Urban Afforestation in Tanzania: Lessons from Sokoine University of Agriculture Landscape Inventory

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ABSTRACT

A study to ascertain the extent to which tree-planting in urban areas of Tanzania have been adhering to the prescribed standards essential for provision of the anticipated services was carried out by taking Sokoine University of Agriculture main campus landscape as a case study. Data pertaining to species and genera composition, age distribution, and overall heath status were collected through a survey which involved 100% sampling intensity. All trees and shrubs encountered were identified by their botanical names, along with taking measurements on their appropriate location, tree-size, and overall health status. The study revealed a tendency of concentrating on few plant species, while much other potential were available. While the acceptable standard requires species not to exceed 10 %, some species were represented by more than 24 %. Diversification at genera level ideal as none of the genera exceeded the prescribed standard of 30%. The distribution of plants in terms of age class was not ideal as the observed proportion in the young (28.3%), mature (62.7%), and over mature (9.0) diverged significantly from the respective prescribed standards of 20%, 60%, and 20%. The overall health status of trees was good, with this class representing more than 95% of the total trees observed. Excessive concentration of few species and genera has a disadvantage, particularly in the incidences of pest and disease outbreak. Large areas could be left bare if a species happened to be severely attacked, which in turn reduces the overall beauty of a landscape. Inappropriate age class distribution complicate future landscape maintenance since many trees may have to be removed and replanted at once. This tends to increase the cost of maintenance, and may make replacement exercise impossible. It is concluded that urban afforestation in most towns of Tanzania are likely to have not adhered to the prescribed standards, as policies related to tree planting have been similar in most cities. It is recommended that cities and urban authorities should consider the use of landscape experts in deciding the appropriate ways of handling urban forest, so as to maximize the benefits that could accrue.

Keywords: Urban forest, species and general diversity, age distribution, tree health, landscaping

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BACKGROUND

Urban Forests in Tanzania like in many other countries, has been going on for decades to meet various purposes such as provision of shade, aesthetical values, and many other environmental and ecological benefits (Phillips, 1993; Nowak, 2000; Nilson, Konijnendikj and Randrup, 2005). Trees in urban areas are now an integral part of large cities, rural areas, streets, backyard, parks and open space in urban cities, adding beauty and character to installations (McPherson, 1998). They influence the environment by improving air quality and reducing energy cost as well as contributing to water and soil conservation (Samyser, 1984; McPherson and Simpson, 2000). Studies have shown that properly placed trees can reduce energy consumption by shading building walls and windows. Shade and canopy cover alter micro-environments and reduce energy costs of cooling the facilities (Xiao, Mc Pherson, Ustin, Grismer and Simpson, 2000; Samyser, 1984; Points, 2000; McPherson, Simpson and Scott, 2002). Urban forestry provides benefit to communities by bringing people together, and they form connections between humans and the urban flora and fauna (Samyser, 1984; Points, 2000). Trees in urban forest add beauty through their shape, texture, colour and fragrance. They soften the appearance of buildings, packing areas and streets. Psychologically, trees create feelings of relaxation and well-being. They can provide privacy and a sense of solitude and security. The habitat and food provided by urban forestry to small animals and birds enhance the character of the environment (Samyser, 1984; Carter 1995).

The environmental values of urban forestry are known with certainty. Trees are essential in intercepting rainfalls and help to control erosion of valuable topsoil. The root system helps stabilize the soil and slow rainfall runoff by absorbing water before it enters a storm drainage system (Moll and Ebernreck, 1989). Carbon fixation and sequestration, reduction of air pollution, attraction of other life forms such as birds and monkeys, and add value to the overall recreation and amenity of an area (IPCC, 2006; Zhao, Kong, Escobedo and Gao, 2009). The value attached to urban forestry in provision of open space for multiplication and conservation of rare endangered or special species have increased the potential of urban forestry. Species like pterocarpus angolensis, Dalbergia melanoxlon, Millicia, excels, kyaya anthotheca and the like, which are known to be threatened can easily be conserved through urban forestry programs. It is now acknowledged that tree planting in urban areas has become a necessity rather than an optional, and no human being can live comfortably without associating himself or herself with trees nearby (Moll and Ebenreck, 1989; Nillsson, 2000; Smith and Smith, 2003).

Tree planting in urban areas of Tanzania is mainly done by individuals around their homestead, and to a certain extent by the municipals in public areas. Sometimes tree-planting has taken a political face, where every individual in a society is obliged to plant a certain number of plants. In most cases prior arrangement on what has to be planted has been lacking, necessitating people to plant whatever species they come across during the planting season. This practice together with the preference to some few species has made landscape in the cities to comprise trees of single or just a mixture of few species. For example, Grevilea robusta is known to dominate most of the Lushoto landscape (SECAP, 2009), while Senna siamea and S. spectabilis are dominant in Hai, Kibaha and Morogoro Municipalities. This tendency has a serious negative effect when species become prone to pests and diseases incidences (Miller, 1988; IUFRO, 1997; Nowak, 2000). Tanzania witnessed the incidence of cypruss aphid that killed most of the Cupressus lusitanica and the allied species. The species, which was widely planted for hedges and fences, turned into a nuisance when it was completely wiped out. In early 1990s' the ever preferred Leucaena leucocephala, an important animal feed was severely threatened by Leucaena psyllid (Heteropsylla cubana), thus affecting livestock keepers who solely depended on it as feed supplement (Arnold, 1993). Such kinds of disaster and the associated impact were experienced due to lack of reasonable level of diversification at species level.

To assist in the successful management of urban forestry, several principles and standards which are essential to be adhered to have been prescribed. The first step to assure success is the need to carry out an inventory on a variety of tree/shrub species that could be used. Such data aid in the development of long term plans and design decisions such as new plantings, ensuring species diversification and prioritising maintenance actions (Miller, 1988; Moll and Ebernreck, 1989). Under any circumstances no single species should be allowed to exceed 10% of the total tree population, and no single genus should comprise more than 30% (Moll and Ebernreck, 1989; USAF, 1998; Santamour, 2002). Age-wise, young trees are recommended to be around 20% while mature trees have to be around 60 %. The over mature tree are not recommended to exceed 20% (Moll and Ebernreck, 1989; USAF, 1998). With this criterion, trees with diameter of 20-40 cm are considered to be the early functional, while functional mature trees range between 40- 60 cm. The over mature trees are those with diameter exceeding 60 cm (Moll and Ebernreck, 1989; USAF, 1998; Mc Pherson, 2000)

Based on what have been observed in most cities of Tanzania in terms of tree-planting in urban centres, and what is prescribed as standards, this study was initiated to establish the extent to which tree-planting in urban areas has been adhering to prescribed standards that are meant to provide maximum benefit and alleviate some problems associated with urban afforestation. It also aimed at determining whether there is a culture of planting trees frequently to replace the over mature species and whether this replacement has been adhering to the prescribed standards by landscape specialists.

MATERIALS AND METHODS

Study area description

The study was conducted at the Sokoine University of Agriculture (SUA) main campus, which is located within the Morogoro Municipality. The campus lies on the foot of the Uluguru Mountain at 37^0 39" E and $4^0$9" S at an altitude about 500 m above sea level, about 200 km west of Dar es Salaam. The area experiences sub-humid type of climate with rainfall patterns characterized by two rainfall seasons. The dry season is between May and December, being interrupted by short rains in October and November. The mean annual rainfall is about 870 mm, with the total annual evapo-transpiration of 1300 mm. Average annual temperature is 24 ^{0}C, with minimum and maximum temperatures of 18 ^{0}C and 30 ^{0}C respectively (Ulvila, 1993). Soils are of meta-sedimentary rock origin, made up of pyroxene granulates containing plagioclase and quartz-rich veins, luvi soils and feral soils are the main soil type (Mackenzie, Mnkeni, Semoka, Msanya and Kaaya, 1994).

Sampling and data collection procedure

Data pertaining to species and genera composition were obtained through a survey that covered areas around students' hostels, lecture theatres, administration blocks and other buildings as indicated in Figure 1. In these areas, a sampling intensity of 100% was employed. All tree species encountered during the survey were identified on the spot by their botanical names. Where impossible or uncertain sample, specimens were collected and taken to Tanzania Forestry Research Institute (TAFORI) Herbaria for identification or confirmation. Along with the identification, positions of all trees were determined using a global positioning system (GPS), where a record on Easting and Northings (x,y) were taken.

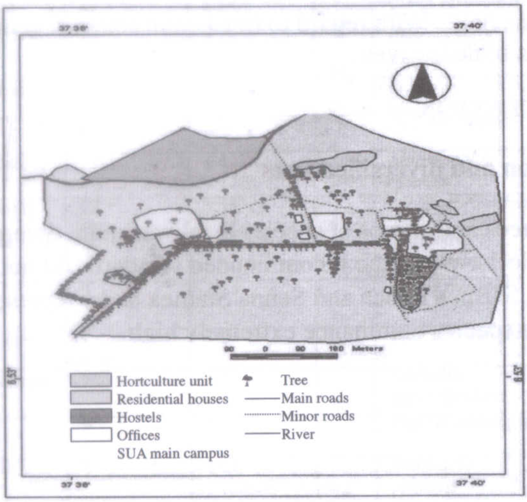

Figure 1: A Sketch of Sokoine University of Agriculture (SUA) landscape used in the study

Approximate ages of the trees were determined through observation of tree diameter, which is an approximate indicator (Moll and Ebernreck, 1989; USAF, 1998). Thus, diameter at breast height (dbh) for each tree encountered was recorded. Data on the overall health status of trees was done by observing the conditions of the trees, which looked at the level of presence of dead branches, pest and disease attack, and nutritional problems. A four scale ranking of Danis' (1992), with some modification was adapted in scoring the health status. Trees with excellent condition were those which had the best qualities in terms of form and had very minor maintenance problems; virtually they had no dead branches, deformities or nutritional problems, and were in an acceptable location that could make them achieve a full mature shape and life expectancy. Good trees were those with desirable form and with proper maintenance that could be returned to an excellent classification. They were those trees that interfered with utility lines, planted in overcrowded location, or have minor insect, pathogen, or nutritional problems. Immediate maintenance and proper care may be able to save such trees. Poor trees were those with degraded condition which are irreversible. They had over 50% dead branches, drastic deformities, and severe insect, pathogen or nutritional problems. Such trees have to be removed as soon as possible. Dead trees included those that were either dead or in such a poor condition that calls for mandatory immediate. They posses over 90% dead branches and have completely succumbed to insects, pathogens, or nutritional deficiencies.

Data analysis

Data on species diversification were summarised to tell the number of individuals of each tree species that occurred in the area. These individuals were compared to what was anticipated to be the ideal situation, through a paired T-test. Presence of significant difference was declared at 0.05 probability level. Similar procedure was used to summarise and analyse the data on genera diversification. Data on age class were classified into three classes as described by Moll and Ebernreck (1989), USAF (1998) and Mc Pherson 2000. Young trees were those with diameters ≤ 15 cm while mature trees had a diameter exceeding 15 but less than 60 cm. Over mature were those whose diameter exceeded 60 cm. Thus descriptive statistics, involving summarisation of data into these classes class was adopted. Thereafter a Chi-square test was used to compare the ideal situation with what was observed in the field. With regard to tree health status, a general description on the status as per Dafni's scale is given.

RESULTS AND DISCUSSION

Tree/shrub composition and diversification

The diversification of trees and shrubs at species level was quite divergent from the expected scenario (Table 1). While the recommended standards do not allow individual species to exceed 10%, Sarraca indica and Senna Siamea had a representation of 24.3 % and 17.5 %, making the species dominance extremely high.

Table 1: Proportion of tree/shrub species occupying the landscape of SUA main campus

S/N	Scientific name species	Number of Individual	% of total population	SN	Scientific name species	Number of Individual	% of total population
1	*Saraca indica*	217	24.35	37	*Cananga odorata*	4	0.44
2	*Senna siamea*	143	16.04	38	*Syzygium cuminii*	4	0.44
3	*Peltophorum africunum*	45	5.05	39	*Annona senegalensis*	4	0.44
4	*Azadirachta indica*	45	5.05	40	*Bridelia micrantha*	4	0.44
5	*Mangifera indica*	42	4.7	41	*Persea americana*	4	0.44
6	*Khaya anthotheca*	40	4.48	42	*Casuarina spp*	4	0.44
7	*Ficus benjamina*	20	2.24	43	*Citrus reticulata*	4	0.44
8	*Royal palm*	19	2.13	44	*Brachystegia spicifomis*	3	0.33
9	*Psidium guajava*	17	1.71	45	*Ranfobvia inebrians*	3	0.33
10	*Albizia spp*	14	1.57	46	*Delonix regia*	3	0.33
11	*Senna spectabilis*	13	1.45	47	*Milonoteane lotensis*	3	0.33
12	*Annona muricata*	12	1.34	48	*Citrus aurantifolia*	3	0.33
13	*Hura crepitans*	12	1.34	49	*Spathodea campanulata*	3	0.33
14	*Jacaranda mimosifolia*	9	1.01	50	*Citrus paradisi*	3	0.33
15	*Bauhinia variagata*	9	1.01	51	*Phoenix reclinata*	3	0.33
16	*Terminalia catappa*	9	1.01	52	*Sterculia appendiculata*	3	0.33
17	*Terminalia ivorensis*	9	1.01	53	*Kigelia aetheopica*	2	0.22
18	*Citrus sinensis*	9	1.01	54	*Araucaria celmalis*	2	0.22
19	*Araucaria spp*	9	1.01	55	*Ximenia Americana*	2	0.22
20	*Kigelia aficana*	9	1.01	56	*Treculia africana*	2	0.22
21	*Terminalia mantaly*	8	0.89	57	*Artocarpus heterophyllus*	2	0.22
22	*Pinus patula*	8	0.89	58	*Collembora spp*	2	0.22
23	*Leucaena leucocephala*	8	0.89	59	*Euphorbia tirucalli*	2	0.22
24	*Milicia excelsa*	8	0.89	60	*Euphorbia spp*	1	0.11
25	*Grevillea robusta*	7	0.78	61	*Fraximus intagifolies*	1	0.11
26	*Albizia lebbeck*	7	0.78	62	*Ficus eyeamanis*	1	0.11
27	*Eucalyptus maidenii*	6	0.67	63	*Bauhinia spp*	1	0.11
28	*Cocus nucifera*	6	0.67	64	*Cordia sebastina*	1	0.11
29	*Thuja occidentalis*	6	0.67	65	*Vitex doniana*	1	0.11
30	*Khaya senegalensis*	6	0.67	66	*Rauvolfia caffra*	1	0.11
31	*Pteleopsis mytifolia*	5	0.56	67	*Annona squamosa*	1	0.11
32	*Citrus limon*	5	0.56	68	*Markhamia obtusifolia*	1	0.11
33	*Albizia versicolor*	5	0.56	69	*Elasis guinensia*	1	0.11
34	*Albizia schimperiana*	5	0.56	70	*Others (dead)*	14	1.57
35	*Cellistemon citrinus*	5	0.56		*Total*	891	100

However, many other potential species such as *Rauvoria caffra, Annona squamosa, Markhamia obtusifolia, Cordia sebastina, Vitex doniana and Spathodea camapnulata, Millicia excelsa* were poorly utilized, with majority being represented by less than 1%. Tree composition at genus level was ideal as none of the genera exceeded the prescribed 30 % (Table 2).

Table 2: Proportions of current tree/shrub genera occupying the landscape of SUA main campus

S/N	Scientific name species	Number Of Individual	% of total population	SN	Scientific name species	Number Of Individual	% of total population
1	Senna	156	17.51	28	Cellistemon	5	0.56
2	Saraca	217	24.3.5	29	Cananga	4	0.44
3	Albizia	31	3.47	30	Syzygium	4	0.44
4	Terminalia	26	2.92	31	Bridelia	4	0.44
5	Citrus	24	2.69	32	Persea	4	0.44
6	Ficus	21	2.36	33	Casuarina	4	0.44
7	Annona	17	1.91	34	Brachystegia	4	0.44
8	Peltophorum	45	5.05	35	Ranfobvia	3	0.33
9	Azadirachta	45	5.05	36	Delonix	3	0.33
10	Mangifera	42	4.7	37	Milonoteane	3	0.33
11	Khaya	46	5.16	38	Spathodea	3	0.33
12	Ficus	21	2.36	39	Phoenix	3	0.33
13	Royal	19	2.13	40	Sterculia	3	0.33
14	Psidium	17	1.71	41	Araucaria	2	0.22
15	Hura	12	1.34	42	Ximenia	2	0.22
16	Jacaranda	9	1.01	43	Treculia	2	0.22
17	Bauhinia	10	1.12	44	Artocarpus	2	0.22
18	Araucaria	9	1.01	45	Collembora	2	0.22
19	Kigelia	11	1.23	46	Euphorbia	3	0.33
20	Pinus	8	0.89	47	Fraximus	1	0.11
21	Leucaena	8	0.89	48	Cordia	1	0.11
22	Milicia	8	0.89	49	Vitex	1	0.11
23	Grevillea	7	0.78	50	Rauvolfia	1	0.11
24	Eucalyptus	6	0.67	51	Markhamia	1	0.11
25	Cocus	6	0.67	52	Elasis	1	0.11
26	Thuja	6	0.67		Others (dead)	14	1.57
27	Pteleopsis	5	0.56				
					Total	**891**	**100**

The overall distribution of species within the landscape showed a clustering tendency, since high concentration of individual species was noted in some places. For example, areas around the Department of Crop Science and Administration blocks were overstocked with *Saraca indica*, while areas behind the Department of Forest Biology, Faculty of Forestry and Nature Conservation, Faculty of Veterinary Medicine, Institute of Sustainable Rural Development, Business Centre were concentrated with *Senna siamea*.

The noted diversification gives a clear indication on what has been happening with tree planting in most urban areas of Tanzania. Diversification of species has been quite poor, with only a few occupying large proportion of landscape. The tendency of concentrating on few species has a negative effect, particular in the incidences of pest and disease. Single species or monoculture type of planting tends to provide an insect with the same type of food, and if found palatable, then, chances of clearing and leaving the landscape bare is quite large (Nair, 1993). Concentration of a few species does not only expose the species to risks of the pest and disease, but it reduces the overall beauty of the landscape. Important aspects of landscaping such as colour, form, texture, line and scale are difficult to be achieved with the use of one or two species (Richard, 1982). There are many other advantages of incorporating a diversity of plants in a landscape since such diversification increases the number of habitats (both vertical and horizontal), which can be used by a variety of flora and fauna. This makes urban forestry to contribute toward biodiversity conservation, and provide a wonderful recreation sites where people can interact with a diverse of flora and fauna. These aspects cannot be achieved with a kind of species and genera diversity noted in the current study (Phillips, 1993).

Age class distribution and overall health status

The age class distribution of trees and shrubs was observed to diverge from the prescribed standard as per chi-square test (Table 3). While the prescribed standard requires the distribution to be 20%, 60% and 20% for young, mature, and over-mature trees respectively (McPherson, 2000; Moll and Ebernreck), the field observation noted the distribution of 28.3 %, 62.7 % and 9.0% respectively.

Table 3: Age class distribution of tree/shrub species occurring at SUA main campus: comparison of observed and ideal age class distribution

DBH range	Number of trees		Proportions	
	Observed (O)	Expected (E)	Observed	Expected
	252	178.2	28.3	20
Mature (>15-61cm)	559	534.6	62.7	60
Over mature(>61cm)	80	178.2	9.0	20
Total	**891**	**891**	**100**	**100**

$\chi^2 = 6.991$, P = 0.033

The improper age class distribution is also of great concern. The noted more trees being concentrated in the mature class predict some danger of having too many over mature trees at a particular time in the future. This means, at a particular time in the future, SUA may have to engage itself in massive tree removal and replanting to return the landscape to the standard scenario. It is important to note that having an ideal age class distribution help to avoid excessive removal and replanting at any given time, because resources are always scarce and the possibility of embarking on an expensive action can hardly be accommodated. However, if done in small pieces, the budget at any given time tends to be small and can easily be accommodated (Santamour, 2002).

The overall health status of trees around the campus ranked most trees to be in good and excellent condition with over 95 % of trees falling under these two categories (Table 4). The small proportion, which was insignificant, belonged to poor and dead class.

Table 4: Indicative health status of trees/shrubs at SUA main campus

Status	Number of tree	% age of trees
Excellent	486	54.5
Good	369	41.4
Poor	27	2.5
Dead	14	1.6
Total	**891**	**100**

Healthy trees usually reduce expenses that are involved in tending and curing pests and diseases. It also discourages build up of diseases that, in turn, could affect other plants in a landscape or the nearby areas (Richard, 1982). However, trees noted with poor health need to be given deserving attention or else removed. Where signs of irreversibility are obvious, the importance of removing trees with poor condition follows the need of reducing risk to people and their property. Furthermore removing dead tree interferes with the enhancement of breeding site for pathogens and it tends to improve site appearance (IUFRO, 1997)

CONCLUSION AND RECOMMENDATIONS

Conclusion

In the light of the study findings, it can be concluded that species diversification in certain urban centres of Tanzania are likely to have not adhered to the prescribed standards. Single or few species have dominated the landscape in some cities, which is undesirable. The same scenario was noted at genus level, giving an impression on how narrow tree planting at genus level have been. Age class distribution was similarly not ideal. In some urban cities, tree species are as old as the cities themselves with limited new planting. This reduces the future prosperity of the function of urban forest.

Recommendations

SUA, being one among the higher learning institutions majoring in forestry, nature conservation and environmental sciences among other fields needs to maintain high level of professionalism in landscaping to enable others learn from her. In order to maximize the benefits that could accrue from the urban forestry, land-owners and municipals are encouraged to consider employing or seeking technical advice from the landscaping professionals who could take care of the deficit observed. These professionals could start by carrying out an inventory to ascertain what species are available on the land and how best they can be manipulated. Furthermore, tree planting in urban centres need to be pre-planned and town dwellers have to be educated on the ideal way of manipulating the landscape rather than planting whatever they come across.

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