. Stem base type no buttress slightly buttressed	5. Stem base type: no buttress	5. stem base type: no buttress slightly buttressed buttressed stilt
6. Growth rate: slow, quick	6. Growth rate: Quick	6….Growth rate: slow, quick

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Tree Selection Criteria for Reserved areas

Reserved areas encompass diverse landscapes from wetlands, riverine sites, steep slopes, dump sites, flat and dry lands. They call for indigenous trees that enhance or maintain a feeling of a "natural" environment by preserving an "uncontrolled" appearance, (WFC and Morgan, 1993). Thus all tree heights, form, leaf fall, flowering and so on fit into this natural environment. Reserved sites are used as one of the conservation sites to protect threatened species. These endangered species are most often commercial timber species (Oteng-Amoako, 2006).

Table 3.10 Tree Selection Criteria for Reserved areas

Reserved areas	
Criteria 1. conservation status: Threatened species meaning Vulnerable, endangered or critically endangered	
Vulnerable – facing high risk of extinction endangered - facing very high risk of extinction critically endangered - facing extremely high risk of extinction	

Parklands and Campuses

These areas also follow a "naturalistic" plant arrangements except that selection should gear towards reducing maintenance costs, encourage wildlife habitat or allow for a wider variety of uses to occur within these campus areas, (WFC and Morgan,1993) . The long term implications of these trends must be considered when trees are selected.

In effect, the selection was open, not restrictive, to allow many species with different qualities to satisfy wider variety of uses, Thus, the large manned areas of parkland and campuses would need low maintenance trees characterized by evergreen, semi-deciduous leaf fall and medium to very high wood density.

Table 3.11 Tree Selection Criteria for Parklands and Campuses

Parklands and Campuses:
Criteria
1. Leaf fall: evergreen and semi deciduous 2. Wood density: medium to very high.

For all criteria built, dominant or frequently used exotic species were checked to find out if they were appropriately located in their present landscape area by passing them through the tree criteria built for the various landscape areas.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 INTRODUCTION

Exploration and collection of tree species to constitute the extensive tree list for the selection has been discussed. This list is made up by Kumasi - Danyame exotic tree count and Ghanaian indigenous trees that thrive in the semi – deciduous forest zone, of Ghana, in which Kumasi can be found.

Evaluation and selection of suitable species, from the extensive list, through the use of set criteria, was also discussed by answering the following questions:

i) What are the current exotic and indigenous tree populations and uses in Kumasi?

ii) If the indigenous tree population is found to be on the low side, what indigenous trees have the potential to be evaluated, selected and added to the exotic stock for landscape applications in Ghana?

iii) How would the evaluation process be carried out?

iv) Where would the selected indigenous trees be planted in the urban environment?

v) Can the selected indigenous trees match up with the exotic species?

4.2 CURRENT EXOTIC AND INDIGENOUS TREE POPULATIONS AND USES IN KUMASI.

In the Danyame – Kumasi exotic – indigenous tree count (Table 4.1), *Ceiba pentandra*, *Milletia thonningii*, were the indigenous species and *Acacia auriculiformis, Cassia siamea*, *Cedrella odorata*, *Poinciana regia, Polyalthia longifolia, Terminalia mantaly* among others formed the exotic group.

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Table 4.1 Current indigenous and exotic tree populations and uses in Kumasi

DANYAME KUMASI INDIGENOUS AND EXOTIC TREE COUNT

No	SCIENTIFIC NAME	COMMON NAME	ORIGIN	STREET	RESID	PARKL	RESER	TOT
1	*Acacia auriculiformis*	Earleaf Acacia	exotic			1	89	90
2	*Artocarpus incisus*	Bread fruit	exotic		2			2
3	*Azadirachta indica*	Neem	exotic		6	9		15
4	*Cassia fistula*	Golden shower	exotic	2				2
5	*Cassia nodosa*	Pink Cassia	exotic			1	40	41
6	*Cassia siamea*	Siamese Cassia	exotic	139	79	74	960	1252
7	*Cedrella odorata*	Cedar	exotic	15		1		16
8	*Gmelina arborea*	Snapdragon	exotic		1	10		11
9	*Lagestroemia speciosa*	Queen Flower	exotic			1		1
10	*Mangifera indica*	Mango	exotic	6	19	11		36

11	*Peltophorum pterocarpum*	Rust tree	exotic		1	2		3
12	*Persea americana*	Avocardo Pear	exotic		4			4
13	*Pithecelobium dulce*	Madras thorn	exotic	4	2	1		7
14	*Pithecelobium saman*	Rain tree	exotic		2	11		13
15	*Plumeria rubra*	Red Frangipani	exotic		10			10
16	*Poinciana regia*	Flamboyante	exotic	15	14	11		40
17	*Polyalthia longifolia*	Weeping Willow	exotic	16	41			57
18	*Tabebuia rosea*	Tabebuia	exotic		1			1
19	*Tectona grandis*	Teak	exotic		8	120		128
20	*Terminalia catappa*	Indian almond	exotic	7				7
21	*Terminalia mantaly*	Madg. Almond	exotic	1	1	5		7
22	*Ceiba pentandra*	Silkicotton Tree	indigenous			1		1
23	*Milletia thonningii*	Milletia	indigenous	1		4		5

In terms of total number of species, there were twenty one exotic as compared to two indigenous trees, meaning the introduced trees were well known and used in Kumasi. Additionally, the exotic tree population in the sampled area was one thousand, seven hundred and forty three (1743) as compared to a mere six (6) trees for the indigenous trees. *Cassia siamea* alone constituted seventy two percent (72%) of the total tree count. At the level of use, as street, residential, reserve and parkland, *Cassia siamea* was used across all landscape areas in comparatively greater numbers, followed by *Mangifera indica, Polyalthia longifolia, Tectona grandis and Terminalia mantaly*. The comparatively high level of use, could be attributed to their form and most importantly rapid rate of growth. Fruit value and shade for *Mangifera indica* and wood value (residential tree harvested as poles) for *Tectona grandis* could have some additional values. Some of the trees in the count were found to be inappropriately located or used, for example *Cedrella odorata* as street tree with aggressive buttressed stem base (Plate 4.1).

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Plate 4.1 Buttressed *Cedrella odorata* inappropriately planted in Danyame as street tree

Plate 4.2 Non buttress *Cassia siamea* appropriately planted in Danyame as street tree, physically unobstructive to vehicular passage with its narrow fastigate form.

Because of the open nature and greater number of uses (shade, fruit, screen, specimen) a comparatively larger number of the trees species were planted in the residential and parkland / campus landscapes, some of which were *Mangifera indica, Pithecelobium dulce, Cassia siamea and Polyalthia longifolia.*

Having established the dominance of exotic over indigenous trees in Kumasi, there is the need then to search for indigenous species to support potential number and choices of tree species for landscape applications in Kumasi. This is because the approximate range of trees sampled in the count is comparatively narrow, as compared to landscape trees in South Africa, India, Indonesia and Britain. The study, at this time, offers the opportunity to search from within indigenous trees for potential ones to add up to the existing stock , by compiling tree species list with their characteristics and evaluating them with set criteria.

4.3 EXPLORATION AND COLLECTION OF TREE SPECIES

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The indigenous tree list for Kumasi was prepared by selecting trees that thrive, among others, in the semi – deciduous forest of Ghana. Existing exotic tree species identified in the exotic – indigenous tree count in Danyame were added to the native tree list to come up Tree Database of Kumasi for the selection processes of the study. Characteristics of interest used for building the database were trees form, height, wood density (for design considerations), vegetation zone and conservation status (for site considerations) and growth rate, stem base 'root' type and leaf fall (for maintenance considerations).

The characteristics of interest were basic physical requirements used to appropriately select trees for use in the various urban landscape areas. The question of adaptability to soil compaction, drought, flooding, air pollution, pests and diseases, cultural acceptance and so on can be considered on different level.

The complete list of this table is found in appendix 1. It was on this composite list that evaluation criteria were set to select appropriate trees for use in the classified urban landscape areas namely Street, Residential, Reserved areas and Parklands and Campuses.

4.4 EVALUATION AND SELECTION OF SUITABLE SPECIES

Evaluation and selection exercise was carried out using criteria sets.

The criteria were set, for various urban landscape areas, to appropriately select trees to meet their needs. Each area has its own site conditions and tree requirements. The areas listed were as follows,

- Street
- Residential
- Reserved areas.
- Parklands and Campuses

4.4.1 Tree Selection for Streets

A general criteria was set to select all trees having the potential to be planted as street trees and it was out of this potential list that specific street trees were selected for specific classified locations close or away from the street side.

4.4.1.1 General Street Tree Selection Criteria

The general street criteria was set based on characteristics that affected all street tree needs, namely leaf fall (extent of littering), wood density (for accidental limb shear) and rate of growth (Table 4.2).

Table 4.2 General Street Trees Selection Criteria.

General Factors for all streets	Trees Selected		
	Names		
	Scientific	Common	Local
1.Leaf-fall : evergreen, semi deciduous	Indigenous		
	Acacia nilotica	Scented thorn	Odanwoma
	Allanblackia floribunda	Tallow tree	
	Alstonia boonei	Alstonia	Sinduro
	Anogeissus leicarpus	Anogeissus	Sakane
	Anthonotha macrophylla		Nsuroko
	Antrocaryon micraster	Antrocaryon	Aprokuma
	Beilschmiedia mannii		Tweanka
	Blighia sapida	Akee Apple	Akye
	Canarium schiveinfurthii	African Canarium	Bediwonua
	Carapa procera	African Crabwood	Kwakuo-bese
	Cassia sieberiana	African Laburmum	Ekwo Prankese
	Celtis mildbraedii	Celtis	Esa-fufuo
2.Wood density: medium to very high	*Chrysophyllum subnudum*	Chrysophyllum	Akasa
	Cola gigantea var glab		Watapuo
	Drypetes floribunda		Bedibesa
	Ekebergia capensis	Cape Ash	
	Guarea cedrata	Scented Guarea	Kwabohoro
	Hura crepitans	Sandbox Tree	
	Khaya anthotheca	African Mahogany	Kruben
	Kigelia africana	Sausage Tree	Nufutene
	Lonchocarpus sericeus	Senegal lilac	Sante
	Milletia thonningii	Milletia	Okuro-Sante
	Monodora myristica	African Nutmeg	Awerewa
	Newbouldia laevis	Newbouldia	Sesemasa
	Parkia bicolor	Parkia	Asoma
3.Growth rate: high	*Parkia biglobosa (clappert)*	African Locust B	Dawadawa
	Parkia filicoidea		Esereso-Asawa
	Pentaclethra macrophylla	African Oil Bean	Atta Bean
	Spathodea campanulata	African Tulip Tree	Kokoanisua
	Tabernaemontana crassa	Adams Apple Flower	Obonawa
	Trichilia emetican	Natal Mahogany	Kisiga

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	Exotic		
	Cassia siamea	Siamese Cassia	
	Mangifera indica	Mango	Mango
	Pithecellobium dulce	Madras Thorn	
	Polyalthia longifolia	Weeping Willow	

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As tree leaves absorb pollutants and offer constant shade, street tree leaf fall characteristics in the tropics do not need to be deciduous, but evergreen and semi-deciduous. Evergreen broad-leaf trees do shed leaves but not as noticeable in deciduous or semi- deciduous species,. therefore evergreen and semi-deciduous leaf fall behaviour were chosen for the criteria. In the temperate regions the reverse is the case (Davies, *et al.* 2004).

As a street limb shear must be guarded to prevent trapping vehicles and pedestrians, so trees with low wood strength such as *Gmelina arborea* and *Persea americana* were excluded (Davies, *et al.* 2004). Most often, it is wind storm that cause limb shear and so eliminating trees with low wood strength (low modulus of elasticity) gives an amount of safety. The need for selecting high or quick rate of growth for trees too, stems from the fact that street landscape construction and expansion programmes are shorter than the life span of the tree which is normally over fifty years. It is in these early decades too that trees with quick growth exhibit desirable characteristics, for example form, height and non – buttress stem bases, for street use. Among such general trees are indigenous species such as *Blighia sapida* and *Milletia thonningii* which have been planted as street trees in Ghana specifically in Accra and Kumasi. *Spathodea campanulata* has also been reported by Invasive Species Specialist Group (ISSG, 2006) to be used as street tree throughout tropical and subtropical regions.

Cassia siamea, Mangifera indica, Polyalthia longifolia, Pithecellobium dulce are among a list of ten exotic trees that are currently planted as street trees in Kumasi but have been duly selected for general street planting for passing the leaf fall, wood density and growth rate requirements.

To get trees from the general street tree list, specific criteria were set to select trees to fit the specific uses.

4.4.1.2 Specific Street Tree Selection Criteria

Specific street tree selection has been done based on tree locations and tree characteristics. The tree locations are basically those close to the street side (within 2m-6m) and those over 6m away from the street side. In both locations, the tree can be either under a utility line or away from it. Thus, there are four locations namely:

- Close to street side and under power cable.
- Close to street side but not under power cable.
- Away from street side and under power cable.
- Away from street side but not under power cable

The tree characteristics considered were height, form and stem base.. The location was however a determining factor in the selection for street planting since it has a bearing on the form, height and stem base (buttress development).

a) Trees Close to Street and Under Utility Line

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The avoidance of root damage potential is a key factor considered in the selection of trees for close to street locations, (CSU, 2006; CSSTMP200, 2004). Thus non buttressed trees are desired here. Critical height of utility line of 8m given by the Electricity Corporation of Ghana (ECG) and 6.5m by VODAPHONE Ghana determine the mature height of trees to use. In order not to physically obstruct vehicular and pedestrian movement, desired tree forms should fit into the narrow space close to street side space which falls between 2m – 4m in city centre and close to city centre situations. In this case, columnar, oval and fastigate forms with no buttresses and not more than 8m high passed the test (Table 4.3 and Fig. 4.1).

Non of the general trees could be selected for 6.5 -8.0m height limitations, but because fastigate forms could safely grow and acrh over utility line *Ekebergia capensis, Newbouldia laevis, Spathodea campanulata* as indigenous species and *Cassia siamea* an exotic tree were selected..

In overlooking the height issue, tall trees could be selected which would at maturity undergo top pruning to allow line passage through the canopy (Fig. 4.2). This though may not be cost effective and would also not be aesthetically pleasing (Bloniarz and Ryan, 1991)

Table 4.3 Specific Street Tree Selecting Criteria for Tree Planting Close to Street and under Overhead Utility Lines.

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Location close to street, under utility lines			
Trees Selected			
Detailed Criteria for street tree selection	Names		
	Scientific	Common	Local
1. Forms:	Indigenous		
columnar, conical, fastigate,	*Ekebergia capensis*	Cape Ash	
oval,	*Newbouldia laevis*	Newbouldia	Sesemasa
2. Stem base type: no buttress	*Pentaclethra macrophylla*	African Oil Bean	Atta Bean
slightly buttressed	*Spathodea campanulata*	African Tulip Tree	Kokoanisua
3. Height 8m. or less	Exotic		
but fastigate form exempted	*Cassia siamea*	Siamese Cassia	

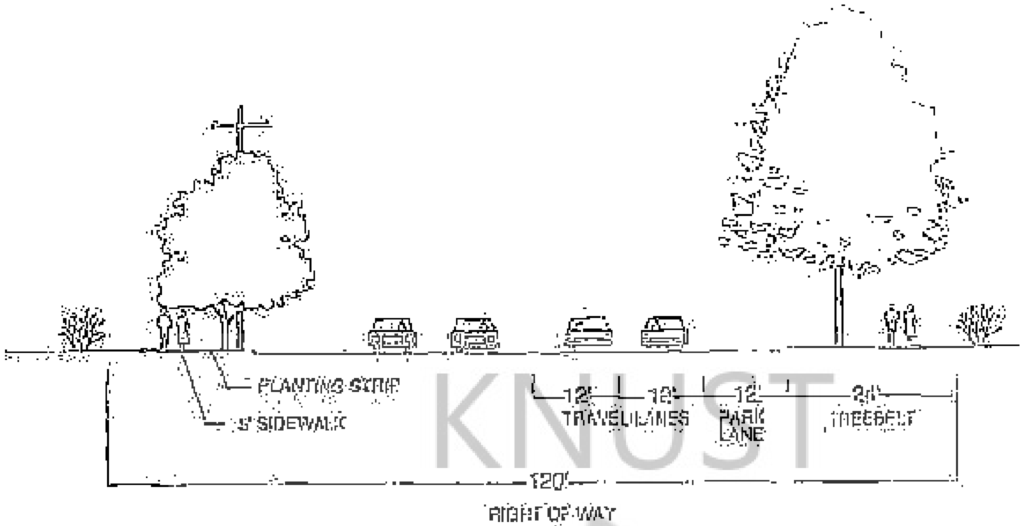

Fig.4.1 The ideal street tree selection when tree is below 8m and in right form.

Source : Bloniarz and Ryan (1991)

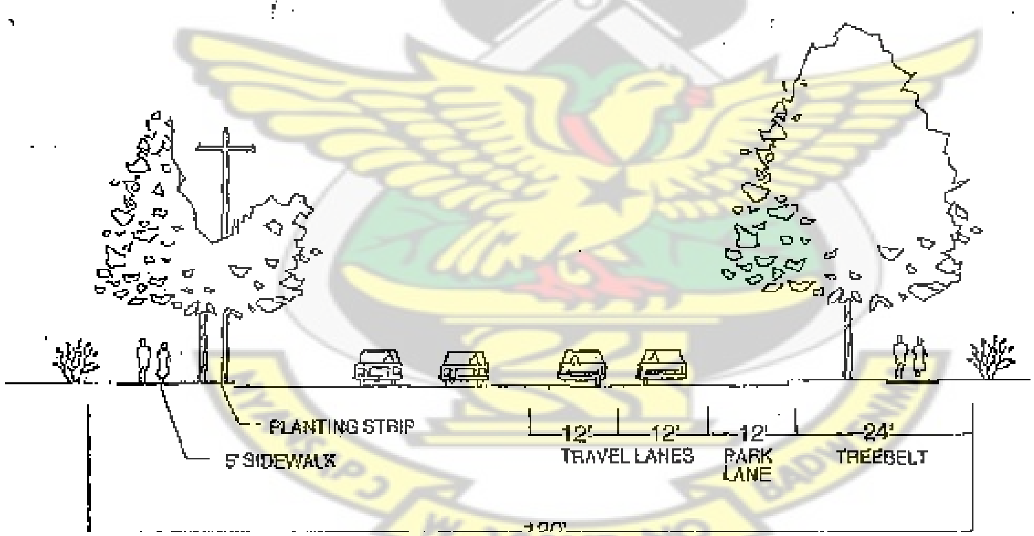

Fig.4.2 Top pruning spreading and tall trees close to street and under utility line.

Source : Bloniarz and Ryan (1991).

Plate 4.3 *Spathodea campanulata* in its youthful form and size can fit the narrow streetscape

b) Trees Close to Street but Not Under Overhead Utility Line

Similar to the situation close to street and under utility location, the critical issue here is with the available width of space which inevitably require narrow crown forms as columnar, conical, oval, and fastigate. Furthermore, because of the close to street side location, buttressed trees are not desired, but since utility lines are absent on this case, tree height is not critical but scale with nearby buildings and street must be taken into consideration. Examples of indigenous trees that met the criteria were *Allanblackia floribunda, Carapa procera, Ekebergia capensis* and *Pentaclethra macrophylla* . The selected exotic trees were *Cassia siamea* and *Polyalthia longifolia.*

Plate 4.4 Narrow canopied (oval shaped) *Allanblackia floribunda* can fit into a close to street position.

Source : www.prota.org (2009)

Table 4.4 Specific Street Tree Selecting Criteria for Tree Planting Close to Street but not under Overhead Utility Lines.

Location close to street, not under utility lines			
	Tree Selected		
Detailed Criteria for street tree selection	Names		
	Scientific	Common	Local
	Indigenous		
1. Forms: columnar, conical, fastigate, oval	*Allanblackia floribunda*	Tallow tree	
	Carapa procera	African Crabwood	Kwakuo-bese
	Ekebergia capensis	Cape Ash	
	Lonchocarpus sericeus	Senegal lilac	Sante
2. Height : Select to on - site scale	*Monodora myristica*	African Nutmeg	Awerewa
	Newbouldia laevis		Sesemasa
	Pentaclethra macrophylla	African Oil Bean	Atta Bean
	Spathodea campanulata	African Tulip Tree	Kokoanisua
	Exotic		
	Cassia siamea	Siamese Cassia	
3. Stem base type: no buttress, slightly buttressed	*Polyalthia longifolia*	Weeping Willow	

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Plate 4.5 Columnar tree *Polyalthia longifolia* planted close to streetside and not under utility line.

Plate 4.6 Indigenous *Ekebergia capensis* a candidate tree for street side use.

Source : www.prota.org (2009)

c) Trees Away from Street and Under Utility Line

When the tree is far from the street, the root damage potential is not considered as tree would be growing in a spacious bare land without pavement. As such, all manner of tree bases would pass the test. Mature tree height remains 8m or below but the form can be opened to all because the location is no more in a restricted horizontal space. Thus round, vase, picturesque and spreading forms are acceptable.

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Table 4.5 Specific Street Tree Selecting Criteria for Tree Planting Away from Street but under Overhead Utility Lines.

Location away from street, under utility lines			
	Tree Selected		
Detailed Criteria for street tree selection	Names		
	Scientific	Common	Local
1. Height 8m or less but fastigate trees exempted	Indigenous		
	Beilschmiedia mannii		Tweanka
	(above 8m but fastigate)		
	Ekebergia capensis	Cape Ash	
	Pentaclethra macrophylla	African Oil Bean	Atta Bean
2. Forms: columnar, conical, fastigate, oval, pyramid	*Newbouldia laevis*		Sesemasa
	Spathodea campanulata	African Tulip Tree	Kokoanisua

3. Stem base All types: non-buttressed, slightly, buttressed, buttressed	Exotic *Cassia siamea* Siamese Cassia

d) Trees Away from Street but not Under Utility Line

The situation for trees away from street and not under any utilities location presents no horizontal or vertical restriction level as space available is large enough to contain all forms, heights and stem base types. As a result, the criteria selection picked all trees considered to be potential street trees in the general considerations.

This is wider right of way situation. At the ground level, such locations are grass strips, and so choice over here has to do with the scale of the setting. Scale determinants for the tree in this instance, are height and spread. In Plate 4.7 the umbrella-shaped indigenous *Ficus sp* has enough space to spread its crown in its away from street situation.

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Table 4.6 Specific Street Tree Selecting Criteria for Tree Planting Away from Street and not under Overhead Utility Lines.

Location away from street, not under utility lines			
Trees Selected			
Detailed Criteria for street tree selection	Names		
	Scientific	Common	Local
1. Height : select to on - site scale	Indigenous		
	Acacia nilotica	Scented thorn	Odanwoma
2. Forms: columnar, conical, fastigate, oval, pyramid, round, vase irregular (all forms)	*Allanblackia floribunda*	Tallow tree	
	Alstonia boonei	Alstonia	Sinduro
	Anogeissus leicarpus	Anogeissus	Sakane
	Anthonotha macrophylla		Nsuroko
	Antrocaryon micraster	Antrocaryon	Aprokuma
	Beilschmiedia mannii		Tweanka
	Blighia sapida	Akee Apple	Akye
	Canarium schiveinfurthii	African Canarium	Bediwonua
	Carapa procera	African Crabwood	Kwakuo-bese
	Celtis mildbraedii	Celtis	Esa-fufuo
	Chrysophyllum subnudum	Chrysophyllum	Akasa
	Cola gigantea var glab		Watapuo
	Drypetes floribunda		Bedibesa
	Ekebergia capensis	Cape Ash	
3. Stem base: non-buttressed, slightly buttressed, buttressed (all types)	*Guarea cedrata*	Scented Guarea	Kwabohoro
	Hura crepitans	Sandbox Tree	
	Lonchocarpus sericeus	Senegal lilac	Sante or
	Milletia thonningii	Milletia	Okuro-Sante
	Monodora myristica	African Nutmeg	Awerewa
	Newbouldia laevis		Sesemasa
	Parkia bicolor	Parkia	Asoma
	Parkia biglobosa (clappert)	African Locust B	Dawadawa
	Parkia filicoidea		Esereso Asawa
	Pentaclethra macrophylla	African Oil Bean	Atta Bean
	Spathodea campanulata	African Tulip Tree	Kokoanisua
	Tabernaemontana crassa	Adams Apple Flower	Obonawa
	Trichilia emetican	Natal Mahogany	Kisiga

	Exotic		
	Cassia siamea	Siamese Cassia	
	Mangifera indica	Mango	Mango
	Pithecellobium dulce	Madras Thorn	
	Polyalthia longifolia	Weeping Willow	

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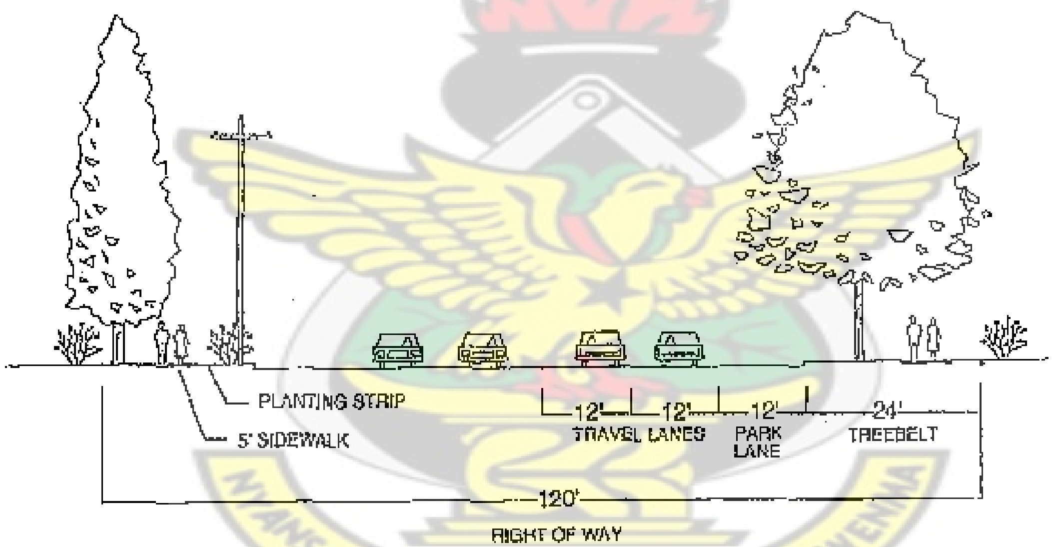

Fig. 4.3 Diagramatic situation of a columnar tree for away from street and not under utility line situation.

Source : Bloniarz and Ryan (1991)

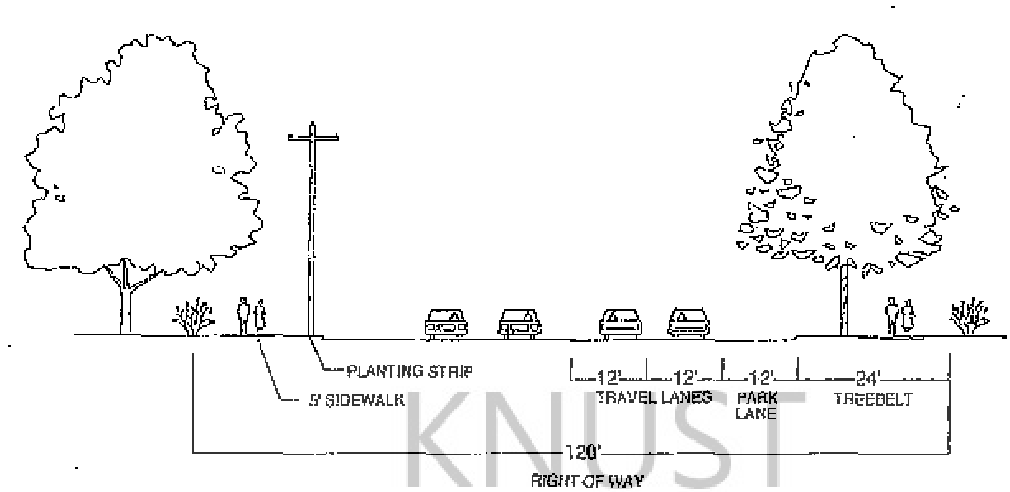

Fig. 4.4 Diagramatic situation of a round tree in an away from street and not under utility line situation.

Source : Bloniarz and Ryan (1991)

Plate 4.7 Round shaped indigenous *Milletia thonningii*. planted away from street and not under utility on KNUST campus, Kumasi.

4.4.2 Tree Selection for Residential Property

In residential landscape, the intensity of uses include passive visual appreciation, active recreation and even storage of personal possessions such as vehicles and kiosks. There may not be a consistent pattern of open spaces. In some cases, buildings and paved surfaces occupy most of the outdoor space, while on others, they cover only a small portion of the total area. Because of this diversity found in residential areas, planting guidelines, according to WFC and Morgan (1993), should be general rather than specific. Carefully, in another way, the home landscape tree uses can be broken down to make specific choices. Some common uses are specimen, shade, boundary, planting for screening and demarcation.

One criteria considered in the selection for residential property included tree height. At human scale, for the home environment, that is not expected to go over 15m (small to medium size), wood density (not low to prevent accidents) and leaf fall generally not deciduous to minimize clearing and cleaning of leaf litter.

a) Criteria for Specific Home Use as Shade Tree

The criteria for home shade tree presented in Table 4.7 could only select few trees.

So many indigenous trees, even *Milletia thonningii* in Plate 2.1 could not pass the evaluation, neither could the exotic trees in the Danyame- Kumasi count pass for a shade tree though there were over four being used successfully, for example *Terminalia mantaly* and *Pithecelobium saman.* This was mainly because the mature height of these trees were over the 15 m height criteria for small to medium sized trees. It is highly possible that recorded tree heights were taken from forest environments where naturally for lack of spreading space trees would be forced to go up.

Besides the height criteria, taller trees in practice are difficult and dangerous to prune and buttresses make mowing and paving difficult. *Pithecelobium saman,* a large spreading tree, missed the selection on the account of its wandering buttress system which is unacceptable to mowing and paving. Selected shade trees (Table 4.7) included *Acacia nilotica*, indigenous and evergreen, pictures in Plate 4.8. Critical factor in the shade provision is the canopy spread as expressed in the form. Rodekohr, *et al.* (1990) had form as the highest factor among height, width, and growth rate in shade tree selection.

Table 4.7 Detailed criteria for specific home use as shade tree

Home shade trees			
Tree Selected			
Criteria for selection	Names		
	Scientific	Common	Local
1 Form: round, vase, umbrella, irregular	Indigenous		
	Tabernaemontana crassa	Adams Apple Flower	Obonawa
2. Height: not more than 15m (small to medium size)	*Acacia nilotica*	Scented thorn	Odanwoma
	Beilschmiedia mannii		Tweanka
	Drypetes floribunda		Bedibesa

3. wood density: medium to high	
4. leaf fall: evergreen semi-deciduous	Exotic
5. stem base type: no buttress slightly buttressed	
6. growth rate: moderate to high	

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Plate. 4.8 Indigenous *Acacia nilotica* as shade tree.

Source: Fagg and Mugedo (2005)

Plate 4.9 Exotic *Terminalia mantaly* shade tree in a home landscape in Danyame, Kumasi

b) Criteria for Selection of Trees for Specific Home Use (Boundary and Screen Trees)

Spatial width on residential property boundaries and screens in Ghana, as the case may be elsewhere is quite narrow in the region of 3m (10ft) or less. This can be termed as tight and need narrow crown trees such as columnar oval, conical, fastigate and pyramidal with no buttresses to affect pavement, kerbs, boundary and building walls.

Tree height could be adjusted to on-site to scale, but the stem base has to be non-buttressed so that it does not destroy boundary walls and fences.

In criteria Table 4.8 both indigenous and exotic species were selected. *Ekebergia capensis, Newbouldia laevis* and *Spathodea*. *Campanulata* (Plate 4.10) were among the local trees and *Cassia siamea Polyalthia longifolia* among the exotics (Plate 4.11)

Table 4.8 Detailed criteria for specific home use as screen and boundary tree.

Home screen and boundary trees			
Tree Selected			
Criteria for selection	Names		
	Scientific	Common	Local
1. Form: columnar, conical, oval, fastigate, pyramidal	Indigenous		
	Ekebergia capensis	Cape Ash	
2. Height: to scale	*Newbouldia laevis*		Sesemasa
	Pentaclethra macrophylla	African Oil Bean	Atta Bean
	Spathodea campanulata	African Tulip Tree	Kokoanisua
3. Wood density: medium to high			
4. Leaf fall: evergreen semi deciduous	Exotic		
	Cassia siamea	Siamese Cassia	
	Pithecellobium dulce	Madras Thorn	
5. Stem base type: no buttress	*Polyalthia longifolia*	Weeping Willow	
6. Growth rate: quick			

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Plate 4.10 Indigenous *Newbouldia laevis* and *Spathodea campanulata* as residential screen and boundary trees in Kumasi.

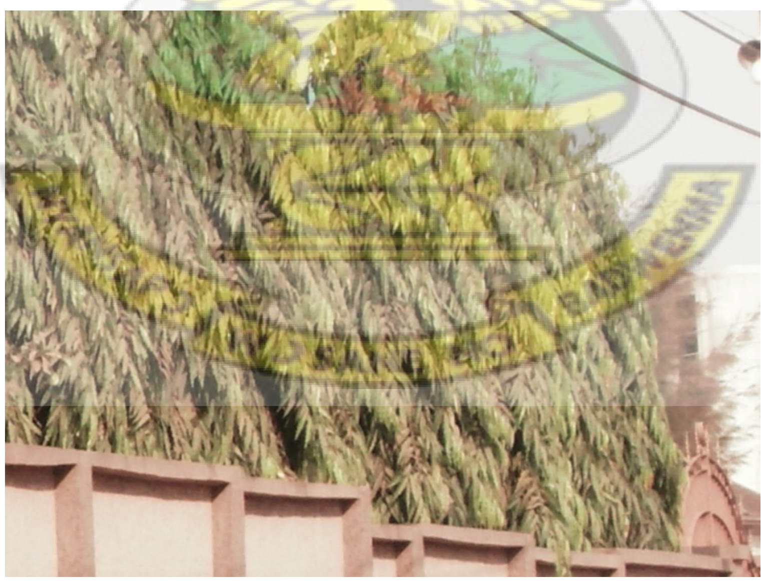

Plate 4.11 Exotic *Polyalthia longifolia* as screen tree at a residence in Ayigya, Kumasi

c) Criteria for Specific Home Use as Specimen Trees

A specimen tree is one that is appreciated for its form, leaf or flower colour, height, fruit size or texture. Generally all trees are specimen in their own right, but in a home environment height would be determining factor as large trees would be too overpowering to cause vertigo. Jaron (1996) and Grey and Deneke (1986) shared the same view. Still to prevent accidents caused by limb shear, trees with low wood density had to be avoided. There were no limitations in leaf fall, stem base and growth rate because these are characteristics from which trees can exhibit their specimen nature. For example, *Burkea africana* and *Poiciana regia* can demonstrate their beauty in their form and even colour as shown in plates 4.12 and 4.13

Plate 4.12 Indigenous *Burkea africana* as specimen tree for its umbrella form.

Source: Wilde (2008) [online]

Plate 4.13 Exotic *Poinciana regia* as specimen tree for its umbrella form and colour.

Source: anonymous (2010) [online]

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Table- 4.9 Detailed criteria for selection of trees for specific home use as (specimen tree)

Home specimen trees			
Tree Selected			
Criteria for selection	Names		
	Scientific	Common	Local
1. Form: all forms	Indigenous		
	Acacia nilotica	Scented thorn	Odanwoma
2. Height: up to 15m small to medium	*Baphia nitida*	Camwood	Odwene kroben
	Beilschmiedia mannii		Tweanka
	Burkea africana	Bussea	Pinimo
3. Wood density: medium to high	*Calencoba gilgiana*		Asratoa
	Carapa procera	African Crabwood	Kwakuo-bese
	Drypetes floribunda		Bedibesa
	Garcinia kola	Bitter Kola	Tweapea
4. Leaf fall: all trees	*Hildergardia bateri*		Akyere
	Hymenostegia afzelli		Takorowa
	Lecaniodiscus cupanioides		Dwindwera
5. Stem base type: all	*Newbouldia laevis*		Sesemasa
	Securinega virosa		Nkanaa
	Tabernaemontana crassa	Adams Apple Flower	Obonawa

6. growth rate: all	Exotic		
	Cassia nodosa	Pink Cassia	
	Lagestroemia speciosa	Queen Flower	
	Poinciana regia	Flamboyante	Sempoadua
	Polyalthia longifolia	Weeping Willow	
	Tectona grandis	Teak	

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Plate 4.14 *Cassia nodosa* with spectacular umbrella form and colour as a specimen tree in a residential environment.

Source: Xemenendura (2008)

4.4.3 Tree Selection for Reserved areas

Reserved areas encompass diverse landscapes from wetlands, valleys, steep, greenbelts and disused lands. They are strategically used as storehouse for plants that are rare or threatened. As suggested by WFC and Morgan (1993) these are areas where trees that fulfill the conservation of threatened and rare species and enhance the feeling of a "natural" environment (preserving an "uncontrolled" appearance) must be planted. Thus, all tree heights (upper, middle, lower storeys) forms, growth rate, leaf fall and flowering fit into this reserved environment. The key issue here is conservation of threatened species and in the criteria, conservation status was the only determining factor used to select threatened trees to conserve in a reserved site, as suggested by WFC and Morgan (1993). In Ghana, according to Oteng-Amoako (2006), indigenous trees mainly face threat from commercial exploitation, and attempts such as logging limitations, complete ban and conservation of germplasm have been instituted.

In the selection process, (Table 4.10) *Acacia auriculiformis, Cassia siamea and Cassia nodosa* were the dominant few reserve trees in the Kumasi –Danyame tree count but were not selected in the evaluation because they were not under threat. Two facts known about these trees are that they grow rapidly and their planting materials, that is seeds, are viable and readily available. These could have influenced the urban re-aforestation decision in Kumasi to have hurriedly planted these three trees species which do not merit protection. However, *Albizia ferruginea, Macaranga spinusa, and Pentadesma butyracea* among the selected threatened local trees are also quick growers with readily available seeds and they can add up to the exotic species, if not replace them, to increase biodiversity in the urban environment.

Table 4.10 Detailed selection criteria for specific reserved areas

Reserved areas			
Tree Selected			
Criteria	Names		
	Scientific	Common	Local
1. Conservation status: threatened species	*Afzelia africana*	African mahogany	Papao
	Albizia ferruginea	West Africa Albizia	Awiemfo-samena
	Anopyxis klaineana	African White Oak	Kokote
	Antrocaryon micraster	Antrocaryon	Aprokuma
	Copaifera salikounda	Salikounda	Entedua
	Detarium senegalense	TallowTree	Takyikyiriwa
	Entandrophragma cylindricum	Sapele	Sapele
	Garcinia kola	Bitter Kola	Tweapea
	Hildergardia bateri		Akyere
	Hymenostegia gracilipes		Ababima kokoo
	Khaya grandifolia	Broad-leafed Mahogany	Kruba
	Khaya senegalensis	Dry zone Mahogany	
	Lavoa trichiloides	African Walnut	Dubinbiri

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	Lophira lancelata		Esreso kaku
	Lovoa trichilioides	African Walnut	Dubinbiri
	Macaranga spinusa		Opam
	Milicia excelsa	African Oak	Iroko
	Monodora crispata		
	Pentadesma butyracea		Paegya
	Pouteria altissima		Asanfona

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4.4.4 Tree Selection for Parklands and Campuses

These areas also follow a "naturalistic" plant arrangements except that selection should be geared towards reducing maintenance costs, encourage wildlife habitat or allow for a wider variety of uses to occur within these campus areas, (WFC and Morgan,1993) . The long term implications of these trends must be considered when trees are selected. Critically, low maintenance trees in urban landscape have more to do with low leaf shedding, disease and drought resistance, strong wood and less prolific fruit trees to create a ‘nuisance’ free environment. In considering the variety of uses, there are colourful, shade, wildlife attracting trees with various forms and height to satisfy the multiple of uses that occur in the parklands and campuses. Parklands and campuses, for example university campus or large industrial complex, possess elements of street, home and reserve area characteristics and as such tree selection needs to be wide.

Table 4.11 Detailed criteria for Parklands and Campuses

Parklands and Campuses			
Tree Selected			
Criteria	Names		
	Scientific	Common	Local
1. Leaf fall: evergreen and semi deciduous	Indigenous		
	Acacia nilotica	Scented thorn	Odanwoma
	Allanblackia floribunda	Tallow tree	
	Alstonia boonei	Alstonia	Sinduro
	Anogeissus leicarpus	Anogeissus	Sakane
	Anthonotha macrophylla		Nsuroko
	Antrocaryon micraster	Antrocaryon	Aprokuma
	Baphia nitida	Camwood	Odwene kroben
2. Wood density: medium to very high.	*Beilschmiedia mannii*		Tweanka
	Blighia sapida	Akee Apple	Akye
	Bussea occidentalis	Bussea	Kotoprepre
	Calpocalyx brevibracteatus	Calpocalyx	Atrotre
	Canarium schiveinfurthii	African Canarium	Bediwonua
	Carapa procera	African Crabwood	Kwakuo-bese
	Cassia sieberiana	African Laburmum	Ekwo Prankese

	Celtis mildbraedii	Celtis	Esa-fufuo
	Chrysophyllum albidum	Chrysophyllum	Akasaa
	Chrysophyllum perpulchrum	Chrysophyllum	Atabene
	Chrysophyllum subnudum	Chrysophyllum	Akasa
	Cola gigantea var glab		Watapuo
	Copaifera salikounda	Salikounda	Entedua
	Corynanthe pachyceras	Corynanthe	Paprama
	Drypetes floribunda		Bedibesa
	Ekebergia capensis	Cape Ash	
	Erythrophleum suaveoleus	Forest Ordeal Tree	Potrodom
	Garcinia kola	Bitter Kola	Tweapea
	Guarea cedrata	Scented Guarea	Kwabohoro
	Hexalobus crispiflorius	Hexalobus	Duabaha
	Hura crepitans	Sandbox Tree	
	Hymenostegia afzelli		Takorowa
	Irvingia gabonensis	Bush Mango	Abesebuo
	Khaya anthotheca	African Mahogany	Kruben
	Kigelia africana	Sausage Tree	Nufutene
	Klaindoxa gabonesis	Klaindoxa	Kroma
	Lavoa trichiloides	African Walnut	Dubinbiri
	Lonchocarpus sericeus	Senegal lilac	Sante
	Lophira lancelata		Esreso kaku
	Lovoa trichilioides	African Walnut	Dubinbiri

	Mammea africana	Africa Apple	Bompagya
	Milletia thonningii	Milletia	Okuro-Sante
	Monodora myristica	African Nutmeg	Awerewa
	Napoleonea vogelii		Obua
	Newbouldia laevis		Sesemasa
	Parinari excelsa	African Greenheart	Afam
	Parkia bicolor	Parkia	Asoma
	Parkia biglobosa (clappert)	African Locust B	Dawadawa
	Parkia filicoidea		Esereso_Asawa
	Pentaclethra macrophylla	African Oil Bean	Atta Bean
	Sacoglottis gabonaensis	Sacoglottis	Fawere
	Spathodea campanulata	African Tulip Tree	Kokoanisua
	Synsepalum brevipes	Musaka	Aframsua
	Tabernaemontana crassa	Adams Apple Flower	Obonawa
	Tamarindus indica	Tamarind	Brofo
	Sonhorang		
	Trichilia emetican	Natal Mahogany	Kisiga
	Exotic		
	Pithecellobium dulce		
	Polyalthia longifolia	Weeping Willow	
	Mangifera indica	Mango	Mango
	Cassia siamea	Siamese Cassia	

Though *Cedrella odorata, Ceiba pentandra and Poinciana regia* are currently being used as parkland and campus trees in Kumasi, they were not selected as such in the evaluation process because of their low wood density level. *Milletia thonningii* was however picked because of its favourable leaf fall and wood density. It is not surprising that *Cassia siamea, Mangifera indica* and *Pithecellobium dulce,* the traditional exotic parkland trees, were captured by the criteria due to their acceptable leaf fall (semi-deciduous and evergreen) and wood densities. *Mangifera indica,* for example, is evergreen and possesses high wood density from its malleable nature.

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CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 SUMMARY

Out of this study have emerged indigenous trees that have the potential of being planted in the urban landscape in the semi-deciduous region of Ghana, to add up to the existing dominant stock of exotic trees. In addition, some of the exotic species have been reassigned through selection criteria, other than ethnobotanic reasons, to their rightful uses and locations in the urban landscape.

Selection criteria used were based on the canopy form, height, wood density, vegetation zone, conservation status, stem base behaviour, rate of growth and leaf fall. They were selected to fit into classified urban landscapes, namely street, residential area, reserve, and parkland and campus trees. The evaluation consisted of setting requirements or criteria for trees to satisfy in a particular urban landscape area, for example for street landscape, moderate to high growth rate, moderate to high wood density were some of the criteria set. In the street landscape selection, indigenous *Ekebergia capensis. Newbouldia laevis,* and *Spathodea campanulata and* exotic *Cassia siamea* and *Polyalthia longifolia* were picked as street trees indicating that the indigenous species are as good candidate trees as the exotic ones.

In residential landscape, indigenous and exotic trees were also selected for uses as shade, specimen, screen and border. For shade, none of the existing exotic species could meet the requirements because of the 15 m critical maximum height (for small to medium sized trees). As such, *Mangifera indica* and *Terminalia mantaly* which generally make good shade trees in Kumasi missed the selection.

Criteria for the reserved area was focused only on conservation status. Only threatened trees were selected and their germplasm assigned to the reserve to be conserved. *Garcinia cola and Pouteria altissima* were among the selected. None of the existing exotic trees in use as reserved area was selected particularly because they had not been classified as threatened.

In the Parkland and Campus situation, there is a diversity of uses from street, shade, specimen, so few criteria (leaf fall and wood density) were set for the evaluation process. Comparatively, a larger number of over forty indigenous trees and four exotic species were selected. Among the local trees were *Spathodea campanulata*, *Synsepalum brevipes Tabernaemontana crassa* and *Trichilia emetican* and the exotic ones were *Pithecellobium dulce, Polyalthia longifolia, Mangifera indica and Cassia siamea.*

5.2 CONCLUSION

In effect, there are some indigenous trees that have the potential to be used as urban landscape trees and are also at par with the dominating exotic amenity trees.

5.3 RECOMMENDATIONS

In this study, the attempt has been made to isolate and classify urban landscape uses for some indigenous and existing exotic trees. Future work is recommended on the selected trees, for example, tolerance to flooding, dry and wet and low nutrient soils in reserve area trees. Street trees need to be looked further into for tolerance against drought, heat, and air pollution. Further research also needs to be done to find more narrow canopied trees below 8m high and even small shrubs that can grow into small trees to fit into tight spaces under utility lines.

In secondary literature, mature heights are given for all trees. Regional ecological differences in height can cause regional discrepancies, for instance height or size of *Garcinia cola* (Tweapea) in the wet evergreen forest of Ghana may not be the same in the semi deciduous zone; so heights may have to be referenced to where the source tree was picked or an average found for all zones. From World Agroforestry Centre, *Mangifera indica* is a large evergreen tree that grows 20 m tall with a dark green, umbrella-shaped crown, but has been observed that the tree in Kumasi it matures at a height less than 15 m (Plate 6.1).

Many trees in their youthful stages of five to over ten years, possess striking features eg. non buttressed stem bases and other forms, therefore, it is recommended that youthful heights, sizes and forms are recorded to aid species selection for use into short-lived urban landscapes such as streets. For example, *Khaya senegalensis* whose mature height is 35 m (seven to nine floors) can grow beautifully as a shade tree in a car park and later be removed if found growing out of control or at the next road construction.

Plate 6.1 Mature 13m high *Mangifera indica*, over fifty years old, growing less than the documented height of over 20 m.

Plate 6.2 Young *Khaya senegalensis* growing as a shade tree at a car park

So also can *Spathodea campanulata* be enjoyed for its youthful height and size for over ten years of age other than in its mature outlook. From the home selections made, more work could also be carried out to look for species with striking flower colours and / or sweet fragrances to enhance their popularity.

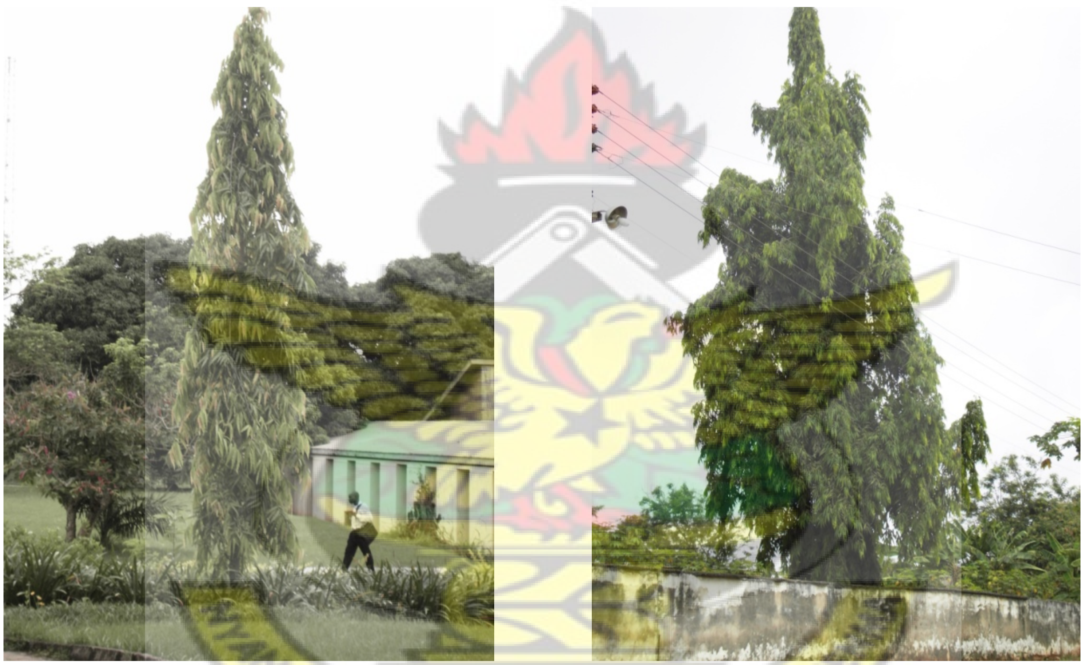

Plate 6.3. Comparatively young and mature *Polyalthia longifolia* have different forms and spread.

Plate 6.4 Comparatively young and mature *Spathodea campanulata* have different form and spread.

Lastly, in the current era of global warming, additional effort is suggested to evaluate the atmospheric carbon dioxide reduction capacity of the selected tress for the purpose of reducing global warming.

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APPENDICES

APPENDIX 1

LIST OF SOME INDIGENOUS TREES OF GHANA ETHNOBOTANICALLY USED FOR LANDSCAPE APPLICATIONS

Scientific Name	Common Name	Local Name
Acacia farnesiana		
Acacia nilotica	Scented thorn	Odanwoma
Adenanthera pavonina	Bead Tree	
Afzelia africana	African mahogany	Papao
Afzelia beila var gracilior		Papao,
Albizia adianthifolia	West Africa Albizia	Pampena
Albizia ferruginea	West Africa Albizia	Awiemfo-samena
Albizia Lebbek	East indian walnut	
Albizia zygia	West African Albizia	Okoro
Allanblackia floribunda	Tallow tree	
Alstonia boonei	Alstonia	Sinduro
Amphimas pterocarpoides	Bokanga	Asanfran
Aningeria altissima		Asafena
Anogeissus leicarpus	Anogeissus	Sakane
Anopyxis klaineana	African White Oak	Kokote
Anthonotha macrophylla		Nsuroko

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Antiaris toxicaria	Bark Cloth Tree	Kyenkyen
Antrocaryon micraster	Antrocaryon	Aprokuma
Baphia nitida	Camwood	Odwene kroben
Beilschmiedia mannii		Tweanka
Berlinia confusa		Kwatafompaboa
Blighia sapida	Akee Apple	Akye
Blighia unijugata		Akyebiri
Bombax buonopozense	Kapok	Akonkodie
Burkea africana	Bussea	Pinimo
Bussea occidentalis	Bussea	Kotoprepre
Calencoba gilgiana		Asratoa
Calpocalyx brevibracteatus	Calpocalyx	Atrotre
Canarium schiveinfurthii	African Canarium	Bediwonua
Carapa procera	African Crabwood	Kwakuo-bese
Cassia sieberiana	African Laburmum	Ekwo Prankese
Ceiba pentandra	Ceiba	Onyina
Celtis adolfi-friderici	Celtis	Esa-kosua
Celtis mildbraedii	Celtis	Esa-fufuo
Celtis zenkeri	Celtis	Esa-kokoo
Chrysophyllum albidum	Chrysophyllum	Akasaa
Chrysophyllum perpulchrum	Chrysophyllum	Atabene
Chrysophyllum subnudum	Chrysophyllum	Akasa
Cola gigantea va.r glab		Watapuo

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Cola gigontea	Colawood	Watapuo/Dodowa
Copaifera salikounda	Salikounda	Entedua
Cordia milleni	Drum Tree	Tweneboa
Cordia plantythyrsa		Tweneboa
Corynanthe pachyceras	Corynanthe	Paprama
Crateva adansonii	Corynanthe	Chelum punga
Cychcodiscus gabunensis	Denya	Denya
Detarium senegalense	TallowTree	Takyikyiriwa Bowisi
Dissomeria eranata	TallowTree	Papa-ye
Drypetes floribunda		Bedibesa
Ekebergia capensis	Cape Ash	
Entandrophragma ango.	Tiama Mahogany	Edinam
Entandrophragma cylind.	Sapele Mahogany	Sapele
Erythrina addisoniae		Osorowa
Erythrina excelsa		
Erythrina mildbraedii		Osoronim
Erythrina senegalensis	Coral Tree	Osorokasoro
Erythrophleum suaveoleus	Forest Ordeal Tree	Potrodom
Euphorbia laterifolia		Kamfo Barima
Ficus dekdekena		Gamperoga
Ficus glumosa var glabercima	Fence Tree	Galinziela
Ficus ingens var ingens		Kunkwiya
Ficus leprieuri		Amangyedua

Ficus lutea		Ofonto
Ficus lyrata		
Ficus ovata		
Ficus platyphylla	Gutta-Pereha Tree	
Ficus sur	Cape Fig	
Ficus umbrellata		Gyedua
Garcinia kola	Bitter Kola	Tweapea
Guarea cedrata	Scented Guarea	Kwabohoro
Hannoa klaineana	Hannoa	Fotie
Hexalobus crispiflorius	Hexalobus	Duabaha
Hildergardia bateri		Akyere
Holarrhena floribunda	False Rubber Tree	Sese
Homalium letestui		Osononankroma
Hura crepitans	Sandbox Tree	
Hymenostegia afzelli		Takorowa
Hymenostegia gracilipes		Ababima kokoo
Irvingia gabonensis	Bush Mango	Abesebuo
Isobelinia doko	Doka	Sibila
Khaya anthotheca	African Mahogany	Kruben
Khaya grandifolia	Broad-leafed M.	Kruba
Khaya senegalensis	Dry zone Mahogany	
Kigelia africana	Sausage Tree	Nufutene
Klaindoxa gabonesis	Klaindoxa	Kroma

Lannea welwitschii	Lannea	Kumanini
Lavoa trichiloides	African Walnut	Dubinbiri
Lecaniodiscus cupanioides		Dwindwera
Leucaena lecocephala	Wild Tamarind	
Lonchocarpus griffonianus		Senyana
Lonchocarpus sericeus	Senegal lilac	Sante or Nsamantai
Lophira lancelata		Esreso kaku
Lovoa trichilioides	African Walnut	Dubinbiri
Macaranga spinusa		Opam
Majidea fosteri		Ankyewa
Mammea africana	Africa Apple	Bompagya
Milicia excelsa	African Oak	Iroko
Milletia thonningii	Milletia	Okuro-Sante
Monodora brevipes		Abotokuradua
Monodora crispata		
Monodora myristica	African Nutmeg	Awerewa
Morus mesozygia		Wonton
Napoleonea vogelii		Obua
Newbouldia laevis		Sesemasa
Parinari excelsa	African Greenheart	Afam
Parkia bicolor	Parkia	Asoma
Parkia biglobosa (clappert)	African Locust B	Dawadawa
Parkia filicoidea		Esereso_Asawa

Pentaclethra macrophylla	African Oil Bean	Atta Bean
Pentadesma butyracea		Paegya
Piptad eniastrum africanum		Dahoma
Poinciana regia	Flamboyante	Sempoadua
Pouteria altissima	Anigeria	Asanfona
Pycanthus angolensis	African Nutmeg	Otie
Quassia undulata		Effeu
Rauvolfia caffra	Quinine Tree	
Rauvolfia vomitoria	Swizzle Stick	Kakapenpen
Ricinodendron heudelottii	Groundnut Tree	Nwamma
Ricinus communis	Castor Oil Plant	Abronkuma
Sacoglottis gabonaensis	Sacoglottis	Fawere
Sclerocarga birrea		Nanogba
Securinega virosa		Nkanaa
Senna singueana	Winter Cassia	
Spathodea campanulata	African Tulip Tree	Kokoanisua
Stereospermum acumin.	Stereospermum	Esonotokwakofuo
Symphonia globulifera	Boardwood	Ahureke
Synsepalum brevipes	Musaka	Aframsua
Tabernaemontana crassa	Adams Apple Flower	Obonawa
Tamarindus indica	Tamarind	Brofo Sonhorang
Tetrapleura tetraptera	Tetrapleura	Prekese
Trichilia dregeana	Thunder Tree	

Trichilia emetican	Natal Mahogany	Kisiga
Vitex doniana	West African Plum	
Voacanga africana	Voacanga	Badowa
Zanthoxylum gilletii	African Satinwood	Okuo

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